Optimising Passenger Transport Information to Materialize Insights for Sustainable Mobility

Coordination and Support Action FP7- 284892

List of potential Megatrends influencing transport system and mobility behaviour			
Deliverable No.		D.3.2	
Workpackage No.	WP3	Workpackage Title	Demand and supply factors for passenger transport and mobility patterns – status quo and foresight
Task No.	3.2.	Task Title	Future trends and their requirements for passenger transport
Issue Date:	01/06/2012	Revision Date:	28/09/2012
Authors		Mr P. Delle Site and Mr M.V. Salucci (CTL); Ms. M. Hoppe, Ms T. Seppänen and Mr A. Christ (ZHAW); Ms E. Arsenio (LNEC); Ms A. van Grinsven (CE DELFT); Prof. D. Morris, Ms E. Anoyrkati, Mr R. Brooks (CUE); Mr M. Hepting (DLR); Mr M. Kompil (JRC); Ms E. Tavlaki and Mr D. Micharikopoulos (SIGNOSIS); Mr L. Akkermans (TML).	
Status (F: final; D: draft; RD: revised draft		F	
Distribution		PU	
Document ID / File Name		D3.2 List of potential megatrends.docx	

Table of contents

EXECUTIVE SUMMARY

The OPTIMISM project is a Coordination and Support Action of the 7th EU Framework Programme. Its objective is to develop strategies based on co-modality ICT solutions for optimising passenger transport systems with the intention of defining which of the future changes in the travel system would lead to more sustainable ways of travelling.

One of the main tasks of OPTIMISM is building scenarios for modelling the impacts of different transport strategies on the passenger transport system. One of the steps in this process is the identification of key factor trends affecting the passenger transport systems.

Another task is the identification of so called Megatrends, which are fundamental, long lasting (more than 10 years), global (or at least international) and transformation processes leading in a certain direction. Those Megatrends are characterised by their broad scope affecting multiple aspects of life. Therefore they are stable over time – or at least over years or decades. The use of Megatrends in OPTIMISM permits the project to include long lasting direct or indirect effects on transport systems, which is needed for modelling the horizon of 2030 and 2050.

The first part of deliverable D3.2 includes the results of the analysis of literature sources performed to find evidence on **trends of key factors**[1]. D3.2 includes a summary of the results in Chapter 2 "Trends of key factors and causal patterns"[2]. This analysis is limited to the literature sources which have been identified by project partners. A Delphi survey, which will involve experts from all over Europe, will provide further insight and will fill gaps identified in the literature review.

According to the conceptual framework for the analysis of sources
(
Figure 1), key factors have been grouped into:

1. External key factors (chapter 2.1): as they relate to those variables which are not specific to the passenger transport system but impact on it and contribute to shape its development.
2. Policy actions (chapter 2.2): as key factors they coordinate and steer the development of social and economic systems as well as transport systems
3. The key characteristics of the passenger transport system (chapter 2.3): the interaction between supply and demand in the transport determines the system performance and mobility patterns.

[1] Annex 1 "Database of sources for literature review" contains the details of sources identified by project partners drawing on their own databases of publications as well as national and international studies, libraries, scientific journals and on the Internet.

[2] Annex 3 "Complete description of trends of key factors and causal patterns" contains the full reporting on the analysis of key factors trends and causal patterns.

The report also includes a description of causal patterns (chapter 2.4) [3]. Interrelationships between key factors have been identified which permits better insight into the mechanisms which shape future passenger transport scenarios.

Based on the results of the analysis on key factors combined with expert knowledge eleven **Megatrends** have been identified:

- Globalisation 2.0
- World Population Growth
- Urbanisation
- Increase of Inter-/Intra-national Social Disparities
- Demographic and Social Change
- The Knowledge Society and Economy
- Climate Change and Environmental Ethics
- Shortage of Resources
- Technology Change
- European Market Deregulation
- Crisis of Mobility

The identification of Megatrends permits us to select the most significant key factors for the definition of future scenarios. Also the impact of the Megatrends on selected key factors has been analysed by expert consultation during a workshop. One of the results was that experts agreed overall with the list elaborated before, while the Megatrends were assessed to have quite different impact on the factors of the transport system. Urbanization has been rated as the main important Megatrend with impact on the transport system, followed by Shortage of Resources and Globalisation 2.0. As global trends are likely to have a great impact on the transportation system; this has to be taken into account when elaborating policy strategies.

The results of this deliverable provide preliminary information for the scenario building activities which will also be performed as part of OPTIMISM WP3. Gaps in key factors trends will be filled during the expert workshop whose main objective is the identification of scenarios for modelling the implementation of ICT-based co-modality strategies for the optimisation of transport systems. In addition, during the workshop, gaps and lack of information on the Megatrends affecting transport systems will be filled.

The result of the expert workshop and the result of the Delphi survey on scenario building will be the subject of the next deliverable of WP3: D3.3 "Delphi expert report on the future scenarios of transport and mobility".

[3] Annex 2 "Table of key factor causal patterns" this summarises only causal patterns identified by partners on the basis of evidence collected by analysing the identified sources.

1 Introduction

OPTIMISM project is a Coordination and Support Action of the 7th EU Framework Programme. Its objective is to develop strategies based on co-modality ICT solutions for optimising passenger transport systems with the intention of defining which future changes in the travel system are most likely to lead to the most sustainable way of travelling.

OPTIMISM includes a group of activities (WP3) aimed at providing an insight into the key factors that shape passenger transport systems and mobility patterns as well as identifying possible future trends. WP3 intends to create scenarios for modelling the impact of the implementation of co-modality ICT-based strategies for the optimisation of passenger transport systems.

The objective of Task 3.1 of WP3 was the identification of relevant key factors affecting passenger transport systems. OPTIMISM deliverable D3.1 "Research scheme for transport system and mobility behaviour" (OPTIMISM, 2012) includes a list of identified key factors classified according to specific topic areas.

This deliverable (D3.2) is the first document produced within the task 3.2 of WP3 whose objective is to identify trends of the key factors and define scenarios which will be the input to task 3.3 "Modelling future mobility".

This deliverable reports on the analysis of literature sources relating to key the factors and their trends. It also reports on causal patterns: the identification of the interrelationships between the key factors permits a better insight into the mechanisms which shape future passenger transport. Finally Megatrends, defined as global pressures/drivers of change on the world passenger transport system such as the intensified global competition for resources, were identified.

The analysis of literature sources is limited to those sources which have been identified by project partners drawing on their own database of publications as well as national and international studies, libraries, scientific journals and on the internet. Annex 1 contains the database of sources collected by project partners and is organised in two main groups: "Grey" literature is associated with projects which have produced reports or have put in place a website; "True" scientific literature is found in books, papers in journals and papers in conference proceedings.

