



**European Road Transport Research
Advisory Council**

**ERTRAC Road Transport Scenario 2030+
“Road to Implementation”**



October 2009

Major stakeholders and public bodies represented by ERTRAC

The European Road Transport Research Advisory Council (ERTRAC) represents a diverse group of contributors to a successful European road transport system: consumers, vehicle manufacturers, component suppliers, road infrastructure operators and developers, service providers, energy suppliers, research organisations, and cities and regions as well as public policy experts and authorities at both European and national levels.



The European road transport industry spends more than 30 billion on research and development (R&D) every year. In addition, much of the research and technological development (RTD) is financed in the EU through 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 shorter timescales for the application of new innovations.

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

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. 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

As a multi-stakeholder technology platform, ERTRAC provides road maps for cross-cutting research that will guide the development of RTD and provide a primary reference in the future planning of European and national road transport programmes. In addition, it is hoped that this reference provides an overarching framework for research and technological development as well as guidance for individual research planning.

ERTRAC will continue to support 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, please visit the ERTRAC website at www.ertrac.org. Your feedback is always welcome!

ERTRAC ROAD TRANSPORT SCENARIO 2030+ Road to Implementation

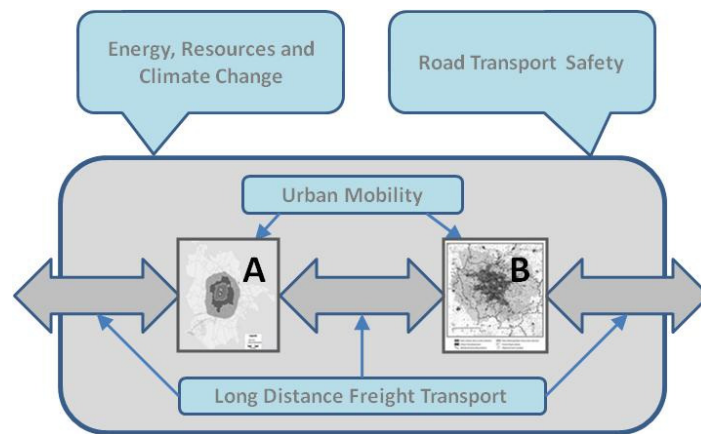
TABLE OF CONTENTS

EXECUTIVE SUMMARY.....	4
1 THE CHALLENGES AHEAD FOR EUROPEAN ROAD TRANSPORT.....	12
1.1 <i>The Working Groups—challenges and key points.....</i>	<i>13</i>
1.2 <i>Putting it all in context.....</i>	<i>15</i>
2 THE SCENARIO PROCESS.....	16
2.1 <i>What has changed?.....</i>	<i>16</i>
2.2 <i>What did we do?.....</i>	<i>17</i>
2.3 <i>Delimitation of the ERTRAC Road Transport Scenario 2030+.....</i>	<i>18</i>
3 FUTURE TRENDS FOR EUROPEAN ROAD TRANSPORT.....	20
3.1 <i>Public Policies.....</i>	<i>20</i>
3.2 <i>Environment and Economy.....</i>	<i>25</i>
3.3 <i>Society.....</i>	<i>34</i>
3.4 <i>Technology.....</i>	<i>39</i>
4 AN INSPIRING FUTURE FOR ROAD TRANSPORT IN 2030+.....	43
4.1 <i>Energy and Environment.....</i>	<i>43</i>
4.2 <i>Urban Mobility.....</i>	<i>50</i>
4.3 <i>Long-distance Freight Transport.....</i>	<i>62</i>
4.4 <i>Road Transport Safety.....</i>	<i>73</i>
A. ABBREVIATIONS.....	88
B. REFERENCES.....	90
C. SCENARIOS AND PAPERS ANALYSED.....	91
D. CONTRIBUTIONS FROM ERTRAC MEMBERS.....	94

EXECUTIVE SUMMARY

This brochure presents the result of ERTRAC's work to develop a 'road transport scenario' and follows on from the publication *ERTRAC Research Framework: Steps to Implementation* (published in March 2008). The *2008 Research Framework* presented an overview of the major technological challenges that lie ahead, and which must be addressed in order to ensure that society's expectations continue to be realised for a greener, safer, and smarter European road transport system. On this basis, ERTRAC identified four 'Strategic Research Priorities' and established Working Groups in each area to address major challenges for the future:

1. **Energy, Resources and Climate Change:** to provide environmentally friendly road transport systems and a secure, renewable energy supply.
2. **Urban Mobility:** to achieve sustainable mobility for passengers and freight in the urban environment.
3. **Long-distance Freight Transport:** to provide (energy) efficient transport solutions (and vehicles) contributing to a reduced environmental footprint for the freight logistics chain, outside the urban environment.
4. **Road Transport Safety:** to reduce road transport injuries, fatalities, and accidents.



The combined efforts of these four Working Groups provide an 'integrated systems approach' to tackling these challenges. Such approach will be also aimed at the early identification and mitigation of barriers to the commercial introduction of new technology, to ensure that implemented technologies not only meet public policy objectives (including those that are not directly related to transport, such as on environment and energy as well as taxation policies of the memberstates) but are cost-competitive, meet consumer expectations, and avoid premature technology lock-in.

ERTRAC's *Road Transport Scenario 2030+* presents a forward-looking guide to these challenges, together with the opportunities that will arise for research, development and innovative technologies through 2030 and beyond. The primary purpose of the scenario is to provide a basis to update ERTRAC's extensive R&D agenda that will extend to 2030 and beyond, in some areas, to 2050. The scenario-building process also provides a basis to translate these needs and objectives into realistic R&D road maps that distinguish between nearer-term priorities, such as the electrification road map to 2020, recently published by ERTRAC, and longer-term priorities for the coming decades.

In the scenario the future of European road Transport is presented from three points of view: (i) the most likely outcome, called the 'common sense' scenario; (ii) a more 'enthusiastic' alternative; and (iii) a more 'pessimistic' alternative. In each case, these scenarios address the key factors for each of ERTRAC's four Working Groups. The scenarios were prepared by ERTRAC stakeholders and other technical experts, and are based on a comprehensive review of previously published information related to energy, environment and mobility. As this document reflects ERTRAC's opinion of the future of European road transport, it may be different in some aspects from the published scenarios and papers that were analyzed in the course of this

assessment. In spite of this, ERTRAC believes that this assessment is robust and will allow a reliable prioritisation of cross-cutting research needs and objectives.

ERTRAC's *Road Transport Scenario 2030+* was developed parallel to the ERTRAC European Industry Roadmap – Electrification of Road Transport, which in turn treats a particular facet of the Road Transport system in more extension and on a nearer term (2020). Special care was taken to harmonise between both parallel documents.

Common Observations

The following observations for 2030 and beyond are common to all four Working Groups.

- By 2030, a harmonised policy framework concerning the European transport sector will be needed to achieve sustainable transport in the two decades leading up to 2050.
 - By 2030, global framework agreements on trade, energy/resources, climate change and environment will have set clear objectives for the European Union to meet over time. This policy framework will result in specific sectoral policies that will be underpinned by thorough and transparent systems analyses to enable each sector to be allocated with its proportional share of responsibilities in meeting the objectives and targets. These agreements are likely to impact the challenges presented to all four Working Groups.
 - The early standardisation of requirements and specifications will also be important in order to achieve successful and cost-effective transitions.
 - This framework would have to be in compliance with other, 'non-transport' policies as well, such as European environment and energy policies, taxation policies of the Member States, as they can create market provisions, positive or negative, for new solutions on the market.
 - Strategies will be needed to have the growth in energy and transport demand in a slower pace than the economic growth; this will be especially important to prepare for challenges beyond 2030. Such strategies must consider the demand for personal mobility within the limits of a sustainable society and avoid social segregation between urban and rural communities and could be for instance based on creative applications of ICT (e-commerce, 'e-freight', etc.) .
- Perhaps the most important common element will be the ability to adapt the road transport system to meet society's needs within the constraints of available finances. Some of the innovative technologies that will be important for future road transport will cost substantial amounts of money, and wise decisions will be needed when considering such investments. It is also important that these decisions are implemented in a coherent way, so that investments are not wasted but build on each other. This must be done through public-private partnerships and a commonly implemented framework for financing the development of the transport infrastructure to optimise capacity, improve road safety, and integrate the infrastructure into the urban and suburban environments.
- The introduction of industrially-oriented ICT applications will greatly increase the economic and environmental efficiency of transport operators and the manufacturing industry in terms of their design, planning, operation and control processes. This will, in turn, lead to the production and transport industries becoming increasingly integrated. Such tools would include sophisticated, predictive simulation and design tools that will help to minimise empirical testing while still producing reliable systems and components as well as a variety of global, logistical network-oriented applications, e.g. to facilitate the tracking and tracing of freight modules to enable the optimal planning and control of transport flows, and to minimise delays and avoid load carriers returning empty. Reliable and validated data and databases will be needed to drive these applications.

- By 2030, a highly integrated and service driven information society will have emerged in which the mobility consumer takes part actively and continuously regardless of his/her location (home, work, commuting, leisure). Especially in the urban areas, where by then more than 80 per cent of the European population will live, a wide variety of on-line services provided by advanced, cheap digital outlets, will bring on dramatic changes in consumer awareness, attitude and behaviour towards transport in general and personal mobility in particular.
 - Available information will be updated in real time, based on consumers' active responses or feedback to services being used. For example, a consumer may choose to relay information to the service concerning a traffic situation on a particular section of the infrastructure, or may provide valuable real-time feedback by the simple act of choosing a particular mode of travel in reaction to a change in tariff. In addition to such 'active' personal responses, a supply of 'passive' information will also be relayed to the service provider, e.g. through the usage patterns of various items of digital equipment used by the consumer, including mobile telephones, computers, vehicles etc. Thus, service providers will receive a wide variety of data and information from many sources, allowing them to provide a tailored, real-time service to each consumer.
 - Mobility operators will be able to use the same information services, for example to optimise the efficiency of the network infrastructure, or to limit the environmental impact of mobility patterns, by offering travel incentives to specific consumer groups or to customers on preferred travel modes and routes, or even by implementing controls to speed limits—all in real time. For those living in rural environments, the same development will reduce social exclusion and ensure consumer access to information and cost-effective mobility options, comparable to those living in urban environments.

Energy and Environment (see also chapter 4.1)

By 2030, concerns about global climate change, combined with increasing demand for energy, will force public policy on a global and regional level, while environmental concerns related to air, water, and noise pollution will be prominent on a regional, country and local level. Energy conservation and diversification and materials recycling will be well-advanced, driven by climate change, energy security concerns and public policy. Energy consumption and greenhouse gas (GHG) emissions from road transport will stabilise due to efficiency improvements in the engine, vehicle and transport system and to the replacement of non-renewable fuels by renewable fuels. The biggest gains will be in the light-duty vehicle fleet.

The energy efficiency of the personal and freight transport system will continue to improve through the application of diverse technological and non-technological measures. Energy supplies will continue to evolve to enable more efficient vehicle technologies. Climate change and competitiveness concerns will encourage greater intermodality of freight transport. For personal mobility, consumer expectations for transportation will be increasingly aligned with public policy directions, while financial and other incentives will encourage changes in consumer choices and behaviour.

Non-renewable fuels will continue to dominate the total energy demand, but global availability and climate change concerns will increase costs and drive innovation for renewable fuels and alternative energy sources. Electrification will become more important in urban transportation, benefiting from improvements in the electric grid and the increasing contribution from renewable energy sources.

Economic growth will continue to depend on a complex, diversified and highly integrated transport system, and will be shaped by the continuing growth and decline in different business sectors. Business will be increasingly motivated to develop and implement new and cost-effective energy and transport technology options that are aligned with enabling legislation and regulations. The cost of energy will be a critical factor for driving investments in renewable and alternative energy technologies, and a stable investment climate will be required to exploit new hydrocarbon reserves and develop alternative and renewable energy resources. Energy demand and supply will increasingly be coordinated on a global scale.

- Improvements in fuel efficiency from the on-road fleet will continue to reduce GHG and tailpipe emissions from passenger cars and freight transport through advances in internal combustion engine and vehicle design.
- Growing contributions to GHG reduction will come from the introduction of hybrid-electric, fully electric, and fuel-cell powered vehicles, although advanced combustion engines will continue to dominate the vehicle fleet through 2030.
- The availability and cost of other non-renewable resources critical to road transport, such as precious metals and lithium, will drive recycling and the development of alternative technologies using more abundant materials and resources.
- Further reductions in energy and GHG emissions will come from fuel production and distribution through manufacturing efficiency, fuel diversification, and the longer-term use of carbon sequestration.
- There will be a greater diversification in the energy and fuel mix, including renewable and alternative fuels in the near term and greater use of electrification from renewable resources in the longer term, with an on-going need for pan-European vehicle and fuel specifications.
- 'Non technological' improvements will additionally add to transport fuel efficiency, ranging from subtle changes in engine and vehicle design to improvements in vehicle maintenance, changes in consumer driving habits, and improved traffic management and logistics.
- Improvements in transport mobility modes enable energy and GHG reductions through better choices and better network management for personal and freight transport. This development is propagated by the expanded use of economic incentives and information technology to improve decision-making and reduce congestion and journey times.

Urban Mobility (see also chapter 4.2)

By 2030, urban mobility will have changed due to socio-demographic evolution (ageing and immigration), urbanization, the increase of energy costs, the implementation of environmental regulations, and the further diffusion of sophisticated Information and Communication Technology (ICT) applications in virtually all aspects of life. The result will be a complex, integrated mobility system, managed with greater efficiency to answer the challenges of reducing environmental impact and minimising urban congestion, while providing comfortable mobility to the traveller.

- Personal mobility demand will diversify as a consequence of a greater choice of comfortable mobility solutions, often multimodal, and new information services made readily available to the consumer. Conveniently located hubs will provide the urban traveller with easy transfers between transport modes.
- The demand for public and collective modes of transport will increase considerably, as a consequence of socio-demographic changes, urbanization and continued urban sprawl. Part of the answer will be provided by public transport (urban rail and bus systems). This will create financial pressure on the mobility system as a whole and on public transport services in particular, while at the same time public finances will have to cope with an increase of social spending, also due to socio-demographic changes.
- Urban development and environment policies, land use and sustainable urban mobility planning will become increasingly integrated. Pan European efforts to generalize approaches for sustainable urban mobility plans will further support this trend. This will only partly contain urban sprawl and it will encourage an evolution towards polycentric urban areas. Public transport systems (bus and rail) will contribute to shape the future urban environment.
- Although the urban transport infrastructure will be optimized to the very limit of its capacity, financial and spatial constraints will prohibit the full accommodation of the increase in (private) mobility demand. Hence, demand management, including pricing policies, will be implemented on a large scale in European cities as part of their mobility network management strategies, and as a way to influence consumer behaviour. Priority will be given to sustainable transport modes and services, including walking and cycling, which will be encouraged and considered as alternatives for certain trips. The use of personal cars in urban environments will nevertheless not decrease significantly.

- New services and business models will emerge for urban mobility, encouraging public and collective services, journey sharing, and shared ownership of vehicles. These will address the increase in mobility demand to mitigate the impact of mobility on the environment and address the challenges presented by the evolution of energy supply and the rising cost of energy. Access to these services will be made much easier, e.g. by single ticketing concepts, allowing the urban consumer to travel leisurely and seamlessly from door to door.
- Information services and e-commerce services will become fully integrated in the everyday life of the urban consumer to the extent that he/she will be on-line continuously and will take part actively in a vibrant virtual community.
- The increasing availability of mobility information combined with ITS will play a major role in optimising network efficiency and allow the traveller to select the optimal combination of travel modes for a specific destination. Traffic and Travel Information (TTI) will support the implementation of advanced management systems (through cooperative systems) and mobility demand management.
- The demand for advanced (home) delivery of goods and services will increase as the urban consumer continues to have access to an increasing variety of on-line information and e-commerce services. In response urban logistics strategies will aim for greater integration of urban freight challenges in urban planning. This will allow for the consolidation of freight delivery and the optimum use of the infrastructure. Transfer hubs will provide a smooth and efficient interface between long-distance freight transport and urban freight deliveries.

The urban vehicle fleet (both passenger and goods delivery) will undergo a transition towards energy-efficiency, electrification and diversification in design (e.g. modular), that ensures that vehicles are more suited to the urban environment and the diversified mobility demand. Especially in the urban environment electrification of the transport fleet will pick up, as up to 15% of the new sold vehicles will be plug-in hybrid and fully-electric. Electrification will also apply to the use of bicycles, mopeds and motorcycles in the urban environment. The diversified demand for public transport and urban goods delivery will have a strong influence on new vehicle design.

Long-distance Freight Transport (see also chapter 4.3)

By 2030 the (freight) transport system will be highly integrated and able to balance energy efficiency and flexibility using ICT based logistic solutions and business models.

Policy measures on the internalisation of external costs will have an impact on freight transport considerations, such as the distances over which goods are moved as well as on the current just-in-time principles and modal choice. New business models for logistics will have an impact on efficiency and flexibility such as transport capacity being offered on demand and enhanced cooperation between different organizations involved in the transportation of goods.

Road (and rail) transport between Europe and Asia will increase considerably as a consequence of the shift in Europe's global trading partners towards those in much closer 'low wage' regions. However, this represents strong growth from a very low starting point and would require significant (expensive) improvements in infrastructure and removal of regulatory or institutional barriers that prevent the development of efficient transport services, such that ocean freight shipping will continue to dominate European-Asian freight transport. Different gateways to, and from, southeast Asia (ASEAN) will develop, concentrated in the eastern European Member States and connecting to the corridors to Asia.

- European road infrastructure capacity will be stretched to its absolute limit. While rail and waterway systems will have grown substantially and increased their market share, rail infrastructure constraints and the economics of short-haul freight movements will mean that road remains the dominant freight mode.
 - Short-term relief to the growing transport demand will be provided by full-scale and comprehensive traffic management of the congested corridors interconnecting the economic/metropolitan regions as well as those connecting these regions to the important intracontinental corridors. In addition the introduction of new, more durable materials, construction and management concepts will help to reduce maintenance 'down time' of the capacity.

- Additional long-term relief will be provided by ‘debottlenecking’ of the congested sections of the road infrastructure (e.g. short cuts, bridges and viaducts, the use of ICT based systems). It is likely that legislation will be introduced to streamline the procedures for civil participation and ensure that such projects are completed in the least possible time.
- Additional measures, including new pan-European transport strategies will need to be introduced in the decades following 2030, to minimise the risk of a breakdown in the transport system. Government policies will aim to maximise socio-economic benefits and limiting external costs per unit of freight moved.
- The majority of EU Member States will voluntarily adopt new policies and standards on weight, dimensions and ICT that will allow for the development of new vehicle designs with significantly improved aerodynamics, fuel consumption, safety performance and driver comfort—features that will be employed in almost all long-distance freight transportation by 2030.
- The concept of modularisation will be implemented by 2030 and will bring increased efficiency and flexibility to freight transport system as all freight transport modes can share the same interfaces and will be able to use the same freight modules. Depending on the need and transport assignment, small freight modules (goods containers) that will typically be used for urban transport can be combined into bigger ones for long-distance transport and vice-versa.
- Longer and heavier vehicles (LHVs) with significantly higher load capacity will be widely used along with measures to mitigate or prevent any consequential mode shift. The acceptance of these developments is to be considered a critical factor, but the trend shows acceptance by the public for LHV’s as viable solutions to congestion and environmental constraints, especially in North-Western Europe.
- By 2030 vehicles will be smart enough to ‘sense’ their surroundings and navigate through traffic safely and efficiently, while providing their occupants personalized comfort and convenience. The vehicle will be a ‘node on the internet’, and will be ‘on-line’ with other vehicles (V2V), with the transport infrastructure (V2I), and with homes, businesses and other sources (V2X). Support systems will assist the driver by offering automated responses to developing traffic situations, by coaching the driver to operate the vehicle in the most energy efficient way etc.
- Additional long-term relief will be provided by ‘debottlenecking’ of the congested sections of the road infrastructure (e.g. short cuts, bridges and viaducts, the use of ICT). It is likely that legislation will be introduced to streamline the procedures for civil participation and ensure that such projects are completed in the least possible time.
- Additional measures, including new pan-European transport strategies will need to be introduced in the decades following 2030, to minimise the risk of a breakdown in the transport system.
- The ‘green corridor’ concept will have been introduced and will be used for highly populated highways throughout Europe. The criteria for access to these corridors will be related to new vehicle concepts and transport and energy efficiency. In these corridors, longer and heavier vehicles will be the majority, and ‘platooning’ (electronic coupling of trucks) will be widely used. Transport modes complementing each other will be used on the basis of optimal resource utilisation.
- The concept will include infrastructure dedicated to freight transport but the cost of this will be minimised by ensuring that new roads/tunnels etc. are constructed for light vehicles only and the old facilities will be dedicated to heavy vehicles.
- In 2030, tri-modal land hubs will provide fast (i.e. efficient) transshipment of people and goods between rail, inland waterways and road services. Especially in and around urban areas, these hubs will attract other commercial activities such as shopping, finance and office facilities. Conventional inland terminals, as exist today, will still be operating, serving regional traffic and local distribution.
- The important interconnection between long-distance transport (longer vehicles) and urban distribution (smaller trucks) represents a big challenge and will be handled by terminals and vehicle concepts that accommodate the interface at an extreme minimum of efficiency loss to the overall chain.
- Automatic locking on container castings and tray castings, in combination with the automatic positioning will be standard as will enhanced communication technology to enable cargo and pallets to remotely communicate their status, and ‘smart dust’ providing physical security for loading units.

- The fuel pool for long-distance freight transport will consist predominantly of fossil distillates while the share of renewables and synthetics in the fuel pool will be small compared with urban freight transport. The typical powertrain system will be an integrated unit, tolerant to alternative fuels and multi-fuel blends and will use advanced control systems for optimised operation and fuel efficiency, such as integrated waste heat recovery systems combined with efficient exhaust aftertreatment systems securing low emissions, whereas auxiliary systems will typically be powered by low-carbon technologies such as fuel cells .
- A certain degree of hybridisation is expected in long-distance transport enabling e.g. downsizing of the engine and thereby reducing fuel consumption. However, ongoing electrification of the powertrain will be confronted by unrealistic costs and standardisation issues, e.g. power storage and recharging requirements. Battery cost and weight will probably be a limiting factor for the foreseeable future.

Road Transport Safety (see also chapter 4.4)

By 2030, road transport safety will still be an important social problem in spite of the wide introduction of sophisticated safety measures to the user, the vehicle and the infrastructure. Factors that are likely to contribute to an increase in road transport safety risks include the increasing number of vulnerable road users, an increase in accident incompatibility between vehicles, the increasing number of elderly people and an overall increase in mobility demand, particularly in the more critical context of urban road use. On the other hand, the introduction of safety systems, e.g. Advanced Driver Assistance Systems (ADAS) and cooperative systems, in vehicles and transport infrastructure, as well as increased consumer awareness and acceptance of these safety systems, will offset the aforementioned impacts on safety risk, but it is not clear whether the overall result will be positive, i.e. a net reduction of the safety risk.

- Consumer awareness of road safety issues will have led to the general acceptance of advanced safety technologies (e.g. anti-lock braking systems, electronic stability controls, emergency call facilities, etc.) and safer conduct. Policies on, for example reducing speed limits and the adoption of eco-driving strategies (e.g. smoother acceleration and deceleration), as well as on continuous education of the road user and the provision of discounts on insurance premiums or taxes, will further enhance this trend.
- Safety systems will be implemented on the vast majority of vehicles, but the sophistication of the individual systems will depend on the class and age of the vehicle.
- The rising number of vulnerable road users, together with the introduction of more small, new vehicles and the growing number of trucks combined with developments such as vehicle 'platooning' which allows for better aerodynamics and thus for improved fuel efficiency, will increase vehicle incompatibility in relation to accidents, and therefore will also increase safety risks. This will be addressed by a completely new approach to vehicle and infrastructure design, which will be aimed at maximising both the passive and active safety of vehicle occupants and other road users.
- The next generations of 'elderly' people will not change their mobility behaviour, and this will lead to an increase in safety risk due to their enhanced vulnerability and reduced driving proficiency.
- Although the congested sections of the European road infrastructure will be 'debottlenecked' to accommodate the increased volume of personal and freight transport, capacity will still be stretched to its limits and sensitive to disturbances, therefore creating a relatively high safety risk for the road user.
- The costs for maintaining and developing the road infrastructure will increasingly be financed by private capital; hence the balance between costs, benefits, user needs and safety requirements will be the subject of ongoing public debate.
- Policy and measures, adopted either at European or at Member States level, will continue to have an important role in the improvement of Road Transport Safety.

ERTRAC's guiding ambition for Future Research Priorities

As stated, the primary purpose of the scenario presented in this document is to provide a basis to update ERTRAC's extensive R&D agenda that will extend to 2030 and beyond, in some areas, to 2050.

In view of the observations that are common to all four working groups as well as their specific scenario elements, the R&D agenda will be structured around three crucial applications in the road transport system, being:

- **passenger and freight transport/delivery inside the urban areas**, where over 80% of the European population will reside.
- **freight transport outside the urban areas**, that services the connection between Europe's urban areas and between Europe and the world
- **Interconnection between both**, that allows for a clear but unhindering separation between the two transport subsystems

The R&D agenda will have to enable a leap in efficiency for all three applications, implying they have to become much smarter, safer and greener than now. As a guiding direction ERTRAC's update of its R&D agenda is set out on following ambition:

In 2050 the road transport system will be 50% more efficient than in 2010.

The required R&D will be structured in cross-cutting themes and systems approaches that reflect the major elements in the common sense scenario, concerning obviously the kernel for Road Transport consisting of the user, the vehicle and the infrastructure but also the more systemic aspects of the road transport system, such as urban planning & design, energy & resources supply, manufacturing & production, logistical and mobility services, consumer awareness as well as the enabling policy framework and strategies.

These themes, driven by the findings from the scenario analysis, will enable a comprehensive re-evaluation of ERTRAC's future research priorities. This additional work will be completed in 2009-10.

1 THE CHALLENGES AHEAD FOR EUROPEAN ROAD TRANSPORT

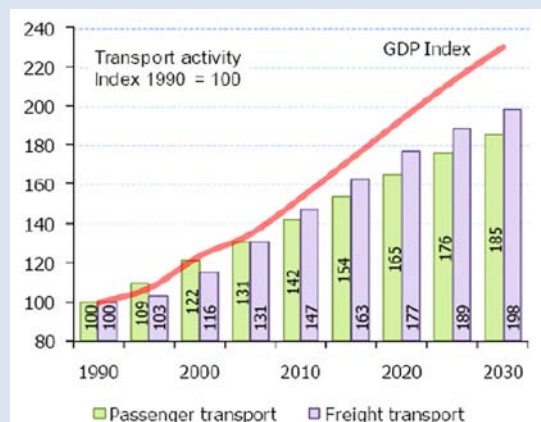
For many years, society has benefited from major improvements in the road transport sector, including improvements in vehicle safety, fuel consumption, and emissions performance. Challenges remain, however. For example: accidents and fatalities remain unacceptably high; air quality and noise are on-going issues, especially in urban environments; energy consumption is increasingly contributing to global GHG emissions; while Europe faces the prospect of becoming ever more reliant on imported energy.

The road transport sector is already facing strong global competition. Hence, addressing the challenges that lie ahead will require:

- an integrated, forward-looking approach that takes account of all key drivers for future road transport development; and
- a clearly established time-frame for broad commercial implementation of technologies that is consistent with the established goals and objectives for the sector.
- The public-private partnership (PPP) model for the integration of research activities between industrial, national and EC programs

Size and projected growth of EU passenger and freight transport

It is difficult to overstate the 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 European Union's Gross Domestic Product (GDP). Road transport supplies the majority of mobility services demanded by Europe's citizens and businesses and will continue to do so in the foreseeable future. It is also responsible for more than 40% of inland freight transport and, as such, plays a critical role in the success of all European industrial and commercial activities.



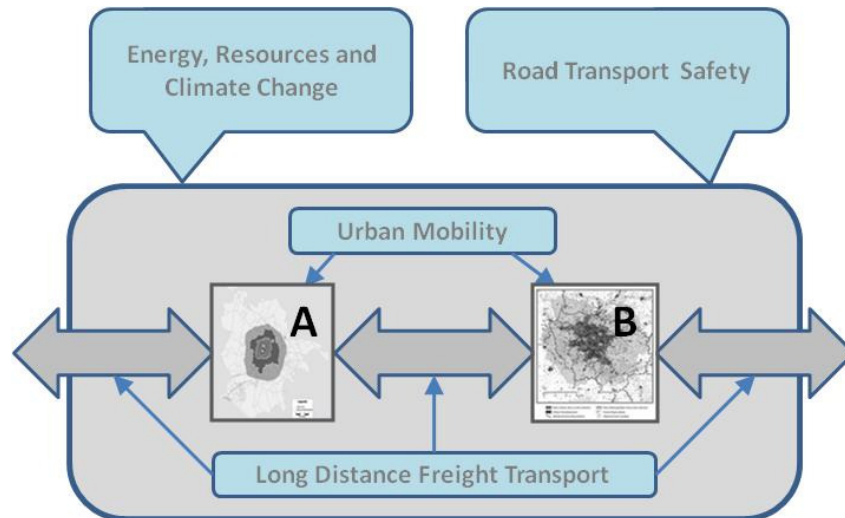
Source:

Within the time horizon of this scenario analysis, the volume of European passenger and freight transport activity can be expected to increase between 40 to 50% compared to today.

This study is the result of ERTRAC's work to develop a 'road transport scenario'. The primary purpose of the study is to provide a basis to prioritize ERTRAC's extensive R&D agenda that extends to 2030 and beyond, in some areas, to 2050.

This report reflects the technical opinion of ERTRAC's experts and stakeholders and follows on from the March 2008 publication *ERTRAC Research Framework: Steps to Implementation*. The 2008 *Research Framework* presented an overview of the major technological challenges that lie ahead, and which must be addressed in order to ensure that society's expectations continue to be realised for a greener, safer, and smarter European road transport system. On this basis, ERTRAC identified four 'Strategic Research Priorities' and established Working Groups in each area to address major challenges for the future:

1. **Energy and Environment:** to provide environmentally friendly road transport systems and a secure, renewable energy supply.
2. **Urban Mobility:** to achieve sustainable mobility for passengers and freight in the urban environment.
3. **Long-distance Freight Transport:** to provide (energy) efficient transport solutions (and vehicles) contributing to a reduced environmental footprint for the freight logistics chain, outside the urban environment¹.
4. **Road Transport Safety:** to reduce road transport injuries, fatalities, and accidents.



The combined efforts of these four Working Groups provided an ‘integrated systems approach’ to tackling these challenges.

1.1 The Working Groups—challenges and key points

1.1.1 Energy and Environment

The challenge here is to develop commercial opportunities to meet individual and societal demands for mobility, vehicle performance, reductions in GHG emissions and improvements in energy efficiency while delivering low environmental emissions from road transport. Reducing GHG emissions from road transport is a particular challenge, given the anticipated growth in passenger and freight transport demand through 2030 and beyond. Reducing energy consumption and diversifying the energy mix used for road transport are equally challenging and driven by the need to reduce European dependence on imported oil. Key points include:

- Improvements in fuel efficiency from the on-road fleet will continue to reduce GHG and tailpipe emissions from passenger cars and freight transport through advances in internal combustion engines and vehicle design.
- Further reductions in energy and GHG emissions from fuel production and distribution through manufacturing efficiency, fuel diversification, and the longer-term use of carbon sequestration.
- Greater diversification in the energy and fuel mix, including renewable and alternative fuels in the near term and greater use of electricity from renewable resources in the longer term.

¹ In this document Long Distance Freight Transport (LDFT) is concerned with transport that generally takes place between hubs and terminals and business to business. In Europe where the transport network is relatively dense compared to comparable markets elsewhere in the world, one can realistically define long-distance freight transport as that share of freight transport that does not occur in urban areas.

- Growing contributions to GHG reduction from hybrid electric, electric and fuel cell vehicles through 2030 and beyond.
- Improvements in transport fuel efficiency, including subtle changes in vehicle design and auxiliary systems to capture energy losses, improvements in vehicle maintenance, changes in driving habits, and improved traffic management and logistics.
- Improvements in road transport infrastructure to enable energy and GHG reductions, through better choices for personal and freight mobility modes and the expanded use of information technology (IT) to improve decision-making, reduce congestion, and speed up travel.

1.1.2 Urban Mobility

The challenges are to provide society with high-quality public transport that people will want to use, and to enable traffic to be free-flowing in the urban setting. The many complexities associated with the urban environment should be considered together, to ensure that an intelligent and efficient road transport network will be a vibrant part of our future. Key points include:

- 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 emphasis 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 between freight delivery, 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.

1.1.3 Long-distance Freight Transport

The challenge for this area is to meet the increasing demand for road freight transport and the rapidly changing needs of customers, while contributing to an environmentally sustainable transport system. Enabling greener long-distance transport corridors is a specific target where the focus includes innovative solutions for increased freight transport efficiency and effectiveness. Key points include:

- The possibility of increasing efficiency through a better understanding of distribution/logistics system practices.
- Development of energy-efficient transport solutions.
- Development of customized truck and load carrier concepts, including modular vehicles, that are readily optimised for specific freight transport purposes.
- Options to deal with the increasing competitiveness for available liquid fuels.
- Development of the transport infrastructure, i.e. infrastructure dedicated to freight transport could allow roads, bridges and tunnels to be optimised for particular types of vehicles, reducing build and maintenance costs, and environmental impact.
- Improved interconnection between long-distance and urban transport as well as between modes, e.g. the development of hubs, terminals, vehicles and load carriers that enable goods to move seamlessly between modes and from heavy- to light-duty transportation.