The definition of trends and causal patterns for key factors, which were not covered by the reviewed literature, will be made on the basis of expert opinions in order to have a complete picture of future development for the definition of scenarios.

Figure 1 shows the Conceptual Framework for the analysis of sources.

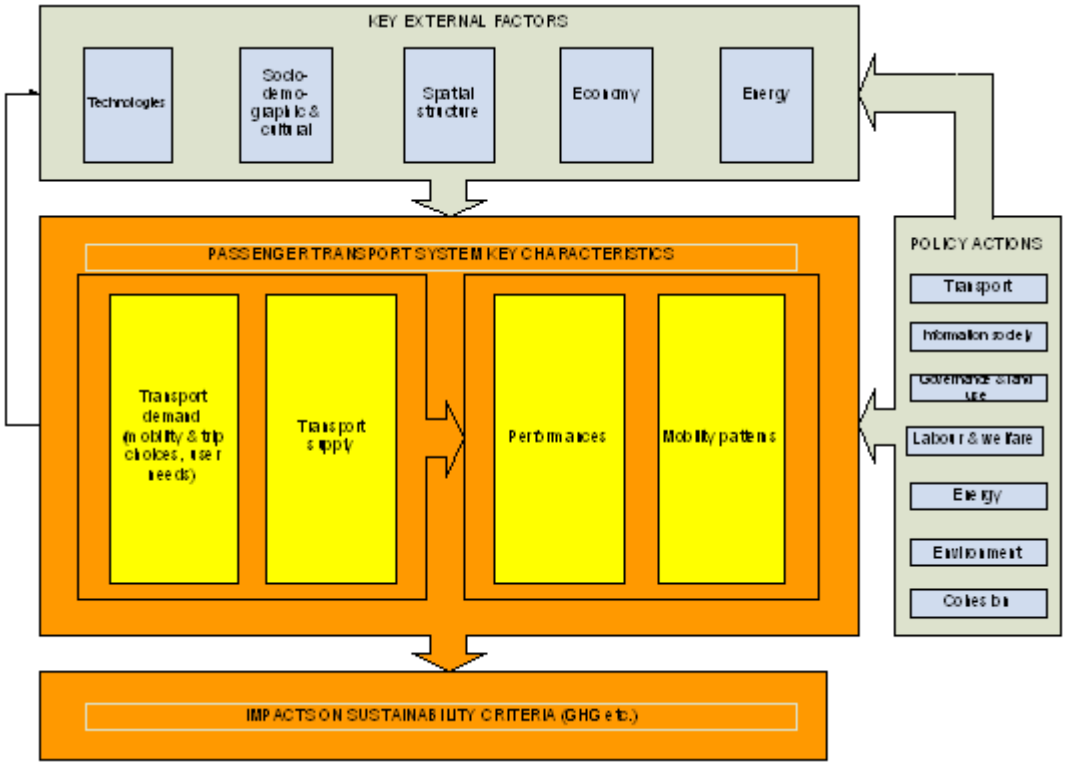

Figure 1 - The conceptual framework for the analysis of sources.

The conceptual framework consists of four main components which are interrelated.

The core is the passenger transport system: the interaction between supply and demand of transport determines system performances and mobility patterns. The way the transport system performs generates impacts which can be compliant or not with sustainability criteria.

Then there are the external key factors and policy actions which interact with the passenger transport system. External key factors relate to those variables which are not specific to the passenger transport system, but have impacts on it and contribute to shape its development. They include socio-demographic and cultural factors, spatial structure, economy, energy and technologies. Policy actions are the fundamental instruments used to coordinate and steer the development of social and economic systems and naturally the development of transport systems. Therefore, policy actions have impacts on the development of both external key factors and passenger transport system key characteristics.

The fourth component relates to the impacts on sustainability criteria caused by the key characteristics of the passenger transport system.

On the basis of the conceptual framework and the desk research scheme outlined in D3.1, a number of topic areas have been identified and allocated to partners on the basis of their competence (Table 1).

Table 1 – Allocation of key factor topic areas

External key factors	*Policy actions*	*Passenger transport systems*
ICT for information society and ICT enabling technologies	Information society	
Socio-demographic and cultural factors Spatial structure	Governance & land use	Driving licencing Vehicle ownership
Economy	Competition Labour and welfare	
Propulsion and vehicle technologies Energy	Transport (internalisation of externalities,subsidies and incentives, infrastructure planning) Energy Environment	
	Urban and metropolitan transport	Urban and metropolitan transport
	Interurban transport Cohesion	Interurban transport
		Global trends in mobility patterns and in impacts on sustainability criteria
ICT for transport applications		

For each assigned topic area project partners were asked to identify events, trends and causal patterns. They were asked to separately consider studies relating to past developments and studies relating to future trends (forecast).

The suggested steps for the analysis were as follows:

- to specify the phenomena that can be observed and the important events;
- to discover the trends in terms of time and space (i.e. which is the time frame of the trend and where is the trend detected: in which country, region etc.);
- to identify key indicators for which the time series and quantitative forecasts are available;
- to infer causal patterns among variables, i.e. the interrelationships between factors ("cross-impact" impacts).

This document comprises the following parts in addition to this introduction.

Section 2 reports on the results of the analysis of sources, in other words on the evidence collected from literature on key factors, their trends and causal patterns.

Section 3 illustrates a list of Megatrends based on the evidence collected from literature review and on the basis of project partners' experience.

The full reporting of the analysis of the trends of key factors and causal patterns can be found in the Annex 3.

Besides Annex 3, this deliverable includes:

- Annex 1 "Database of sources for literature review", which contains details of sources identified by project partners drawing on their own database of publications and national and international studies, libraries, scientific journals, and on the Internet (the annex is in the form of a separate Microsoft Excel™ file);
- Annex 2 "Table of key factor causal patterns", which summarises only causal patterns identified by partners on the basis of evidence collected by analysing identified sources (the annex is in the form of a separate Microsoft Excel™ file).

2 Trends of key factors and causal patterns

2.1 External key factors

Key external factors relate to those variables which are not specific to the passenger transport system, but have impacts on it and contribute to shape its development.

Key external factors include socio-demographic and cultural factors, spatial structure, economy, energy and technologies.

2.1.1 ICT for information society and ICT enabling technologies

According to a vision of road transport provided by ERTRAC (2009), by 2030, a **highly integrated and service driven information society will emerge** 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% of the European population will live, **a wide variety of online 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 personalised 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 developments will reduce social exclusion and ensure consumer access to information and cost-effective mobility options, comparable to those living in urban environments** (ERTRAC, 2009).

2.1.2 Socio-demographic and cultural factors

2.1.2.1 Past trends

The global population has been steadily growing during the past 60 years, but with clear regional differences. **In Europe population growth has stabilized** (EEA, 2011a). At the national level, some European countries show stagnating or declining populations (Germany, Hungary and Croatia), and some others show population

growth (Belgium, the Netherlands and Austria) (USEmobility, 2011; InnoZ-Bausteine, 2008).

Past demographic trends in Europe show decreasing child birth rates and increasing life expectancy, which lead to ageing populations (Rudinger G. et al., 2006; Brög W. et al., 2005). People older than 65 years currently make up to over 12% of the total population in Europe (Rudinger G. et al., 2006).

The changing lifestyles in Europe in the past two decades have created a growing demand for personal transport. Individual mobility has become essential because of separated locations of residential, work and leisure activities and more spread out social networks (Donaghy K., 2004). During the past two decades most of the OECD countries have achieved a complete motorisation and the domestic expenditures on travel and communication have almost doubled since the early 1900s (Donaghy K., 2004).

Seniors are becoming more mobile than in the past and the amount of yearly trips of the elderly has almost doubled (Kotavaara O. et al., 2011; Frändberg L. et al., 2011; Dejoux V. et al., 2010).

2.1.2.2 *Future trends*

If past trends show a stable global population growth, the future projections vary from extreme population growth to a decreasing population. However, **stagnation and ageing of population in Europe is identified in all the projections** (EEA, 2011a).

Age structure projections show an increased life expectancy and a proportional reduction of younger people (EEA, 2011a; EC, 2009a). **An ageing population has been identified in Europe** and specific studies conducted in Germany, the UK and the Netherlands confirm this trend (InnoZ-Bausteine, 2008; Mobil 2030, 2011; Rogge, L., 2005; Su, F. et al., 2009; Harms, L., 2011; Rosenbloom, S., 2002; Rudinger, G., 2006). In many of these countries every fourth citizen will be aged 65 or older in 2020 or latest in 2030 (OECD, 2001; Rosenbloom, S. et al., 2002) and the number of seniors over 80 years is going to triple (OECD, 2001). Eurostat statistics predict that **the share of the elderly above the age 65 in Europe is going to grow from 16% in 2000 to approximately 21% by 2020 and 28% is expected in 2050** (Brög, W., 2005; Rogge, L., 2005). These figures are in line with those provided by another study (Rogge, L., 2005): the population aged over 65 years will increase its share from 17% in 2009 to 30% in 2060.

Another study shows regional differences in the demographic development in Germany. **Due to inter-regional migration the populations in Eastern Germany and in the old-industrialized parts of Western Germany are ageing and declining, whereas the populations in highly competitive regions like Munich, Hamburg or Rhine-Main are still growing** (Lanzendorf M., 2010).

The household structure is changing in most European countries and has an influence on the mobility sector. The average household size has decreased by 10-15% in several European countries. In 1995 the average household in Europe had 2.5

persons, but by 2015 approximately 36% of the households will only contain one person (Brög W., 2005; Rogge L., 2005).

Studies identified some key aspects for the changing lifestyles and values affecting mobility. Key words used to describe the change were individualisation and flexibility (InnoZ-Bausteine, 2008; Rogge L., 2005; Harms, L., 2011). **Demand for individual mobility services will increase**. **Life styles are becoming more versatile, leisure activities are gaining on importance and the everyday life becomes more irregular and quickly changing** (InnoZ-Bausteine, 2008; Brög W., 2005; Rogge L., 2005). Individual mobility needs are strengthened by the liberalisation of working hours and conditions, making working life less regular (Lanzendorf M. et al., 2005).

2.1.3 Spatial Structure

An ESPON study (EU, 2011) **showed that land use has changed drastically in Europe during the last fifty years, sometimes with important negative effects** such as urban sprawl, soil sealing, biodiversity losses, soil erosion, soil degradation, floods or desertification. **Land use specialisation** (urbanisation, natural afforestation, agricultural abandonment or intensification, etc.) **is a major trend identified in the last decade** (SOER, 2010. Quoted in EU, 2011) and has resulted in an inefficient spatial land use distribution.

75% of Europeans live in cities (where most Europe's wealth is generated) **and this percentage is expected to increase to 85% by 2050** (EC, 2011a).

2.1.4 Economy

The European common market and the enlargement process are challenging the national economies and increasing regional and national disparities. (Lanzendorf M. et al., 2005).

World GDP per capita has increased on average by a factor of 3.5 between 1895 and 1995 even though it is distributed rather unevenly across the world being mostly concentrated in the United States and Europe (Sessa C. et al., 2009).

Growth in world output and trade decelerated in 2007. According to the last World Trade Organisation (WTO) outlook, weaker demand in the developed economies reduced global economic growth from 3.7% to 3.4%. GDP growth in developing countries (7%) was significantly higher than in the developed countries (in Europe GDP growth of 2.8% was recorded, a little higher than that recorded in Japan and the United States). The annual growth rate for China was 9.6% in 2008, while it was 10.4 in 2010 and 9.2 in 2011 (IMF, 2012). **The sharp economic deceleration in key developed countries is only partly offset by continued strong growth in emerging economies** (according to World Trade Organisation economists).

According to the analysis presented in the EC DGTREN Trends to 2030 (EC, 2008), in the period 1990 to 2005, the GDP elasticity of transport activity in the EU was estimated at 0.90 for both passenger and freight transport. This is a remarkably high value indicating great dependence of economic and social activity on transport. A

closer look at the period 2000 to 2005 shows that the GDP elasticity of passenger transport in EU remained constant at a level just below one, but for freight transport in EU it became as high as 1.45. This reflects the considerable increase in commodity trading following the EU enlargement and the market integration.

The projections for the EC DGTREN Trends to 2030 assume that values of the GDP elasticity for passenger transport activity will remain stable over time and equal to 0.65. As the values of GDP elasticity of transport activities are lower than one, the trend to 2030 displays in EU a gradual decoupling of transport from GDP growth. (Sessa C. et al., 2009).

2.1.5 Propulsion and vehicle technologies

A drastic improvement in fuel economy is projected by 2020 thanks to improved propulsion and vehicle technologies (WEC, 2011).

The technology mix for cars has been projected for the period from 2015 to 2050, including years 2020 and 2030 for two scenarios: a "freeway" scenario in which pure market forces prevail to create a climate for open global competition; a "tollway" scenario where governments decide to intervene in markets to promote technology solutions and infrastructure development that put common interests at the forefront. The most important result is that both in 2030 and 2050, in the freeway scenario the share of conventional liquid fuel internal combustion engine vehicles (ICEV) would be predominant (84% in 2030 and 78% in 2050). In the Tollway scenario, in 2030 conventional liquid fuel ICEV would be still predominant with a share of 64%, but in 2050 such vehicles would only account for 26% (with liquid hybrids having a share of 26%, liquid fuel plug-ins 18%, electric 16%, and gas vehicles 8%) (WEC, 2011).