1.1.4 Road Transport Safety

The challenge here is to continuously improve safety in the road transport sector through an integrated approach covering accidentology, preventive and protective safety, cooperative systems, and emergency management. 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 the ways in which he/she responds to this information. Key points include:

- Continue and accelerate the progress started under the European Commission's Road Safety Action Plan and eSafety Programme. These programmes set a clear target for reducing road accident fatalities by 50 per cent in 2010 (compared to a 2001 baseline). The challenge is to ensure that this progress is not adversely affected by the significant changes expected in the transport system as a result of competing pressures on the economy and the environment.
- Improve on the above process, through new technologies to help the driver control the vehicle and to facilitate the adoption of 'safe' decisions, resulting in improved driver perception and awareness of the risks involved. Human factors studies and network infrastructure improvements will also be needed to achieve these safety objectives.
- Beyond technology, enable effective driver training so that the driver adopts a safe and alert behaviour that ensures control of the vehicle while removing or minimising potential accident risks.

1.2 Putting it all in context

Having briefly described the challenges for each Working Group, it is important to put these challenges in the proper context of the current and future social, political and business environment:

- Economic development is enabled by an effective and efficient road transport system that binds together the different sectors of the economy and the different stages of production within each sector. It is crucial therefore that the future challenges of road transport be met with consideration given towards the other sectors of the economy. This scenario therefore extends beyond the system boundary of road transport itself and considers the relationships with other modes of transport (e.g. rail, air and cycle transport) as well as the relationship with other sectors of the economy (e.g. mining, energy/power, ICT, production, etc.).
- 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 scenario priorities described in this document must be underpinned by enabling studies in behavioural changes, social and economic trends, predictive tools and models, financing and investment strategies, and decision-making processes to speed R&D concepts to commercial realities.
- Society's increasing reliance on the road transport system has the potential to negate continuing improvements in transport efficiency. For this reason, social trends or measures that reduce the growth in demand for personal mobility or 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 consumer and driver behaviours are also important.
- Finally, appropriate data and research tools are needed to drive this understanding and innovation. Models of human interactions and user acceptance of different mobility modes must be defined. Common methodologies for routinely collecting and interpreting 'mobility information' will be needed that span European and international boundaries.

2 THE SCENARIO PROCESS

2.1 What has changed?

This assessment of Europe's road transport to 2030 and beyond was driven by several realities. When ERTRAC released its first major publication, *Vision 2020 and Challenges* (ERTRAC, 2004) in June 2004, its work was focused on a 2020 time horizon that now appears to be much closer than it did just five years ago. Following the *Vision 2020* document, the *Strategic Research Agenda* (ERTRAC, December 2004) and *Research Framework* (ERTRAC, April 2006) were published to translate the vision statement into the first research agenda for road transport. These documents were complemented in March 2008 by the *ERTRAC Research Framework 2008*, a first attempt to describe the R&D priorities for road transport in the form of technology road maps.

When the current work was initiated in mid-2008, there was an opportunity to look again at the future of European road transport and extend the vision further into the future. For this reason, this scenario document projects to a 2030 horizon, with a brief look ahead to 2050 in some areas of the study. More importantly, the drivers for Europe's road transport future are much different today than they were five years ago. These differences seem likely to impact the future of road transport for many years to come, and perhaps much more profoundly than can be imagined today.

Here are a few examples of the major changes in focus that have occurred in a very short time: the prominence of climate change in policy decisions; the costs and availability of fossil energy; the increasing focus on vehicle fuel consumption; the emphasis on renewable and alternative sources for energy and fuels; the changes in population and consumer expectations; and the emerging role of information and modelling technologies in road transport. At the same time, the traditional expectations from road transport are as important today as they were in 2004: reducing vehicle emissions; improving air quality; unrelenting demand for long-distance freight transport; need to continuously improve safety for all road users; and providing inexpensive on-demand personal mobility to consumers.

The consequence of these emerging and traditional pressures is that today's road transport system is entering a period of significant change. New vehicle and propulsion concepts, diversification of the energy and fuel supply, the need to accommodate a growing urban population, and many other factors will continue to present challenges for many years to come. These changes, driven by public policy priorities that extend well beyond city, country, and regional boundaries, are poised to dramatically challenge the consumer's perception of personal mobility while stimulating energy conservation and production from local sources. For these reasons, the time seemed right to re-assess the future of European road transport and the opportunities that will arise for research, development and innovative technologies.

The objective of this re-assessment is to examine the future of road transport up to 2030, and to use the results of this re-examination as the basis for carrying out a more critical appraisal of research priorities than had been done before. Achieving the public policy targets and societal expectations without significant sacrifices in personal mobility and economic growth will be an enormous challenge. Meeting this challenge will depend on the ability of multi-stakeholder groups like ERTRAC to be highly specific about the technological and non-technological opportunities, and to challenge the imagination, talent and long-term commitment of Europe's engineers and scientists.

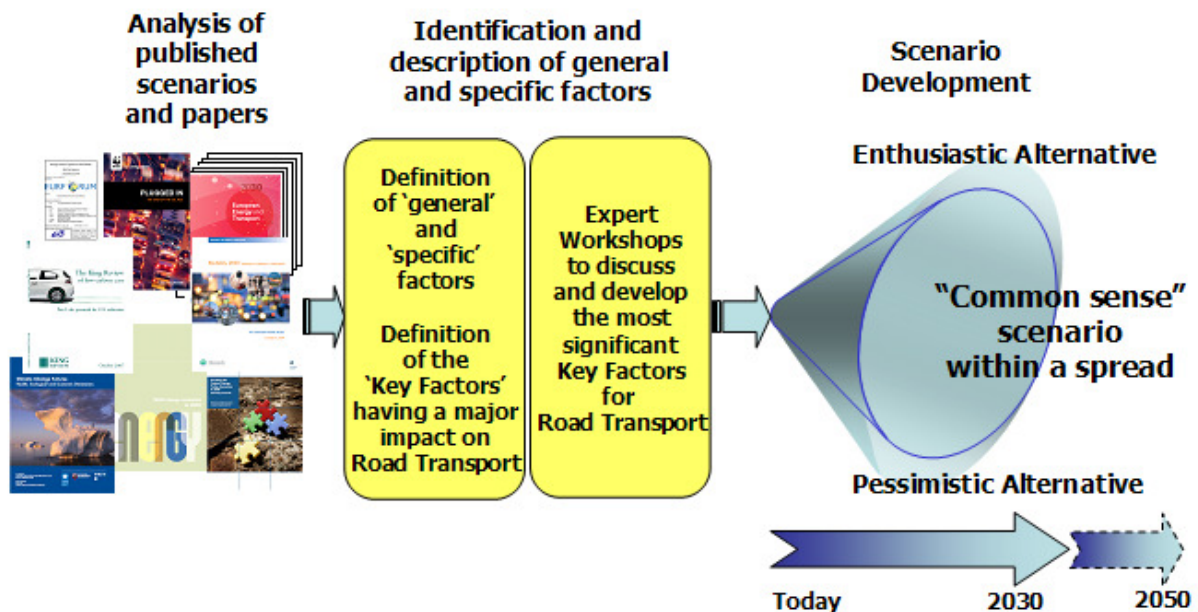
Based on a detailed assessment of a broad range of published scenarios and papers, ERTRAC has developed an integrated Road Transport Scenario with a 2030+ outlook, representing all relevant factors that are concerned with road transport. The scenario, presented in this publication, reflects a 'common sense' view, that is, an extrapolation to the 2030+ future based on expert input from knowledgeable sources.

The objective is to determine the research and development priorities for road transport that appear most likely to result in positive change over the longer term. Finally, with a scenario for the future and an assessment of R&D priorities, ERTRAC's task will be to encourage implementation of these priorities through public-private partnerships (PPPs).

2.2 What did we do?

The first task was to identify and review recently published scenarios and papers for key messages that were especially relevant to the future of road transport, and for the factors that were considered to be important for driving or enabling future positive and negative responses to global problems. The scenarios studied were not always directly related to road transport but often addressed many important related aspects including, among others, the potential impact of climate change, energy demand, population demographics and urbanisation.

Although some scenarios considered a particularly long time horizon up to 2100, most were focused on the 2030 horizon selected for ERTRAC's study. Examples include the European Commission's DG-TREN publications *European Energy & Transport—Trends to 2030* and *Report on Transport Scenarios with a 20 and 40 Years Horizon* (published jointly with Tetraplan A/S). Other examples include *Shell's Energy Scenarios to 2050*, the *IPCC Fourth Assessment Report Climate Change 2007 Synthesis Report (Summary for Policymakers)* and the *Stern Review on the Economics of Climate Change*. In total, about 60 such scenarios were analysed, and a complete listing can be found at the end of this report.



These factors covered a range of properties and were considered to be either generally applicable to all Working Groups (e.g. economy development, which seemed likely to impact all aspects of the scenario analysis) or specifically applicable to one, or perhaps two, Working Groups (e.g. vehicle emission standards, which seemed likely to be applicable only to the Energy and Environment Working Group).

A cross-impact analysis was then carried out to identify those factors that had either a particularly active or passive role as a future driver. After the key factors were identified and described, the second task followed in which the actual scenario development was done.

In this step, the generally applicable factors were subdivided into classes: policies, economy and environment, society and technology. Then, for each class, a future trend was established that would serve as a reference to the scenario development within the Working Groups. Where appropriate, upper and lower bounds to the reference trend were also indicated.

With these future trends as a reference, each Working Group independently considered the implications of the future development of those factors that were applicable to their area. Based on the consensus from the Working Group's experts, the most likely development of the factors involved was determined together with a shared opinion on the implications for the year 2030. Thus the 'common-sense' scenario was created.

In several instances, however, the 'common-sense' scenario was identified as the most likely outcome but was not necessarily the only possible outcome. For this reason, possible alternatives were considered, some more 'enthusiastic' and some more 'pessimistic' about a particular future outcome. These three possible futures are described as follows:

- **'Common-Sense' Scenario:** Road transport as it is most likely to be in 2030, in the opinion of ERTRAC's experts. The assumption for this scenario is that development in Europe will continue to follow the current long-term trends without extremes. Within the time frame considered, climate change will impose no unmanageable constraints. This is the reference scenario for the upcoming evaluation of research priorities and for developing road maps and implementation plans.
- **'Enthusiastic' Alternative:** Road transport as it may be in 2030 if most factors develop to a better level than that anticipated under the 'common-sense' scenario. Europe will 'green' its society to the greatest extent possible, supported by economic growth leading to greater prosperity and affluence. Economic development will be driven by liberalisation and globalisation, and will be successfully decoupled from energy consumption. Society will respond in a dynamic way as it sees the changing basic conditions as a major opportunity. Within the time frame considered, climate change will represent a challenge but will not impose unmanageable constraints.
- **'Pessimistic' Alternative:** Future transport as it may be in 2030 if most factors develop to a worse level than that anticipated under the 'common-sense' scenario. Europe will be confronted with longer-lasting economic problems, resulting partly from extremes or uncertainties in energy costs and significant impacts from climate change. As a result, development in Europe will fall behind the global trends. Society will hesitate in their response to the sometimes dramatic negative changes, and people may fear that they will lose touch with their social environment. Within the time frame considered, climate change will impose increasing constraints on the economy as mitigation efforts place a substantial burden on the economy and adverse weather events (storms, droughts etc.) increase in frequency and severity.

After the 'common-sense' scenario and the two alternative futures had been drafted, the Working Groups began a process of consultation with experts in ERTRAC organizations and beyond to obtain consensus on a final draft prior to publication.

The Working Groups started from the key notions for the 'common-sense' scenario and the 'enthusiastic' and 'pessimistic' alternatives. First, experts were consulted on a preliminary draft of the 'common-sense' scenario, checking for omissions and inconsistencies, and discussing what would be required to achieve the future depicted, presuming that all key factors would develop according to long-term trends. In this way, the 'common-sense' scenario was consolidated. Experts were then consulted on drafts of the 'enthusiastic' and 'pessimistic' alternatives. Again, opinions were solicited to improve and clarify both alternatives and to check on the degree to which the future depicted would either be met or remain a challenge.

Finally, after the three alternative scenarios were consolidated, a broader consultation was held on the final draft of the scenario document. The draft was presented to ERTRAC members and other stakeholders for final consultation and comment. All comments were gathered and their impact on the consolidated scenario was discussed. Thus the scenarios were finalised.

The result, we believe, is a robust scenario for European road transport, stretching out beyond 2030, in which future challenges are captured in a consistent and comprehensive way.

2.3 Delimitation of the *ERTRAC Road Transport Scenario 2030+*

The purpose of the *ERTRAC Road Transport Scenario 2030+* is to provide a basis for the ERTRAC research agenda that extends to 2030 and, in some areas, beyond to 2050. When completed, this agenda will define the R&D priorities and timing needed to achieve a robust, sustainable, and cost-effective road transport system. This research agenda reflects the combined opinion of ERTRAC experts on the future development of road transport, including factors external to road transport that will impact future developments.

Nevertheless, the *Road Transport Scenario 2030+* analysis presented here has certain limitations:

ERTRAC Road Transport Scenario 2030+

- This scenario analysis is an ERTRAC perspective based on its own stakeholders' interpretation of the relevant and recently published scenarios and papers on the future of energy, environment, transport, and related topics.
- The scenario analysis primarily focuses on road transport of passengers and freight and does not extensively cover related aspects of rail or waterborne transport. This is the combined responsibility of ERTRAC and other groups. The interrelationships among all transport modes are highlighted, however, where appropriate.
- The scenario analysis is focused on a 2030 horizon with a 2050 outlook in some areas. Where possible, a nearer-term view is also provided in order to identify key milestones and necessary deliverables that will be essential in order to set the stage for a successful outcome in 2030+.
- Finally, this scenario analysis is a snapshot in time and will be modified and improved as new information becomes available. Most importantly, the key conclusions regarding important research and development targets will be monitored by the ERTRAC Working Groups and adjusted accordingly as new outlooks and perspectives emerge.

3 FUTURE TRENDS FOR EUROPEAN ROAD TRANSPORT

Many of the challenges faced by future road transport arise from a number of general factors that are external to the road transport system itself. In order to describe the reference outlook and possible alternatives for each of the Working Groups in greater detail, it is first necessary to consider the impact of these general factors on future regional and global decisions and how they are likely to impact road transport at the 2030+ time horizon. For each factor, this will be presented as a background trend including an indication of upper and lower bounds.

Public Policies	➤ Business and consumer motivation
Environment and Economy	<ul style="list-style-type: none"> ➤ Climate change ➤ Economic growth ➤ Energy and resources ➤ Environment and ecology ➤ Mobility and transport costs ➤ Globalisation
Society	<ul style="list-style-type: none"> ➤ Demographic change ➤ Increasing urbanisation ➤ Changing society and consumer trends
Technology	<ul style="list-style-type: none"> ➤ Technology development ➤ Information and Communication Technologies (ICT)

3.1 Public Policies

Public policies, and the legislation, regulations, and standards that follow, can strongly influence the way that the present evolves into the future. Policies are a major motivator for businesses and consumers to reconsider future opportunities and behaviours and, perhaps, adopt ‘greener’ alternatives that are more likely to lead to a particularly desirable outcome. Policies can enhance developments and trends either directly (e.g. through financial incentives or penalties) or indirectly, by providing beneficial political, societal and economic conditions (e.g. political and social cohesion, international cooperation and alliances, education, infrastructural investment/participation, etc.).

The transport system is a widespread and extremely complex public-private enterprise, hence a wide range of policies and regulations have an impact. These concern not only the movement of goods and passengers, but also taxation, employment, working conditions, environmental impact, road safety, and performance standards. Not all policies originate from or are the responsibility of the European Union. In several areas, such as infrastructure, policy initiatives are primarily governed by Member States (principle of subsidiarity) or by global organisations and agreements.

This paragraph will not intend to display a comprehensive over view of all policies involved with the road transport sector nor will it present an elaborate scenario with alternatives on what the situation in 2030 could look like for the different policies. Instead it provides a global impression of the different issues covered by policies and legislation concerned as well as a indicative common sense future trend towards 2030.

Of special interest to this scenario analysis are policy initiatives that are concerned with:

- **General transport policies**, including road safety (e.g. Road Safety Action Programme (2003–2010); driving licences; drinking and driving regulations; roadworthiness testing of (heavy goods) vehicles; and many others.

- **Environmental policies**, including climate change, fuel quality, and renewable energy; air and water quality; type-approval of motor vehicles; regulated emissions from vehicles (e.g. Euro 5/6 standards); quality of gasoline and diesel fuels (e.g. sulphur, lead); reusing, recycling and recovering motor vehicles; noise pollution from vehicles; emissions from large-scale industrial and agricultural activities; registration of chemicals; promotion of clean road transport vehicles within public authorities; quality of nature and biodiversity (e.g. NATURA 2000), and many others.
- **Research and innovation policies**, including the 'green car' initiative; satellite navigation (Galileo); nanotechnology; and many others.
- **Internal market policies**, including procedures for regulating vehicle insurance across Member States; Intellectual property; and many others.
- **Taxation policies**, including passenger car related taxes; taxation of heavy goods vehicles (e.g. Eurovignette Directive); European Community framework for the taxation of energy products and electricity; and fiscal marking of gas oils and kerosene.
- **Safety policies**, as in the past the Road Safety Programme (2001), aiming to reduce of the 50% the fatalities in 2010.

Although not comprehensive, some public policies, described below, are especially relevant to the road transport scenario.

Climate change and GHG emissions

In its climate change legislation, the EU established a target to reduce GHG emissions by 20 per cent by 2020, based on 1990 baseline levels. In addition, the EU endorsed reducing GHG emissions by an additional 30 per cent by 2020 if other developed countries commit to comparable reductions under a global agreement. To underpin these commitments, EU leaders set three key targets to be met by 2020: a 20 per cent reduction in energy consumption compared with projected trends; an increase to 20 per cent in the share of renewable energy of total energy consumption; and a 10 per cent replacement (on an energy basis) of fossil fuel-derived gasoline and diesel with sustainably-produced biofuels.

At the end of 2008, the EU approved legislation to lower the fuel consumption of new passenger cars to an average of 120 g CO₂/km by 2012 and 95 g CO₂/km by 2020. Some portion of these improvements can come from biofuels and improvements in air-conditioning and tyres. An excess emissions premium will also be imposed if the average emission levels are above the limit values. The Commission is currently developing a new legislative proposal to reduce CO₂ emissions from light commercial vehicles (vans and minibuses). Directive 2009/30/EC (Fuel Quality Directive) also approved in 2008 requires reductions in GHG emissions from fuel manufacturing, based on a 2010 baseline.

Air quality

Population living and working close to major transport infrastructure may be at risk due to increased levels of air pollution and noise. A first assessment shows that approximately 9 per cent of the EU population will live closer than 200 meters from a major road carrying more than 3 million vehicles per year, and as many as 25 per cent of the EU population will live closer than 500 meters from such a road. Hence, there will be a small increase in population exposed to air pollution from road traffic, except for those living very close to major roadways.

Public policy in this area has focused on improving air quality by controlling emissions of harmful substances into the atmosphere, by improving vehicle emissions performance, and by integrating environmental protection requirements into the transport and energy sectors. Examples are Directive 98/69/EC on air pollution by emissions from motor vehicles and Regulation (EC) No. 443/2009 on emission performance standards for new passenger cars.

For light-duty vehicles, the current emission standard is Euro 4, as defined by Directive 98/70/EC. Following the Clean Air for Europe (CAFE) programme and the resulting Thematic Strategy on Air Pollution (TSAP), new vehicle emissions standards have already been agreed by Council and Parliament and the Euro 5 vehicle emissions standard for light-duty vehicles will be introduced this year.

Noise pollution

It is estimated that about 14 per cent of the EU population lives closer than 300 meters from a major road carrying more than 3 million vehicles per year. Approximately 3 per cent of these people will experience road noise exceeding 65 dBA. These levels are sufficient to be associated with significant levels of annoyance, sleep disturbance and cardiovascular effects.

The European Commission has developed a noise policy framework, based on shared responsibility among Member States, at national and local level. This framework includes measures to improve the accuracy and standardisation of data in order to improve the coherency of specific actions. This framework leads to a comprehensive set of measures, related to transport-related noise sources such as motor vehicles, aircraft and railway rolling stock.

Nature and biodiversity

Over the past 25 years, a vast EU network of protected areas has been established consisting of more than 26,000 parcels. This network covers land in all Member States and totals around 850,000 km², representing more than 20 per cent of total EU territory. This vast array of sites is known as the Natura 2000 network, the largest coherent network of protected areas in the world. The legal basis for the Natura 2000 network comes from the 1979 Birds Directive and 1991 Habitats Directive. Taken together, these Directives constitute the backbone of the EU's internal policy on biodiversity protection.

Land use

More than 80 per cent of the EU's 377 million citizens live in cities and towns and, on average, 117.5 people live on each of the EU's 3 million square kilometres. This makes land-use planning and management an important environmental and land development issue. Land use can have major impacts on environmental conditions including the loss of natural habitats and landscapes or increased air pollution and GHG due to higher traffic levels. Although land-use planning and management decisions are usually made at local or regional level, the EC plays a role by ensuring that Member States take environmental concerns into account when putting together their land-use development plans. One of the Commission goals in this area is the development and implementation of a European urban environment strategy to develop a sustainable and integrated approach to urban development and management together with the improvement of the natural systems.

Biofuels and renewable energy

Energy consumption in the transport sector depends almost exclusively on imported fossil fuels, mainly crude oil. The transport sector is forecast to grow more rapidly than any other sector up to 2020 and beyond and will remain crucial to the functioning of the European economy. The importance—and the vulnerability—of the transport sector require that action is taken to improve sustainability and reduce its demand on Europe's energy supply.

Under Directive 2009/28/EC (Renewable Energy Directive), a firm target has been set for increasing the share of renewable energy in transport fuels to a minimum of 10 per cent (on an energy basis) by 2020. The greater use of renewable fuels is expected to reduce GHG emissions and have no negative impact on biodiversity and land use. Implementation issues on these topics will be resolved in 2009.

Sustainable use of natural resources

Resources are the backbone of every economy. In using, or transforming these resources, capital stocks are built up which add to the wealth of present and future generations. Most resources are commodities that are traded in a global market. In recent decades, concerns have risen over the extent of global resource use.

Several studies have been released on the possible depletion of mineral resources, including some precious metals that are vital to the transport industry (e.g. platinum, palladium, rhodium, etc.). This depletion will restrict access to certain specific resources that are needed to achieve performance targets. For example, the treatment of tailpipe emissions to reduce tailpipe emissions requires catalysts that are based on precious

metals. Although current estimates are that the Earth's sources of minerals will be sufficient to meet future demand, mining them is a costly matter and will have an impact that goes beyond the carrying capacity of the environment. These effects risk being aggravated when the level of growth and resource use in the developing world begins to approach that of the industrialised countries.

The transport sector as a whole requires a large amount of resources, varying from well-known industrial mineral resources, such as metals and natural oil and gas, to environmental resources, such as space and biodiversity, which often fail to be taken into account. Some of these resources can be recycled back into the system after the economic or technical service of the concerned goods or materials has ended. Europe has a tradition of recycling a large proportion of its mineral resources, e.g. metals and demolition wastes. In addition, several policies on waste are currently providing extra incentives.

In 2005, the European Commission proposed a Strategy on the Sustainable Use of Natural Resources used in Europe. The objective of the strategy is to reduce the environmental impacts associated with resource use in a growing economy. Focusing on the environmental impacts of resource use will be a decisive factor in helping the EU to achieve sustainable development. It is likely that over the timeframe considered by this road transport scenario (2030–2050), the topics presented here will be the centre of attention for policy makers.

Internalising external cost

Transport activities give rise to environmental impacts, accidents and congestion. In contrast to the benefits, the costs of these effects impacts are generally not borne by the transport users. The 'internalisation of external costs' means making such effects part of the decision-making process of transport users.

This will doubtless have an effect on aspects of road transport such as the distances over which goods and persons are moved, the 'just-in-time' (JIT) principles that industry applies to its supply-chain strategy and the choice of mode.

The impact on the transport sector of such internalisation of costs will depend on the level of the cost itself. If it is lower than 15 per cent, the impact will be very small.

In 2006, the Directive on the charging of heavy goods vehicles in the EU (the 'Eurovignette' Directive) included a request by the European Parliament to the Commission to present 'a generally applicable, transparent and comprehensible model for the assessment of all external costs to serve as the basis for future calculations of infrastructure charges'. Furthermore, the Directive stated that, 'this model shall be accompanied by an impact analysis of the internalisation of external costs for all modes of transport, and a strategy for a stepwise implementation of the model for all modes of transport'.

Work has been done to arrive at a strategy on the internalisation of external cost. Part of this work concerned an approach to estimate and monetise external costs. This work has led to a Handbook on the estimation of external costs in the transport sector. This handbook outlines a model for the internalisation of external costs which will serve as a basis for future calculations of infrastructure charges.

In addition an impact assessment has been carried out on the internalisation of external costs analysing their impact on the economy, on the environment and on society at large. Finally a Communication was adopted in July 2008 (the 'Greening transport' package) which provides a general framework of reference for the internalisation of external costs in the transport sector.

Road Safety

Policies are crucial to reduce safety impact of road transport. On one side policies introduce new regulatory framework aiming to enforce better driver behaviour, but on the other side they are important also in the promotion of safer infrastructures, forgiving roads, driver education and the introduction of incentives for the fast dissemination of new technologies.

Market introduction of cooperative systems will mainly depend on appropriate policies to promote their wide diffusion, needed for them to become really effective.

All European Member States will agree on common policies to promote safer road transport. These policies will become the primary way to guarantee synergy of efforts between all involved stakeholders. A good example is the 'e112' emergency call initiative. Only through a common effort, supported by the European Commission with the common agreement of Member States, will the introduction of such solutions be possible.

Future Trends for Public Policies

In 2030 global agreements on trade, energy/resources, climate change and environment will have established an overarching framework of objectives for the European Union to be met over time. This framework will be translated into specific sectoral policies that are underpinned by transparent systems analyses that assign each sector its proportional share of the objectives and targets.

In the framework most if not all of the current topics that have the attention of policy makers will still receive focus. However, they will more integrated in a uniform policy framework, dedicated to (road) transport and containing a comprehensive of ambitions, targets, objectives and incentives on the different issues concerning (road) transport. These targets will be in line with even longer-term (2050) objectives and will comprise significant improvements compared to the operation of today's road transport system. Also the framework will recognize the chain relationships with other sectors of economy e.g. energy production and growth in consumption of services and goods. This frame work will be implemented to different degrees in the Member States.

In principle, these policies will not impose restrictions on road transport other than providing incentives from traffic management (e.g. to make use of infrastructure outside the peak hours) and through the internalisation of external cost. This will lead to significant increases in transport cost over all modes. Consequently, businesses and consumers will alter their attitude and behaviour considerably towards sustainability.

In order to raise the necessary public investments for debottlenecking road infrastructure, and to allow for the growth in road transport, different forms of dedicated taxes and pricing will be imposed on large sections of the road infrastructure. Furthermore, a portion of the existing fuel tax will be directed toward climate change abatement.

The EU and its Member States will support innovative research and development to achieve sustainable surface transport and, consequently, significant joint/coordinated support actions will be put in place. Public-Private Partnerships (PPP) will be the preferred vehicle to drive innovations in line with policy initiatives. Policy will be developed to attract private investors in research and development.

In city centres, stringent reduction targets for noise and air pollution will be imposed. Consumer attitude and behaviour will be stimulated by restricting/prohibiting the use of vehicles that exceed minimum emissions, noise, and safety standards.

The EU will be one of the largest economic blocks in the world and the last remaining barriers to trade will be resolved. The rise of BRIC economies will give birth to discussion on their contribution to the abatement of global climate change. Technology transfer policies will be effective and will help BRIC nations improve their energy efficiency. Competition for resources will be fierce. To control the market, extreme quota will be agreed on the essential resources.

By 2030, freight capacity will have increased substantially as new standards for the weights and dimensions of trucks and buses will have been agreed by the majority of EU Member States. Standards will allow for longer and heavier vehicles with substantially increased carrying capacity. However, they will not be implemented equally in every Member State because some States will still retain the standard 40/44 tonne articulated vehicles, or will have allowed only modest increases in weight and dimension due to potential impacts on the infrastructure. Greatly improved safety and environmental performance, as well as the implementation of mechanisms to ensure no adverse mode shift effects, will mean that LHVs will be accepted by the public as a viable and efficient option for freight transport, particularly in North-Western Europe.

At the same time as allowing for increased load carrying capacity, changes to weights and dimensions policy will also provide for greater scope in vehicle design, leading to significantly improved aerodynamics, fuel consumption, safety performance and driver comfort. Such features will become standard for almost all long-distance freight transport.

The combined effect of these changes in weights and dimensions policy will be a relative reduction across Europe of between 8 and 10 per cent in commercial vehicle kilometres travelled, and a relative reduction of approximately 5 per cent in freight CO₂ emissions.

By 2030, a range of policies to improve road safety will have been implemented throughout the EU, in an approach similar to that used for the 'e112' initiative. These policies will have implications for cooperative systems and infrastructure development, among others. Although the economy will have grown considerably, the resources available to support policy measures will be limited due to other priorities, including debottlenecking/upgrading of the infrastructure, demands for public funding from other sectors of the economy (e.g. social security, health care, etc.).

3.2 Environment and Economy

Climate change

Although the impact of climate change on global warming has been debated for many decades, the mobilisation of global efforts to curb greenhouse gas emissions and reduce their impact on global warming and climate change is much more recent.

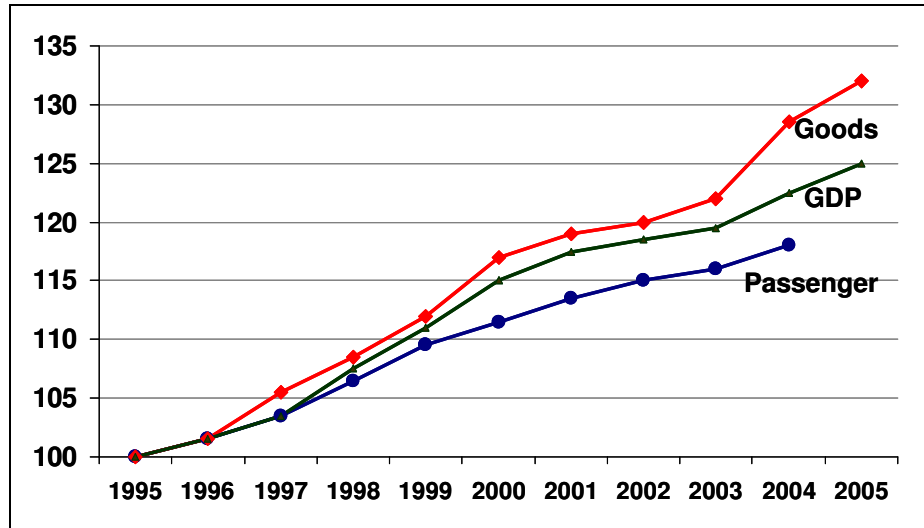
Starting with the 1997 Kyoto Conference, political agreements between countries and regions were first initiated to set meaningful targets for reducing GHG emissions. In Europe, mandatory targets for reducing GHG emissions from power generation, heavy industry, transport, building construction and other sources have now been included in binding legislation.

Even more aggressive reductions are still possible in response to global pressure and increasing evidence of global warming. Since transport accounts for about 25 per cent of GHG emissions from the energy sector and is the only sector continuing to increase, special regulatory attention has been directed at limiting the growth in GHG emissions from road transport. Climate change will be a major driver for the future of road transport for the foreseeable future. In addition, although hard to predict, the effects of climate change (weather extremes, changes to water supply etc.) in the longer term will inevitably influence transport.

Concerns over energy security and the greater use of renewables are likely to lead to a gradual decentralisation of energy production.

Economic growth

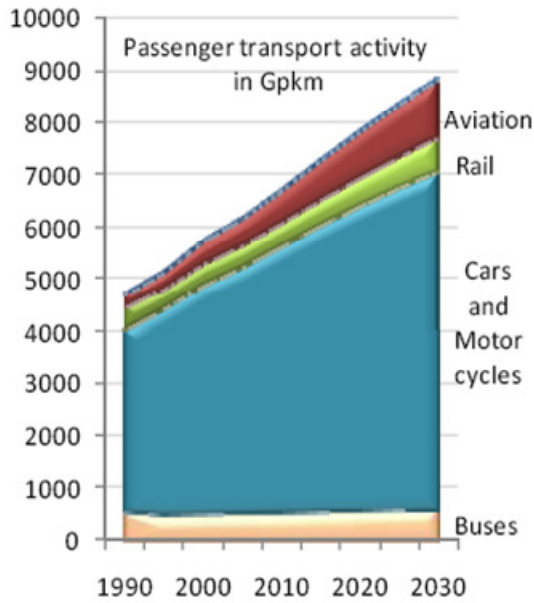
Transport depends strongly on the development of the economy, and will be shaped by overall levels of growth or decline in different sectors (e.g. service industries or manufacturing/construction) and geographical aspects including globalisation and the location of affordable resources and labour). But the economy also depends strongly on transport because efficient and affordable transport is necessary to move people and goods to where they are in demand (e.g. places of work and the marketplace). Historical data have shown that there is a strong correlation between per capita income and the demand for personal mobility. Changing this historical trend, and reducing GHG emissions from road transport, will require effective approaches to decouple economic growth from energy and transport demand.



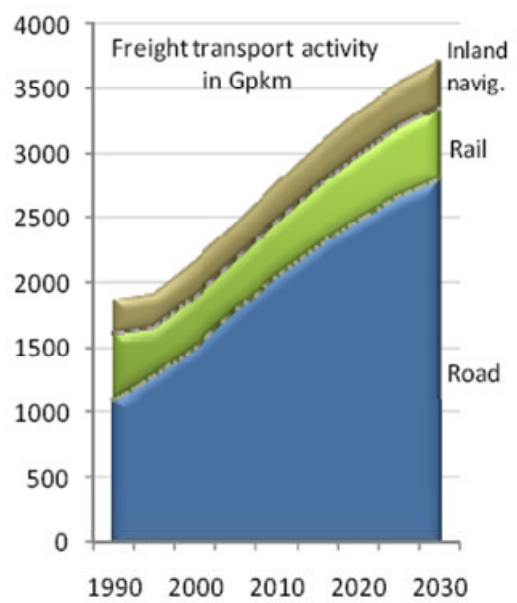
Source:

Of all the factors comprising economic development, economic growth is the most important to the development of future road transport. Economic growth is defined as the increase in the production and consumption of goods and services over time, and is measured by Gross Domestic Product (GDP). Growth in GDP will be different across European regions and Member States and will be influenced by population growth, production costs, availability of skilled labour/personnel, energy availability, a hesitant or optimistic society, governmental barriers and bureaucracy, world economy, household income and public finance.

Passenger Transport by Mode 1990-2030



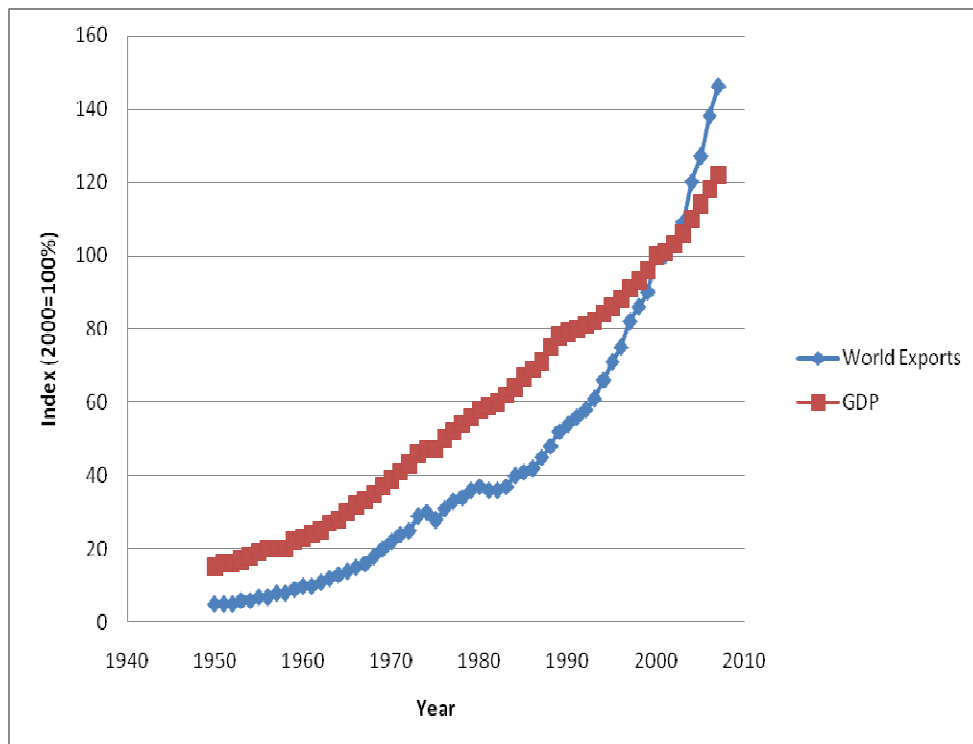
Freight Transport Activity 1990-2030



Source: DG-Energy & Transport – Trends to 2030 (2007)

In recent years, the overall traffic volume in the EU-27 has increased significantly, both in passenger and freight transport. For freight transport, the volume of road traffic has been gradually increasing while, for passenger transport, the most significant increase has been in air traffic.

Freight transport is considered to be one of the backbones of the 'real economy' because it binds together different sectors and different stages of production within a sector. The freight logistics industry itself is estimated to be responsible for approximately 14 per cent of European GDP. The volume of freight transport is therefore closely linked to overall economic growth.



Source: WTO International Trade Statistics 2008

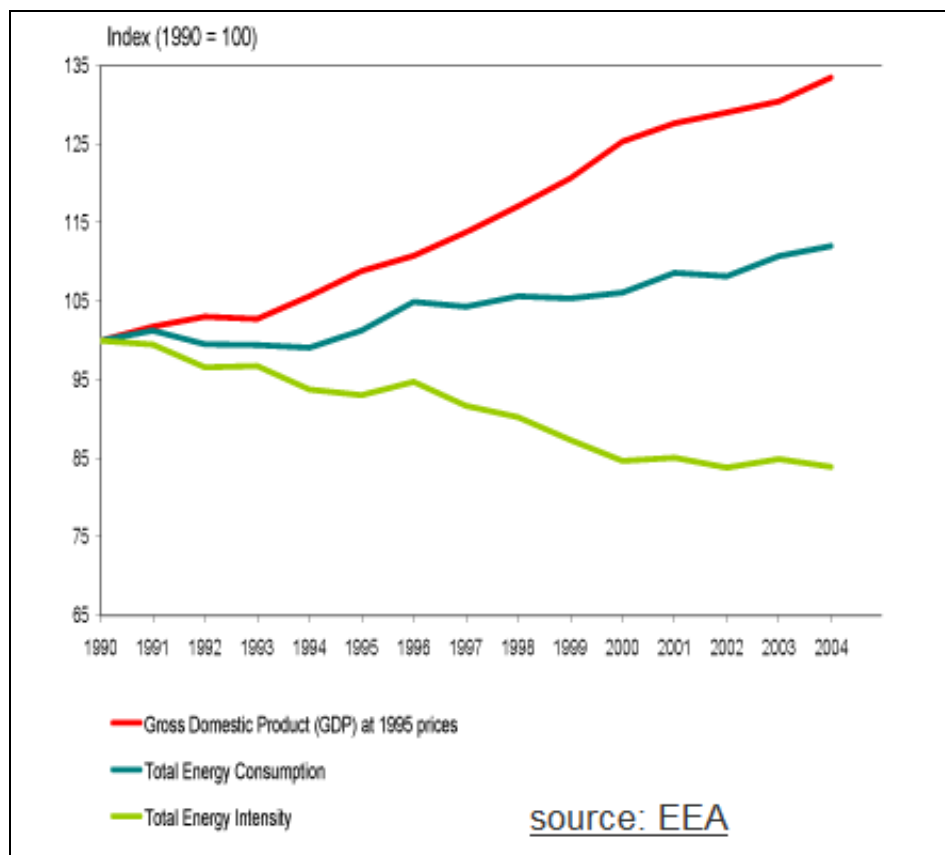
Recent years have seen a considerable increase in the globalisation of the economy, with a global increase in free trade and a growth in multi-national and international corporations. This can be seen in the above figure which shows that the growth in world exports has exceeded the growth in GDP in recent years, suggesting that international trade typically represents a greater proportion of the world's economic prosperity.

While this growth in international trade has helped the development of the world economy, it is also widely considered to have been responsible for a substantial increase in transport demand. The available evidence suggests that global trade is also likely to continue to increase for the foreseeable future. By 2010, today's 'emerging' economies will have reached a similar level of maturity to that of Europe, and 'new' economies will emerge from today's developing countries (e.g. in Africa). Low-cost production countries will, however, still continue to exist.

There is also evidence to suggest that increasing transport costs and environmental concerns could change the shape of international trade. For some commodities, there is a tendency towards regionalisation, i.e. where the sources of production are moved closer to their end markets. This may be particularly true for lower-value products that do not require specific expertise or high levels of technology to produce.

The dominance of road transport in the current economy is based largely on the relatively low cost to the public and to industry.

In recent decades, mobility and transport costs have fallen to relatively low levels compared to the size of population/business enterprise that it serves. For passenger transport, the low relative cost is reflected in longer commuting distances. Freight transport is inexpensive compared to labour costs, as reflected in the trend towards the delocalisation of production, i.e. where the sources of production are moved to countries and regions where labour costs are especially low. It is nevertheless true that 90 per cent of journeys made by freight traffic cover a distance of less than 100 km.



The cost of mobility and transport is made up of components such as energy cost, labour cost, maintenance cost, and vehicle cost and transport fees, sometimes introduced by policies. Among these, energy cost is the component that is most likely to change due to policies and global development of demand and supply. However, it should be noted that, up to a critical threshold, elasticity is low and increases in energy costs will only slightly influence transport. In fact, over the past decade, the cost of fuel had barely any influence on passenger travel at all.

However, concerns over energy security and the greater use of renewables are likely to lead to the gradual decentralisation of energy production. This could reduce the volume of goods imported by sea, since about 50 per cent currently relates to the shipping of fossil fuels.

In the past 30 years, the EU has adopted a substantial and diverse range of environmental measures aimed at improving the quality of the environment for European citizens and providing them with a high quality of life.

Energy and resources

The scarcity of resources that was anticipated in the 1970s did not occur as expected. On the contrary, it is estimated that, with continued technological and economic development, the available energy resource base will continue to increase. The scenarios presented in this document reflect a variety of assumptions about the timing and extent of new discoveries of fossil energy reserves (conventional and unconventional), improvements in the economics of their recovery, and the pace of development of alternatives.

Most of the published scenarios, however, indicate that economic development over the coming decades will not be limited by resources although resource conservation will be important. Regional shortages and price increases are likely to occur, due to the unequal distribution of fossil resources but, on a global level, they will not be a constraint. It is more likely that environmental concerns, the availability of investment financing, and technological needs will place constraints on economic developments in the future. The short-term volatility of international politics, speculation and business cycles will periodically upset the long-term expansion of resources. But it is worth noting that no regional review has voiced significant concerns about the imminent scarcity of resources that were so dominant even a decade ago.

Resource availability is no longer seen as geologically preordained; this view is in agreement with the global analysis. Rather, it is considered more as a function of the incentives and policies put in place for exploring and developing resources, constructing the necessary long-distance transport infrastructures and, above all, attracting capital to energy investments. All are necessary to translate potentially vast geological resources into economically and technically recoverable reserves.

Environment and ecology

Over the last decade, strict legislation was implemented to preserve and improve the spatial and ecological quality of Europe's environment. This legislation puts a clear boundary condition to the expansion and use of the road infrastructure. The need to develop additional transport infrastructure to support the growth of transport demand will cause conflicting interests.

Future Trends for the Environment and Economy

Climate change

By 2030, the effects of climate change will have become apparent. In coastal areas, snow will become an extremely rare occurrence. Although extreme weather conditions will still occur, the impact on the transport system as a whole will be minimal, and will affect mainly those parts of the road infrastructure that are already stretched to the limits of their capacity. Even during periods when increased water levels due to flooding prohibit waterborne transport, the impact will only be marginal as available road transport capacity will serve as a temporary buffer. The average temperature will rise, and the increasing number and duration of heat waves in summer may require adaptation of the road infrastructure.

Economic growth

The longer-term expectation is that both the global and European economies will have developed following

the trends of recent decades, albeit at a slightly lower rate of growth. There will be clear distinction in growth rate between the EU-12 (higher) and EU-15 (lower) countries. With it, road transport demand will have increased by 80 per cent. In 2030, trade and services will account for more than 70 per cent of the EU economy.

The level of unemployment throughout European will be low, due to both the robust economic trends as well as the ageing population leading to increased personal spending. There will be considerable regional differences in the demand for labour, and this will lead to substantial intra-European migration of the labour force as well as an increase in immigration.

- The current economic downturn could have a short-term effect on R&D and technology investments from private companies. However, this will be compensated by large-scale public investment, through Member States, in transport innovation and infrastructure developments. Although this intervention will continue for one or two decades, it will slow down thereafter due to cuts in public spending dictated by limited public finances and shifts in public priorities (e.g. towards education, social- and health-care, etc.).
- Increased public investments in infrastructure will be concentrated on the large-scale 'debottlenecking' (local expansion of road area) and upgrading (more, and stronger, bridges, tunnels, viaducts) of the congested economic regions and interconnecting corridors. The initial focus will be on those regions and corridors where the existing quality of infrastructure will allow for the most cost-effective development. After the next decade, investment will shift towards the development and introduction of advanced technology, such as intelligent systems for traffic management (e.g. cooperative systems).
- By 2030, investment in the transport infrastructure will increase network capacity so that it is just able to cope with the growth in transport demand.
- To address the continued economic growth and the consequent increase in the demand for road transport beyond 2030, a cohesive and holistic transport strategy will have been developed for pan-European deployment under EU coordination.
- The economy will have 'greened' significantly with greater electrification of vehicles, and the opportunistic use of alternative fuels such as CNG and DME for buses, taxis, company fleets, etc. in urban areas. In addition, the proportion of alternative renewable and synthetic fuels in use will have increased considerably, more than 10% share of the fuel pool on an energy basis.

The transport sector will have become more integrated with its strategic partners in the other economic sectors, such as energy (to develop tailored/dedicated fuel and power supplies as well as carbon capture and storage technology), and services and production (to provide transport on demand, 'can go' vs. 'must go' solutions, etc).

Environment and ecology

With environmental legislation in place, and subject to continuous development, greater consideration will be given towards the use of space in general, e.g. there will be a clear separation between the space used for anthropogenic activities and that dedicated to ecological functions. The major divisions will be between (sub)urban and rural areas, but even within the urban areas, distinct ecological areas and zones will be set aside to accommodate, for example, the migratory routes of birds. As a result, space will become limited, especially in metropolitan/urban areas and densely populated corridors. To allow for the necessary economic growth, as well as to preserve the ecological bounds AND improve the quality of life for people living in urban areas (about 80 per cent of the entire population), functions that are closely linked to each other will be integrated within common areas. These integrated 'hot spots' will emerge around the multimodal transport nodes, especially in the more densely populated cities. Multiple transport modes will be integrated along specific transport corridors, and similar areas will be allocated for the development of business centres and industrial sites. The energy grid will also be integrated into the transport nodes and corridors, and this will offer further relief to urban spatial stress.

As a consequence, the city centres will experience lower levels of industrial and commuter transport. City centre economies will shift away from business and industry, and will be increasingly based around social and cultural activities.

Under certain circumstances dictated by extreme economical considerations, infrastructure development will

be allowed to cross the legislated ecological boundaries. However, compensation measures will be undertaken in the proximity of the areas concerned. Air quality will no longer be a major problem resulting from road transport activities. Noise pollution, however, will be an ongoing issue, although the electrification of urban transport as well as the introduction of speed limits through progressive traffic management policies, and restrictions on tyre sizes (and hence, reduced tyre noise) will significantly reduce pollution from noise in the vicinity of the urban roads and corridors.

Mobility and transport costs

By 2030, mobility and transport costs will have increased by 30 per cent over current prices due to increasing fuel costs as well as environmental policies (e.g. the internalisation of external costs). This will lead to the development of alternative forms of passenger transport and the increased use of new trade forms, such as e-commerce. However, the total mileage for both passenger and freight transport will have increased.

Economic development of the new Member States will continue to be of importance to the freight transport sector. The average distance for freight transport in Europe will remain at its current level (i.e. at an approximate journey average of 100 km).

Globalisation

By 2030, international trade will have increased considerably, and the majority of trade barriers will have been removed. Global competition will have increased the strength of the BRIC economies on the global playing field.

On average, global economic welfare will have improved. Developing economies will have been growing at a substantially faster rate than developed economies, and this will affect the nature of goods traded because lower value commodities will no longer dominate the trade pallet.

- The transport flows/patterns between ASEAN and Europe will have changed considerably with more transport by road. As a consequence, different gateways to and from ASEAN will have developed. Road transport (i.e. trucking) will be able to accommodate these new flows.
- In addition, the EU will have important new nearby/regional trading partners, particularly where it concerns lower-value manufactured commodities. This will result from political/strategic considerations as well from increasing transport costs which will have increased considerably, partly due to fuel price increases and to policies aimed at reducing the environmental impact of transport. This will reduce the cost-effectiveness of products shipped over long distances in both directions.

In response, transport will have become increasingly diverse and flexible to accommodate changes in trading partners and transport modes. This will be reflected in the development of highly advanced, functionally integrated transport hubs and corridors which will facilitate the highly efficient supply of goods and services, and will provide the opportunity to combine economic growth with increased environmental quality.

Short-haul sea shipping will not depend on infrastructure, and may therefore prove to be more cost-effective and more popular than road transport, in particular with regard to the accommodation of trade with nearby African and Middle-Eastern regions. Short-sea shipping will provide limited options for an alternative to road transport between coastal economic centres.

Upper Bounds	Lower Bounds
<p>Climate change</p> <p>The effects of climate change will be apparent but will present no problems for the transport system because the infrastructure will have been developed to such an extent that any sensitivities towards extreme weather conditions will have been reduced to the minimum.</p> <p>Economic growth has allowed sufficient time to anticipate and complete investments in critical</p>	<p>Climate change</p> <p>Climate change will have a serious impact on the transport system, which will be seriously hindered by frequent weather extremes and occasional climate catastrophes.</p> <p>Global warming will lead to climate catastrophes that will disrupt the transport/logistics systems. As a consequence, the cost of freight transport will rise to</p>

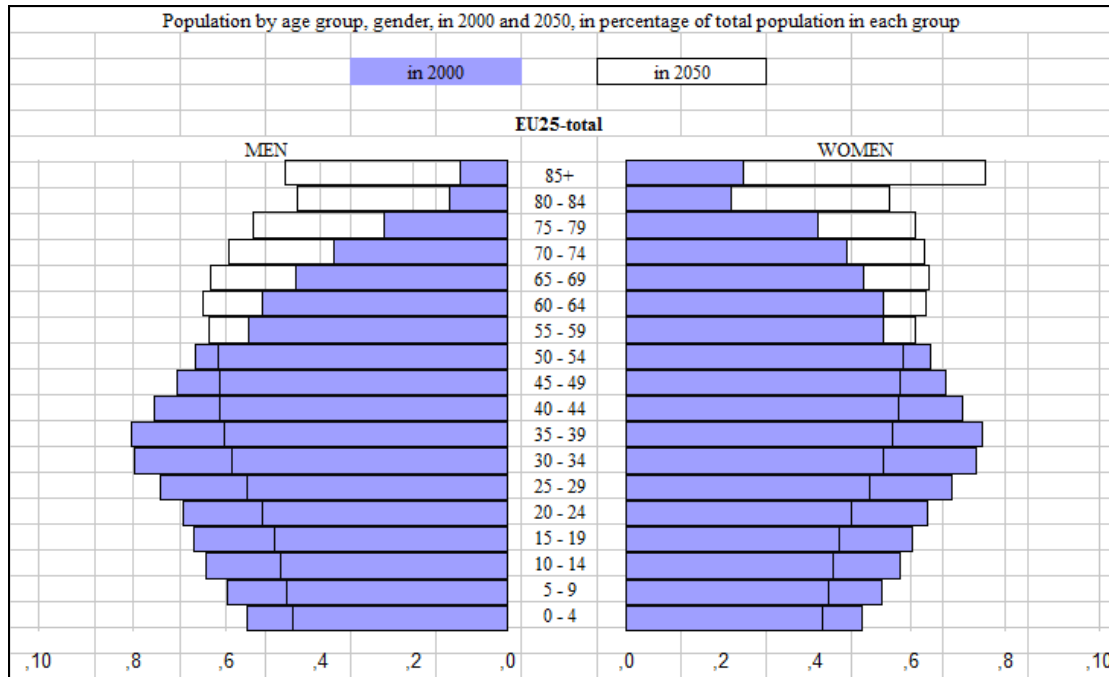
<p>components of the transport system, especially infrastructure.</p>	<p>extreme levels.</p>
<p>Economic growth</p> <p>Economic growth will stabilise such that a consistent level of annual growth of 3-4 per cent will be reached. The economy will be stable and strong enough to handle ups and downs. Economic crises will have little effect on the economy. Transport demand will more than double.</p>	<p>Economic growth</p> <p>Economic growth will, on average, be substantially lower than the historical trend, and subject to major uncertainty and fluctuation (boom and bust). Crises have a lasting effect and there is a big imbalance in growth with regard to geography.</p>
<p>Energy and resources</p> <p>The higher levels of global economic growth and the increasing demand for resources will place a strain on supply. Far-reaching and globally coordinated measures will be established to preserve the ecology and environment, and the cost of mineral resources will reach peak levels. In response, Europe will become a recycling society, with closed loops for even the more abundant mineral resources.</p>	<p>Energy and resources</p> <p>Resources will be on the verge of depletion as investments lag due to the continued economic downturn and political instability. This, in turn, will restrict the development of new and efficient technologies.</p>
<p>Environment and ecology</p> <p>Integrated corridors and nodes will become widespread and of high quality.</p> <p>City centre economies will be driven predominantly by social/cultural activities. As a result, peak hours will shift to the evening/early night. City centres will become the preferred locations for the homes of the upper classes.</p> <p>Clear and stringent caps on development activities will be established to maintain the ecological integrity of the (metropolitan/economic) regions. These regional caps will be derived from national caps that will, in turn, be based on similar restrictions established at the European level. The regional caps will stimulate interregional cooperation leading to regionally shared benefits.</p>	<p>Environment and ecology</p> <p>To curb the limiting effects of environmental legislation on the already failing economy, further development of the respective legislative framework will be postponed across numerous Member States pending a turnaround in the European economy.</p> <p>As competition in industry intensifies in the major economic centres, the development of transport nodes and corridors is accelerated. Nevertheless, the net result is a sprawl of activities out of the city areas and into the countryside.</p>
<p>Mobility and transport costs</p> <p>Mobility/transport costs will increase by approximately 50 per cent, mainly due to the (policy-driven) full internalisation of external costs and the increased cost of fuel.</p> <p>Competition will be fair and policies will be agreed worldwide. Politicians will refrain from taking populist, local, decisions.</p> <p>The revenues from transport costs will be recycled, leading to more sustainable transport solutions.</p> <p>The current economic downturn will stimulate new</p>	<p>Mobility and transport costs</p> <p>Competition will be unfair, and politicians will take populist, local decisions. Revenues will not be reinvested.</p> <p>The current economic downturn will last well in to the coming decades, leading to a lower than expected or even zero growth for Europe.</p> <p>There will be an increasing divergence in the rate of economic development of the EU-15 and the EU-12 countries.</p> <p>Transport demand will decline due to reductions in</p>

<p>structures and incentives for the economy, eventually leading to higher than expected levels of growth as well as significant changes in economic structure (e-commerce, etc.).</p> <p>Considerable public and private investment in infrastructure in congested urban regions and interregional corridors will allow for faster than expected technological advances in vehicles and traffic management systems (e.g. cooperative systems, logistical interfaces between long-distance freight transport and urban freight transport, etc.).</p> <p>Public intervention will be sustained even after private investments have recovered.</p> <p>Strong private-public partnerships will enable investment and technology transfer.</p> <p>There will be an emphasis on ‘greening’ the economy, and comprehensive objectives will be established for global sustainability.</p> <p>(Information) technology will be more successful than expected at breaking the historical correlation between energy consumption and GDP.</p> <p>Economic growth and the corresponding growth in disposable income will offset this increase with a net effect of relative cost remaining on current level or somewhat higher.</p>	<p>individual wealth and consumer spending (moderation of wages and high levels of unemployment) with inherent effects on transport volumes.</p> <p>Private, as well as public, investments will remain low because there will be a lack of available finance in both sectors.</p> <p>The emphasis will be on increasing economic growth rather than on sustainability.</p> <p>New technologies will be introduced at a slower pace and will have only regional impacts.</p> <p>As the economy declines and fuel costs increase, the relative cost of mobility/transport will rise to a level that inhibits demand.</p> <p>Climate catastrophes will lead to extreme rises in the cost of freight transport.</p> <p>There will be zero internalisation of external costs.</p> <p>Business, industry and the public will all adopt a different outlook and their behaviours will change drastically.</p> <p>An increase in the availability of public transport modes will be contrasted by a reduction in personal car ownership.</p> <p>The number of commuters and the associated distances travelled will fall sharply as people will tend to live closer to their jobs and/or make greater use of information technology.</p> <p>Alternative fuels will only be used in niche markets. Hybrid-electric and fully-electric vehicles will penetrate the urban market at a slower pace than under the common-sense scenario.</p> <p>Hydrogen and fuel-cell powered vehicles will not be introduced in significant numbers until well beyond 2030.</p> <p>Freight transport will be extremely expensive, slowing trade and economic development.</p>
<p>Globalisation</p> <p>Increases in transport costs will combine with policies, consumer behaviour and a general atmosphere of corporate responsibility to develop international trade in a manner that brings both economic prosperity and</p>	<p>Globalisation</p> <p>Large global corporations misuse their power resulting in sustainability issues being overlooked and governmental powers being weakened. The gap between rich and poor communities widens.</p>

sustainability across the globe.

3.3 Society

The key factors influencing society's development will be: **demographic change, increasing urbanisation, and changes in consumer trends and lifestyle.**



Source:

Demographic change

Demographic change is linked to birth rates and the level of migration both within Europe and between Europe and the surrounding countries. In recent decades, the birth rate in the EU-15 has dropped to levels that are lower than the required replenishment rate.

As a consequence, the demographic structure reflects an ageing population, leading inevitably to a decrease in the indigenous population. This trend, to a certain extent, is compensated by the recent expansion of the EU into Eastern Europe, which has a relatively younger population. Immigration of mainly younger individuals from outside the EU also compensates for the demographic effects of the ageing indigenous population.

There is a clear distinction between economic immigration, which is encouraged by the host country and generally attracts individuals with a relatively high level of personal development/education, and illegal immigration, which is predominantly concerned with individuals who have relatively low levels of personal development/education. Europe attracts migrants from younger, less developed and faster growing African and Asian regions nearby.

Demographic effects are not evenly distributed across the EU. For example, the EU-12 has a negative net migration compared to the EU-15. Within the EU-15, the net migration differs from country to country.

As the decreasing EU population is supplemented by (im)migration, it is inevitable that an increasing proportion of the population will consist of communities from other cultures and with different social patterns. Because the majority of (im)migrants will seek employment and settle in urban areas, in particular in the most economically dynamic cities, demographic and social change will be most prevalent in these locations.

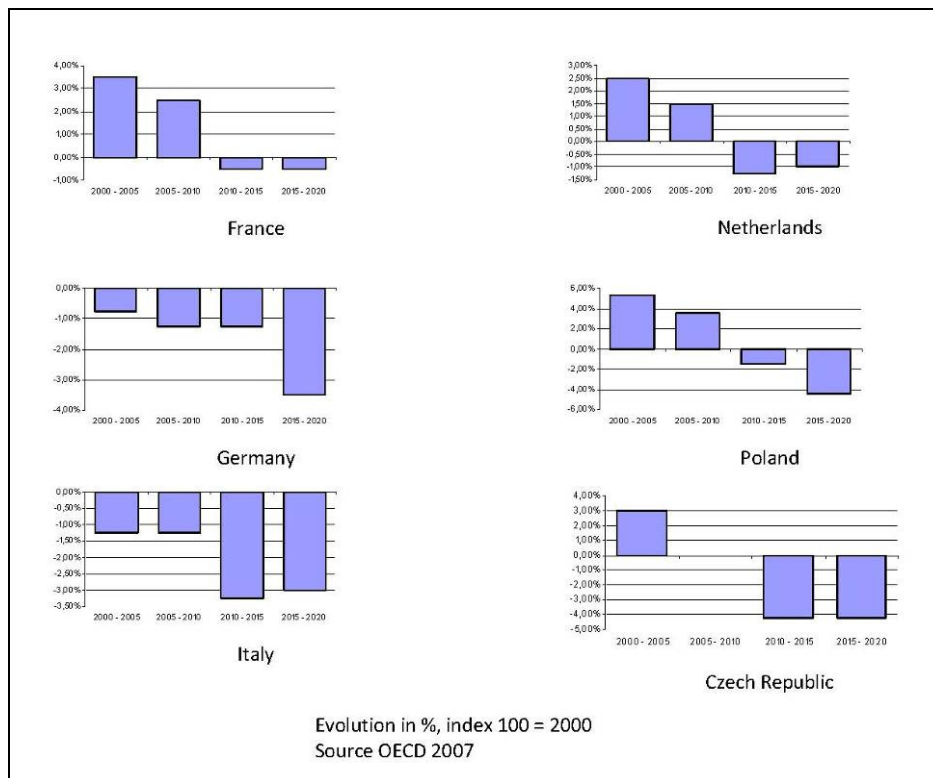
POPULATION CHANGE				
Region	Population size on January 1 st , 2007 (millions)	Projected population size, 2030 (millions)	Annual rate of population change, 2002-2006 (per 1000)	Projected annual rate of population change, 2007-2030 (per 1000)
POPULATION AGEING				
Region	Proportion of the population above age 65, 2007 (%)	Projected proportion of the population above age 65, 2030 (%)	Old-age dependency ratio 65+/15-64, 2007 (%)	Projected old-age dependency ratio 65+/15-64, 2030 (%)
Southern Europe	18.4	26.2	27.3	42.4
Western Europe	15.9	23.1	24.1	38.6
German speaking countries	19.3	27.6	29.0	46.7
Nordic countries	16.1	23.5	24.5	39.7
Central-Eastern Europe	14.3	22.5	20.4	35.3
South-Eastern Europe	15.1	20.5	21.8	31.5
Eastern Europe	14.5	19.4	20.5	28.9
Caucasus	9.9	15.8	14.4	23.7
EU-27	17.0	24.6	25.2	40.3
EU-15	17.6	25.2	26.5	41.8
EU-12	14.5	22.0	20.7	34.3

Source:

An ageing population is likely to mean that there will be greater diversity of income, with a larger share of the population receiving a lower income. With a greater proportion of older people in society, there will be smaller households and therefore a greater diversity of demand for public services.

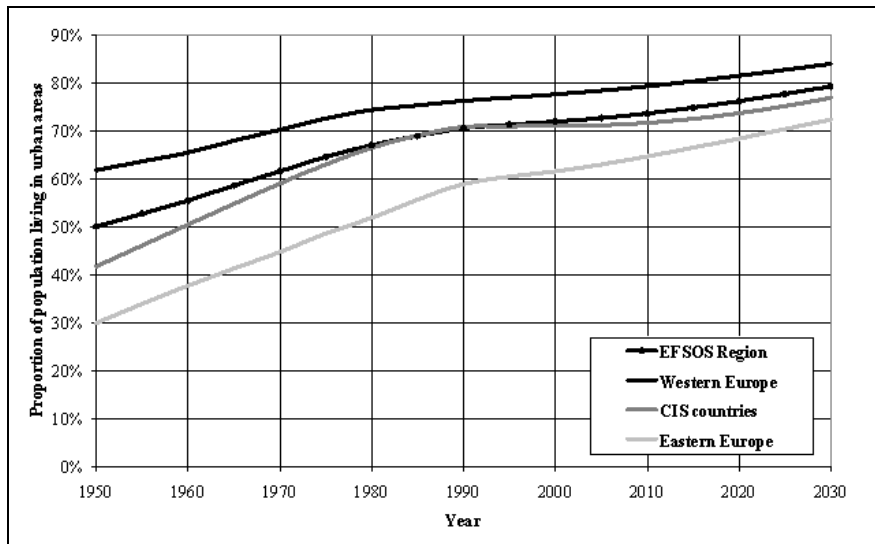
On the other hand, older people in the future are more likely to travel than their counterparts today. Their preferences for urban travel will depend on the quality, accessibility and price of public transport.

Evolution of active population in Europe, 2000-2020



Increasing urbanisation

The global trend towards urbanisation and the growth of megacities will have strong impacts on Europe, because it raises challenges for European industry to provide vehicles and services such as public transport to help these cities improve their mobility systems and contain their emissions. In Europe, however, the degree of urbanisation will be relatively modest by comparison.



Future Trends for Society

Demographic change

By 2030, approximately one-quarter of the European population will be over 65 years old, creating a significant fiscal burden² on the community. This is only partly compensated by (economic) immigration. The EU-15 will have the highest average age, and the EU-12 the lowest.

By 2030, the effects of an ageing population will have become clear. There will be a necessary shift in public spending towards old-age benefit programmes, as well as a slowing down in economic growth as the average personal income levels off due to increased retirement. This will be the case even though the average retirement age will have been increased by several years and some jobs will progressively be allocated to the elderly.

In 2030, there will be continued migration from the EU-12 to the EU-15 to replenish decreasing labour forces. In effect, there will be negative net migration from the EU-12³. In addition, economic immigration as well as illegal immigration from outside EU will have increased to more than 800,000 persons a year⁴. This will lead to minority communities constituting 15 per cent or more of the population in nearly all Western European countries. As the immigrants will, on average, be substantially younger than the indigenous population, and will also have a lower education and different cultural background, tensions within the communities will increase considerably in some countries⁵, especially in the more economically dynamic urban areas where the large majority of migrants will settle.