Shell (2009) has analysed the fuel consumption of different types of propulsion systems with projections until 2030 (petrol and diesel, with and without hybrid-propulsion) in two scenarios: the trend-scenario in which primarily conventional and simple technology is used; the alternative-scenario in which technical developments (like downsizing of engines, new transmissions, better aerodynamics, lightweight constructions etc.) are taken in to consideration. In the trend-scenario, average fuel consumption of the vehicle stock is projected to decrease from 7.8l/100km in 2006 to 6.1l/100km (22% less than the consumption in 2006) in 2030. The alternative-scenario shows a more significant reduction up to 5.2l/100km (41% less than the consumption in 2006).

2.1.6 Energy

A study (EIA, 2011) shows that the total world energy consumption will increase by 53% from 2008 (505 quadrillion Btu) to 2035 (770 quadrillion Btu). Much of the growth in energy consumption occurs in countries outside the Organisation for Economic Cooperation and Development (non-OECD nations), where demand is driven by strong long-term economic growth. In fact, the energy **consumption of OECD members only shows a smaller increase in energy demand (30%) from 2008 (230 quadrillion Btu) to 2035 (300 quadrillion Btu)**.

The same study (EIA, 2011) has provided forecasts for oil price developments until 2035. In the High Oil Price scenario, world oil prices are about $200 per barrel in 2035 ($320 per barrel in nominal terms[4]), while in the Low Oil Price scenario, world crude prices are $50 per barrel in 2035 ($80 per barrel in nominal terms). In the reference case (do-nothing scenario) the price is $125 per barrel ($200 per barrel in nominal terms).

In addition to the general energy consumption, the EIA study provides an overview of world liquid fuels consumption. Consumption of petroleum and other liquid fuels increases from 85.7 million barrels per day in 2008 to 112.2 million barrels per day in 2035 in the reference case. **World liquid fuel consumption is expected to increasingly grow from 2011 and beyond, as economic growth strengthens, especially among the developing non-OECD nations**. In the long term, world liquids consumption is projected to increase despite world oil prices that rise to $125 per barrel by 2035. More than 75 percent of the increase in total liquids consumption is projected for the nations of non-OECD Asia and the Middle East, where strong economic growth and, in the case of some Middle East countries, access to ample and relatively inexpensive domestic resources drive the increase in demand (EIA 2011).

To satisfy the increase in world liquids demand in the reference case, **liquids production increases by 30% from 2008 (86 million barrels per day) to 2035 (112 million barrels per day)**, including the production of both conventional liquid supplies (crude oil and lease condensate, natural gas, plant liquids, and refinery gain) and unconventional supplies (biofuels, oil sands, extra-heavy oil, coal-to-liquids, gas-to-liquids, and oil shale).

International fossil fuel (oil, gas and coal) prices are projected to increase from 2010 to 2030: oil prices will reach 88$'08/bbl[5] in 2020 and 106$'08/bbl in 2030; gas prices follow a trajectory similar to oil prices reaching 62$'08/boe in 2020 and 77$'08/boe in 2030; finally, coal prices will reach 26$'08/boe in 2020 and 29$'08/boe in 2030 (EC, 2010).

2.2 Policy Actions

Policy actions are important key factors affecting the transport system. They have to take into account a broad variety of socioeconomic aspects and react to actual developments. Policy actions have been considered for different fields such as transport, energy, environment, urban and interurban transport; they have been structured by their focus of measures.

[4] In nominal terms means the price of oil in dollars at the time it is traded, while in real terms means the price of oil corrected for inflation.

[5] $'08 stands for US-Dollars of the year 2008.

2.2.1 Transport

2.2.1.1 Investments

The transport investment strategy in Western Europe from 1975 up to 1999 has been characterized by an initial decline till the late 1980s when the investment levels rose again to peak in 1992. From 1992 to 1999 there was a decline in investment in Western Europe and an increase in Central and Eastern Europe (Short and Kopp, 2005).

In terms of percentages of GDP, the trend follows a similar pattern: a decline since the 1970s in Western Europe with a brief increase in the late 1980s, and an increase in Central and Eastern Europe in the 1990s. The investment level reached in the Western countries in the 1990s was 1 % of GDP, which was roughly the norm over many years in countries which are generally considered to have good transport infrastructure, like France or Germany.

2.2.1.2 Internalisation of externalities

The internalisation of external costs (externalities) is integrated in the list of policy measures designated as "smart pricing and taxation". **The White Paper "Roadmap to a Single European Transport Area" (EC, 2011a) declares that transport charges and taxes must be restructured in the direction of wider application of the 'polluter-pays' and 'user-pays' principles**. It also points out that the internalisation of externalities, the elimination of tax distortions and unjustified subsidies and free and undistorted competition are therefore part of the effort to align market choices with sustainability needs. They are also necessary to establish a level playing field between modes which are in direct competition. For passenger cars, road charges are increasingly considered as an alternative way to generate revenue and influence traffic and travel behaviour. The Commission will develop guidelines for the application of internalisation charges to all vehicles and for all main externalities.

Regarding transport policy trends, a key issue is the optimisation of transport demand through the internalisation of the external costs of transport (satellite-based road pricing systems, which can adjust prices according to location and time are envisaged; these will allow price to be used to optimise demand at peak congestion times) (EEA, 2011).

2.2.1.3 Infrastructure planning

The EU is aware of the need for a coherent funding framework for transport infrastructure and is expected to support the development and deployment of technologies that improve infrastructure use, efficiency and decarbonisation.

The EC describes **a number of measures for infrastructure planning and financing** in its White Paper (EC, 2011a). The main aspects relate to **the development of the Trans-European Transport network (TEN-T), the deployment of technologies that improve infrastructure use, efficiency and decarbonisation, the compliance of infrastructure with sustainability criteria,**

multimodal transport, and the development of Public-Private Partnership schemes.

2.2.1.4 *Transport policy Megatrends*

The following transport policy and planning trends have been identified as having a megatrend character:

- **Increasing policy awareness of the importance for the integration of transport and land use (spatial) planning** (EC, 2011a; EC, 2011b);
- **The lack of effective policy tools to internalize the long-term international costs of climate change and the belief that policy should tend towards a global-term carbon price** (Zachmann, G. et al. 2012).
- As Stead and Banister (2003) argue, long-term planning decisions must be as robust as possible to cover all future challenges in the policy-making environment. This calls for **a new approach for identifying ex ante** (and ex post on a regular basis) **all impacts of policies under different types of conditions, aiming to identify which policies are cost-effective and robust**. This would represent change in the planning paradigm and an inflection point from past EU transport policy to a more sustainable future.
- **Restructuring of future taxation systems in Europe** (e.g. for passenger vehicles) may encompass different approaches and encourage innovation.