² Global trends 2025

³ ibid

⁴ GHG Routes to 2050

⁵ ibid

Increasing urbanisation

By 2030, approximately 80 per cent of the European population will live in urban environments. There will be a clear distinction between the EU-15 (upper bound) and the EU-12 (lower bound), i.e. urban areas in the EU-15 will cope with migration levels, whereas those in the EU-12 will struggle. European cities will evolve through different scenarios/strategies as they try to reinvent themselves (e.g. Paris), developed their urban environment to face the challenges of their economic and demographic growth (e.g. London) or on the contrary have adapted to the decrease in their population (e.g. Dresden). The influx of migrants and immigrants into the major economic urban centres will result in them ultimately forming the majority population in those cities.

Although urbanisation in Europe will be relatively modest compared with other continents on the world, continued evolution of European megacities and metropolitan areas will lead industry to provide vehicles and services such as public transport to improve the urban and interurban mobility system.

Changing society and consumer trends

By 2030, consumer attitude will have shifted towards 'green', but with changes in consumer behaviour lagging.

Technology, in particular ICT, will have become integral to the life of individuals and will be a prominent part of their surrounding environment. The hardware required to enable individuals to communicate online will be commonplace in society, with individuals having multiple points of access at home and on the streets (e.g. via public/shared WiFi spots). The supporting data infrastructure will be wireless as well as wired. As a consequence, the individual will be almost permanently 'connected' to an information society that concerns almost every aspect of existence. Individuals will be exposed to a vast range of information, of which the precision, reliability, security and topicality will be guaranteed to be independent from the supplying source.

Collective ownership of knowledge, goods and services, regulated by the market, will be well established. This will lead to the rise of new business models and specialist information services, e.g. e-commerce, housekeeping, healthcare, etc., that can be accessed easily and tailored to meet a specific desire or need⁶. This will help (older) people to remain physically and mentally active, and will contribute to their safety and security.

ICT will help to establish a vast array of 'web based' virtual social groups that reinforce social networks and thus serve as collaborative environments adapted to the particular needs and ways of living of the communities concerned⁷. ICT will make group operations as much possible independent from the member location and on the other hand, when relevant, exploit the information on their location to feed group process efficiency⁸. Through this, people will forge meaning and identity through new interests and networked associations, organising virtual long term communities. In fact the travel/movement patterns of individuals are a constituting factor of the groups.

This vast information society will be continuously interconnected with the operators that manage mobility, but there will be adequate safeguards in place to ensure the required level of privacy, wherever one goes. As a consequence, the energy efficiency of an individual's activities will improve significantly.

With the mounting sensitivity to (global) economic interdependency and environmental dilemmas in 2030, the attitude and expectations of European society will be predominantly oriented towards achieving a sustainable future within their lifetimes. However, this will be only partly reflected in the perception towards personal mobility as private ownership will continue to be the preferred status. However, with adequate policies directed towards optimising the use of the (congested) road networks, car ownership in the urban/metropolitan centres will remain well below 50 per cent. In the peripheral/suburban regions, car ownership will remain high due to a lack of alternative transportation modes. However, GHG policies will lead

⁶ ITEA – Roadmap for software intensive systems and services

⁷ ibid

⁸ ibid

to significant penetration of 'greener' cars.

Tourism and leisure activities within the European Community and abroad will have grown considerably by 2030, as a result of evolving lifestyles and the ageing of the population. This will generate an increase in long-distance travel and in the volume of local traffic to and from transport hubs. However, short-distance travel related to commuting and recreational activities will decrease. The movement of goods by personal consignment will increase due to e-commerce, leading to 'transport on demand'.

Upper Bounds	Lower Bounds
<p>Demographic change</p> <p>As the economy grows, net annual immigration will more than double; this will compensate more than adequately for the decrease in the natural demographic growth rate. As a consequence, the relative size of the productive workforce will expand, helping to avert potential social crises. This will be complemented by the introduction of new technology, improved public health, and laws encouraging greater female participation in the economy.</p> <p>Economic development in those countries nearby that will have become the new trading partners of EU will lead to a significant proportion of immigrants returning to their country of origin, after having worked to achieve a level of personal wealth in Europe. In addition, a significant proportion of the elderly population will relocate to countries beyond Europe where they will enjoy a pleasant climate and a higher purchasing power.</p>	<p>Demographic change</p> <p>By 2030, European society will be in structural crisis over the (financial) consequences of demographic development (ageing) as well as over migration within the EU, and immigration from the surrounding countries.</p> <p>Technological development will have been unable to compensate for the negative demographics, and many European economies will begin a long-term decline.</p> <p>It is expected that slower employment growth due to a reducing workforce will probably reduce the growth in GDP in Europe by 1 per cent.</p> <p>The inward flow of refugees, driven by climate catastrophes, will exceed capacity of the European countries to absorb them, and this will contribute further to the economic and social crisis.</p> <p>The European population will shrink considerably as net immigration falls below the required replenishing rates beyond 2030.</p>
<p>Increasing urbanisation</p> <p>Although net immigration will lead to a two-fold increase in the number of people living in urban areas, the major urban centres will cope with this trend. Metropolitan areas will expand due to the more active economies in medium to large cities, where the quality of life will be even better.</p> <p>In 2030, city networks, such as the Rhône-Alpes or Provence-Alpes-Côtes d'Azur, will have emerged at the regional level throughout Europe, creating new economic regions with a greater specialisation of economic activities shared between these cities. This will give rise to intense mobility within these regions but will reduce the demand for international transport.</p> <p>To cope with the challenge of increased demand for</p>	<p>Increasing urbanisation</p> <p>Cities/metropolitan regions lack the funds to cope with urbanisation. The result will be a deteriorating quality of life leading to further social unrest/crises. Those that can afford to do so will move to protected, 'gated' communities, both within prestigious quarters of the urban centres and also in the suburbs.</p>

<p>mobility while meeting strict environmental and spatial constraints, large urban centres/metropolitan regions will invest heavily in ICT and infrastructural development, and will implement far-reaching land-use policies and regulations to restructure the major transport corridors and hubs which will serve as hotspots for industrial production and services. All modes and services required for the seamless and reliable transport of goods and people to, from or within the metropolis will be efficiently combined, including the integration of power and ICT grids. This will lead to high levels of social and environmental quality.</p>	
<p>Changing society and consumer trends</p> <p>By 2030, society will behave in a manner which is compatible with sustainability. Well-conceived social policies, based on ICT, will stimulate decentralised working, e.g. working from home offices, etc., especially in the services sector. The sophistication of ICT services and hardware will reduce the need for physical meetings, and personal contact will be reduced considerably. These facilities will also enhance the security for the elderly who may not always have physical help nearby.</p> <p>As a result the demand for personal transport will decrease considerably, especially at peak hours, providing relief to the overstretched infrastructure in urban regions and densely populated corridors.</p> <p>Through sophisticated ICT services, socially oriented business models will emerge, such as the collective/shared ownership of specific goods and services, leading to greater efficiency in their use.</p>	<p>Changing society and consumer trends</p> <p>The continued global economic decline will lead to a state of near-emergency; the general reduction in personal wealth will contribute to a deterioration in social stability, and the increasing cost of personal mobility will mean that only the wealthy minority will be able to afford their travel needs.</p> <p>Regulation and policies on transport will be set on a regional political level.</p>

3.4 Technology

As road transport faces an increasing number of challenges, the development of new technology will be key to providing appropriate solutions. An abundance of technological opportunities will become available to meet future transport needs. This will bring new benefits for vehicles, infrastructure, logistics and goods handling technology, information and communications technology (ICT), as well as the ability to integrate the transport system in terms of different modes and to match the characteristics of vehicles with the road infrastructure.

Greater efficiency will be required in the areas of infrastructure, vehicles, load carriers and communication. The areas will need to be efficiently linked, and emphasis will be placed on co-modal and intermodal transport solutions.

Development will be an ongoing process, but the resulting implementation/application will occur spasmodically due to certain thresholds (e.g. legal, financial, technological) having to be overcome before the various applications are available to the general public. Public acceptance of new technological solutions will also need to be sought.

The growth in new technology is predicted to take place at a much faster pace over the forthcoming 25 years than over the past 25 years. Examples of future development considerations include:

- There will be variations in delivery lead times for new technologies due to a range of factors, including: different levels of need for laboratory testing (e.g. for reliability) prior to market release; commercial considerations (e.g. return on investment (ROI)); technology transfer in a highly competitive market; etc.
- There will be a need for the simultaneous application of approaches to reduce GHG emissions from both passenger and freight transport. GHG emissions reductions will be captured through technological and non-technological measures, including the diversification of vehicle power plants, alternative and renewable fuel options, and a 'systems' approach to reducing energy losses.
- ICT will be an important enabler for future intelligent transport solutions (ITS). ICT applications do not generally require the same level of investment and development infrastructure as vehicle and road infrastructure. ICT is an enabler that will make important strides that could provide unexpected benefits for the efficiency of road transport. It allows for advanced applications such as on board systems to monitor and coach the driver on awareness and driver behavior.
- There will be continued fuel efficiency improvements in the internal combustion engine (ICE) and vehicle systems.
- The development of new, alternative powertrains will be a primary consideration.
- New concepts for vehicles and load carriers will be required, with an emphasis on modularity.
- Alternative/new fuel types, including electricity generation and supply systems, will be required.
- The development of cooperative and in-car systems supporting the vehicle operation and the driver will be an important aspect for future integration of the road transport system as a whole.
- There will be a need for technology solutions to support energy efficiency throughout the transport system, e.g. through energy management, new materials, alternative fuels, etc.

Future Trends for Technology

Technology development

The recent economic downturn will have had an impact on private technology investments but will be largely overcome by public intervention. Public-private partnerships and policy will contribute to the recovery of technology developments needed to meet the demanding objectives for GHG reductions and sustainable road transport. The need for trained engineers and scientists to create and implement these developments will have been recognized.

In the period leading up to 2030, research will result in solutions that will be introduced on a commercial scale in 2030. Some of these solutions, e.g. ADAS and cooperative systems, will already have found their way into new vehicles sold prior to 2030.

In 2030, technology development will be focused on the challenges ahead towards 2050. By then, further reductions in GHG emissions will require technologies that go well beyond the ICE, e.g. fuel-cell powered vehicles and low carbon/hydrogen-based fuels. Future developments aimed at reducing GHG emissions will include:

- Advances in fuel production methods, such as carbon capture and storage, will lead to further reductions in GHG emissions.
- Good vehicle maintenance and driver support/driver coaching will contribute to better fuel efficiency, at least 10 per cent for cars and 15 per cent for heavy-duty vehicles.
- Improvements to the road transport infrastructure and in information efficiency, such as the implementation of ITS solutions, will contribute to further reductions in fuel consumption by 10–20 per cent.
- Improvements in vehicle fuel efficiency will deliver as much as a 40 per cent reduction in CO₂ emissions for passenger cars and 20 per cent for heavy-duty vehicles (compared to a 2001 baseline) for the new vehicle fleet.
- New business models (e.g. co-sharing of vehicles, etc.) that promote smarter logistics regimes will reduce the number of empty runs and the unnecessary transport of both people and goods, and will contribute a further 10 per cent reduction of CO₂.

By 2030, the sustained availability of, and continued demand for, liquid fuels and a convenient refuelling infrastructure will have led to the development of highly advanced versions of today's ICEs; this type of engine will continue to be the dominant power plant for both freight transport and personal mobility.

Vehicles designed to run on alternative fuels, especially CNG and biogas, will have found greater acceptance where the refuelling infrastructure has been implemented, while other fuel alternatives (DME, E100, etc.) will typically be used in intermediate transport services in the urban area (e.g. buses, taxis, company fleets).

. In 2030, plug-in hybrid and fully-electric vehicles will be a growing segment of the light-duty fleet, especially in urban environments with their share in new sold vehicles rising up to 15%. Electrification of bicycles, mopeds and motorcycles will take up considerably. However, the ICE will remain the most important powerplant for motor vehicles but will become considerably more sophisticated and complemented by more advanced engine management systems. Vehicles powered by hydrogen and fuel cells will not yet be introduced on a commercial scale due to their higher costs

Over time, policy targets on fuel efficiency will cut the caps on CO₂ considerably, leading to highly advanced versions of today's internal combustion engines that will be 30 per cent more efficient than they were in 2005. Additional developments will increase fuel efficiency and GHG emissions including:

- The use of new materials in vehicle design, i.e. a decreasing dependency on metals, and the development of lightweight, super strong materials, including sophisticated engine/powertrain parts.
- The development of new fuels, e.g. synthetic fuels and second generation biofuel processes.
- Advanced information/communication facilities, e.g. the use of ITS for both in-car and cooperative systems to increase increased logistics efficiency.

ICT applications

By 2030, the application of ICT in transport will be commonplace, and will be incorporated at both the component/vehicle level as well as at the systems level (e.g. for logistics and traffic management). This will enable 'smart vehicles' that will be able to optimise their performance depending on the traffic situation. Almost the entire freight transport fleet and half of the personal vehicle fleet will have vehicle positioning technology on board. Vehicle-to-vehicle (v2v) communication and vehicle-to-infrastructure (v2i) communications will be common. Cooperative systems will be introduced in urban regions and (congested) corridors.

The resulting information flows will allow the traffic management authorities to establish sophisticated traffic management policies in urban areas and densely populated corridors, based on prediction models for consumer behaviour. This will enable the optimisation of infrastructure capacity to its utmost limits.

In 2030, the use of ICT for v2v communication will have reduced fatalities and injuries. In logistics, the use of ICT will have increased systems efficiency to its theoretical maximum.

The application of ICT in production and manufacturing will have reached a new level of sophistication with models and simulation tools.

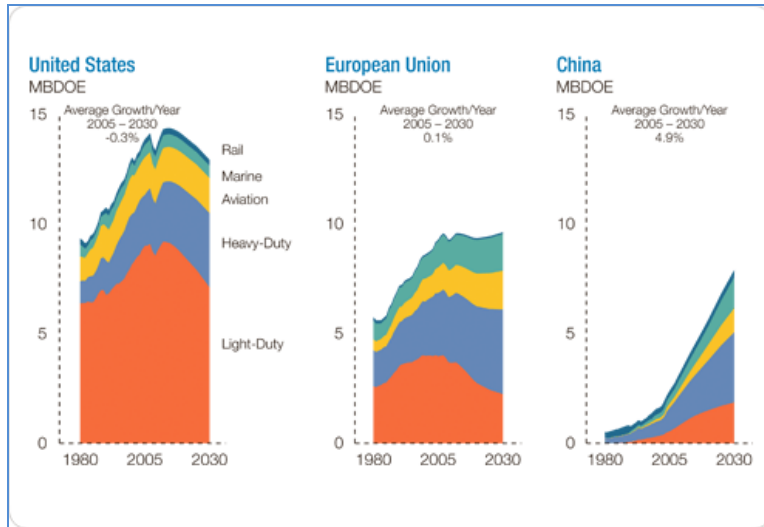
Upper Bounds	Lower Bounds
<p>Technology development Major breakthroughs in battery technology, hydrogen storage concepts and fuel-cell technology (methanol/ethanol fuel types possible) will lead to faster penetration of electric/hybrid and fuel-cell</p>	<p>Technology development Scientific advances will not reach the industrial/commercial scale at the pace expected. Consequently, the penetration of electric/hybrid and fuel-cell driven cars will be slow.</p>

<p>driven cars.</p> <p>The design of vehicle fuel systems will be standardised, allowing full interchangeability between different brands of cars. This will speed up the deployment of the electric grid and the distribution network for alternative type of fuels.</p> <p>The development of a hydrogen distribution network will still lag due to cost/safety concerns.</p> <p>Car construction will become less dependent on metals than was previously expected, with advanced plastics and the use of nanotechnology in the development of lighter and stronger structural parts/components.</p>	
<p>ICT applications</p> <p>ITS (intelligent transport systems) will increase logistics efficiency to unexpected levels, providing seamless transport of people and goods (using intermodal solutions). Seamless and safe transmission of data, and clear communication interfaces (standards), will be integral to the transport system. Autonomous driving will support high levels of energy efficiency in vehicle operations.</p> <p>Interoperable, seamless and roaming across Europe ICT applications.</p> <p>Advanced human-machine interfaces</p>	<p>ICT applications</p> <p>ICT system breakdowns will be common; data transfer will be compromised, leading to, for example, security and privacy issues. No agreement will be reached on standards for communication between vehicles and the transport infrastructure.</p> <p>ICT-islands of applications on regional or urban level</p>

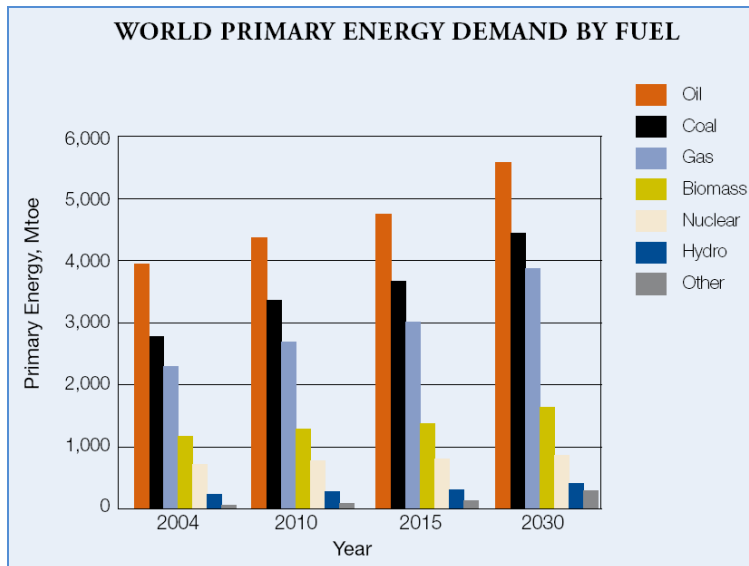
4 AN INSPIRING FUTURE FOR ROAD TRANSPORT IN 2030+

4.1 Energy and Environment

The world primary energy demand is expected to grow by more than 30 per cent between 2010 and 2030 due to economic growth in the developed and developing worlds. In spite of global efforts to rapidly accelerate the production of renewable and alternative fuels, crude oil, coal, and natural gas are projected to be the primary fuels for many decades. Although the recent global economic downturn has slowed this demand growth, most energy studies reported since 2008 project that energy demand will parallel previous trends when the economy improves.



Source: ExxonMobil Energy Outlook (2008)



Source: IEA World Energy Outlook (2006)

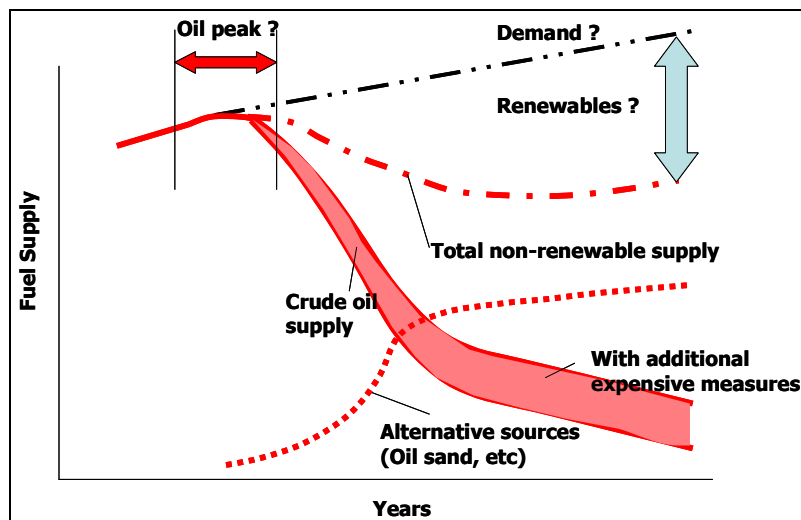
For road transport, a significant future challenge is changing the dependency on non-renewable fuels derived from crude oil and natural gas. This dependency is especially significant in the aviation, freight, and marine industries where good alternatives to fossil jet and distillate fuels are hard to find and approve for routine use. Crude oil dependency is also driving concerns about the future security of energy supplies while climate change concerns are driving energy efficiency improvements and the replacement of fossil fuels with

renewable fuels. The degree to which fossil fuel replacement will succeed depends on many factors, such as vehicle compatibility, fuel efficiency of alternative fuels on a well-to-wheels basis, the pace of development and investments in alternative fuels, the demand for alternative fuels from other sectors, and many others. While these questions are being addressed, reducing energy and fuel consumption from all sectors and from all parts of the world is the most significant step that can be taken immediately. The importance of energy conservation is highlighted many places in this scenario report.

The challenge that lies ahead is summarized in the following figure. At some point in time, the amount of easily extracted crude oil will peak and begin to decline. This means that the amount of crude oil that is readily extracted from the earth and refined for use will exceed the amount of new oil that is discovered.

Recent discussions have focused on when this peak in global crude oil production will occur. The production volume is closely related to the level of investment in exploration and exploitation and approximately half of the required oil/gas supply between now and 2030 will come from sources that have yet to be discovered or developed. Although the crude oil peak is an interesting question, a more relevant question is when the price of crude oil on the global market will consistently exceed viable alternatives, such as non-renewable, renewable and alternative energies.

Although a production peak is inevitable for any non-renewable resource, there are much larger proven reserves of other fossil fuels, such as natural gas, coal, and oil sands. Refining coal and oil sands into liquid fuels usable by road transport is known technology but it is more expensive than refining oil at today's crude oil price. These technologies may also be in conflict with climate change concerns unless carbon dioxide sequestration is also used (carbon capture and storage (CCS)). Currently, CCS is a technology under development and is not expected to make a significant impact on CO₂ emissions from power plants and refining until after 2020.



Source: ERTRAC (2008)

Thus, the total supply of non-renewable fuels is unlikely to keep pace with the growing global demand. Renewable and alternative energy and fuels will be required and work is already in progress to accelerate these developments. Due to regional differences in fuel infrastructure, imports, climate, water supply, prevailing winds, available crop lands, and many other factors, the best alternative for one country or region may not necessarily be the best alternative for another. For this reason, a coherent and cost-effective transition from non-renewable to renewable energy and fuels will be a significant challenge. Succeeding, however, is a pre-requisite for a sustainable road transport future.

Using this picture of the future, the Energy and Environment Working Group identified three key factors for its 2030+ outlook:

1. **Demand and supply of energy and fuel**, both from non-renewable and renewable sources.
2. **Enabling legislation and regulations**, driven by strategic policy priorities, especially those related to climate change, energy security and conservation, economic growth and environmental protection.
3. **Business motivation** to develop and implement new and cost-effective energy and transport technology options that are aligned with enabling legislation and regulations.

Six additional priority issues were also identified and these will be discussed later.

As mentioned previously, numerous projections exist for the future global and regional demand of energy and fuel. In all cases, historical trends show that there is a close relationship between the gross domestic product (GDP) of a country or region and its energy demand. Without energy, a country or region will struggle to become, or remain, competitive in the world market. The supply of energy and fuel required to meet future demand will almost certainly be a dynamic balance between aggressive energy conservation, energy production and energy diversification. A broad range of technological and non-technological options will therefore be required, both to save energy, and to produce energy from non-renewable and renewable sources in compliance with climate change and sustainable development expectations. It will also become necessary to utilise available renewable resource for energy production as long as sustainability and environmental concerns are satisfied.

At the individual's level, personal wealth has traditionally been found to drive personal mobility. Although climate change concerns will put pressure on this historical trend, consumers in developed countries will continue to demand a higher fraction of global energy to support economic growth, lifestyle and personal mobility. It is feasible that 'home officing' and similar concepts could impact this trend somewhat, including public policy and incentives or penalties, drive changes in consumer behaviour. It seems more likely that an individual's mobility will continue to be a personal expectation, whether that mobility comes from cars, trains, planes or other modes of transport. An important question is whether the consumer will be prepared to expend a greater percentage of disposable income for personal transport and travel flexibility.

Enabling legislation, coupled with regulations, must establish clear and long-term directions for businesses and consumers that are consistent with public policy priorities. At the same time, this direction must be 'technology neutral' (i.e. regulators should avoid promoting specific technologies) while encouraging innovation and fast-to-market commercialisation.

The development of new, innovative technologies requires talented people, development time and financial investment, and it is therefore highly important that public policy direction is consistently applied over a period of years. In addition, the state of the economic business environment and the availability of skilled and creative engineers and scientists will be critical to meeting future road transport challenges with innovative solutions.

Common-sense scenario for Energy and Environment
<p>Demand and supply of energy and fuel</p> <ul style="list-style-type: none"> • By 2030, crude oil and natural gas will still be available in significant volumes and represent more than 75 per cent of the transport energy demand. The primary sources for these product sources will continue to shift to politically unstable regions. • The responsibility for developing these resources will increasingly be with national oil companies. This will drive developing countries into strategic alliances with countries that own the fossil fuel resources. • The cost of crude oil and refined products will continue to rise on the global market and the commercial implementation of alternatives will depend on the projected return-on-investment proposition. • Long-term governmental policies and the cost of non-renewable energy will have had some success in driving investments in renewable and alternative energy technologies but to a lower degree than expected because global demand and supply will have kept the price of non-renewable fuels at a

competitive level.

- In 2030, the total road transport fuel/energy demand will level off due to policy-driven efficiency gains (e.g. stringent caps on new vehicle CO₂ emissions). Efficiency gains will be highest in light-duty passenger transport. The resulting decrease in energy demand will be offset by the growing energy demand from the heavy-duty transport sector. Efficiency improvements will be mandatory in all sectors, not just in road transport.
- Long-term governmental policies and the cost of energy will have had some success in driving investments in renewable and alternative energy technologies. Driven by climate change and energy security concerns, fuels derived from renewable and sustainable biomass will have displaced some of the non-renewable fuels used for energy and road transport applications, but to a lower degree than expected because global demand and supply will have kept the price of non-renewable fuels at a competitive level.
- The cost of energy will be a critical factor for driving investments in renewable and alternative energy technologies, and a stable investment climate will be required to develop alternative and renewable energy resources and to exploit new and more expensive non-renewable reserves. Therefore, the balance between demand and supply will be increasingly coordinated on a global scale, leading to gradual rather than turbulent cost increases on a long-term basis.
- Innovative developments in renewable and alternative energy technologies will be driven by public-private partnerships but global contraction in economic growth will inhibit major investments in the short term.
- In addition to the cost of renewable fuels, questions regarding sustainable development and the contribution of renewable fuels to climate change will inhibit early penetration until sustainability criteria are implemented on a global basis.
- Renewable fuels from 'second' and 'third generation' technologies will have been developed but, to an increasing extent, these will increasingly be reserved for aviation and freight transport applications. Alternatively, fossil fuel distillates will be increasingly reserved for aviation applications as long as the renewable alternatives are more expensive and limited in volume.
- Electric vehicle options will be growing in urban regions and in some densely populated corridors, for both passenger as well as freight transport, with their share in new sold vehicles rising up to 15%.
- As policy will set clear targets on other sectors of the economy, non-transport related energy demand will also be under pressure to reduce. As a consequence, the overall level of demand will decrease, relieving pressure on supply and leading to a relatively stable (price) equilibrium.
- Transport energy demand will diversify due to a 'green car initiative'. A proportion of the GHG emission gain achieved by the transport sector will be offset by increased emissions in the energy sector.
- Global competition for non-transport related energy will increase, leading to a growing segregation between countries that can afford their energy needs and those that cannot. This will lead to increasing global competition and higher crude oil prices.
- The impact of climate change induced weather on the transport infrastructure system will be marginal within this time frame.

Enabling legislation

- Mobility expectations for individuals and the freight transport sector will generally be encouraged by economic growth alongside an aggressive public policy aimed at controlling GHG emissions.
- Achieving this expectation, however, will require the simultaneous application of strategies to reduce GHG emissions from both passenger and freight transport. Reductions in GHG emissions will be achieved through technological developments (e.g. a diversification of vehicle power plants, alternative and renewable fuel options, and a 'systems' approach to reducing energy losses), and through non-technology measures (e.g. some limitations on personal mobility or increased costs for personal mobility, especially in urban areas).
- Regulatory decisions will encourage greater intermodality of freight transport, although concerted efforts and investments will be required to achieve significant benefits in Europe. On the personal mobility side, lower costs for vehicles having better fuel consumption, road pricing, city access charges, etc. will be

implemented alongside competitive fares for public transport to encourage changes in consumer choice.

- At the same time, energy production will become more efficient and will make greater use of alternative energy opportunities and renewable energy sources. The long-term and efficient utilisation of this energy will require greater electrification of road transport, for passenger cars and bicycles.
- Other transport modes (e.g. walking, cycling) will also be encouraged by public policy and safe pathways.

Business motivation

- Encouraged by a consistent and long-term public policy framework, business will be motivated to develop innovative solutions to the road transport problems posed by energy demand and climate change.
- Public-Private Partnerships will prove to be a valuable model for launching new, complex, and expensive initiatives aligned with the policy priorities.
- In some critical technology areas, ‘man on the moon’ mega-projects of an even larger and more complex nature will be implemented in order to accelerate development and solidify business and consumer support.

Enthusiastic Alternative	Pessimistic Alternative
<p>Energy demand and supply</p> <ul style="list-style-type: none"> • The carbon loop will be closed by 50 per cent through changes in industrial/agricultural processes (organic fertiliser, greenhouses, etc.) • Energy supply will be reliable due to global agreements on distribution. • Higher than expected GDP growth will lead to higher than expected energy prices, and thus to more incentives to invest in innovative approaches to exploration and exploitation. • New, innovative technologies for exploration and recovery are brought to market faster than expected, reducing concerns about the reliability and security of crude oil supplies. • The same innovations are rapidly applied to renewable and alternative energy technologies, diversifying the global energy supply faster than expected. • There will be a significant fall in total fuel demand for road transport due to the enhanced pace of electrification of passenger transport (plug-in hybrids). • The light-duty fleet will adopt alternative fuel types, including plug-in hybrid and fully-electric power, at a pace that is faster than expected. • Greater than expected fuel efficiencies will be achieved in heavy-duty transport due to fuel prices and perhaps policy (because of the continued rise in heavy-duty transport volume). • Energy will be inexpensive and available. Energy pricing will be fairly predictable and will not depend on price speculation. • Society will cope with changes in energy prices. 	<p>Energy demand and supply</p> <ul style="list-style-type: none"> • Energy supply will be unreliable over longer periods leading to uncertainties and fluctuations in energy prices. Investments in exploration and exploitation will not reach the required levels and pressure on energy supply will continue to increase. • Renewable and alternative energy technologies will not be deployed as quickly as required. Target volumes and prices will not be met. • Greater than expected competition for fossil fuels in developing countries will result in higher fuel prices in Europe, leading to pressure on economic growth and mobility (personal as well as freight transport).The impact of global warming will be significant, and will have a growing impact on energy supply and production. This will include impacts on the reliability of sea shipments due to storms, the impact of sea-level changes on refineries in coastal areas, etc.

<p>Price swings on the oil market will not affect the transport sector. The energy price will provide a good basis for business models supporting alternative 'green transport solutions'.</p>	
<p>Enabling legislation</p> <ul style="list-style-type: none"> • All Member States will establish carbon emissions limits which will be distributed across economic regions. • Consumers and industry will have progressive cost profiles based on their individual carbon footprints (baseline + incremental steps). • Technological innovation will achieve the expected reduction in GHG emissions, reducing the pressure to mandate radical changes in the energy and transport sectors. 	<p>Enabling legislation</p> <ul style="list-style-type: none"> • Global warming will be perceived as being in danger of running away. Hence, increasingly aggressive public policies will be implemented in an attempt to control GHG emissions. • These policies will have a significant impact on the availability of personal mobility. • Regulatory decisions, driven by the need to address climate change, will be introduced, e.g. to influence the choice of transport mode; discourage the use of personal vehicles; restrict air travel; introduce taxes and fees on personal mobility, etc.
<p>Business motivation</p> <ul style="list-style-type: none"> • The move to green technologies provides business and employment opportunities as well as globally-competitive technologies. 	<p>Business motivation</p> <ul style="list-style-type: none"> • The recent economic downturn has a longer-term impact than expected delaying business initiatives that will be needed to achieve longer-term energy objectives.

Additional Priority Issues

Having identified the above key factors, six additional priority issues were identified that can be expected to enable the technological and social change in road transport needed in the future:

- Enhanced energy production, including electricity

All viable sources of locally-produced energy will become increasingly important in the future as a means to decentralise energy production, improve energy security and reduce GHG emissions from the energy sector. Many approaches can be expected resulting in some local business opportunities and success stories. These approaches, including wind, solar, hydroelectric, wave, geothermal, and waste, will cover a wide range of possible technologies until the most cost-effective and technically robust concepts are clearly identified.

One challenge will be to ensure that the apparently best concepts do indeed meet policy and commercial expectations and should not be 'locked in' by over-investment. A commonly-applied business development model (such as stage-gate) may help to speed the commercialization of new ideas and provide a common basis for comparing different technologies. These new concepts must also be scaleable and easily translated to other locations and applications to be broadly beneficial. In the near-term, added value will be the local business and employment opportunities and the public awareness of growing energy and environment problems.

- An efficient, integrated and robust energy infrastructure

However the energy is produced, it must then be efficiently moved to where it will be consumed. For this reason, many of the most efficient approaches that are already in development produce electricity. Although the electricity can be beneficially used to offset local needs, it can also help to buffer peak electricity demand as long as a smart electricity transmission grid is available. Large-scale wind and solar parks will be erected that supply electricity to the power grid. Local solar energy systems will also be in place, e.g. to support road infrastructure lighting, static communications, and other needs.

In urban areas and in densely populated corridors, dedicated smart grids will be in place downstream of the main supply structures to supply (peak) demand for recharging electric vehicles. Many approaches are being

considered to do this that depend upon the speed of recharging required by the consumer and whether the recharging occurs during the day or overnight. At the same time, vehicle-to-grid (v2g) technology will be possible to buffer the electricity network when the vehicle is not in use.

Local fuel infrastructure for niche fuel applications, such as CNG or DME, will also be in place but generally restricted to metropolitan areas where intermediate services (buses, taxis, dedicated fleets) can make effective use of them. For fuel logistics servicing the mainstream vehicle market, careful study will be required before initiating investments in major new fuel distribution and supply infrastructure due to the cost, complexity, and land used by such facilities.

- Vehicle/transport efficiency through technological and non-technological measures

In order to meet future fuel consumption targets for light-duty vehicles required by recent EU legislation, a wide variety of technological measures will be implemented in the next decade and beyond. From an engine perspective, it is widely assumed that considerable fuel consumption improvement is possible from today's ICE through a combination of engine downsizing, downspeeding, and turbocharging. Additional improvements will come about by capturing small energy losses from all parts of the engine by optimizing engine combustion, reducing heat loss and recovering waste heat, reducing mechanical losses, etc. In the near-term, both gasoline and diesel engines will be popular among different consumer demographics.

From a vehicle perspective, fuel consumption improvements will result from recovering braking energy, optimizing the transmission, increasing hybridisation, range extension, start-stop, low-friction tyres, better aerodynamics, and many other ideas. Of course, additional and cost-effective improvements can result from infrastructure changes such as better signage, low-rolling resistance highway surfaces, ticketless toll booths, etc.

Although technology still offers considerable potential for fuel consumption improvements, 'non-technology' approaches will also be needed to meet future priorities. Strictly speaking, these approaches will also utilize technological improvements to achieve success but they will require communication tools or the greater cooperation of the driver to achieve results. These will include the greater use of 'eco-driving', vehicle-to-infrastructure (v2i) communications to speed travel and reduce congestion, speed limitations, and similar approaches.

- Fuels, and fuel supply, to enable new vehicle technologies

Vehicles and fuels have traditionally worked together to achieve the required fuel consumption and emissions performance. As ICE engines continue to evolve over the coming decades, it is conceivable that our traditional views of gasoline and diesel engines and fuels will merge in the future. There are already some indications of this with prototype advanced combustion engines although it is too early to anticipate the fuel appetite of these engines. Changes in fuel properties can also have significant impacts elsewhere in the fuel cycle, such as refinery GHG emissions, refinery production of other products, supply and distribution infrastructure, etc. and these would need to be carefully evaluated.

- Consumer expectations and behaviours that are aligned with public policy directions
- Financial and other transportation incentives for consumers to encourage a change in behaviour.

Most consumers are already aware of public policy initiatives, such as the need to reduce GHG emissions. It is not yet clear, however, that most consumers are changing their expectations and behaviours related to road transport to support these public policy directions.

Active education campaigns will undoubtedly be necessary, but these will need to be coupled with financial incentives and penalties, before a substantial change in behaviour can be expected. The education required to achieve a significant shift in consumer behaviour will take a long time and should ideally begin with pre-school training related to energy use and conservation.

4.2 Urban Mobility

Urban mobility is the mobility of persons and goods on the urban environment, facilitated by the management of the urban mobility network.

The future of urban mobility will mainly depend on four key drivers: **climate change; energy supply and cost; demographic change and changing society; and urbanisation.**

Regulation, adopted by all levels of government to address **climate change** and contain the level of GHG emissions from the transport sector, is likely to trigger a broad range of developments affecting the future of urban mobility. For example, restricted access to city centres, including through pricing, according to the time of day, the type of vehicle and the purpose of the trip; and similar restrictive measures to encourage society to become more aware of the impact of their personal behaviour, will have a direct influence on personal mobility.

Demographic change and lifestyle trends, such as the ageing of the population and the growing number of immigrant, will have a significant impact on Europe's future and will put pressure on the urban mobility systems of the major European cities. These are great challenges on the path towards sustainable urban mobility. The level of economic development is also an important factor. The economies of European cities will continue to grow for the foreseeable future, and there is no reason to believe that such growth will be substantially different from the average level of economic growth across Europe. The current financial and economic turmoil highlight the fundamental need for a healthy urban economy as a prerequisite for social stability, and this will also be an essential element for the successful design of urban mobility systems in the future.

A growing urban economy will, according to current trends, lead to a growing urban transport demand. In contrast to the case for long-distance freight transport (where the total mileage will, to a degree, be decoupled from economic growth due to the fact that industrial production will be localised much closer to, or even within, the EU itself), the growth of urban distribution and transport will remain dependent on economic growth. This implies that, as the economy grows, there will be a need to develop the urban structure at a faster pace than that required to develop the interconnecting infrastructure.

The evolution of energy supply and the increasing cost of energy will lead to a demand for higher levels of efficiency in the transport network. The challenges will be to react to the increasing cost of transport fuels and to satisfy the mobility needs and expectations of a growing economy while also addressing the potential negative impacts on the environment resulting from an increase in the level of urban mobility.

The future of urban mobility systems can be considered by observing its four key components:

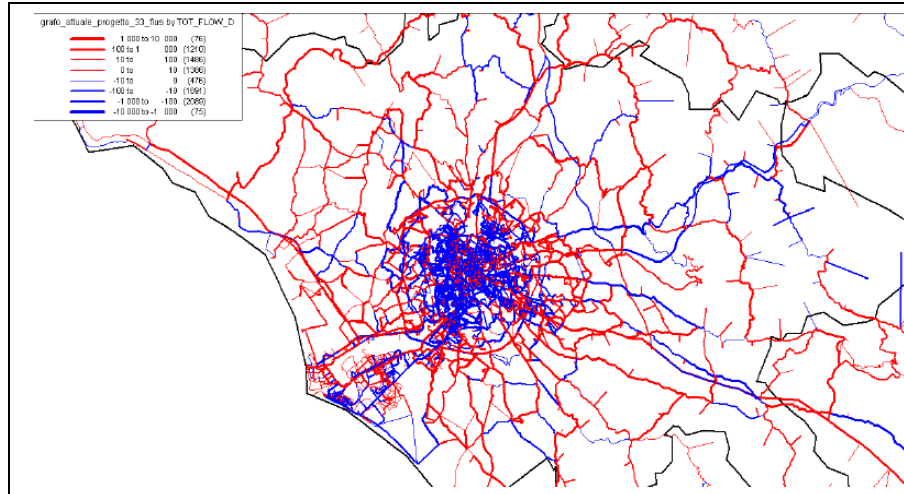
1. The level of demand for urban mobility, driven by consumer needs and behaviour.
2. The urban (infra)structure.
3. The availability of solutions for enhanced urban mobility (e.g. advanced vehicles, services).
4. The state of the urban mobility system as a whole.

Challenges for the future urban mobility system, the example of Rome, Italy

Every city has its own characteristics, and it is therefore necessary to exercise care when making assumptions about the future of the urban mobility system throughout Europe as a whole. For example, some cities may possess extremely dense rail networks, while many have none. The architectural heritage and historical or artistic value of others may place unique constraints on mobility development. Unfortunately, the lack of specific data on European cities means that a pan-European assessment of the general trends in urban development is not a straightforward exercise. However, it is possible to identify several key patterns.

Future urban developments will be driven by the effects of urbanisation, globalisation, demographic changes and economic development. An example of the consequences of urbanisation can be seen in the case of

Rome, Italy (see maps below). The tendency is for a gradual decrease in traffic flows in urban centres, with increasing concentrations around the periphery of the cities. Surveys and forecasts in other cities, in particular in France, show the same pattern over time. Hence, the challenge is to address a tendency towards urban sprawl.



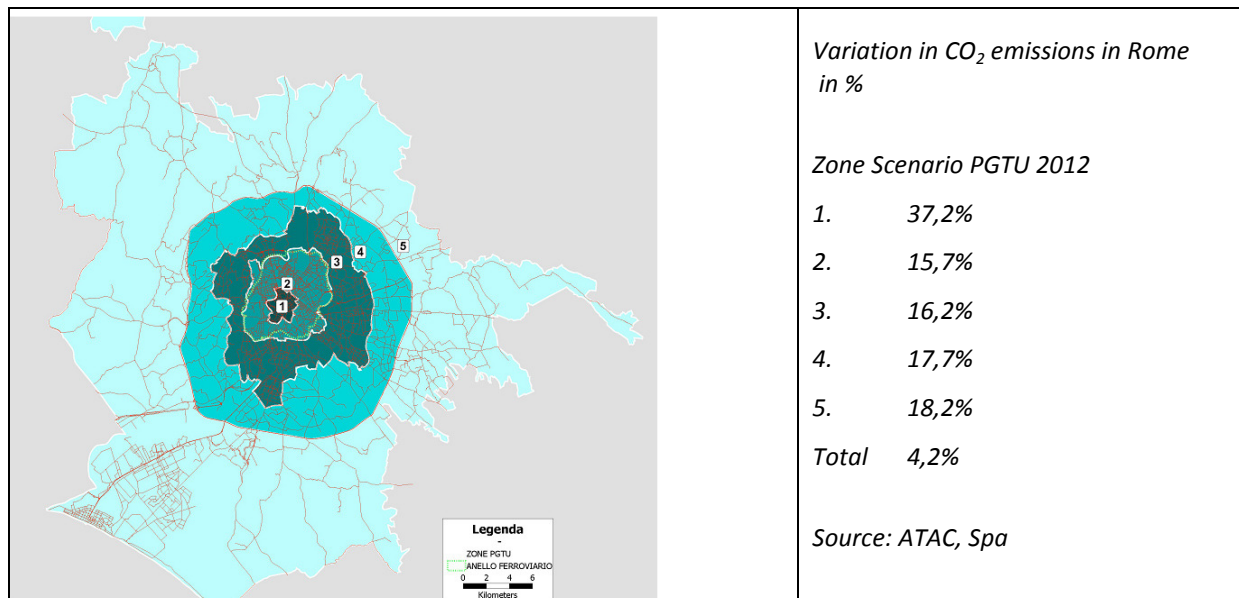
Comparisons of traffic flows in Rome at peak hours, 2006–2012

Blue indicates a decrease in traffic volumes

Red represents an increase.

Source: ATAC Spa

In the case of Rome, with its anticipated growth in both population and jobs, it is unlikely that the city will be able to contain the growth of urban sprawl, despite its best efforts. As a result, the demand for mobility in the urban periphery will continue to grow. Investment in public transport (PT)⁹ will attempt to address this growing demand. Further growth in the demand for mobility will lead to an increase in traffic, though to a lesser extent. As a result, CO₂ emissions in the urban periphery will continue to grow while, in contrast, they are likely to fall in the city centre as a result of policies implemented to manage demand and support sustainable urban mobility.



This scenario is most relevant for large urban centres. To a lesser extent, it is also relevant for dynamic, medium-sized cities, although for many of these there may be the temptation to build new infrastructures. Such development will be largely dedicated to public transport to ensure a more sustainable degree of mobility.

⁹ Public transport is used to refer to passenger transportation services available for use by the general public.

Common-sense scenario for Urban Mobility

By 2030, urban mobility will have changed due to socio-demographic evolution (ageing, immigration), urbanization, the increase of energy costs, the implementation of environmental regulation, and the further diffusion of sophisticated Information and Communication Technology (ICT) applications in virtually all aspects of life. The result will be a complex, integrated system, managed with greater efficiency to answer the challenges of reducing its environmental impact and minimising congestion.

- Personal mobility demand will diversify. This will be driven partly by socio-demographic changes such as ageing, income distribution and immigration. There will be a greater choice of mobility solutions, often multimodal, and new information services that will become readily available to the consumer. By 2030, the urban traveller will go more or less seamlessly from door to door. Multimodal hubs will provide the urban traveller with easy transfer between modes. Collective transport services will diversify, and public transport will grow significantly in major urban centers.
- The demand for public and collective modes of transport will increase, as a consequence of socio-demographic changes, urbanization and continued urban sprawl. This will create financial pressure on the mobility system as a whole and on public transport services in particular, while at the same time public finances will have to cope with an increase of social spending, also due to socio-demographic changes. The ability to answer this challenge and ensure the provision of good quality public transport and collective mobility services will be key to achieve the vision of a sustainable urban mobility system. Part of the answer will be provided by public transport systems (urban rail and bus systems) which will become even more energy efficient through advanced energy storage technologies and use of new materials. They will provide high levels of interoperability, accessibility, safety and comfort.
- Urban development and environment policies, land use and sustainable urban mobility planning will become increasingly integrated. Pan-European efforts to generalize approaches for sustainable urban mobility plans will further support this trend. It will only partly contain urban sprawl and it will encourage an evolution towards polycentric urban areas. Public transport systems (bus and rail) will contribute to shape the future urban environment.
- Although the urban transport infrastructure will be optimized to the very limit of its capacity, financial and spatial constraints will prohibit the full accommodation of the increase in mobility demand. Hence, demand management, including pricing policies, will be implemented on a large scale in cities across Europe to influence behaviours and as part of their mobility network management strategy. Priority will be given to sustainable transport modes and services, including walking and cycling. Soft modes will be further encouraged, and be considered as alternative modes of transport for certain trips. The rate of motorization will nevertheless not decrease significantly.
- New services and business models will emerge for urban mobility, encouraging public and collective services, journey sharing, shared ownership of vehicles. They will address the increase in mobility demand, to mitigate the impact of mobility on the environment, and to address the challenges presented by the evolution of energy supply and the rising cost of energy. Access to these services will be made easy, e.g. by single ticketing concepts, allowing the urban consumer to travel leisurely and seamlessly from door to door.
- ICT will become fully integrated in the everyday life of the urban consumer to the extent that he/she will be on-line continuously and will take part actively in a vibrant virtual community. In addition to receiving mobility information from the service provider, the urban traveller will actively and passively reciprocate to the service provider, leading to real-time, accurate and reliable mobility information services.
- ITS and the increasing availability of mobility information will play a major role in optimising network efficiency and allow for the selection of the optimal combination of travel modes for a specific destination by the traveller. Traffic and Travel Information will support the implementation of advanced management systems (through cooperative systems) and mobility demand management.

- The demand for advanced (home) delivery of goods and services will increase as the urban consumer continues to have access to an increasing variety of on-line information and e-commerce services.
- Urban logistics strategies will lead to a greater efficiency in urban freight delivery, with greater integration of urban freight challenges in urban planning. This will allow for the consolidation of freight delivery and the optimum use of the infrastructure. Transfer hubs will provide an interface between long-distance freight transport and urban freight deliveries. 'e-freight' will be integrated with urban logistics.
- The urban vehicle fleet will undergo a transition towards electrification and diversification in design. An increasing number of cars in cities will be electric. The demand for public transport and urban freight delivery will have a strong influence on new vehicle design. The share of hybrid and fully-electric vehicles will increase progressively. In addition, the shifts to more tailored public transport and urban freight delivery will lead to a greater diversity of vehicles on the urban network, with the appearance of modular vehicle design allowing using vehicles better fitted to the urban environment and mobility demand. All types of vehicles will be increasingly energy efficient, including urban rail vehicles.

Consumer needs and behaviour

By 2030, the personal demand for urban mobility will have changed significantly due to economic, social and demographic changes.

Evolution of the demand in response to socio-demographic changes

Personal mobility demand will evolve and be increasingly diversified according to the category of user as dictated by a person's age and social standards and trends (increase in the number of single households for instance). Much more than today, the mobility service providers will offer business models that are dedicated to the specific purpose of the desired journey (for instance school, work, leisure).

Mobility demand will consist of three main components: demand for flexibility of mobility services; accessibility to services of all types; and assurance of safe and secure travel. Such expectations will be met only if the solutions prove to be cost-efficient both for the user and for society in general.

One answer to the ageing of the population will be the increase of immigration. Economic immigrants are likely to concentrate mainly in dynamic urban areas, and they will often be poorer and younger than the average of the population at the time of their arrival. They will therefore contribute to an increase in demand for short-distance urban transport, in particular public transport.

It is also expected that a larger share of the population will have a lower income due to ageing of the European population. The subsequent division in personal income/wealth, combined with increased costs, will lead to a situation where part of the elderly population and the growing less-affluent immigrant population will have limited access to personal mobility. These population groups traditionally use more public transport than do other demographic groups. In the case of wealthier segments of the population, older people will be more likely to travel in the future than their counterparts today. The preferred mode of urban travel will depend on the quality, accessibility and price of the available public and collective transport.

The private car will still be the preferred mode of travel for the older generations and for families with young children. It will remain the least physically challenging mobility solution for older people, and will therefore be the most obvious and, in many cases the only, mobility choice. The elderly will not be as comfortable with other modes of transport because they will have driven most of their lives, unlike younger generations.

In parallel, parts of the urban population will change their mobility behaviour due to environmental consciousness, attractive alternative transport modes and demand management policies. User needs will create a demand for more and high quality collective transport services. This demand will grow with the provision of alternative services inside public transport to create productive personal or professional travel time.

As a result of these combined factors, the demand for public transport will increase significantly.

But the same ageing of the population will also result in a higher burden on public funding (for social and health care), hence the supply of public transport will be challenged by a lack of available public finance. It is worth remembering that the operational income of public transport does not cover its operational costs, with the operational deficit being mostly covered by public funding.

By 2030, a significant part of the poorer elderly community will be at risk of having even less access to mobility because these individuals will not be able to walk or cycle as an alternative to motorised forms of mobility.

How ICT will influence urban mobility demand

Due to the development of an information-driven society, the mobility demand will be well understood by industry and public bodies, and their services and products will be highly tuned in to that demand, providing seamless door-to-door mobility for many travellers.

New technologies, and new management and organisational models, will support distance working. This may lead to a decrease in commuter travel and, at the same time, accelerate the emergence of polycentric cities, facilitating a reduction in the demand for travel.

New technologies should also allow for an increase in the provision of 'e-services', which may also result in a reduced demand for personal mobility.

The growth of social networks and virtual communities, possibly at the expense of physical communities, would reinforce the same trend. However, this may contribute to urban sprawl by lowering the demand for, and the need for access to, city centre services.

Users of mobility services will increasingly constitute 'groups', e.g. company groups, social groups, etc. This could lead to the provision of targeted community transport services, and various forms of demand-responsive transport.

The information flow in city centres will provide real-time, precise and accurate mobility information to the consumer, as well as other benefits. This will enable the consumer to select from a wide variety of alternatives and possibly to follow the lead provided by the appropriate information services.

It is expected that new technologies will trigger a growth in long-distance travel for both business and leisure. This will lead to an increase in traffic to and from travel hubs such as rail stations, ports and airports, which themselves will be increasingly integrated into the urban transport system. The increase in long-distance transport will, in turn, lead to an increase in specific short-distance services providing connections for long-distance travellers. However, this pattern will be possibly offset by increasingly competitive business practices that will most likely lead to a fall in the general demand for business travel. The greater use of new technologies to better support e-services will enhance this trend.

The increased use of e-commerce will generate more journeys for urban goods delivery services, in spite of efforts made to rationalise urban logistics.

The number of actors involved in the distribution of goods may be greater than today due to access to a broader range of services and a greater diversity of goods. This could also contribute to an increase in urban goods delivery traffic.

Influence on demand and behaviours through policy

To influence mobility demand, optimise the efficiency of urban mobility systems and minimise emissions resulting from urban mobility, a majority of cities will implement comprehensive and integrated planning,

including demand management schemes. These will cover all types of vehicles, i.e. not only private cars but also delivery vehicles and powered two-wheeled vehicles.

Policies, including fiscal policy will increasingly limit and tax carbon emissions, and hence influence individual and collective behaviours. This will accompany the increased application of the internalisation of external costs.

The cost of mobility will be an important factor when considering the amount, and the mix, of mobility that a person will be able to afford. As travel in urban areas will become significantly more expensive due to policy measures and increasing energy costs, the mobility mix should shift significantly to the cheaper modes of travel (e.g. public transport, bicycles or walking).

Individuals in cities will become increasingly aware of their environmental impact and, in particular, of their impact on climate change, via the provision of information on their CO₂ emissions at each trip. They will also be better informed about local air quality and the impact of noise on health.

An increasing number of companies will begin to invest in more sustainable transport; they will employ 'green marketing' techniques in an attempt to raise their environmental profile and increase public awareness, though sometimes with conflicting messages.

Urban structure

Although cities will change and their landscapes will shape mobility systems over time, this will be a slow process and no radical changes in land use should be expected. Rising energy costs, economic and private activities, as well as policies and regulation, will shape the evolution of urban design but their effects are likely to be gradual.

The importance of integrating land use and mobility planning in addressing the demand for urban mobility will become increasingly recognised and taken into account in urban development projects. For this reason, if urbanisation continues to lead to more urban sprawl, the pace of urban sprawl will be slower than today.

New urban rail and bus systems with highly attractive designs and services as well as good intermodal connections will be increasingly used by city planners and decision makers to reshape and redevelop parts of the urban environment.

The decreasing size of households, which is also a consequence of demographic and lifestyle changes, will slow the pace of urban sprawl. This, in turn, will contribute to the (re)vitalisation of urban centres where, in general, economic services will continue to be conveniently located to reach the population. City centres will continue to be attractive for business and residential purposes.

People will be encouraged to live closer to their jobs, or at least to reduce their need for commuting. For this purpose, a functional mix of services and housing will be encouraged in cities and neighbourhoods will be more heavily populated. Policy and regulations will play a big role in this change.

Urbanisation will lead to an increase in commuter travel in the medium term, until technology enables a significant reduction in business travel. Sustainable urban transport planning, land taxes and land-use planning will contribute to the emergence of polycentric urban areas, although this may not prevent the growth in commuting. The demand for collective transport is therefore likely to increase, as will the number of car journeys.

Travel between suburbs will also increase, which will support the demand for new public transport services on these routes. Urban sprawl will therefore create further pressure on the financing of public transport.

Overall, the volume of transport in cities will continue to grow, although possibly to a lower extent than today and at a slower pace than the anticipated global rate of increase. This growth will not be matched by a

comparative increase in transport capacity.

Cities in regions of net migration will decline in population, and their economies will therefore also decline. This will lead to less support for services and facilities in general which, in turn, will encourage an urban planning approach that focuses on the development of specific neighbourhoods. Infrastructure will be adapted to accommodate the evolving demographics. Where the existing infrastructure provides sufficient capacity, it will be more difficult to influence mobility patterns and contain urban sprawl.

Future physical infrastructure for urban transport will experience a radical reallocation of road space, in particular between transport modes and between type of road users, with the specific allocation of corridors to certain type of vehicles, users or services. Traffic speed may also be taken into consideration.. This will go beyond what is currently being experienced across Europe. The transport network will also evolve in response to the development of new vehicles and services for an ageing population.

Urban mobility services and vehicles

Towards enhanced public transport and new mobility services

The various types of collective transport will adapt to changes in traffic volumes. Mass public transport will remain essential for transporting large numbers of persons, and will be complemented by new mobility services. These will emerge as alternatives to the use of private vehicles with new forms of vehicle ownership and usage patterns for all types of vehicles. In this framework, the provision of more flexible mobility services will keep growing, especially in the centre of major urban areas where space will be increasingly scarce and expensive, providing that a culture for the provision and use of these services continues to emerge. They will be supported by new business models. Examples include shared and collective forms of private ownership such as car sharing, car pooling, and the use of public bikes and cars. Car pooling will be stimulated through company mobility plans, which will become standard practice. Sustainable urban development will provide the facilities and organizational support for car sharing and car pooling for its inhabitants.

The financing of mobility services will face significant constraints due to the increasing pressure on public finances and the lack of business models. Various ways of generating revenue (e.g. road pricing) for investment in the transport system will be explored.

There will be a growing number of households in the city centres that will share a vehicle or will have a subscription to collective services in order to minimize such expenses.

This evolution will trigger the development of new activities in the sector that are aimed at providing integrated mobility services to the private and commercial client, e.g. seamless 'door-to-door' transport for the traveller. As a consequence, the traditional distinction between the actors in the transport sector (e.g. vehicle manufacturers, public transport operators, road administrators, etc.) will diminish with their conversion into mobility solutions providers. Mobility service integrators, as well as other types of new actors, will appear.

The growth of more diverse public transport services and the development of new mobility services to answer a changing demand, will also serve to address groups of persons and new patterns of leisure activities¹⁰, in particular for the older population.

Peak transport hours are already increasing, with more mid-morning leisure travel. Different speeds and modes of transport may be demanded by different sectors of the population; modes and services (e.g. buses, underground rail systems) may become targeted at specific age categories, and demand-responsive transport services will be further developed. Public transport vehicle design will also react to these changes.

There will be a growth in both rail- and road-based public transport services. Bus systems providing enhanced services (e.g. rapid transit facilities) will begin to operate in cities across Europe. Several advanced and

¹⁰ GHG: route to 2050

automated systems, such as cooperative systems, will emerge in collective transport. These systems will provide services with greater flexibility to adapt to variations in demand, time and location, e.g. by using modular vehicles.

Collective transport services (e.g. taxis) will become better integrated with the rest of the mobility network in general, enabling improved communication of information to travellers. Greater consideration will be given to energy supply by the transport system as a whole.

A new generation of 'intermodal nodes' (parking, stations, etc.) will contribute to a smoother and more enjoyable transition between private and collective modes of transport.

The quality of public transport services will continue to depend also on the density of the city and on the urban structure. There will be a need to develop business models for public transport in low-density areas.

Nevertheless, the motorisation rate (i.e. the number of vehicles per inhabitant) will not decrease significantly.

Vehicles for the urban network

New generations of vehicles for urban goods delivery will be developed. They will be more fuel efficient and rely much more on electric power. They will be designed with lower emissions as a priority. This will be driven by the introduction of more stringent controls to restrict commercial vehicle access to urban areas, and which favour 'cleaner' vehicles. Depending on their function and the nature of the delivery, electric-powered vehicles will become popular, as will hybrid and fuel-cell powered vehicles. The movement of goods from long-distance freight vehicles to urban goods delivery vehicles will be managed in the framework of the urban logistics management system.

Goods vehicles will increasingly be modular and have a size more adapted to the urban environment and the new patterns of urban goods delivery.

The increased price of energy, combined with the reduced availability of fossil fuels, will be a significant incentive for private, public and commercial transport providers to consider alternative propulsion concepts, especially in the urban area where alternative fuels and energy supply structures are more cost-effective to implement. The obvious and most likely path forward will be the progressive deployment of new, more energy-efficient vehicles. These will most probably take the form of smaller urban cars with non-petroleum based propulsion systems, and will become the dominant non-public mode of transport in urban areas. A combination of physical, fiscal and other new measures will be put in place to facilitate their continued development. For public transport, new vehicles will also be significantly more energy efficient, including for rail vehicles with the deployment of more efficient energy storage and recovery systems.

Electric vehicles will constitute a growing portion of the urban passenger transport fleet, with an estimated five million units on European roads by 2020 (about 2 per cent of the European fleet of passenger cars). By 2030, it is expected that more than 20 per cent of new passenger cars sold will be fully electric or hybrid-electric vehicles. The deployment of electric road vehicles will also impact on the pattern of vehicle usage in the cities, and new types of vehicles will emerge, e.g. dedicated 'city cars' designed purely for local, short-distance travel.

Because the price of electric vehicles will be significantly higher compared with today's vehicles, the policy-driven introduction of such vehicles will lead to new business models. Car sharing and public car schemes for instance will contribute to the increasing penetration of electric vehicles in urban areas.

For public transport (mainly lighter vehicles), the use of hybrid and plug-in electric systems will be introduced. Specific systems will be designed to fulfil the requirements of various types of vehicles, for instance electric buses but also waste collection vehicles, which will require larger energy storage due to high daily mileage and specific fast charging solutions. Intelligent management of the power source used in public transportation will also enable the optimisation of energy use for maximum efficiency.

Other propulsion technologies will also be explored or become more common. These could include biofuels and fuel cells, but also CNG which is likely to be used for buses, taxis and intermediate services. This will be particularly common in countries that possess national resources of natural gas.

A variety of new specialized vehicle concepts will emerge that will be tailored to the needs of the consumer, with different functions and forms, and with a predominance of smaller vehicles in the urban environment. For example, new designs may specifically target the requirements of the older generation for leisure-related mobility.

The shifts to more tailored public transport and urban freight delivery will also lead to a greater diversity of vehicles on the urban network, with the appearance of modular vehicle design allowing the use of vehicles better suited to the urban environment and mobility demand. All types of vehicles will be increasingly energy efficient, including urban rail vehicles. Such developments will be driven by the growing financial pressure on public transport operations. Other responses will be to increase passenger capacity, thus reducing operating costs and optimising capacity, consumption and frequency. Further reduction in operating costs for public transport will be achieved through intelligent vehicle maintenance management using ICT.

ITS will permit efficient in-vehicle energy management and provide comprehensive road and traffic data to enable the driver to adapt more effectively to the urban environment and urban traffic conditions. ITS will also support 'eco-driving', reducing fuel consumption, vehicle emissions, accident rates and noise levels.

Vehicles will become increasingly connected with both their operating environment and their passengers. Information received by the vehicle will have the potential to be personalised for distribution to individual occupants, in both private and public vehicles. Such access to personalised information will encourage the development of new business models for the deployment of cooperative systems.

In-vehicle ITS will contribute to road safety in urban areas, by incorporating features such as pedestrian and cyclist detection systems, and road safety and hazard information. Such systems will be supported by cooperative systems.

As infrastructure and vehicles become more advanced, a capacity for automated and fully guided vehicles will emerge, controlled either from a central management system for private vehicles, or combined with guidance systems for public transport vehicles. These concepts of vehicles will contribute, in certain cases with new modes of ownership and usage, to make less relevant the traditional distinction between private vehicles and public transport.

Cycling will grow as a fully recognized transport mode in the smart urban mobility system of the future. New bicycle types will be developed which better fit the profile of the various types of users, and which provide enhanced levels of safety. Their use will be supported by ITS and they will become integrated into cooperative mobility systems in the city.

Powered two wheelers will also offer flexible mobility solutions to the extent that the vehicles limit their impact on the environment and contribute to sustainable and efficient urban mobility. Their use of space will need to be limited and they will be required to provide a high level of safety.

Urban mobility systems

The pressure on the urban mobility system in the next 20 years, created by the rise in energy costs, financial constraints on public transport, urbanisation and the evolution of mobility demand, will require greater efficiency in all components of the system as well as in the management of the urban mobility network as a whole. This will require the integrated management of the movements of people and goods, including all types of vehicles, private vehicles, soft modes, public and other collective transport services, triggering higher quality mobility services and solutions and the deployment of more energy-efficient vehicles. In this framework, private car ownership will remain the dominant mode for personal transport.

Infrastructure use will be optimised with dynamic management systems, e.g. to prioritise the use of available

road space, and through the development of dedicated new infrastructure.

More efficient use of energy and the prioritisation of functional mobility needs will be key factors in addressing both the increase in the demand for fuel and rising fuel prices. This will require the careful management of mobility demand, which will also be a major consideration for climate change, e.g. by introducing controls to reduce congestion, emissions and local pollution.

All urban areas will adopt some form of demand management. Several tools are available for this purpose, including road charges and pricing (dependent on time, place, type of vehicle, type of driver and possibly the nature of driving behaviour), parking management, and the restriction of access to urban centres, through for instance the introduction of congestion charging, 'low emissions zones', mobility credits or, in certain cases, carbon credits. In those parts of the city that are faced with tight environmental and spatial, as well as public, budget constraints there will be a considerable degree of 'compulsory mobility'¹¹ leaving less room for 'chosen mobility'¹².

Support must be provided to the public to assist them in their travel planning arrangements to, and from, urban centres. This will be enabled by the development of integrated network management systems which, in turn, will rely on more advanced monitoring of the transport environment. A variety of data collected from across the network infrastructure will include information about temperature, humidity, local air pollution, noise, congestion, etc. Advanced traffic management systems will also have access to data relating to the traffic patterns of individuals. For example, information about the occupancy of vehicles could be used for dynamic traffic management, such as giving access to dedicated traffic lanes for high occupancy vehicles. It is likely that the data collected to support the real-time supply of information on travel options and mobility solutions for travellers will be provided by a range of planners/networks, and integrated into a common database. Network managers will attempt to adjust time and distance of travel, possibly using time as a variable to influence mobility patterns. These data will be also used for dynamic traffic management. The first large-scale dynamic traffic management systems will be put into operation in some European regions by 2030.

The development of affordable information systems and services will support complex multimodal journeys by providing information and payment facilities both before and during journeys. These systems will enable travellers to plan complex journeys by providing them with the available travel options, and they will also offer incentives (e.g. faster or cheaper travel options) according to the mode and time of travel chosen by the traveller. For each travel option, the individual will also be informed about his/her carbon impact and, consequently, whether or not a travel charge will be applicable. This may become a legal requirement in Europe.