2.2.2 Energy

In the WEC Energy Policy Scenarios 2050 study (WEC, 2007), four scenarios have been developed in order to show the energy intensity which will be demanded in the future, combining two variables: the development of government engagement, and intensity of cooperation. The result is that in all four scenarios the **percentage change in global energy intensity** (expressed as the rate between energy consumption and GDP) **is expected to decline**; the amount of the reduction depends on the specific scenario.

2.2.3 Environment

2.2.3.1 *Noise emissions*

EU has issued the Directive 2002/49/EC relating to the assessment and management of environmental noise stress on strategic noise mapping. In this Directive stress is placed upon the development (by Member States) of strategic noise maps showing the situation in terms of noise emissions. Furthermore, Member States must draw up action plans designed to manage, within their territories, noise issues and effects. Member States must also involve the public in the action plan development (CEC, 2008).

2.2.3.2 *GHG mitigation*

The EU is well aware of the need to drastically reduce world greenhouse gas emissions, and, consequently, limit climate change. EU aims at reducing emissions by 80-95% below 1990 levels by 2050. Commission analysis shows that while deeper cuts can be achieved in other sectors of the economy, a reduction of at least 60% of GHGs by 2050 with respect to 1990 is required from the transport sector, which is a significant and still growing source of GHGs. **By 2030, the goal for transport will be to reduce GHG emissions to around 20% below their 2008 level**. Given the substantial increase in transport emissions over the past two decades, this would still put them 8% above the 1990 level (EC, 2011a).

However, it has been pointed out that transport is the only sector in the EU in which greenhouse gas emissions continue to rise (Egenhofer, 2011). Therefore, unless this trend can be reversed, the EU will have little chance of reaching its objectives in the context of global obligations to reduce emissions between 80% and 95% by 2050 compared to 1990 levels.

In this respect, **a number of policies have the potential to reduce transport GHG emissions**.

Those targeting fuel economy and fuels arguably can act quickest but will not be sufficient to reach ambitious GHG reductions over the longer term (OECD/ITF, 2009). As noted by Kunert and Kuhfeld (2007), the market value of future fuel savings may be small because of imperfections in the market for fuel economy. Therefore, additional instruments (example: system of rebates for high fuel economy vehicles combined with fees levied on lower fuel economy vehicles – "feebates") aimed at influencing the vehicle purchase decision may correct this distortion.

Zachmann, G. et al. (2012) recognize that a consistent policy approach will be needed to allow a friendly decarbonisation growth and also to extend carbon pricing both in time and space. To ensure economic efficiency, the carbon price needs to be aligned across sectors, over time and across regions, and hence (Zachmann et al., 2012) argue that:

- marginal abatement costs have to be aligned across sectors to minimize welfare losses, and emissions shall be reduced in those sectors in which lower costs are involved;
- the price signal must have a long term component such that pollution rights will be scarce beyond 2020 to encourage low-carbon investments;
- the price signal has to account for international spill-overs in such a way as to provide incentives for low carbon technologies to help reducing emissions outside Europe as well.

Regarding other policy responses to resolving the infrastructure externality, Zito and Salvo (2011) conclude that **direct subsidies or indirect finance through higher fossil fuel prices for fuelling stations using a given technology (e.g. hydrogen) will be very difficult to implement politically**.

Technological innovation has the potential to deliver larger emission reductions on a much faster track than changes in travel and settlement patterns. A consistent finding of the study of the International Transport Forum (OECD/ITF, 2009) was that many technology and fuel-related GHG reduction measures in the transport sector are available at relatively low cost or may even save money over time.

This ITF report (OECD/ITF, 2009) identified other measures for reducing GHG emissions which might be adopted by policy-makers: road traffic management, demand management, mode shift (PT, cycling and walking) opportunities that help to reduce CO2 emissions in some cities depending on local and national circumstances.

As regards transport policy trends, a key issue is the reinforcement of fuel taxes towards fair energy carbon taxes (a result of the future electrification of transport and the increasing use of alternative fuels) (EEA, 2011b).

2.2.4 Urban transport

2.2.4.1 Integrated mobility plans

When taking land-use planning or location decisions, public authorities and companies often do not properly take into account the consequences of their choices on the operation of the transport system as a whole, which can generate inefficiencies. The problem is particularly acute in urban areas. Significant changes in urban mobility require comprehensive actions that bring together land-use planning, road use and parking, transport pricing, infrastructure development, public transport policy and much more. Achieving integrated and sustainable urban transport is an increasingly complex task which touches upon many stakeholders and interests. **A greater coordination of all authorities having an influence on the transport system is highly desirable, possibly bringing together the responsibilities for land-use and transport planning, public transport, road use and transport infrastructure**. Equally desirable is an extension of activity by these authorities to co-ordinate transport policy beyond the strict city borders, so as to cover entire metropolitan areas or regional transport systems (EC, 2011b).

The demographic trends of an increasingly ageing population will create new mobility patterns and needs, as well as a strong demand for a seamless, flexible, more attractive and more user-friendly mobility system. This will be achieved through **better information and integration between all modes** of collective and individual private transport (including walking and cycling), as well as through better land use planning (ERTRAC, 2004).

However, integration between transport modes is still far from being achieved. Multimodal infrastructure such as integrated rail-air-public transport nodes for passengers is not sufficiently developed. **Exchanging data between the modes is difficult because of the co-existence of non-interoperable modal IT systems** (EC, 2011b).

The various transport modes are in general expected to maintain their relative importance at EU level. Passenger cars would represent almost 70% of total passenger activity in 2030 and 67% in 2050, although this would correspond to a decrease of 6 percentage points in modal share by 2050 compared to 2005. Air transport on the contrary is expected to increase its share, reaching almost 15% of total activity in 2050 and consolidating its position as the second most important passenger mode. The increase in air transport demand is a result of the expected increase in the number of trips per person and year and the average distance per trip. Rail will improve its share moderately, gaining less than 1 percentage point by 2050, up to 8% of passenger transport (EC, 2011b).

2.2.5 Interurban transport

The strong increase in road transport in the 1990s has led to high levels of congestion and air and noise pollution which are not sustainable in the long run. **Shifting the balance between transport modes is one of the main objectives of the 2001 White Paper**; **this objective can be pursued by regulating the competition between transport modes and, in particular, by promoting intermodal/co-modal transport**.

The modal share of private car in passenger transport is still by far the highest (more than 72% of all motorised intra-EU passenger transport), even though, from 1998 to 2008, its share has gone down by almost 1%. Intra-EU air transport has mainly contributed to this reduction, which in the same period has increased by 37%. In spite of the slight decrease in modal share, **the motorisation level has continued to increase, mainly because of developments in the 12 new Member States** where a 60% increase has been recorded since 1998. In particular, from 2005 and 2008, more than 4 million cars have been added each year to the vehicle stock in the EU (EC, 2011b).

2.2.5.1 Infrastructure planning

The higher motorisation levels together with the development of high-speed rail and increased passenger transport air traffic has resulted in an increase by 7% of passenger-kilometres per inhabitant between 2000 and 2008 in the EU. However, the framework conditions in which this development was possible are changing; the ever increasing oil prices, stricter environmental constraints and the limited resources for infrastructure expansion draw the line at future development of transport system (EC, 2011b).

One of the main challenges is to cope with the increasing demand for transport and the limited resources for infrastructure expansion and the environmental impacts of infrastructure.

"***In many places, the current capacity of transport networks is not able to meet the demand that is, or will be, regularly placed on them****… When networks are overused, journey times lengthen and reliability suffers*" (EC, 2011b).

"***The building of new infrastructure to reduce congestion and accommodate higher levels of traffic is less and less a practicable solution***. *The impact of*

infrastructure on the environment is a growing concern. In addition, the current economic crisis reasserts the importance of putting budget accounts into a long-term sustainable path. This implies reducing public deficit and debt and improving the quality of public finance. ***More cost-effective solutions would have to be found to tackle congestion than relying on expanding 'hard' infrastructure***" (EC, 2011b).

Integration of the EU infrastructure

The level of integration of the EU transport market remains low in comparison to other parts of the economy. A genuine EU-wide internal market exists only in air transport, while other transport modes suffer from different degrees of fragmentation along national borders; this concerns in first place rail and inland waterways, but road and short sea shipping are also affected (EC, 2011b).

The EU has an ambitious policy for the development of the TEN-T to ultimately achieve a single multimodal network that is both logistically efficient and environmental friendly. The White Paper envisaged the establishment of a firm long-term infrastructure plan for the completion of a core network by bridging missing links and enhancing its efficiency using ITS and smart mobility solutions and encouraging multimodality (EC, 2011b). This plan includes 30 priority projects.

In 2010, only 5 of these priority projects were completed, and by the end of 2009 more than 40% of the nearly 400 billion € of projected costs for the 30 priority projects had been invested. Part of the interventions relates to the development of high-speed/high-capacity rail lines. In recent years, the development of high speed rail lines in Germany, Italy, Spain, France and the Benelux countries has improved accessibility and proven that improved rail systems can take away market share from air and road transport (EC, 2011b).

However, the Trans-European Transport Network planning showed some weaknesses. The most important weakness is the lack of international cooperation and coordination between national infrastructure planning and EU level planning, which resulted in a number of inefficiencies. Furthermore, national infrastructure planning appears to focus more on individual transport modes rather than the integration of modes. Furthermore, "*national and European infrastructure projects have largely focused on developing individual priority projects rather than on creating a network. Infrastructure planning and assessment of individual projects failed to give an accurate representation of wider effects of infrastructure projects and of how these projects contribute to the overall infrastructure network*" (EC, 2011b).

2.2.5.2 *Priorities in infrastructure investment policy*

Infrastructure needs to be carefully planned and prioritised with a view to optimising transport chains and the overall transport network. In addition to the removal of bottlenecks, it will be essential to identify green corridors in order to reduce congestion and environmental pollution. Infrastructure projects include the European global navigation satellite systems (Galileo and EGNOS), which will complement the 'traditional' networks and improve their exploitation (EC, 2009a).

The TEN-T policy has much increased the coordination in the planning of infrastructure projects by the Member States. Progress in implementation has been substantial and about one third of the necessary investments (EUR 400 billion) in TEN-T has been made. **The extension of the TENs to cover the new Member States**, building on the investment already made prior to enlargement, **has provided the blueprint for Structural and Cohesion Funds to gradually fill their infrastructure deficits**. Much remains to be done, but the **TENs have already gone a long way in linking EU markets and peoples**. Especially, **progress has been achieved in reducing air pollution and road accidents** (EC, 2009a).

2.2.5.3 *Infrastructure financing*

There are various financial instruments supporting the EU-wide infrastructure projects. The majority of the investments are supported by the TEN-T budget, the Structural Funds and the Cohesion Fund, and loans from the European Investment Bank (EIB).

A significant proportion of the EU budget is currently allocated to co-finance TEN-T projects. As already said in the previous paragraph 400 billion € have been allocated to the TEN-T priority projects. It has been pointed out that co-financing should focus on those projects with a proven economic rationale and with environmental benefits in order to meet the EU climate change objectives. In particular, it was estimated that at least 10% of projected investments in road infrastructure should be re-allocated to rail infrastructure in order to obtain significant shifts from road to rail transport (Rothengatter, 2009; cited in PBL, 2009).

Furthermore, the economic efficiency of TEN-T investment is being debated. In fact, the EU-funded project TIPMAC has pointed out the very small net economic impact of the TEN-T programme (in the period up to 2020), mainly because of the difficulties of a number of transport projects on the corridor list to generate enough transport benefits in the next two decades (PBL, 2009).

2.2.5.4 *Definition of aims in strategic transport planning*

The goal of the **European Transport Policy** is to establish a sustainable transport system that meets society's economic, social and environmental needs, and is conducive to an inclusive society and a fully integrated and competitive Europe. **The most immediate priorities appear to be the better integration of the different modes of transport as a way to improve the overall efficiency of the system and the acceleration of the development and deployment of innovative technologies** — within an approach that always keeps the transport users and workers, with their needs and rights, at the centre of policy-making (EC, 2009a).

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**. This policy framework will result in specific sectoral policies that will be underpinned by a thorough and transparent system analysis to enable each sector to be allocated with its proportional share of responsibilities in meeting the objectives and targets. 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. Strategies will be needed to ensure the growth of energy and transport demand rises at a slower pace than economic growth. Such strategies must consider the demand for personal mobility within the limits of a sustainable society and to avoid social segregation between urban and rural communities. This could be based on creative applications of ICT such as e-commerce, 'e-freight', etc. (ERTRAC, 2009).

The 2006 Mid-Term Review of the Transport White Paper formulated **the objectives of EU transport policy** as contributing to efficient, effective transport in the EU. The key objectives are to (PBL, 2009):

- **offer a high level of mobility to people and businesses** throughout the Union;
- **protect the environment, ensure energy security, promote labour standards for the sector and protect passengers and citizens**;
- **develop and bring to market tomorrow's innovative solutions** that are energy efficient, use alternative energy sources, or support mature, large intelligent transport projects;
- **connect internationally**, projecting the EU's policies to reinforce sustainable mobility, protection and innovation.

2.2.5.5 *Taxation*

In 2007, revenues from environmental taxes in the EU-27 accounted for 2.5 % of GDP and for 6.2% of total tax revenues in the EU. Environmental taxes can be divided into four broad categories: energy (1.8 % of GDP), transport vehicle taxes (0.6 % of GDP) and pollution and resource taxes (0.1 % of GDP taken together). The vast majority of energy taxes are being levied on (mostly road) transport fuels (EC, 2009a).