On-line and off-line technologies with high-quality interfaces will be introduced to the market, to suit all user groups. The costs of such systems and services will be relatively small compared to the resources needed for major road infrastructure projects. The technology will be implemented both in the vehicle and at strategic locations along the road side.

These systems will rely on various technologies, e.g. 4G, Galileo and GSM and RFID sensors to gather and transmit data in real-time about traffic flow, optimal journey times and route choices.¹³

Questions remain, however, regarding the relationship between the constant supply of real-time information about available services, and the network's ability to deliver those services in practice. It is important to realise that information alone will not solve everything, and that its contribution to more efficient travel behaviour will most probably require some further study, not least with regard to the nature and degree of incentives

¹¹ Defined as the fulfilment of trips considered as essential for economic and social purposes (work, schools, etc.)

¹² Defined as the fulfilment of trips considered as non essential for economic and social purposes (leisure) from the point of view of the individuals

¹³ Foresight

required to encourage travellers to make optimal decisions when planning their journeys. Experience gained by network managers will become invaluable in addressing these questions.

New technologies, such as integrated ticketing and integrated, reliable information services will make access to public transport much easier and, in effect, provide an incentive to use the public transport services.

The use of ICT will contribute to reducing both travel time and urban congestion, but may add to journey distance, due to real-time route guidance and hazard warning¹⁴.

More efficient organization of urban logistics will be required, and this will be an important issue in any transport and land-use planning process such as sustainable urban mobility plans (SUMPs). The integration between neighbouring urban centres to enable more efficient freight delivery, will be coordinated with SUMPs, as well as with the creation of urban logistics and distribution centres. In this framework, public consultation and stakeholder involvement will both be necessary to ensure the maximum efficiency of urban logistics strategies. These will cover issues including parking for loading and unloading in the urban environment, the use of dedicated infrastructure, and improved access to facilities, buildings and other developments for freight delivery. They will be supported by ITS which will also allow the integration of ‘e-freight’ into the urban logistics management systems. ITS will allow route guidance systems, an analysis of city logistics to, e.g. reduce the time spent by each vehicle delivering goods in the urban environment, and the efficient occupation of dedicated delivery areas for different times of the day.

Interactions between vehicles and their environment via an ‘intermodal information platform’ will enable travellers to access real-time, up-to-date information on collective transport services. Furthermore, such a system will be able to optimise a traveller’s journey from door to door. For example, the system will already be aware of the traveller’s location and when the next bus is due to arrive. All the system will need are the details of the traveller’s destination, and the information platform will then mediate between travellers and vehicles already *en route* to determine the available options. These may include several possibilities: simply waiting for the next bus, the bus taking the traveller to the bus stop nearest to his final destination, or other travel options including details of any connections along the way.

A European observatory on urban mobility will be established to monitor urban mobility and collect the data needed to guide the development of urban mobility systems into the future.

Enthusiastic Alternative	Pessimistic Alternative
<p>User needs and behaviour</p> <ul style="list-style-type: none"> Major retailers and freight operators will have a dominant position in the city markets, allowing them to optimise their delivery systems. The urban population, supported by comprehensive and reliable information services, will be well aware of the environmental impacts related to their mobility behaviour; moreover, it will become socially unacceptable not to take such impacts into account. In the more densely populated urban areas, where space and environment dictate the need for restrictions on mobility, a stringent system of permits and credits will be implemented to limit 	<p>User needs and behaviour</p> <ul style="list-style-type: none"> As the dominant players in the marketplace refuse to establish common strategies, the urban consumer will be confronted with fragmented services, hampering the development of an efficient and multimodal personal transport system. In addition, the increasing use of e-shopping and e-services will lead to a rapid growth in urban freight delivery. No reliable information will be available on the duration, cost and environmental impact of different modal choices, hence only a minority in the urban population will reach the high level of awareness required to adapt their mobility behaviours in an environmentally conscious

¹⁴ GHG Routes to 2050

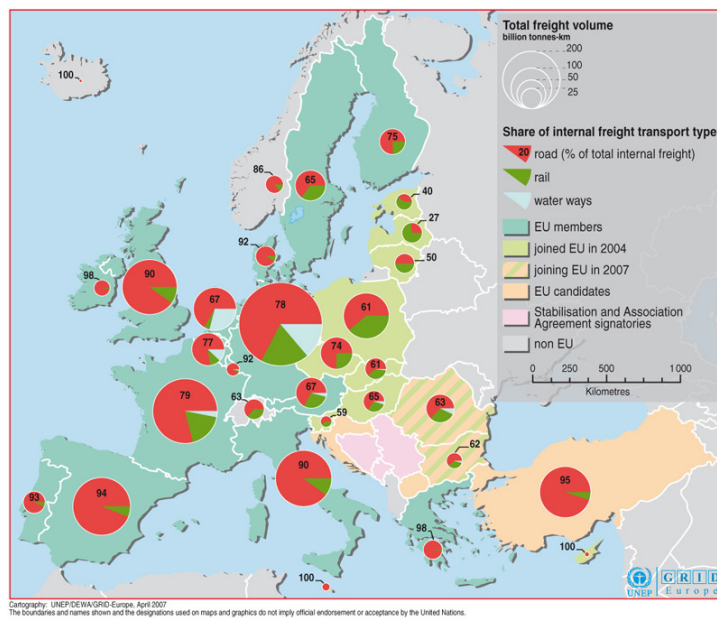
<p>the carbon footprint of the individual traveller; such a system will be facilitated by the use of advanced ICT applications.</p>	<p>manner.</p>
<p>Urban structure</p> <ul style="list-style-type: none"> • Efficient land-use policies, coupled with tax incentives driven by mobility objectives, will lead to the emergence of dense polycentric cities. This will serve to slow down the increase in demand for travel, and will contribute to a decoupling of economic growth from the growth in mobility demand. • The high urban density will support an adequate level of high quality, financially sustainable public transport services. 	<p>Urban structure</p> <ul style="list-style-type: none"> • Urban sprawl will not be mitigated and cities will continue to expand geographically. This will result in an overall higher energy consumption in urban areas. There will be greater localisation of specific commercial activities in different urban areas. These trends will result in an unsustainable growth in travel demand, and even stronger pressure on public transport systems.
<p>Urban mobility services and vehicles</p> <ul style="list-style-type: none"> • The market for electric vehicles will grow rapidly due to focused policies on energy and environment. By 2030, about 50 per cent of new cars will be based on hybrid-electric or fully electric technology. • In urban areas, all vehicles will be permanently ‘connected’ to their driver, to each other and to their physical environment (roads, buildings), as well as to different commercial and public services. This will provide real-time support for travel considerations, e.g. the locations of the cheapest vehicle charging points. • Automated vehicles will lead to the emergence of a range of new services. Private vehicles will remain the dominant model but their ownership will become increasingly collective. Traditional public transport will benefit from this evolution and will become strong across Europe. • A majority of personal journeys less than 5km will be made by walking or cycling, due to the implementation of safe and efficient walking and cycling facilities in cities. 	<p>Urban mobility services and vehicles</p> <ul style="list-style-type: none"> • Electric vehicles will prove to be technically unreliable, and market take-up will be slow. Furthermore, the energy infrastructure required to support an electric vehicle fleet will fail to be developed on a sufficient scale. As a consequence, the traditional private car will remain the preferred mode of travel, and demand for such vehicles will increase. • However, the increasingly high relative cost of using traditional, personal vehicles will mean that a decreasing proportion of the population will actually be able to afford to own and use them. • Legal and liability issues will prevent the deployment of automated and guided systems.
<p>Urban mobility systems</p> <ul style="list-style-type: none"> • The ‘personal mobility planner’ will be universally accepted and used by all, giving full TTI to go from Edinburgh city centre to Novosibirsk. Travellers will be offered a broad range of mobility options corresponding with their choice of speed, price, emissions, etc. They will be offered full multimodal mobility packages from which they can choose the options best suited to their needs and spending priorities.¹⁵ • Distribution centres for urban goods delivery will become highly efficient businesses, enabling 	<p>Urban mobility systems</p> <ul style="list-style-type: none"> • Multimodal comprehensive information will be offered, but only in return for payment of high fees. Users of such premium services will receive a guarantee of their travel time and will have preferential access to segregated/dedicated lanes; however, the rest of the population will suffer from increased congestion. Liability and privacy issues will block the development of individualised and delocalized information services. • Transport operators, retailers and public

¹⁵ Transport 2050: A new Mobility Paradigm

<p>goods to be re-dispatched in fuel efficient and zero-emission vehicles for urban distribution, using optimal route choices and load factors. ICT will enable the supply of real-time information to retailers about goods delivery schedules, and to operators about changes in network regulation and access rules.</p> <ul style="list-style-type: none"> • Urban logistics systems will enable the efficient management of the movement of goods. • Sufficient public spending is available for the development and maintenance of the urban transport network as well as the provision of highly attractive public transport services. 	<p>authorities will fail to cooperate, and no viable economic models will be established for optimised urban goods delivery systems.</p>
---	--

4.3 Long-distance Freight Transport

The freight transport system is the backbone of the European economy. For this reason, this section is concerned with the share of freight transport that is transported over the road network, and which accounts for the biggest fraction of total freight transported by road, rail and waterways combined. There is no precise boundary beyond which freight transport is deemed to become ‘long-distance’. In Europe, however, where the transport network is relatively dense compared to comparable markets elsewhere in the world, one can realistically define long-distance freight transport as that share of freight transport that does not occur in urban areas.



Source:

The future of Long-distance Freight Transport is strongly influenced by trends in economic development, the cost of energy, technology development, the integration of the transport system and infrastructure capacity, costs and investment.

Economic development

Economic development has a strong impact on freight growth and logistics efficiency for long-distance freight transport. When considering freight growth, the trend towards the decentralisation of energy production, the volume of intercontinental land transport and the level of infrastructural capacity are all important factors.

- Decentralisation of energy production would reduce the level of international shipping—a large proportion of which involves the transportation of fossil fuels over considerable distances from the place of production to the consumer. The growth in local alternative energies will occur over this timeframe but will be modest considering overall energy demand.
- As international trade increases, it is likely that there will be an increase in intercontinental (i.e. Asia-Europe) land transport. Air transport is fast but expensive, and is thus used for high-value and/or perishable goods. Transport by sea is less expensive but relatively slow, and is therefore more often used for low-value goods. The cost and speed of transport by land (i.e. road or rail) has the potential to fall between the two but would require significant (expensive) improvements in infrastructure and removal of regulatory or institutional barriers that prevent the development of efficient transport services.
- Freight growth will need to be accommodated in today's infrastructure. The challenge will be to accommodate the fast growing requirement for more freight capacity through long-term, policy driven programmes of infrastructure development. The existing transport infrastructure has considerable bottlenecks, especially with regard to the separation of transport by function, etc., e.g. using dedicated lanes for freight transport or longer and heavier vehicles (LHVs).
- ICT will create opportunities for optimising transport processes, as will the level of cooperation between producers/manufacturers and transporters. Consumer trends and behaviour will also be influential.
- Planning for long-distance transport aims at optimising the circulation of vehicles, load units and drivers in response to the shippers' demand for transport. Overall efficiency usually relates to the load factor or to payload capacity utilisation (traditionally weight-based but for light cargos can also relate to the proportion of available volume or deck area that is used). However, this needs to be brought into context with other decisive performance indicators such as on-time delivery (reliability, punctuality), transit time (speed from origin to destination), and costs and environmental impact (fuel efficiency, GHG, local emissions).
- Logistics efficiency can be improved by developing and enhancing cooperation between the different organisations involved in the transportation of goods. Important factors are efficient freight management regimes, a standardised interface between fleet and transport operator, real-time track-and-trace systems, and systems to support route replanning.
- Consolidation of cargos by means of longer lead times, cooperation between different shippers, or cooperation between different operators will all contribute to improving logistics efficiency. However, a variety of other factors will impact logistics efficiency, including: diverse levels of product demand at different destinations en route (i.e. leading to unused payload or cargo capacity), infrastructure limitations (e.g. roadside truck parking); regulatory constraints (e.g. the Working Time Directive, national/regional curfew hours or differing limits on vehicle size/weight); as well as technical constraints such as the compatibility of different types of load units across different transport modes.
- ICT is the most important enabler for many of the systems that will contribute to more logistics efficiency. It will enable increasingly sophisticated applications to plan, execute and control logistics operations. However, the handling and processing of information will continue to be an important legal and organisational issue. Information must be stored and disclosed in a safe, secure and appropriate manner, and in accordance with legal requirements, so that there is confidence in systems which rely on information exchange.
- Low-technology enablers, e.g. cooperation and networking between small companies, and the sharing of information, will also be important factors in the development of logistics structure and efficiency. Instead of competing with each other, businesses will increase their commercial strength by establishing mutually-beneficial relationships with other businesses and with existing and/or potential customers through a networking process. There will be a variety of different types of networks, and each will be shaped by its objectives and participants. By participating in networks in which they share knowledge and resources (e.g. through the exchange of business information, ideas and support, as well as cooperation on logistical arrangements and capacity), the businesses involved may achieve outcomes beyond their individual capabilities.

- The current trend is that transport and logistics solutions are organised according to the urgency with which a consignment needs to be delivered, i.e. high urgency or 'must go' consignments (e.g. flowers) and lower urgency or 'can go' consignments (e.g. building and construction materials, such as sand). In the case of 'must go' consignments, time is critical and such products are often dispatched directly from the production or manufacturing process chains in order to achieve 'just in time' (JIT) or even 'on demand' delivery. These consignments are usually smaller, higher-value goods, and have their origin and destination within the same region. In contrast, the 'can go' consignments are typically more bulky commodities of lower value, and for which transport costs are key to making an acceptable profit. The preferred modes are therefore bulk carriers. Also, as time is not critical, these goods can be organised into considerably large consignments before dispatch, thus maximising cargo capacity.
- Another clear trend is that freight transport facilities are increasingly placed on the 'open market', with transport capacity being offered on demand. Relationships between the party commissioning the transport and that providing the transport are becoming more ad hoc. Such increased flexibility provides the benefit of reduced 'empty running'. There are, however, certain legal aspects to this trend. For example, the monitoring of high risk goods will have to be guaranteed, and some national legislation now prohibits certain transport from stopping overnight in some Member States (e.g. Polish drivers are not allowed to stop over in Germany).
- In addition to trends involving business-to-business transportation, the changing patterns of consumer expectations and behaviour are also relevant to the development of logistical efficiency. The growing trend in e-commerce and in working from home will have an impact, as the delivery of goods to the door increases while travel for shopping or commuting decreases. But apart from influencing the structural arrangements of the freight transport sector, this trend will also provide some relief to congestion as a direct result of the decrease in personal transport volume.

Cost of energy

Long-distance freight transport is a major contributor to the total road transport energy demand. The trend is that this share will increase as personal transport becomes more efficient. Both the cost and the availability of energy can influence the distances over which goods or people are moved, the choice of mode, the shipping cost and hence the price of goods in the shops, the cost of holidays and business travel, and the profitability of the transport companies themselves.

- Concerns over energy security and the greater use of renewables are likely to lead to the gradual decentralisation of energy production. This could substantially reduce the volume of goods imported by sea, of which 50 per cent currently relates to the shipping of fossil fuels.
- The fuel market is a global market. The fast development of the BRIC economies and the increasingly stringent policies on emissions from short distance sea shipping will lead to a rapid growth in demand for liquid distillates. Access to the desired fuel pool will depend primarily on the ability to pay the market price, as dictated by demand and supply. There are uncertainties about the supply side, i.e. the extent to which the production and refining capacity of crude oil and natural gas as well as renewable fuels can cope with such growth and the resulting shift in demand. Competition for distillate fuels will lead to increased costs.
- In long-distance freight transport, the internal combustion engine (ICE) has been, and will remain, the dominant power platform, having already reached a high level of sophistication. There will be only limited flexibility to adjust to shifts and structural changes in the fuel market.

Technology development

The development of alternative (low emission) propulsion/drive train systems, together with the development of new vehicle concepts, the application of ICT and goods/materials handling technology, will be key factors in improving the efficiency of the long-distance freight transport sector.

- New and innovative alternative (low emission) propulsion and drive train systems will emerge in response to climate change driven demand for low emission vehicles for freight transport.

- Powertrains for heavy-duty and long-haul trucks are expected to be based primarily on internal combustion engines (ICEs) for the foreseeable future because of the limited storage/range and long charging times of electric alternatives. However, a degree of hybridisation is expected in long-distance transport. Heavy-duty trucks are often specified with very powerful engines to cope with the most severe requirements they will face (e.g. a steep climb at full load) but most of the time they run in conditions where the engine load and efficiency is considerably less (e.g. a flat road and a lighter load). The expected mild hybridisation is expected to generate modest improvements in fuel efficiency by optimising the ICE for more typical use, thus downsizing the engine, using an electric motor to assist the ICE at times of peak demand and recovering the energy necessary for this assistance from regenerative braking and waste heat recovery systems, etc. However, with smaller capacity engines, oil stress will increase considerably, requiring a new generation of lubricants.
- As with electrification, a focus area for hybrid driveline development will be the efficiency of the energy storage systems. Battery cost and weight will probably be a limiting factor for the foreseeable future. Upcoming research should include advanced start/stop capabilities and energy recovery systems including brakes, suspension and waste heat. Smart energy management and advanced systems for hotel mode¹⁶ will also be also crucial topics.
- The use of hydrogen fuel cells in heavy-duty vehicles is possible, subject to comprehensive well-to-wheel comparisons with current and future state-of-the-art propulsion systems. Fuel cells offer a potentially significant improvement with respect to GHG and regulated emissions, but only if the hydrogen is readily available and obtained from renewable sources. The energy capacity and cost of fuel-cell systems for powering vehicles and the supporting infrastructure means that fuel-cell powered trucks are unlikely to see widespread use by 2030. Fuel cells for auxiliary power generation are more likely and will be used for supplying power while the main engine is not running.
- Additional fuel efficiency could be achieved when waste heat recovery systems are integrated with small auxiliary power units (APUs) that provide a secondary (backup) source of electric power, e.g. for emergency and safety systems, auxiliary systems during hotel mode, and to reduce idling of the main engine.
- The development of future heavy-duty powertrain platforms will depend to some extent on the development of vehicle and transport concepts in general. Vehicle sizes and weights, as well as advances in vehicle aerodynamics and improved truck-trailer dynamics, will affect the torque and power needed from the powertrain.
- The use of biofuels in diesel fuel, and the impact of fuel quality on combustion and aftertreatment systems, is an important factor for future powertrain development and on-road use. Continued standardisation of fuel requirements across all EU countries will be important to ensure reliable engine performance and trouble-free operation.
- The trend in powertrain development will be towards an integrated unit using an advanced control system for optimised operation and fuel efficiency. The powertrain will comprise an engine of optimal size, using low friction technology together with an advanced fuel-efficient combustion process and an efficient aftertreatment system securing low emissions. Energy from the exhaust will be recovered by an integrated waste heat recovery system. The powertrain will be tolerant to alternative fuels and multi-fuel blends, and will use fuel-efficient, multi-fuel compatible lubricants.
- Electric heavy-duty trucks will be possible without having capabilities on-board for electrical storage. Instead, these vehicles will draw electric power from a trolley line, from tracks in the road, or from a similar arrangement. Such vehicles could rely solely on an electric motor, although it would need to be relatively big and powerful. However, such solutions would require a high degree of standardisation throughout Member States, together with high levels of investment.
- Well-functioning and efficient maintenance and service networks and a high level of standardisation will also be important.

¹⁶ When a truck is parked during transport, it is considered to be in 'hotel mode'. Although the truck is not driving the auxiliary systems continue service e.g. to provide cooling to the pay load. In the current situation the power supply to the auxiliary systems is provided by the drive train's engine. When parked the engines basically runs idle and provides low efficiency. Using another, more efficient power supply to the auxiliary system e.g. by using a fuel cell or battery increases fuel efficiency and saves on GHG emissions..

New vehicle concepts

The introduction of new vehicle concepts such as higher-capacity vehicles, new shapes or designs, or multi-modal vehicles will have an influence on co-modality (the use of different modes, on their own and in combination), intermodality (the use of two or more different modes in an integrated manner), logistics efficiency, vehicle efficiency and energy demand, etc.

- Modularisation (when optimised and standardised) will bring efficiency and flexibility to freight transport; all freight transport modes can then share the same interfaces and will be able to use common freight modules (goods containers). Depending on the application, it will also be possible for small freight modules that will typically be used for urban transport to be combined into bigger ones for long-distance transport and vice-versa.
- Widespread implementation of new standards on weights and dimensions will have the potential to increase freight capacity substantially, as they will allow for longer and heavier vehicles (LHV) with much greater carrying capacity. Suitable changes can also allow a greater scope for vehicle design, leading to significantly improved aerodynamics, fuel consumption, safety performance and driver comfort. The combined effect of these new standards could reduce commercial vehicle kilometres travelled across Europe by between 8 and 10 per cent, and freight CO₂ emissions by approximately 5 per cent. Such features will become standard for almost all long-distance freight transport. However, in order to achieve full potential, standards will have to be accepted equally by most, if not all, Member States, and the public will need to be convinced that LHV is a viable (safe) and efficient option for freight transport. Moreover, the full deployment of long-distance freight transport by LHV will depend on a dynamic implementation in existing road network infrastructure.
- Dual-mode vehicles¹⁷, will improve the efficiency of onward distribution in urban areas, and of co-modal operation.
- The use of light-weight materials in vehicle manufacture, and aerodynamically optimised designs for durability and reduced drag, will further contribute to increasing fuel efficiency in the sector.
- In addition, applying the 'green corridor' concept for highly-populated highways in Europe could potentially reduce CO₂ emissions in the corridors by 25 per cent depending on increased demand, congestion, and the fuel efficiency of new vehicle concepts.

Information and communication technology

The development of technology and support systems (e.g. telematics) to improve the routing, scheduling and monitoring of vehicles and loads via ICT could strongly influence transport and logistics efficiency. There is a growing need for such systems, although the magnitude of the benefits they will provide are likely to be influenced by the transport infrastructure. The overall impacts of ICT on transport are usually categorised by means of two possible contrasting effects: the stimulation of more travel, as new opportunities become available; and the substitution for travel, as it becomes increasingly possible to carry out activities remotely.

- The impact of ICT will be greatest in the area of freight distribution and logistics. Increased use of ICT could substantially reduce costs/delays at border crossings. The structure of the supply chain will change, as the location and size of production, processing and warehousing sites adapt to the new technology. This will affect the spatial concentration of production and inventory activities, the development of new bulk and transshipment systems, and hub-satellite networks.
- Advances in ICT and extensive application of the Galileo programme (the joint EU/ESA global navigation satellite system, or GNSS, scheduled to become operational by 2013) would lead to further optimisation along the logistics chain and possibly to a more 'de-materialised' economy where the need for physical movement of people and goods is reduced by the expansion of e-commerce and tele-working. However, this trend could be counter-balanced by changes in consumer behaviour (i.e. new lifestyle and work style

¹⁷ A *dual-mode vehicle* is a vehicle that can run on either a track or roadways. These include both small individual vehicles as well as larger trolleys.

choices) as well as by more frequent deliveries (e-commerce), smaller loads, faster delivery and the greater use of air transport.

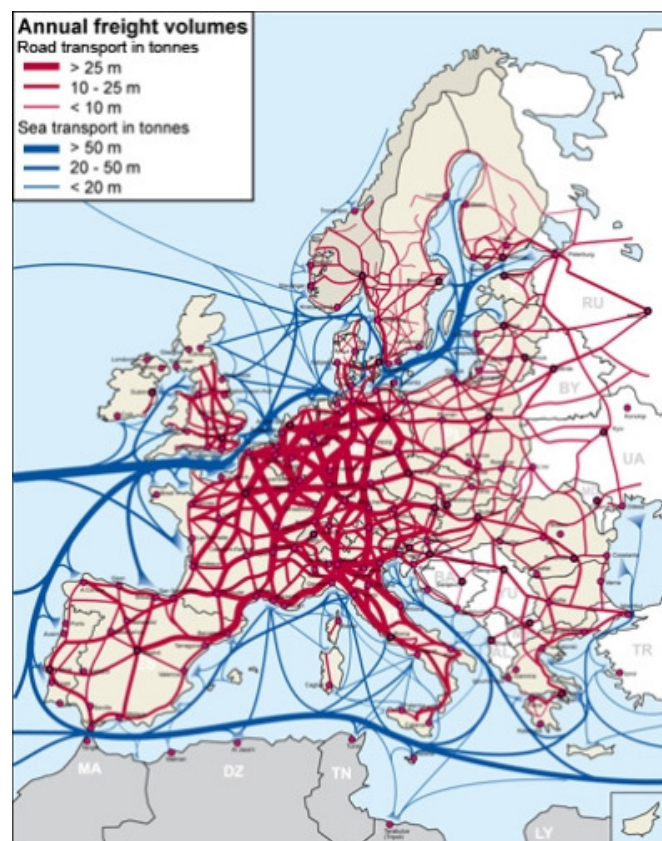
- Innovative, ICT-based solutions for improving the energy efficiency of road transport will be readily incorporated as standard, especially in commercial freight and passenger transport. The cost of such systems will be relatively small compared to the cost of the vehicle, and will not only be a cost that can be recovered by the transport company out of operating revenue but will also generate savings through improved efficiency. For example, driver support systems which provide reliable traffic information as well as vehicle positioning data will enable the driver to operate the vehicle in the most energy-efficient way, i.e. by avoiding heavy traffic, congestion and consequent 'stop-start' driving and also by coaching the driver to operate the vehicle in the most energy efficient way, thus contributing to reduced fuel consumption. With the far-reaching application of ICT, companies will actively construct business models that focus on cost saving and the reduction of GHG emissions.
- The ability to move goods quickly from vehicle to warehouse, and between transport modes, will have an influence on co-modality and logistics efficiency; this will be influenced by the development of new materials handling technology.

Integration of the transport system

- The greater the level of integration of all elements in the transport system, the greater will be the benefit from systems optimisation. However, the need to strike a balance between efficiency and flexibility will be a limiting factor in this regard.

Infrastructure capacity, costs and investment

- Europe has a relatively dense freight transport network compared to many other regions in the world (see figure). Distances over land are relatively short, and the average freight distance is less than 100 km. In addition, the road network is well connected to a wide range of harbours and sea ports.



Source:

Many sections of the European road infrastructure have become increasingly congested in recent decades, i.e. the physical capacity of the road system restricts the free flow of traffic at times of peak demand. The result is congestion, or near congestion, with traffic flows becoming increasingly susceptible to disturbances such as weather conditions, accidents, and maintenance and service requirements. The further growth in freight transport volumes will place additional strain on these sections and will increase the potential for congestion. Current planning faces financial, environmental and spatial constraints, and public participation has intensified. Hence, planning and construction procedures frequently last for many years, often more than a decade.

There is, therefore, a strong need to increase the network capacity. Current trends suggest that this is more likely to be achieved by careful investment in the physical infrastructure to ease key bottlenecks, and smarter systems to enable better use of the existing network. These smarter systems could include those aimed at smoothing demand over time (e.g. night-time deliveries), increasing capacity (e.g. hard shoulder running, platooning, separating freight and passenger traffic), improved infrastructure design (e.g. revolutionary new road surface materials that reduce rolling resistance and increase safety and durability), reducing the need for maintenance (e.g. less aggressive vehicles, automated weight enforcement) and improved maintenance techniques that reduce the impact on traffic.

Common-sense scenario for Long-distance Freight Transport

- Road (and rail) transport between Europe and Asia will increase considerably as a consequence of the shift in Europe's global trading partners towards those in much closer 'low wage' regions, and of significant improvements in the available infrastructure. However, this represents strong growth from a very low starting point, such that ocean freight shipping will continue to dominate European-Asian freight transport. Policy measures on the internalisation of external costs will have an impact on freight transport considerations, such as the distances over which goods are moved as well as on the current just-in-time principles and modal choice.
- European road infrastructure capacity will be stretched to its absolute limit. While rail and waterway systems will have grown substantially and increased their market share, rail infrastructure constraints and the economics of short-haul freight movements will mean that road remains the dominant freight mode.
- Short-term relief to the growing transport demand will be provided by full-scale and comprehensive traffic management of the congested corridors interconnecting the economic/metropolitan regions as well as those connecting these regions to the important intracontinental corridors.
- The majority of EU Member States will voluntarily adopt new policies and standards on weight, dimensions and ICT that will allow for the development of new vehicle designs with significantly improved aerodynamics, fuel consumption, safety performance and driver comfort—features that will be employed in almost all long-distance freight transportation by 2030.
- Longer and heavier vehicles (LHVs) with significantly higher load capacities will be widely used along with measures to mitigate or prevent any consequential mode shift. These developments will be accepted by the public as viable solutions to congestion and environmental constraints, especially in North Western Europe. Additional long-term relief will be provided by sufficient 'debottlenecking' of the congested sections of the road infrastructure (e.g. short cuts, bridges and viaducts, the use of ICT). It is likely that legislation will be introduced to streamline the procedures for civil participation and ensure that such projects are completed in the least possible time.
- Additional measures, including new pan-European transport strategies will need to be introduced in the decades following 2030, to minimise the risk of a breakdown in the transport system.
- The 'green corridor' concept will have been introduced and will be used for highly populated highways throughout Europe. The criteria for access to these corridors will be related to new vehicle concepts and transport efficiency. In these corridors, longer and heavier vehicles will be the majority, and 'platooning' (electronic coupling of trucks) will be widely used. The concept will include infrastructure dedicated to freight transport but the cost of this will be minimised by ensuring that new roads/tunnels etc. are constructed for light vehicles only and the old facilities will be dedicated to heavy vehicles.
- By 2030, tri-modal land hubs will provide fast transshipment of people and goods between rail, inland waterways and road services. These hubs will attract other commercial activities such as shopping, finance

and office facilities. Conventional inland terminals, as exist today, will still be operating, serving regional traffic and local distribution.

- The fuel pool for long-distance freight transport will consist predominantly of fossil distillates, while the share of renewables and synthetics in the fuel pool will be small compared with the situation in urban freight transport.
- The typical powertrain system will be an integrated unit, tolerant to alternative fuels and multi-fuel blends, and will use advanced control systems for optimised operation and fuel efficiency, such as integrated waste heat recovery systems combined with efficient exhaust aftertreatment systems securing low emissions.
- Auxiliary systems will typically be powered by low-carbon technologies such as fuel cells and energy recovery systems.

Economic development

Due to the development of the domestic economies of the current 'low wage' regions, Europe's global trading partners will have shifted considerably from the Asian Pacific rim to much closer 'low wage' regions such as North-Africa and Ukraine/Central-Asia. This will apply particularly to suppliers of lower-value manufactured commodities.

As a consequence, the global/intercontinental corridors to and from Europe will shift. Road transport between Europe and Asia, will increase considerably but will be limited by the lagging development of the road infrastructure. Ocean freight shipping will still dominate European-Asian freight transport.

Different gateways to, and from, southeast Asia (ASEAN) will develop, concentrated in the eastern European Member States and connecting to the corridors to Asia. This trend in the increasing use of geographically closer trading partners will be further enhanced by rising transport fuel costs and political measures aimed at mitigating climate change and societal costs, as well as the general consideration on outsourcing production to regions outside the European domain.

Cost of energy

By 2030, policy measures on the internalisation of external cost will have an impact on freight transport considerations. This will impact the distances over which goods are moved as well as on the current just-in-time principles and modal choice.

By 2030, energy consumed by trucks will represent 45 per cent of energy consumed in transport as a whole. The fuel pool for freight transport will consist predominantly of fossil distillates because electrification of the powertrain will be confronted by unrealistic costs and standardisation issues, e.g. power storage and recharging requirements. Auxiliary systems, however, will have been fully electrified and/or powered by fuel cells. The share of renewables and synthetics in the fuel pool will be small compared with the situation in urban delivery trucks where (fossil) distillates have a minority share. Due to regulations and legislation on climate change and local air pollution (SO_x, NO_x, metals), there will be increased competition for distillate fuels between road transport, shipping and aviation. NO_x emissions will no longer be a problem by 2030 but noise abatement will continue to be a policy focus.

By 2030, a first significant step will be made in decentralising energy production because of the greater use of renewables and concerns over energy security.

Technology development

By 2030, the modularity concept will have been implemented, possibly worldwide, but at least in Europe; all freight transport modes will share the same interfaces and will be able to use the same freight modules (goods containers). New standards for the weights and dimensions of trucks and buses will have been agreed on a voluntary basis at a European level, and will lead to substantial increases in capacity. Vehicles will be flexible, and both trucks and load carriers will be optimised for the specific transport flows, e.g. dense loads carried over short distances, and lightweight loads carried over long distances, will each be carried by different vehicles optimised for those characteristics. The important interconnection between long-distance and urban

transport will be handled by terminals and vehicle concepts that efficiently accommodate the interface between long-distance transport (longer vehicles) and urban transport (smaller trucks). Optimisation of freight modules will enable smaller units, which would essentially be used for urban transport, to be combined into bigger ones for long-distance transport and vice-versa. Vehicles in 2030 will be made of light-weight material and will feature aerodynamically optimised designs for durability and reduced drag. The freight modules themselves will also be self-powered to a limited degree, i.e. so that they can be uncoupled from the truck and moved around under their own power.

By 2030, freight capacity will have increased substantially as new standards for the weights and dimensions of trucks and buses will have been agreed by the majority of EU Member States. Standards will allow for longer and heavier vehicles with substantially increased carrying capacity. However, they will not be implemented equally in every Member State because some States will still retain the standard 40/44 tonne articulated vehicles, or will have allowed only modest increases in weight and dimension due to potential impacts on the infrastructure. Greatly improved safety and environmental performance, as well as the implementation of mechanisms to ensure no adverse mode shift effects, will mean that LHV's will be accepted by the public as a viable and efficient option for freight transport, particularly in North-Western Europe.

At the same time as allowing for increased load carrying capacity, changes to weights and dimensions policy will also provide for greater scope in vehicle design, leading to significantly improved aerodynamics, fuel consumption, safety performance and driver comfort. Such features will become standard for almost all long-distance freight transport.

The combined effect of these changes in weights and dimensions policy will be a relative reduction across Europe of between 8 and 10 per cent in commercial vehicle kilometres travelled, and a relative reduction of approximately 5 per cent in freight CO₂ emissions.

By 2030, the proportion of dual-mode vehicles, aimed at improving the efficiency of onward distribution in urban areas, and of co-modal operation, will have increased substantially but will still represent a small proportion of the overall fleet and will be used in specific niche applications.

By 2030, the 'green corridor' concept will be introduced and used for highly-populated highways in Europe. The criteria for access to these corridors will be related to new vehicle concepts and transport efficiency. In these corridors, longer and heavier vehicles are in the majority, and 'platooning' (electronic coupling of trucks) will be widely used. Emissions will fall, but levels will depend on the increased throughput/ lack of congestion and the fuel efficiency of vehicle concepts. On average, the CO₂ emissions will be 25 per cent lower in a corridor, compared to the overall average vehicle emissions.

By 2030, the typical powertrain system will be an integrated unit using an advanced control system for optimised operation and fuel efficiency. It will comprise an engine of optimal size, using low friction technology together with an advanced fuel-efficient combustion process and an efficient aftertreatment system securing low emissions. Energy from the exhaust will be recovered by an integrated waste heat recovery system. The powertrain will be tolerant to alternative fuels and multi-fuel blends, and will use fuel efficient, multi-fuel compatible lubricants

Integration of the transport system

By 2030, vehicles will be fully integrated into the transport system: vehicles will be smart enough to 'sense' their surroundings and navigate through traffic safely and efficiently, while providing their occupants personalized comfort and convenience. In effect, there will be a seamless transition from life outside the vehicle to life within the vehicle, and vice-versa. The vehicle will be a 'node on the internet', and will be 'on-line' with other vehicles (v2v), with the transport infrastructure (v2i), and with homes, businesses and other sources (v2x). When on-line, the vehicle will assist the driver by offering automated responses to developing traffic situations, leading to increased safety and enhanced quality of service.

In 2030, tri-modal land hubs will provide fast transshipment of people and goods between rail, inland waterways and road services. Conventional inland terminals, as exist today, will still be operating, serving

regional traffic and local distribution. At these sites, fast but cost-effective 'horizontal' transshipment will take place, including the loading and discharge of trains and barges for inland waterways. Small lifting equipment will be used for loading trucks, when needed for short hauls. Dual-container loading facilities will be provided, both 'horizontal', i.e. making use of automatic shuttles rolling on and off the vessels; and 'vertical', using batteries of container cranes in parallel loading several containers at the same time. A standard loading unit (worldwide) will have been agreed and will be used globally, as well as RFID technology (an ICT protocol for the remote tracking and tracing of freight consignments).

A network of intermodal transfer points of various sizes and degrees of reach will facilitate the seamless transfer of cargo between the backbone of interconnecting highways and the regional networks. Automatic locking on container castings and tray castings, in combination with the automatic positioning of the train at the loading floor, will be standard as will enhanced communication technology to enable cargo and pallets to remotely communicate their status, and smart dust providing physical security for loading units. For delivery trucks, this will also enhance road security for cargo and drivers. Transport of goods for delivery to local shops or customers will become autonomous, operating in populated areas by 2012 and becoming commonplace in the urban centre.

Infrastructure capacity, costs and investment

By 2030, European road infrastructure capacity will be stretched to its absolute limit. The volume of road freight transport will be 50 per cent higher than it is today, and passenger transport will have increased by 40 per cent. Yet, no significant expansion of road infrastructure land use will have taken place; this applies especially to the densely populated regions of Europe. This will have been achieved through much more efficient use of the existing network as well as careful investment in the mitigation of key bottlenecks. Traffic management and maintenance/service regimes will be omnipresent in order to optimise usage and to minimise down time due to such instabilities, especially on the congested corridors and economic regions. Up-time and the availability of well-functioning/efficient maintenance and service networks will be the main concerns of both the public and the transport sector. Despite all of this, the road system will remain sensitive to congestion, maintenance/service stops, traffic incidents and extreme weather conditions.

The volume of freight carried by rail and waterway systems will grow considerably and the market share of these modes will increase. However, the total volume of freight transport will also have grown by about 50 per cent compared with today. For this reason, the road transport system will still need to support much of the increased demand, while serving as a back-up option for waterborne transport (e.g. containers) when extreme weather conditions impact the waterways. In regions with good access to harbours, short-haul shipping by sea will provide a significant alternative to road transport. This will not require expensive infrastructure investment and will therefore become an increasingly competitive alternative to road transport over short distances.

To address the challenges presented by the constraints in developing road infrastructure capacity, especially in congested areas, logistics will evolve into a highly advanced, comprehensive and integrated regime that will be both efficient and flexible in providing solutions to such constraints, and also in coping with environmental policies/legislation (e.g. the internalisation of external costs), while still being able to accommodate customers' changing needs.

In the short term, comprehensive approaches to traffic management will provide relief to the congested corridors interconnecting the economic/metropolitan regions, as well as connecting them to the important intracontinental corridors. However, in the longer term, matching infrastructural road capacity with the increasing transport volume will be achieved by effective 'debottlenecking' of congested sections of the road infrastructure (e.g. through the introduction of short cuts, bridges and viaducts, and the use of ICT). Legislation is likely to be introduced specifically to shorten the procedures for civil participation in the development of such projects which, facilitated by pan-European coordination and logistical planning, will lead to greater efficiency and flexibility of the transport system as a whole. The system will be further enhanced by efficient information usage and driver support systems (vehicles will be fully 'connected' and able to communicate with each other as well with the road operator, transport planner, etc.) and by the development of strategically located, advanced hubs for both intermodal transfer and the transfer between urban and non-urban freight

transport.

In the decades following 2030, additional measures will need to be introduced to minimise the risk of a breakdown in the transport system. These will include new pan-European transport strategies involving technical and physical measures as well as regulatory and legislative measures, designed to ensure that the transport system remains sustainable towards 2050.

By 2030, the ‘green corridor’ concept will have been introduced and will be used for highly populated highways throughout Europe. The criteria for access to these corridors will be related to new vehicle concepts and transport efficiency. In these corridors, longer and heavier vehicles will be the majority, and ‘platooning’ (electronic coupling of trucks) will be widely used.

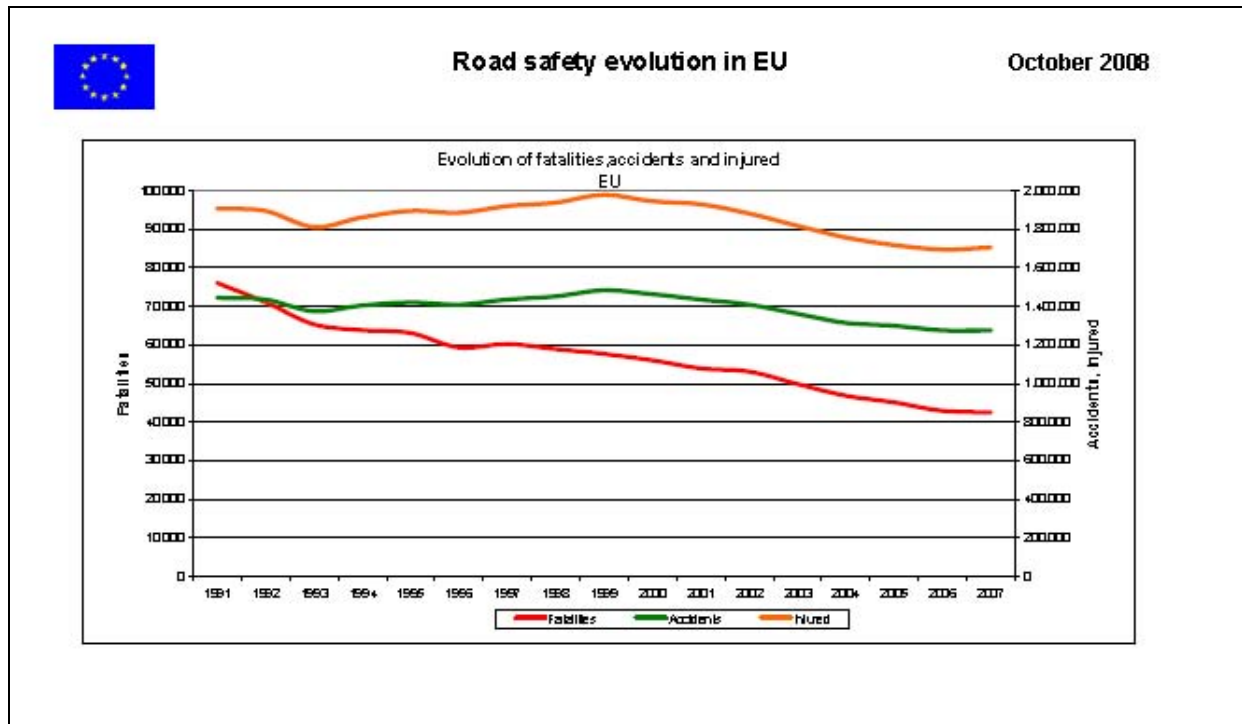
Enthusiastic Alternative	Pessimistic Alternative
<p>Economic growth</p> <p>With significant higher and stable economic growth, the increase in freight transport volume will almost double compared with current volume, and transport will be able to accommodate this increase in a fully sustainable manner.</p>	<p>Economic growth</p> <p>The long-distance freight transport volume throughout Europe will increase by little or none at all. However, there will be large differences between European regions, with the EU-15 showing the highest growth rate.</p>
<p>Technology development</p> <p>A major breakthrough in energy storage and charging will occur, with the development of new, powerful, lightweight systems that will make long-distance journeys both feasible and economical in heavy vehicles with pure electric drive systems.</p> <p>New standards on dimensions, weight and ICT will be fully implemented throughout Europe; there will be few, or no, alternative standards.</p> <p>Electrification of trucks will be introduced for freight transport in corridors throughout North-Western Europe. Solutions will comprise of external power sources (trolley systems or electric roads) and will offer distinctive cost advantages over other modalities such as the use of rail-tracks for freight transport through the Alps.</p> <p>Hybrid vehicles using fuel cells for auxiliary load powering will provide a significant, but still minor, share in the long-distance freight transport fleet. Fully fuel-cell driven trucks will have been introduced but will serve only niche markets.</p>	<p>Technology development</p> <p>Road freight continues to rely solely on fossil fuels.</p> <p>The adoption of hybrid technology will be slow or will prove to have low cost-effectiveness. Electrification of roads will not be possible due to lack of investment.</p>
<p>New vehicle concepts</p> <p>Standard freight modules (goods containers) that can be combined to increase capacity will be used consistently throughout Europe with minimal constraints imposed by infrastructure or policies.</p>	<p>New vehicle concepts</p> <p>No agreement will be reached on new standards for weight, dimensions and ICT across Europe; local solutions will be implemented with major differences across Member States. ‘Green corridor’ concepts will not be adopted at all.</p>

<p>Information and communication technology</p> <p>Standardisation and a fully integrated system of ITS solutions will be implemented throughout Europe. The system is used ‘wisely’ and becomes an important enabler for sustainable transport.</p>	<p>Information and communication technology</p> <p>ICT systems experience data-transfer and security breakdowns, stifling progress in this area.</p>
<p>Goods/materials handling technology</p> <p>There will be global agreement and implementation of common standards for the design and dimensions of freight modules (goods containers). As a result, freight modules will be fully optimised for compatibility throughout the entire world.</p>	<p>Goods/materials handling technology</p> <p>No common standards for freight modules will be established, and the optimisation of load carrying systems for flexibility and compatibility is unlikely to take place.</p>
<p>Cost of energy</p> <p>The cost of energy will be higher than in the common-sense scenario, and will lead to even further developments and shifts in the transport networks and patterns. Production capacity will increasingly shift from low-wage regions to Europe. Businesses are much more organised in networks, sharing virtually all of their transport requirements with each other, both in terms of demand and supply.</p>	<p>Cost of energy</p> <p>Long-distance freight transport will be hampered by extreme energy prices, as will the economy as a whole.</p> <p>Road freight continues to rely solely on fossil fuels.</p>
<p>Logistics efficiency</p> <p>Sustainable transport will become a reality where the effects of policies are such that freight growth can be accommodated without infrastructure constraints.</p>	<p>Logistics efficiency</p> <p>A failure to develop the available infrastructure will lead to congestion, the inability to satisfy the demand for transport and, eventually, to the collapse of the transport system.</p>
<p>Infrastructure capacity, costs and investment</p> <p>To facilitate the growth in freight transport volume, large-scale coordinated ‘debottlenecking’ and (expansion of road infrastructure will be achieved within rigorous timescales and under predominantly private-public partnerships. The same applies to rail and waterway infrastructure. Transport will make the maximum possible use of ICT. However, the road transport system will still suffer from the relative sensitivity to incidents and extreme weather conditions.</p>	<p>Infrastructure capacity, costs and investment</p> <p>Even with the low transport volume increment, the road infrastructure will be unable to cope: there will be insufficient funds to maintain the quality of the road infrastructure overall and climate catastrophes will disrupt the system on a large scale.</p> <p>‘Debottlenecking’ through upgrading of the road transport infrastructure will be limited to regions considered to have the utmost priority, in particular, metropolitan regions.</p>

4.4 Road Transport Safety

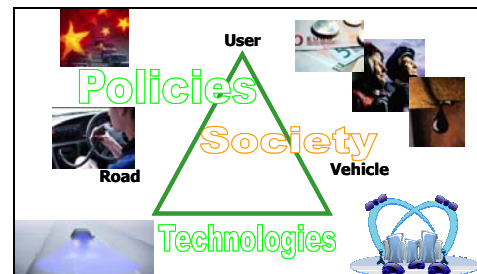
In 2006, there were 85 road accident deaths per million inhabitants in the EU25, compared with 126 in 1997. (In the USA, the rate was 146 per million inhabitants in 2004. (ERSO, 2008)) Although this metric has improved in nearly all Member States over the past decade, the total number of deaths due to road accidents in the EU25 was still almost 40,000 people in 2006.

The following figure shows the trends in EU road accidents between 1991 and 2007, along with the resulting deaths and injuries. Clearly, there have been improvements over the years but the rate is still much higher than is socially acceptable.



Source:

The three main actors with regard to road transport safety are the user (i.e. the driver and other road users), the road or infrastructure and the vehicles used to move people and goods. All three play significant roles, positive and negative, affecting the following types of safety: preventive or primary safety (avoiding accidents); passive or secondary safety (reducing consequential damage/injury); and post-crash or tertiary safety (improving the effectiveness of subsequent intervention, e.g. by the emergency services).



Three main factors have been identified, that work across all these actors and the different types of safety. These are: technology; society; and policy.

Technology: New technology will be required to make available affordable solutions to reduce the risk of accidents and their consequences.

- ADAS (Advanced Driver Assistance Systems) will have great potential to reduce accidents by increasing the level of preventive safety. Where ADAS functions are autonomous (i.e. all instrumentation and intelligence are on board the vehicle), their dissemination will not depend on technical upgrades of the road infrastructure. Greater levels of dissemination by such systems will provide greater benefits for road safety. However, the potentially high cost of such systems may be a drawback.

- In most European countries, between one-third and one-half of the total number of traffic casualties are 'vulnerable road users', i.e. pedestrians, cyclists, children and the elderly. The ageing population and the growth of traffic, including an increase in the volume of goods transported and in the number and proportion of heavier vehicles, means that this will continue to be a persistent road safety issue. New technology will make a valuable contribution towards protecting vulnerable road users.
- The issue of 'crash compatibility' between different types of vehicles is likely to become increasingly important in the future. Again, the most important consideration will be to protect the vulnerable road user. Vehicle design will be a key factor, but efficient management of the transport infrastructure, e.g. the separation of traffic flows according to vehicle type, will also be important in this respect.
- Of primary importance will be the need to reduce the number of fatal collisions. Land-use planning, network design and traffic management (e.g. limiting speed to less than 30 km/h at intersections) and the provision of safety facilities for motorcycles will all require attention. In addition, both the traffic environment and the vehicles themselves should be designed, equipped and managed to be more forgiving in the event of a collision, for example through the improved design of barriers around solid obstacles in the immediate road surroundings (e.g. trees, telegraph poles, etc.), to enable both the vehicle and the object to withstand a collision at high speed.
- New mobility concepts will be developed around novel technical, economical and/or organisational solutions to facilitate the safe transport of people and goods from one destination to another. But this will extend beyond new vehicle design and technology, to include innovative usage patterns for vehicles as well as the necessary constraints within which such usage may take place. Examples of successful mobility concepts developed for freight transport in recent decades include the pick-a-back system (trains carrying trucks on flat-top trailers), RoRo (ships carrying wheeled cargo that can be 'rolled on' and 'rolled off' using built-in ramps) and, in particular, container traffic. Car-sharing is a similar example of an alternative concept for the mobility of people.
- Cooperative systems, which enable vehicles to respond to transport situations by using information received from the infrastructure, have the potential to bring significant improvements in road transport safety, especially in the medium term. As the technology used in such systems becomes more advanced, they will continue to offer great potential, but their reliability and effectiveness will ultimately depend on whether or not they are implemented in most, if not all, vehicles on the road.
- Improvements in the transport infrastructure will help to reduce road accidents and fatalities. Measures designed to address speeding may also serve to reduce greenhouse gas emissions. Developments will include the integration of a communication infrastructure to support innovative new telematics services which, in turn, will provide a wider range of intelligent safety systems that will be installed both on board the vehicles themselves and also integrated into the road infrastructure.
- Electrification will be one of the most important trends in automotive engineering. There will be an increase in the number of vehicles using electric/electronic components in the drive train, (e.g. hybrid electric vehicles, and battery electric vehicles). Advances in the development of battery technology are likely to lead to a rapid and extensive electrification of the European vehicle fleet towards 2030. Electrification introduces additional challenges to traffic safety, related to crash properties of new types of vehicles and batteries, as well as the electric/ hybrid vehicles noiseless operation that may provide a distorted speed notion to a novice driver, as well as be unnoticed by pedestrians.

Society: Changes which affect society as a whole, e.g. demographic change, climate change and energy shortage, will have potentially big impacts on road safety.

- 'Transport mix' is a term which represents the allocation of the different types of transport between the various sectors (e.g. personal, public and goods transport) but which, in a broader sense than just describing the modal split, also includes the different types of vehicle used within each mode (e.g. city cars as opposed to large family cars for personal transport). The considerable variety of different modes and different vehicle designs will present challenges for road safety planning.
- The ageing population will present significant safety risks. By 2030, approximately 25 per cent of the European population (taken as a whole) will be older than 65 years (European Commission, 2008). The ageing process brings with it an increase in the number of physical and mental problems, such as Alzheimer's disease (Rybash et al.) which, especially in the phase prior to diagnosis, present a significantly high risk to road safety.

- Raising customer awareness of road safety issues will be a major factor. Individuals often take for granted the positive effects of road safety measures, and can also be reluctant to accept that a small sacrifice for one individual may sometimes be necessary for the benefit of the majority. This can lead to a lack of compliance with the rules. By raising customer awareness, the traveller may be inclined to take more active decisions, such as a more considered choice of vehicle and related purchases, a safer choice of route, and even a self-assessment of ‘fitness’ to drive or ride.
- The cost of accidents (i.e. the numbers of casualties and fatalities) will depend to a great extent on the application of effective road safety planning. Apart from the humanitarian aspects of road safety, injuries and fatalities that occur as a result of road accidents have serious economic implications for a country. As a result of a wide variety of road safety activities and traffic management measures, road accident levels in most industrialised countries are currently falling. However, in some developing countries, the situation is reversed, with road accident deaths on the increase. **The improvement on passive safety or collision mitigation could have negative impact on accident cost reducing the fatalities but increasing serious injuries.** The cost of road accidents is, on average, equivalent to between 1 and 3 per cent of gross national product in most countries (WHO, 2004)—equivalent to several billion Euros. That said, the cost of the resources devoted to improving road safety is always a small percentage of these high costs.

Policy: A safe and efficient road transport network will depend to a large extent on effective policies designed to promote safe driver behaviour, enforce traffic rules and accelerate the adoption of new technologies. Policies can also be aimed at providing incentives to manufacturers in return for significant and practical advances in the development of new technology aimed at increasing road safety.

- All European Member States will agree on common policies to promote safer road transport. These policies are the primary way to guarantee mutual cooperation between all involved stakeholders. A good example is the European Union’s ‘e112’ emergency call initiative, which enables the operator to identify the location of fixed-line and mobile telephone callers who ring the emergency services. Only through a common effort, supported by the European Commission with the common agreement of Member States, was the introduction of such a solution made possible.
- Efficient coordination of policy development will be essential for the adequate penetration of cooperative systems into the road transport system (i.e. vehicles and road infrastructure). Adapting the road infrastructure to accommodate such systems will be key to speeding up this process, although it should be noted that the road safety benefits are likely to be immediate and will not be dependent on a high penetration rate of such systems into the transport system. Nevertheless, enhancements to the infrastructure that are required to meet other objectives are also likely to accelerate the pace at which cooperative systems will be introduced.

Common-sense scenario for Road Transport Safety

By 2030, road transport safety will still be an important social problem in spite of the wide introduction of sophisticated safety measures to the user, the vehicle and the infrastructure. Factors that are likely to contribute to an increase in road transport safety risks include the increasing number of vulnerable road users, an increase in accident incompatibility between vehicles, the increasing number of elderly people and an overall increase in mobility demand, particularly in the more critical context of urban road use. On the other hand, the introduction of safety systems, e.g. ADAS and cooperative systems, in vehicles and transport infrastructure, as well as increased customer awareness and acceptance of these safety systems, will offset the aforementioned impacts on safety risk, but it is not clear whether the overall result will be positive, i.e. a net reduction of the safety risk.

- Customer awareness of road safety issues will have led to the general acceptance of advanced safety technologies (e.g. anti-lock braking systems, electronic stability controls, emergency call facilities, etc.) and safer conduct. Policies on, for example reducing speed limits and the adoption of eco-driving strategies (e.g. smoother acceleration and deceleration), as well as on continuous education of the road user and the provision of discounts on insurance premiums or taxes, will further enhance this trend.
- Safety systems will be implemented on the vast majority of vehicles, but the sophistication of the individual systems will depend on the class and age of the vehicle.

- The rising number of vulnerable road users, together with the introduction of more small, new vehicles and the growing number of trucks combined with developments such as vehicle ‘platooning’ which allows for better aerodynamics and thus for improved fuel efficiency, will increase vehicle incompatibility in relation to accidents, and therefore will also increase safety risks. This will be addressed by a completely new approach to vehicle and infrastructure design which will be aimed at maximizing both the passive and active safety of vehicle occupants and other road users.
- Future generations of ‘elderly’ people will not change their mobility behaviour, and this will lead to an increase in safety risk due to their enhanced vulnerability and reduced driving proficiency.
- Although the congested sections of the European road infrastructure will be ‘debottlenecked’ to accommodate the increased volume of personal and freight transport, capacity will still be stretched to its limits and sensitive to disturbances, therefore creating a relatively high safety risk for the road user.
- The costs for maintaining and developing the road infrastructure will increasingly be financed by private capital; hence the balance between costs, benefits, user needs and safety requirements will be the subject of ongoing public debate.

TECHNOLOGY

Driving assistance provided by in-vehicle technology and infrastructure support

By 2030, the majority of vehicles will have a safety system implemented, but the sophistication of the system will depend on the class of the vehicle. Medium to high classes of vehicles will have ADAS systems on board as standard, and these systems will also be available as an option on lower classes of vehicle.

Driver assistance systems will become more and more autonomous, with the target to cover all possible dangerous situation (“all around safety cushion”) but without leaving the driver out of the vehicle control.

Specific or adapted driving assistance systems will be developed for PTW.

Incentives and regulation will have led to the full penetration of cooperative systems into the new vehicles by 2030. In addition, 90 per cent of the road infrastructure will also have become similarly equipped.

Vulnerable road-user protection

By 2030, the need to protect the vulnerable road user will have become an important factor in vehicle and infrastructure design. Traffic flows in all urban and rural road networks will be separated. Passive safety will be improved to provide greater protection for the pedestrian, and also for other vulnerable road users including all two-wheeled, and light four-wheeled, vehicles and their passengers. Crash tests between different vehicles will be standardised, and this will lead to higher performance requirements for heavier vehicles.

New concepts for mobility, vehicles and structures

By 2030, the transport fleet will consist of a wide variety of vehicles designed to meet increasingly diverse mobility needs and demands. Many new types of vehicle—very different from current types—will emerge, and many will be specially designed for specific purposes, e.g. for use in the city/urban environment. The use of two-wheeled vehicles will increase considerably in response to the rising cost of transport in general.

Other developments will call for a variety of new approaches to vehicle safety design. For example, new mobility solutions will enable passengers to transfer between different kinds of vehicle and even between different modes, in a leisurely and efficient way, particularly within urban areas. Similar solutions will also benefit the freight transport sector. In addition, innovative design concepts for new vehicles will incorporate the use of lightweight materials for weight reduction and improved fuel economy; vehicle concepts will be increasingly focused on modular, scalable, flexible and lightweight vehicle types, and innovative construction technologies will be deployed to enable the use of new, ‘smart’ materials and enhanced metal forming and joining techniques. These new concepts for mobility solutions and vehicle manufacturing techniques will require new approaches to safety design so that the passive and active safety of vehicles, their occupants and

other road users can be guaranteed.

Infrastructure development/improvement

By 2030, the maintenance and associated costs for road infrastructure will have increased to such an extent that they will rely increasingly on private capital. As a consequence, the balance between costs, benefits, user needs and safety requirements will be a topic of ongoing public debate.

The concept of road forgiving will be widely introduced and will be an important specification in all new or renewed infrastructures, considering driver behaviour and most common errors.

SOCIETY

Customer awareness/consumer trends

By 2030, customer awareness of road safety issues will have increased significantly. There will be general acceptance of advanced safety technologies (e.g. anti-lock braking systems, electronic stability controls, emergency call facilities, etc.), and promotional awareness campaigns will continue to boost this trend.

Transport mix

Even though, by 2030, the transport mix in urban areas will have shifted significantly towards smaller, extremely fuel-efficient cars that meet the 'green driving' aspirations of urban society, larger cars will still constitute the biggest fraction of the vehicle fleet. This will contribute to an increase in the incidence of incompatible vehicle-to-vehicle accidents.

Ageing population

By 2030, the public authorities will have introduced much more stringent requirements for holding a licence to drive. Although this will lead to a greater number of licence denials, the number of elderly people driving will still be higher than it is today. Vehicle design will not be aimed specifically at the older driver, but the needs of the elderly will be given general consideration in most vehicles. The level of personal security in public transport will increase, and this will facilitate the wider use of the public transport network by the older generation.

Mobility behaviour, mobility demand

Mobility will have increased significantly for certain groups, e.g. elderly drivers will constitute a particularly active group. Diversity in travelling will also have increased and there will be many different motorized and non-motorized forms of two-, three- and four-wheeled vehicles on the roads. The number of vulnerable road users will increase as a consequence of rising energy costs and the introduction of incentives and regulations affecting private vehicle use. This increase in the number of vulnerable road users, together with the introduction of more small, new vehicles and more trucks will increase the potential for road safety hazards. Accident compatibility will be an increasingly important issue. ITS solutions will be standard in some applications, supporting 'smart' travelling and intermodality. Increasingly advanced ITS will continue to be piloted in certain areas.

By 2030, the migration to smaller vehicles, the potential reduction in traffic volumes and a better distribution of traffic 'types' will have positive impacts on safety, even in the case of a small increase in mobility demand; however, the greater number of vulnerable road users will contribute to an increase in safety risks.

Driver behaviour (speed reduction, eco-driving, etc.)

The higher cost of energy, combined with a general commitment to reduce GHG emissions, will encourage 'green' driving by reducing speed limits and promoting the adoption of eco-driving strategies (e.g. smoother acceleration and deceleration). This will improve road transport safety significantly. However, some developments such as vehicle 'platooning', which allows for better aerodynamics and thus for improved fuel efficiency, will increase safety risks.

Electrification

Hybrid and fully electric vehicles will present new challenges with regard to safety in terms of crashworthiness and crash compatibility, high-voltage and fire safety, driving dynamics and acoustic perception. However, they will also present opportunities for new safety concepts, e.g. individual torque control at each wheel for improved driving dynamics, or increased structural load capacity through new approaches to vehicle layout design, e.g. the siting of electric motors within the wheels rather than within the main chassis area. In the case of fully-electric vehicles, the avoidance of inflammable fuels will be a safety benefit.

Economic growth

The combination of consumer trends towards smaller and cheaper vehicles and other, more vulnerable modalities (e.g. two-wheelers, walking, etc.) and the fact that the infrastructural capacity will become stretched to its limits will have a negative impact on road safety, e.g. through an increase in the number of more vulnerable users.

Costs of accidents (casualties, fatalities)

By 2030, the first steps towards internalisation of the external cost of accidents will have been taken. There will be clarity with regard to the proportion of public spending allocated to road transport safety policies and incentives, and also in relation to funds raised, e.g. through fines and direct accident costs (and savings).

Transport costs (driver, vehicle, etc.)

Sustainability, in terms of cost, will be an important issue in future transportation systems. Public transport will be pushed towards complete sustainability, with public intervention only to support the poorest segment of the population.

This will potentially lead to an increase in the cost of public transport, and people may tend to use their own personal cars rather than use the more efficient public transport network. As a consequence, this may encourage the development of new concepts for public transport systems based on lower operating costs (e.g. driverless systems) and greatly improved levels of service quality (e.g. transport frequency) and efficiency.

For commercial transport, increasing costs will encourage the development of new logistics solutions, or perhaps lead to the relocation of businesses to reduce transport needs.

A more efficient service should also be a safer one. But if 'basic' public transport services remain expensive, people will still be inclined to use their own personal vehicles, albeit with increased safety risks. Policies may be used to influence choice by increasing the cost of using personal vehicles (e.g. through road pricing), but this will produce negative impacts on the economy and will further reduce the mobility of the poorest segment of the population.

POLICY

All European Member States will agree on common policies to promote safer road transport. These policies will become the primary way to guarantee synergy of efforts between all involved stakeholders. A good example is the 'e112' emergency call initiative. Only through a common effort, supported by the European Commission with the common agreement of Member States, will the introduction of such solutions be possible.

By 2030, a range of policies to improve road safety will have been implemented throughout the EU, in an approach similar to that used for the 'e112' initiative. These policies will have implications for cooperative systems and infrastructure development, among others. Although the economy will have grown considerably, the resources available to support policy measures will be limited due to other priorities, including debottlenecking/upgrading of the infrastructure, demands for public funding from other sectors of the economy (e.g. social security, health care, etc.).

Safety regulations, including speed limits

In 2030, regulations will be harmonised throughout the European Union. As a result, all Member States will have a comparable level of enforcement. In addition, legislation and regulation will be stricter, in particular when concerned with unsafe/dangerous behaviours, e.g. driving under the effect of drugs or alcohol. Alcohol-lock devices in the vehicles will be mandatory for professional users and recommended on personal vehicles.

Incentives

In 2030, safe behaviour will be promoted through strong incentives offered to the consumer, leading to direct economic benefits. This will boost market penetration for road safety technologies, such as collision avoidance systems or lane departure warning systems. Private parties, such as insurance companies, will play an active role in promoting these incentives, e.g. through reduced insurance premiums.

Road user behaviour and education

The understanding of human-machine interaction (HMI) and human behaviour in connection with driving will increase rapidly with the new research tools (field operational tests (FOTs), naturalistic driving studies, etc.). Adaptive HMI will be introduced which provide support and warnings that adapt to driver skills, maturity and driving style. Driver education will be mandatory and real-time teaching tools will be available for young/inexperienced drivers, enabling instant feedback during normal driving. In vehicles, systems such as fatigue detection will be widely used to minimize risks due to driver impairment.

As the number of vulnerable road users increases, measures will be taken to reduce safety hazards. Infrastructure will be designed to separate non-compatible road users, and restrictions will be imposed on trucks and heavy vehicles in city centres. Public transportation will increase, creating new demands on road user behaviour. Nomadic devices¹⁸ and cooperative systems for guiding, warning and providing support will be common.

A new approach to driver education will be adopted, with the emphasis on 'road user' (i.e. driving as a collaborative activity) rather than just 'driver'. Dedicated road networks will be made available for different applications (e.g. for cars, public transport, goods, pedestrians and two-wheeled vehicles, etc.), and solutions will be provided to guarantee safety where these different networks intersect.

¹⁸ "Nomadic Devices" are portable devices used in the car by a driver for support, assistance, communication or entertainment. As in-car use of Bluetooth mobile phones, handheld computers, portable navigators and personal music players grows rapidly, there are concerns that this should not lead to driver distraction and increased safety risk.