In this respect, the White Paper envisaged a number of policy measures such as **vehicle fuel taxation based on environmental performance** and **full internalisation of GHG emission cost for all modes** (EC, 2011b):

The diverse structures of passenger car taxation in Europe (EU25 plus Switzerland and Norway) were analyzed by Kunert and Kuhfeld (2007). **Taxes and fees related to the registration, ownership and use of cars are assessed differently across Europe, and their rates vary significantly**. The study found out that the annual taxes levied on specific types of cars differ across countries by a factor of up to four, while the various kinds of duties levied account for extremely diverse shares of the entire car-related tax burden and give rise to very different ratios of fixed and variable components in the taxes levied. As such, given the importance of taxation systems for market and competitive conditions, **the European Commission might seek to achieve the reciprocal alignment of the various systems in member states**.

2.2.5.6 *Cohesion*

"The rise in fuel costs and congestion levels expected by 2030 will further differentiate the levels of accessibility at the regional level. Differently from the accessibility to central areas, the accessibility to suburban areas requires longer average trips and often more expensive modes and networks. The growing centralisation of economic activity at EU level, transport might not be able to sufficiently support economic growth and job creation in the suburban regions" (EC, 2011b).

Christidis and Ibañez (2010) have also pointed out that currently, in the EU, there is a marked division between central and peripheral areas as regards their transport connectivity and costs as a result of geography and patterns of economic activity. In particular, they pointed out that congestion patterns differ significantly among Member States, because of the different local conditions.

Finally, it has been pointed out that the enlargement of the EU to 27 Member States, and potentially more, presents an unprecedented challenge for the competitiveness and internal cohesion of the Union (ESPON, 2007).

2.3 Passenger transport system

The key characteristics of passenger transport include variables related to transport demand and transport supply. The interaction between these variables, whose development pattern is affected by key external factors and policy actions, determines the performances of passenger transport systems and mobility patterns.

2.3.1 Urban and metropolitan transport

According to a study (EC, 2009b), the first item of expenditure in the household budget of EU states are **house-related costs (housing, electricity, water and gas), which account for 21.4% of the total,** followed by **transport-related goods and services, which account for 13.5% of the total budget. The share of transport expenses has been stable over the past years, while the share spent on communication and leisure services** (hotel, restaurants, recreational activities…) increased and the share spent on clothing and food has decreased.

This study also reported that half of this budget is spent on the operation of personal transport equipment (e.g. fuel), while the other half on the purchase of personal transport equipment (e.g. a car) and transport services (e.g. bus, rail, air tickets).

Furthermore, the study mentioned that the average travel time budget per person (estimated to be 1.1 hour a day) had hardly changed over the last 40 years and appeared to be independent of peoples' income. "*This suggests a **greater relevance of the time constraint versus the resource constraint in determining overall levels of mobility**. Whether this trend will hold in an ageing society with more travel-prone retired people remains to be seen*" (EC, 2009b).

Travel surveys show that most trips (97.5%) are short distance (below 100 km). However, the remaining 2.5% accounts for 53% of all passenger-km. Green modes (walking and cycling) are important for trips below 1 km. (EC, 2009b).

As for the purpose of trips, some studies report that 40% are work-related trips, and the remainder are for leisure activities and informal work (such as household work

and child-care). Surveys show, in the most prosperous countries, a trend consisting in the increase of the time devoted to leisure activities (approaching time devoted to formal and informal work) (EC, 2009b).

It has been pointed out that the increase in life expectancy together with improved health allows older people to travel for longer time than previous generations (people tend to travel less when they come to a certain age). Furthermore, old people today travel more than old people did in previous decades, because of, for example, cheaper mobility services (low cost air lines), higher car ownership and a greater availability of mobility (e.g.; cheaper air travel). The travel behaviour of retired people is also affected by their increased average income (EC, 2009b).

2.3.1.1 Mobility behaviour

Ageing populations do have an impact on the mobility sector. Traditionally seniors travelled significantly less than the younger generations. Daily mobility decreases with age, mainly due to health aspects and the drop out of work related travel. **Since the elderly are becoming healthier and increasingly mobile due to leisure activities, social engagements and errands, the total demand for mobility will grow** (Scheiner J., 2006).

Gender issues are influencing mobility patterns. **Women tend to use the public transport much more than men, who mostly drive by private cars** (Duchene C., 2011; Mobil 2030, 2011; Simma A. et al., 2003). This tendency has been identified in few studies from Germany and Switzerland (Duchene C., 2011; Mobil 2030, 2011; Simma A. et al., 2003)). A study from Austria also highlighted the importance of gender when it comes to car ownership and modal transport choice (Simma A. et al., 2003). In general women are making more trips and trips with greater variety than men, but men make more trips by car and travel further (Duchene C., 2011; Simma A. et al., 2003; Rudinger G. et al., 2006).

There are a number of studies looking at the mobility patterns of women in Europe, North America and in Sweden; they noted a change in women's travel patterns towards the mobility behaviour of men. **Women drive a car more often and further than in the past, but still less than men** (Rudinger G. et al., 2006; Frändberg L. et al., 2011). This trend was seen in a study looking at the female mobility patterns in Sweden during 1978-2006. Especially women and men over 65 years started having similar mobility patterns (Frändberg L. et al., 2011). The women also used public transport services less than in the past (Rudinger G. et al., 2006; Frändberg L. et al., 2011).

The changing age structure is affecting the mobility patterns in Europe, Canada and in the USA.

Several other studies (EC, 2009a; Mota Borges I., 2007; OECD, 2001; Rosenbloom S. et al., 2002; Rudinger G. et al., 2006; Mobil 2030, 2011; Alsnih R., 2003) confirm the trend towads a healthier, more active and more mobile future generation of seniors. **The future elderly want to keep their mobile lifestyle and the ability to travel is essential for their independent and active life** (Mota Borges I., 2007; OECD, 2001; Rudinger G. et al., 2006; Mobil 2030, 2011; Donaghy K. et al., 2004; Alsnih R., 2003). The increasing demand for mobility by 2020 in the Netherlands

may be up to 50%, this is explained by the growing group of more mobile seniors over 65 years (Jorritsma P. et al., 2008).

Improved health together with increased wealth, travelling options and language skills support a more active life style including international travelling (EC, 2009a). However, the mobility behaviour of the elderly strongly varies and depends on individual needs and abilities (Scheiner J., 2006). The elderly as a group are very heterogeneous, the largest differences being between the younger and very old seniors over 80 years (Rudinger G., 2006).