Enthusiastic Alternative	Pessimistic Alternative
<p>Driving support from vehicle and infrastructure</p> <p>Technology development, together with an improved 'willingness-to-pay', will increase the penetration rate, placing pressure on manufacturers to introduce these solutions as standard equipment well before 2030.</p> <p>All types of motor vehicles will have 'e-call' equipment installed which, in the event of a crash, will automatically notify the emergency services.</p> <p>New ITS will be deployed as advisory instruments to prevent road users from involuntarily violating rules.</p> <p>Public incentives and insurance discounts will encourage greater use of driver assistance technology, with some solutions becoming standard on all new vehicles by 2020.</p>	<p>Driving support from vehicle and infrastructure</p> <p>The economic downturn pushes customers towards low-cost vehicles and reduced levels of safety equipment, reducing the penetration rate of such systems. As a result, it will be impossible to evaluate their real benefits. By 2025, the penetration rate will remain marginal (10–20%) on new vehicle sales.</p> <p>The introduction of multiple, not integrated, ADAS on the vehicles will increase driver confusion and errors, ending in a general refuse of such systems.</p>
<p>Cooperative systems technology</p> <p>Initial feedback, e.g. from piloting areas, will show such positive results that the European Commission will provide incentives and introduce regulations to accelerate the introduction of cooperative safety systems into the transport system with the aim of reaching full penetration by 2020.</p>	<p>Cooperative systems technology</p> <p>Privacy issues, insufficient funds, the absence of standards and a lack of updates to the transport infrastructure will all delay the introduction of cooperative safety systems. By 2030, only about 20 per cent of the traffic system will benefit from such technology.</p>
<p>New vehicle concepts/structures (e.g. smaller, lighter, modular and two-wheeled vehicles)</p> <p>As society and its demand for mobility changes, so too will the concepts for road transport also change. Economic requirements and increased environmental awareness will lead to smaller, lighter and modular vehicle designs. Active and passive safety will continue to be a primary focus for maintaining and improving vehicle crashworthiness and road transport safety in general.</p>	<p>New vehicle concepts/structures (e.g. smaller, lighter, modular and two-wheeled vehicles)</p> <p>The lack of advances in vehicle design concepts and manufacturing techniques will have a twofold impact on road transport safety. The demand for modular, lighter and smaller systems is unlikely to be satisfied, hence further advances in transport and traffic technology will be impeded. Consequently, advances in passive safety technology will stagnate and manufacturers will come under pressure to reduce costs; as a result, vehicle crashworthiness is likely to suffer.</p>

<p>Vulnerable road user protection</p> <p>Public and private bodies will be fully aware of the magnitude of risks to the vulnerable road user. Instead of focusing on individual problems, they will aim to provide high quality design and engineering facilities, together with skilled management and personnel, to address the widest scope of related safety issues.</p> <p>New designs and technology to address crash compatibility, accident-friendly vehicle exteriors, and the need for motorcycle-friendly environments and collision warning systems will be fully implemented.</p> <p>Cooperative solutions will enable the introduction of improved protection systems, e.g. external airbags, on specific vehicle classes (public transport, urban freight transport, etc.). The introduction of such systems will be promoted by policy incentives (taxes, city entrance fees, insurance discounts, etc.).</p> <p>Vehicle exteriors will be equipped with smart materials/solutions to mitigate injuries to vulnerable road users, with special consideration for children, other pedestrians and cyclists. ITS designed to monitor and provide advance warnings of obstacles and other road users will be standard.</p>	<p>Vulnerable road user protection</p> <p>Public and private bodies will only take measures to adapt infrastructure if absolutely necessary. The pace of introduction of new and intelligent technologies for the protection of vulnerable road users will slow down.</p> <p>The economic downturn will delay the development of necessary technology.</p> <p>Increased numbers of two-wheeled vehicles and pedestrians in urban areas will lead to an increase in the total number of accidents/fatalities in vulnerable road users.</p>
<p>New mobility concepts</p> <p>New mobility concepts will be implemented in a coordinated, pan-European approach, leading to the availability of new types of vehicles and the necessary infrastructure (e.g. charging stations with standardised metering/billing systems and physical interfaces for electric vehicles in urban environments). Investments into the transport infrastructure will enable the reallocation of road space and the clear separation of traffic flows, even in city centres. This will give rise to novel concepts for public transport. New information services combining data from all transport modes will facilitate the optimum planning and real-time dynamic adaptation of routes, making full use of intermodality for both people and goods. In addition to the traditional concept of personal vehicle ownership to fulfil individual mobility needs, travellers will have the opportunity to book a variety of mobility services, providing them with access to the most appropriate means of transport for each trip. Such services will be tailored to the needs of individual customers, including the specific needs of elderly people. Goods transport in urban areas will be well organised, using hubs outside the cities and small, low-emission vehicles for goods distribution in city centres.</p>	<p>New mobility concepts</p> <p>Due to a prolonged economic downturn, public authorities will not be able to establish a coordinated programme for new mobility concepts. Such concepts will rather follow a bottom-up approach (car-pooling, increased use of two-wheelers etc.), with the aim of reducing mobility costs and travel times in congested city centres.</p>

<p>Infrastructure development/improvement</p> <p>A primary European objective will be for public-private partnerships to identify and remove regulatory barriers to infrastructural improvements. The required steps will be taken at local, national, regional and European levels. Road safety measures (including infrastructure development, management of high-risk sites, road safety audits and safety impact assessments) will help to reduce road accidents and fatalities. Infrastructure improvements to facilitate the introduction of cooperative systems will be carried out under a joint public-private partnership. Regional and European deployment will be encouraged by both industry and authorities through joint initiatives to remove technological and administrative barriers. There will be a willingness to pay for specific and personalised mobility services and traffic information; this market will therefore grow and new opportunities will emerge. Transport safety will benefit from ongoing development and improvement of the transport infrastructure. Different modes of transport will be completely separated in totally new traffic environments operating at a high degree of complexity.</p> <p>Cities with mixed types of road users will impose restrictions on larger, more ‘aggressive’ vehicle types, favouring smaller and lighter vehicles.</p> <p>ICT/ITS technology will complement “hard” infrastructure improving the forgiving and self-explanatory nature of the road infrastructure.</p>	<p>Infrastructure development/improvement</p> <p>The transport infrastructure is the backbone of the economic development, but without the necessary investments in infrastructure development and improvement, there will be a direct negative impact on economic growth and transport safety.</p>
<p>Transport mix</p> <p>The implementation of new mobility concepts will lead to a more effective and convenient use of public transport, resulting in a corresponding shift in the transport mix towards rail, buses and new, less conventional means of public transport. The number of small cars will rise dramatically, as other complementary means of transport will be available for longer trips. Conventional vehicles with aggressive crash zones will be replaced to a large extent. Important advances in driver assistance and in primary safety systems will significantly reduce the number of vehicle crashes; this will more than compensate for the possible shortcomings of a new generation of small cars with regard to secondary safety. Semi-autonomous driving and the use of automatic guided vehicles, in particular for the transport of goods in urban areas, will further improve traffic safety.</p>	<p>Transport mix</p> <p>The overall traffic volume will remain constant or, with regard to freight transport, even decrease because of reduced economic activity. Low-cost motor vehicles will become increasingly popular for economic reasons, while the necessary investments to increase the attractiveness of public transport will not be made. The result will be a shift in the transport mix towards two-wheelers and small cars, while the share of other means of transport will remain relatively constant. The rate of technological progress will also slow down, hence the shift in transport mix will result in negative consequences with regard to road safety.</p>

<p>Demographic change (ageing)</p> <p>Increased accessibility to ‘virtual mobility’ (teleworking, e-commerce, etc.) will reduce the need for actual mobility. Social networks will promote collective ways for individuals to meet and entertain, encouraging the use of public or collective modes of transport.</p>	<p>Demographic change (ageing)</p> <p>A greater incidence of illness and poor health in the elderly population will lead to an increase in driving risks and accidents.</p>
<p>Mobility behaviour/mobility demand</p> <p>Mobility will increase for all users. New light vehicles with high-technology solutions will be introduced. Travellers will use a variety of travelling modes, minimising energy consumption and safety risks. ITS solutions will calculate the most efficient routes for people and goods, reducing congestion and hazardous traffic situations.</p> <p>Advanced ITS solutions will support safe speeds and eco-driving. The results of research on mobility for elderly and children will be implemented in traffic organisation and new technologies.</p> <p>Multimodal travelling in urban areas will become standard, enabling varied use of the road network, giving priority to personal vehicles in the suburbs, to public transport in the main city networks, and to walking and bicycles in urban areas. Better traffic separation will lead to improved road safety.</p>	<p>Mobility behaviour/mobility demand</p> <p>Mobility will be restricted due to negative economic and societal development. ITS solutions will not be successful, and cities will become more congested leading to severe restrictions and regulations. Public transport will not be able to adapt to changes in society’s behaviour, resulting in an increased use of personal cars.</p>
<p>Driver behaviour (speed reduction, eco-driving)</p> <p>‘Green driving’ will be acknowledged and encouraged by the dissemination of information related to ‘eco driving’ techniques. Vehicle-to-Vehicle (v2v) communications and sensor development will allow vehicle platooning on designated road segments, while creating road safety benefits at the same time. A ‘reward’ system will be implemented which will honour desirable behaviour and penalise undesirable behaviour. Insurance premiums will be calculated based upon the individual’s driving behaviour. Other solutions to encourage positive driving behaviour will include a ‘pay as you drive’ system, adaptive systems on board vehicles to maintain driver awareness, and opportunities for driver coaching.</p>	<p>Driver behaviour (speed reduction, eco-driving)</p> <p>Traffic will be composed of a mix of ‘eco-’ and ‘non-eco’ driven vehicles. This will lead to increased differences in speed between the two groups, with the potential for increased collision speeds in the event of an accident. This will have a small, but negative, impact on road safety.</p>

<p>Electrification</p> <p>Plug-in hybrids and fully electric vehicles will play a dominant role in major market segments. The use of battery-electric vehicles will not be limited to urban areas, but will also be a viable alternative for long-distance travel due to breakthroughs in battery technology, the implementation of contactless energy supply while driving, and/or the successful introduction of quick-change concepts for batteries. Battery-electric vehicles will generally be purpose-built in order to make full use of the potential of the electric drive train. Concerted European efforts in the early phase of the introduction of electrified vehicles to the commercial market will aim to establish a standardised interface to the electric grid as well as common safety standards, design and usage guidelines and technical solutions, to ensure that such vehicles are as safe as conventional ones. The electric energy required will be generated from renewable resources to a large extent.</p>	<p>Electrification</p> <p>The absence of major improvements in battery technology, as well as a failure in European harmonisation/standardisation, will make plug-in hybrids and battery-electric vehicles unattractive to customers. Such vehicles will continue to suffer from limited operating ranges as well as from high battery costs; as a consequence, they will remain a niche market product. Because of low production volumes, even fully electric vehicles will, in most cases, be based on the architectures/platforms of conventional vehicles, requiring many compromises and suboptimal solutions in their manufacture. Safety concepts will not be adapted to the specific needs of electric vehicles, hence they will present a safety risk which will be offset only by the relatively low numbers of vehicles sold.</p> <p>The shift of resources in environmental issues and the vehicle electrification drastically reduce the research and deployment funds required for traffic safety equipment and applications, thus leading to an accelerating worsening of traffic safety levels</p>
<p>Economic growth</p> <p>Faster economic recovery, together with a focused approach towards efficient solutions and better practices, will accelerate the introduction of innovative (cooperative) solutions.</p>	<p>Economic growth</p> <p>The current economic downturn will last well into the coming decade. Lower incomes and a lack of public money will slow down the dissemination of technologies related to vehicles and infrastructure. Only easily sustained solutions will be broadly implemented (such as enforcement) having a further negative impact on the economy.</p>
<p>Costs of accidents (casualties, fatalities)</p> <p>Society will fully appreciate the benefits of investing into accident prevention, and will support the wide application of preventive measures. There will be continued investment in road safety solutions, and new technologies for passive and active safety measures in cars will be introduced. New incentives for drivers will encourage a safer approach to driving. Together, these developments will lead to a continuous reduction in the number of accidents, and less disruption to an otherwise optimised transport system. This will ultimately lead to a decrease in the overall cost to society.</p>	<p>Costs of accidents (casualties, fatalities)</p> <p>Investment into a safe road infrastructure, and the introduction of new and innovative technologies on vehicles, will slow down. As a result, the decline in the accident rate over the last decades will also slow down. The accident rate may even begin to increase, leading to a disruption of the transport system. The social and economical costs will be likely to increase as a result.</p>

<p>Transport costs (driver, vehicle, etc.)</p> <p>Greater opportunities for multimodal travelling will lead to an increase in the use of public transport services, which will continue to grow in line with increasing demand but without the need for disproportionate price rises. In the freight transport sector, multimodal solutions will also bring benefits by enabling greater use of off-peak travelling, e.g. night time distribution, and through the use of noiseless (electric) vehicles in urban areas.</p>	<p>Transport costs (driver, vehicle, etc.)</p> <p>New solutions for public and freight transport will not be forthcoming. Policies will be introduced to promote the use of public transport by increasing the cost of using personal cars, e.g. through road pricing, parking pricing, access restrictions, etc.</p>
<p>Customer awareness/consumer trends</p> <p>Initiatives and awareness campaigns from both public bodies and private organisations will lead to higher customer awareness of safety issues. Incentives on a national and regional level will facilitate the deployment of novel safety systems. Society will become inclined to reject higher or increasing risks (individually and collective). The general level of public comprehension of safety matters will increase.</p>	<p>Customer awareness/consumer trends</p> <p>Without incentives and campaigns, users and customers will become less inclined to accept the need for safety measures due to lack of awareness and comprehension. The deployment and adoption of systems for collective benefits will be hindered due to individual suspicion.</p>
<p>Policies</p> <p>A growing economy will enable more investment to support policies. Public-private partnerships will increase the level of funds available for the development and commercial use of safety solutions such as the Alcolock data recorder, which prevents a vehicle from being driven by an individual who has consumed more than the legal limit of alcohol.</p>	<p>Policies</p> <p>Different economic situations across Member States will make it impossible to reach common agreements. The economic downturn will lead to a considerable reduction in available resources.</p>
<p>Safety regulations, including speed limits</p> <p>Cooperative technologies will allow a softer but continuous enforcement of safety regulations. Drug-lock devices will also be made available and introduced to the market.</p>	<p>Safety regulations, including speed limits</p> <p>A lack of common agreement between Member States will delay the enforcement of safety regulations. Insufficient resources and concerns about privacy will reduce the impact of enforcement.</p>
<p>Incentives</p> <p>Technology will enable the continuous monitoring of driver behaviour, allowing incentives to be based on actual behaviour and remunerated directly, for example through a reduction in the cost of fuel used.</p>	<p>Incentives</p> <p>No economic resources will be available due to the economic downturn.</p>

<p>Road user behaviour and education</p> <p>Driver education programmes will be improved based on research into the effectiveness of driver education and its impact on driver attention/action/reactions, etc.</p> <p>A graduated driving licence system will be mandatory. The personal driving licence will take the form of a 'smart card' and will be subject to regular compliance checks, e.g. to monitor driver behaviour.</p> <p>Young drivers will be provided with specific guidance and support, based on research into their needs. Traffic education will be an integral part of children's education.</p> <p>Simulators will be more widely used for driver education.</p>	<p>Road user behaviour and education</p> <p>Driver education will be considered too costly to justify, and improved education methods will not be implemented. ITS systems for providing driver coaching and hazard warning will not be commonly installed.</p> <p>Road infrastructure will be developed without considering the needs of all road users. Cities will become more congested and dangerous for vulnerable road users. In-vehicle technology for avoiding accidents will be too costly and there will be a lack of standardisation, hence such technology will not be implemented in the majority of vehicles. ITS solutions will be used for vehicle tracking and imposing restrictions rather than for support, and will be widely mistrusted by road users.</p>
--	---

A. ABBREVIATIONS

4G	Fourth Generation of Wireless Communication
ADAS	Advanced Driver Assistance System
APU	Auxiliary Power Unit
ASEAN	Association of Southeast Asian Nations
BRIC	Brazil, Russia, India and China
CAFE	Clean Air For Europe
CNG	Compressed Natural Gas
CO ₂	Carbon Dioxide
DME	Dimethyl Ether
e-commerce	Electronic Commerce
e-freight	Electronically-enabled Freight Logistics
e-services	Electronic Services
e-shopping	Electronic Shopping
ERTRAC	European Road Transport Research Advisory Council
EU	European Union
EU-15 (-27, etc.)	15 Member States of the European Union (-27, etc.)
FOT	Field Operational Tests
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GSM	Global Satellite Monitoring
HDT	Heavy-Duty Transport
HMI	Human-Machine Interaction
ICE	Internal Combustion Engine
ICT	Information and Communication Technology
IPPC	Intergovernmental Panel on Climate Change
IT	Information Technology
ITS	Intelligent Transport Systems
JIT	Just In Time
LDT	Light Duty Transport
LHV	Longer and Heavier Vehicles
PPP	Public-Private Partnership
PT	Personal Transport
R&D	Research and Development
RFID	Radio Frequency Identification

ERTRAC Road Transport Scenario 2030+

ROI	Return on Investment
RPM	Revolutions Per Minute
RTD	Research and Technological Development
SUMP	Sustainable Urban Mobility Plans
SUTP	Sustainable Urban Transport Plans
TTI	Traffic and Travel Information
v2g	Vehicle-to-Grid
v2i	Vehicle-to-Infrastructure
v2v	Vehicle-to-Vehicle
v2x	Vehicle-to-'All'
VRU	Vulnerable Road User
ZEV	Zero Emission Vehicle

B. REFERENCES

- C E Delft (2008). Handbook on Estimation of External Costs in the Transport Sector. February 2008. (www.ce.nl/publicatie/deliverables_of_impact_%28internalisation_measures_and_policies_for_all_external_cost_of_transport%29/702)
- ERTRAC (2004). Vision 2020 and Challenges, July 2004. (www.ertrac.org/?m=7&mode=download&id_file=7)
- ERTRAC (2004a). Strategic Research Agenda. December 2004. (www.ertrac.org/?m=7&mode=download&id_file=8)
- ERTRAC (2006). Research Framework 2006. April 2006 (www.ertrac.org/?m=7&mode=download&id_file=23)
- ERTRAC (2008). Research Framework 2008. March 2008) (www.ertrac.org/?m=7&mode=download&id_file=6)
- ERSO (2008). European Road Safety Observatory. Annual Statistical Report, 2008
- European Commission. (2008). Eurostat Statistics in Focus, 72/2008 (http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-SF-08-072/EN/KS-SF-08-072-EN.PDF)
- European Commission. (2008a). Demography Report—Towards Better Societies For Families and Older People. November 2008. (<http://ec.europa.eu/social/main.jsp?langId=en&catId=89&newsId=419>)
- European Commission (2009). Energy and Transport in Figures 2009. Published by the European Commission Directorate General for Energy and Transport and based on data provided by Eurostat. http://ec.europa.eu/transport/publications/statistics/statistics_en.htm
- European Commission (2009a). EU Transport GHG: Routes to 2050? European Union project, funded by the European Commission, to contribute to the development of a long-term strategic approach to ensuring the compatibility of transport's GHG emissions with the EU's long-term climate goals. www.eutransportghg2050.eu
- Foresight (2006). Intelligent Infrastructure Futures. A project to explore how science and technology may be applied over the next fifty years to the design and implementation of intelligent infrastructure systems that are robust, sustainable and safe. www.foresight.gov.uk/OurWork/CompletedProjects/IIS/Index.asp
- Hazel, G. and Cassidy, S. (2008) Transport 2050: A New Mobility Paradigm. In Reducing Carbon Emissions—the View from 2050. Hume Occasional Paper No. 79. The David Hume Institute, 14 October 2008. <http://www.davidhumeinstitute.com/DHI%20Website/publications/hop/HOP%2079%20Reducing%20Carbon%20Emissions%20-%20the%20View%20from%202050.pdf>
- ITEA (2009). ITEA Roadmap for Software-Intensive Systems and Services. Edition 3. February 2009. http://www.itea2.org/itea2_roadmap_3
- Moon, J., and Roehrl, R.A. (2006). Asian Highway Network. Toward an Asian Integrated Transport Network. United Nations ESCAP and Asian Institute for Transport Development (AITD). (http://www.unescap.org/ttdw/Publications/TPTS_pubs/pub_2399-2/pub_2399-2_fulltext.pdf)
- National Intelligence Council (2008). Global Trends 2025: A Transformed World. November 2008. (www.dni.gov/nic/NIC_2025_project.html)
- Rodrigue, J-P., Comtois, C. and Slack, B. (2009). The Geography of Transport Systems. Second Edition. Routledge, May 2009. <http://people.hofstra.edu/geotrans/index.html>
- Shell Deutschland Oil GmbH (2009). Shell Passenger Car Scenarios up to 2030: Facts, Trends and Options for Sustainable Auto-Mobility.
- WTO (2008). World Trade Organization. International Trade Statistics 2008. www.wto.org/english/res_e/statis_e/its2008_e/its08_toc_e.htm

C. SCENARIOS AND PAPERS ANALYSED

This report was based on a detailed analysis of the following broad range of published scenarios, papers and presentations:

- Alfonso Alfonsi: Towards an intelligent and cleaner model of road transport and citizens rights (2008)
- Department for Transport: The Government Response to the King Review of Low-carbon Cars., (November 2008)
- Energy Information Administration (EIA): International Energy Outlook 2008–2030 Highlights (2008)
- Energy Information Administration: International Energy Outlook 2008 (September 2008)
- Energy Watch Group: Crude oil—the supply outlook (October 2007)
- Energy Watch Group: Oil Report (October 2007)
- Energy Watch Group: Zukunft der weltweiten Erdölversorgung (May 2008)
- EREC/Greenpeace: Energy [r]evolution—a sustainable global energy outlook (Report and Executive Summary) (2008)
- ERRAC: Strategic Rail Research Agenda 2020 (May 2007)
- ERTRAC-EPoSS-SMARTGRIDS; European Industry Roadmap Electrification of Road Transport, version 3.0, September 2009
- EURFORUM: Strategic Research Agenda for Urban Mobility (October 2007)
- EURFORUM: The State of the Art on Research and Development in the Field of Urban Mobility (February 2007)
- European Commission: COM(2009)279/4: "A sustainable future for transport: Towards an integrated, technology-led and user friendly system".
- European Commission: COM/2008/0886 - Action plan for the deployment of Intelligent Transport Systems in Europe annex COM/2008/0887 Proposal for a Directive of the European Parliament and of the Council laying down the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other transport modes
- European Commission: World Energy Technology Outlook—2050 (WETO-H2) (2006)
- European Commission's Directorate-General Energy and Transport: The Future of Transport—Focus Groups' Report (20 February 2009)
- European Commission's Directorate-General Energy and Transport/Tetraplan A/S: Report on Transport Scenarios with a 20- and 40-Year Horizon. TRANSvisions, March 2009.
- European Commission's Directorate-General Energy and Transport: European Energy and Transport—Trends to 2030 (April 2008)
- European Commission's Directorate-General Environment: EU Transport GHG: Routes to 2050?—EU transport demand: Trends and drivers (25 March 2009—DRAFT)
- European Commission's Directorate-General RTD/Andrés Monzón, Adriaan Nuijten: Scenarios for the Transport system and Energy supply and their Potential effects (STEPs)—Transport strategies under the scarcity of energy supply (July 2006)
- European Foundation for the Improvement of Living and Working Conditions/European Monitoring Centre on Change (EMCC): Trends and drivers of change in the EU transport and logistic sector: Scenarios (2008)
- European Technology Assessment Group (ETAG): The Future of European Long Distance Transport. Background Paper for Workshop 28t March 2007
- European Transport Safety Council (ETSC): Managing Speed—Towards Safe and Sustainable Road Transport (2008)

- eSafetySupport: Report on the Progress of the 28 eSafety Recommendations (January 2008)
- Federal Ministry of Transport, Building and Urban Affairs: Masterplan Freight Transport and Logistics (September 2008)
- Forum for the Automobile & Society: Environmental Issues
- Forum for the Automobile & Society: Mobility Issues
- German Advisory Council on Global Change (WBGU): Climate Protection Strategies for the 21st Century: Kyoto and beyond (2003)
- Hamburgisches WeltWirtschaftsinstitut (HWWI): Biokraftstoffe und Nachhaltigkeit—Ziele, Probleme, Instrumente, Lösungen. HWWI Policy Report 5. (November 2007)
- Heiko A. von der Gracht: The Future of Logistics—Scenarios for 2025. Gabler Edition Wissenschaft, January 2008.
- IFMO: Mobilität 2025—Der Einfluss von Einkommen, Mobilitätskosten und Demografie (2008)
- Ifmo: Zukunft der Mobilität—Szenarien für das Jahr 2025 (2003)
- Information Technology for European Advancement (ITEA2): ITEA Roadmap for Software-Intensive Systems and Services (2009)
- International Association of Public Transport (UITP): Public Transport in 2020—From Vision to Action (2005)
- International Energy Agency: World Energy Outlook 2006
- International Energy Agency: World Energy Outlook 2007, Executive Summary—China and India Insights
- International Road Transport Union (IRU): Comparative Analysis of Energy Consumption and CO₂ Emissions of Road Transport and Combined Transport Road/Rail (2002)
- International Road Transport Union (IRU): Did you know...? Facts on Road Transport and Oil (2007)
- IPCC Climate Change Synthesis Report/Fourth Assessment report—Summary for Policymakers (November 2007)
- Logistics Research Centre, UK: Decoupling of Road Freight Transport and Economic Growth Trends in the UK—An Exploratory Analysis (2006)
- Ludwig-Bölkow-Systemtechnik GmbH (LBST): Alternative World Energy Outlook (AWEO): Woher kommt der Wasserstoff? Eine Analyse der globalen Energiesituation (2007)
- McKinsey & Company/Erdmann et al.: DRIVE—The Future of Automotive Power (2006)
- Nicholas Stern: The Economics of Climate Change (October 2006)
- OECD: Infrastructure to 2030
- Roger Deckers at TRA 2008: Sustainable mobility for everybody—complementary solutions for passenger and commercial transportation (2008)
- Shell Nachhaltigkeitsbericht 2006: Lösungen für die Energiefrage (2006)
- Shell: Fuelling mobility—The evolution of road transport fuels continues (February 2007)
- Shell: People and Connections: Global Scenarios to 2020—Public Summary (2002)
- Shell: Pkw-Szenarien bis 2030—Flexibilität bestimmt Motorisierung (April 2004)
- Shell: Shell energy scenarios to 2050 (2008)
- Siemens AG, Prof. Dr.-Ing. G. Spiegelberg; Presentation Berlin, 2 July 2008. All electrical car in it's environment—enabler and interfaces
- SWOV Institute for Road Safety Research: Advancing Sustainable Safety—National Road Safety Outlook for 2005–2020 (2006)
- The Center for Health and the Global Environment, Harvard Medical School: Climate Change Futures—Health, Ecological and Economic Dimensions (September 2006)

ERTRAC Road Transport Scenario 2030+

- The King Review of low-carbon cars, Part 1: the potential for CO₂ reduction. HMSO, October 2007.
- The King Review of low-carbon cars, Part 2: recommendations for action. HMSO, March 2008.
- UK Foresight: Intelligent Infrastructure Futures (January 2006)
- United Nations Millennium Project: 2007 State of the Future—Executive Summary (2007)
- United Nations: The Millennium Development Goals Report (2005)
- WBCSD: Mobility 2030—Meeting the challenges to sustainability (2004)
- WBCSD: Mobility for development—Facts and Trends (September 2007)
- World Energy Council: Deciding the Future—Energy Policy Scenarios to 2050 (2007)
- WWF: Plugged in—The end of the oil age (March 2008)

D. CONTRIBUTIONS FROM ERTRAC MEMBERS

A number of technical experts have given valuable input to this document in workshops and during the consultation phase. ERTRAC wishes to acknowledge the contributions and advice provided by following Working Group members, stakeholders, and other technical experts to this Scenario Process.

Organisation	Energy & Environment	Long-distance Freight Transport	Urban Mobility	Road Transport Safety
CLEPA / Bosch	Martin Kruessmann			
CLEPA / Bosch	Kerstin Mayr			
CLEPA / Delphi	Dominique Mormont			
CLEPA / Delphi				Lali Ghosh (Co-Chair)
CLEPA / Ricardo	Nick Powell			
EUROBAT	Erwin Marckx			
LUBRIZOL		Ian Bown		
Valeo	Michel Lifermann			
ERTICO			Maxime Flament	
ERTICO				Maxime Flament
ERTICO		Zeljko Jeftic		
ITS Sweden			Job Klijnhout	
Austriatech		Stephan Helmreich		
FEHRL / Arsenal				Stefan Deix
FEHRL / Danish Road Administration	Michael Larsen			
FEHRL/BRRC			Wanda Debauche	
FEHRL/LCPC		Bernard Jacob		
FEHRL/TRL		Iain Knight (Co-Chair)		
UITP			Ulrich Weber	
UITP			Yves Amsler	
EMTA			Sabine Avril	
POLIS	Sylvain Haon		Sylvain Haon (Co-Chair)	
DHL		Peter Sonnabend		
Daimler	Joerg Wind			

ERTRAC Road Transport Scenario 2030+

Organisation	Energy & Environment	Long-distance Freight Transport	Urban Mobility	Road Transport Safety
EUCAR	Coda Alessandro			
EUCAR				Alessandro Coda
EUCAR / CRF				Gianfranco Burzio (Co-Chair)
EUCAR / Volvo	Göran Wirmark			
EUCAR / Volvo				Karin Svensson Magnus Rilbe
EUCAR / VW	Ulf Stolte (Co-Chair)			
EUCAR/CRF			David Storer	
EUCAR/Scania		Anders Johnson		
EUCAR/Volvo			Laurent Colpier	
EUCAR/Volvo		Helene Niklasson (Co-Chair)		
Renault			Jean Grebert	
TEC (SMMT)	Geoff Callow			
Volkswagen			Maria Schnurr	
CONCAWE	Ken Rose (Co-Chair)	Ken Rose	Ken Rose	
European Biofuels Platform	Harri Turpeinen			
Academia / Thessaloniki University	Zisis Samaras			
Austrian Road Safety Board				Klaus Machata
BAST				Stefan Matena
BAST		Klaus-Peter Glaeser		
BRRC				Cocu Xavier
EARPA / APTL	Athanasios Konstandopoulos			
EARPA / Arsenal Research	Manfred Haider			
EARPA / Arsenal Research	Margit Noll, Ms			
EARPA / CIDAUT	Francisco Vicente Tinaut Fluixa			
EARPA / Czech Technical University Prague	Jan Macek			
EARPA / FEV	Gerhard Lepperhoff			
EARPA / FEV	Christoph Bollig			

ERTRAC Road Transport Scenario 2030+

Organisation	Energy & Environment	Long-distance Freight Transport	Urban Mobility	Road Transport Safety
EARPA / IFP	Christian Angelberger			
EARPA / IKA	Felix Töpler			
EARPA / IKA				Peter Urban
EARPA / K.U.Leuven	Bert Pluymers			
EARPA / K.U.Leuven				Bert Pluymers
EARPA / OTAM	Cem Sorusbay			
EARPA / Ricardo	Nick Owen			
EARPA / SAFER				Anna Nilsson-Ehle
EARPA / TECNALIA	Iñaki Inzunza			
EARPA / TNO	Lori Tavasszy			
EARPA / TNO	Arnaud Burgess			
EARPA / TNO	Gerben Passier			
EARPA / TNO				Ton Versmissen
EARPA / University of Firenze	Massimo Delogu			
EARPA / University of Firenze				Marco Pierini
EARPA/AVL		Alexander Holleis		
EARPA/Fraunhofer		Thilo Bein		
EARPA/LMS	Antonio Vecchio			
EARPA/LMS				Stijn Donders
ECTRI			Barbara Lenz	
ECTRI				Pieter van Vliet
ECTRI / INRETS				Jean-Pierre Medevielle
ECTRI / INRETS				Anne Pauzie Jean-Pierre Verriest
ECTRI/INRETS			Claire Plantié Niclause	
Fraunhofer Institute SCAI				Clement-August Thole
IFP		Simon Vinot		
LCPC				Philippe Lepert
LCPC				Nicolas Hautiere
McLean Hazel			Steve Cassidy	
SINTEF Technology and society				Lillian Fjerdings

ERTRAC Road Transport Scenario 2030+

Organisation	Energy & Environment	Long-distance Freight Transport	Urban Mobility	Road Transport Safety
SP Technical Research Institute of Sweden				Susanne Hurtig
Technical Research Institute of Sweden				Jan Jacobson
Technical University Riga				Juris Smirnovs
Tecnia-Robotiker				Alberto Pena
TNO		Henk Dekker		
TNO Automotive				Gjis Kellendonk
University College Dublin		Eugene O'Brien		
University of Southampton			Mike McDonald (Co-Chair)	
University of Southampton			Mark Beecroft	
EIRAC		Valerio Recagno		
EIRAC		Dirk t'Hooft		
ERRAC			Giorgio Travaini	
ERRAC/Banverket		Bo Olsson		
ERTRAC	Rainer Aust	Rainer Aust	Rainer Aust	Rainer Aust
ERTRAC / RWS	Ruud Smit (Co-Chair)			
ESTEP European Steel Technology Platform				Jean Claude Charbonnier