2.3.1.2 *Car-sharing*

Shaheen and Cohen (2006) found that Germany, Switzerland and the USA had the higher member-vehicle ratios (a consequence of market diversification and less active car users). The car-sharing market in Europe is predominantly neighbourhood, residential and business. Cost savings, convenient locations, and guaranteed parking were identified as the most common motivations for car-sharing growth worldwide. A continued growth and market diversification of car-sharing schemes is predicted particularly in North America (business, fleet, public transport, university markets), newer markets (e.g. Ireland, Israel, Portugal, New Zealand) and in developing countries in Asia and Africa where it is an emerging market.

High energy prices, demand for innovative solutions and road congestion are expected to act as external drivers for car-sharing expansion, along with raising levels of awareness, expertise and technology developments (Shaheen S. A. et al., 2006).

2.3.1.3 *Demand of PT*

The demand for an accessible and affordable public transport is expected to increase in the future. Access to public transport is important for many of the elderly, since it allows those without access to a car or driving licence to independently visit friends and family and to take part in social and cultural activities (Mota Borges I., 2007; Rudinger G., 2006). The share of older women using the public transport services will grow, even though elderly women more often have a driving licence than men (Rudinger G., 2006). An adjusted tariff system for seniors keeps the public transport services available and is an effective way to simulate the use of public transport modes (Jorritsma P. et al., 2008).

Public transport services focusing on regular commuting will become inadequate and need to be adapted to the changing lifestyles (Brög W., 2005; Rogge L., 2005). If the services are not adapted, people will most likely choose the private car to secure flexible and spontaneous travelling (Rogge L., 2005).

2.3.1.4 *Future scenarios*

There have been attempts to outline future scenarios in the literature. **Regarding urban mobility changes the following trends were outlined** by the ERTRAC (2009) study:

- **Diversification of personal mobility demand** due to a greater choice of (multimodal) mobility solutions and new information services.
- **Significant increase in the demand for public and collective modes of transport** due to socio-demographic changes, urbanisation and urban sprawl.
- **Integration of urban development and environment policies, land use and urban mobility planning**.
- **Increase in private mobility demand hampered by financial and spatial constraints**.
- **Large scale implementation in European cities of demand management strategies.**
- **The use of sustainable transport modes** (like walking and cycling) **will be prioritised for certain trips,** but the use of personal cars in urban environments will not significantly decrease.
- **New services and business models will emerge for urban mobility** (supporting public and collective services, car-sharing, car pooling, etc.).
- **Full integration of information services and e-commerce services into everyday life**.
- **Transport system optimisation by enhanced mobility information combined with ITS**.
- **A more energy efficient urban vehicle fleet.**

According to the ERTRAC Scenario 2030+ (ERTRAC, 2009), ICT will influence urban mobility demand through the deployment of a number of mobility services like seamless door-to-door mobility, teleworking, e-services, the spread of social networks and virtual communities and mobility information services.

2.3.2 Interurban transport

At present, transport is characterised by high transport demand with the trend pointing towards further growth, high levels of congestion, external negative effects, an increasing trend towards motorisation and, associated with this, a high level of injuries and fatalities (FORESIGHT for TRANSPORT, 2004). Some figures relating to transport system past trends are the following:

- From 1991-1999, individual transport demand including road, rail and aviation grew by 18% in the EU15. The corresponding increase in transport demand by 2.1% per year was higher than average annual GDP growth of 1.9%.
- As for freight transport, between 1991 and 1999 demand grew by almost 30% in EU15. The average annual growth rate of 3.3% exceeded the annual GDP growth.

- Between 1990 and 1999, the share of air transport in total passenger transport increased by 50% in the EU15 which corresponds to an annual average increase of 5%.
- Between 1990 and 1999, the share of environment-friendly modes of transport in passenger transport decreased by 1.5% in the EU15.
- In the mid-1990s, in the EU15 infrastructure investments were mainly focused on road transport (63%) while only 20% were allocated to rail.
- The number of cars on European streets increased between 1990 and 2000 by 24% in the EU15, which corresponds to an annual average increase of 2.1%.
- The number of cars in new Member States increased between 1990 and 2000 by 60%, which corresponds to an average annual increase of 6%.

The ERTRAC Vision of Road Transport in 2020 (enhanced mobility, optimised and efficient seamless system) envisages that (ERTRAC, 2004):

- People of all ages, incomes and physical abilities have ready access to convenient transport thanks to a combination of collective transport and private vehicles within a better-integrated intermodal framework.
- The infrastructure network has been optimised through continuous investment. It is regularly monitored, upgraded and maintained to consistently high standards. A more efficient use of infrastructure will help to optimise user services.
- Traffic is smoother. Road networks are efficiently utilized and fully interoperable across Europe allowing the seamless connections of road transport with other transport modes.
- Land-use developments are better integrated with transport planning in order to eliminate unnecessary demand for transport and vehicle parking.
- A range of appropriate technical and policy measures are in place to manage mobility demand. They complement the optimisation of capacity utilisation on the road network and enhance quality of life.
- Real time traffic and road data are available in an integrated information infrastructure to assist traffic management and to improve network management so as to enable people to make informed decisions.
- Interchanges between transport modes provide the consumer with new features and services, including information and communication systems.

2.3.3 ICT for transport applications

2.3.3.1 Travel information services

As for **travel information services**, the following trends have been identified (Spruijtenburg, 2009):

- **From pre-trip to en route information services**. With the recent introduction of mobile internet and affordable connection tariffs, departure and arrival times can now be checked en route by using special smart-phone applications. Also changes have occurred in the information displayed at bus stops and train stations. A trend over the last five years is that digital information displays have also been installed in vehicles so that travellers can be informed during their trip of, for example, an expected train arrival and potential interchanges at the next stop. As a result of these developments, information has become easier to receive and makes travel information less location dependent. Travellers are now able to optimise their travel planning en route.
- **From static data to real-time/dynamic information**. Travellers depended on paper timetables in the past. Paper timetables are a good example of static travel data, because paper timetables only include the planned schedule, but not include any changes in it. Real-time information allows travellers to be informed about congestion areas, accidents and incidents, road works, weather conditions and specific events etc., and consequently travellers are able to optimize in their travel plans in real-time.
- **Types of information**. In the past travel information mainly consisted of information on arrival and departure times and information on prices per separate transport mode. Within the transport sector itself, the scope of travel information has shifted from single-mode information to multi-modal travel information. Besides this multimodal approach, the current scope also includes information related to pre- and post-transport, like information on bike-rent and Park and Ride facilities.
- **Customised information**. Information displayed at railway stations or bus stops is meant to be useful for all travellers, although only a small fraction of all information displayed is relevant for the individual traveller, who might be distracted or might spend a lot of time filtering the overload of information. Due to the increase of personal communication devices, such as mobile phones, travel information becomes more and more personalised. Such devices can filter the information and adapt the travel recommendations to personal preferences, like type of mode or the number of interchanges.

Mobility services

As for **mobility services**, the following trends have been identified:

- **From the ownership of transport modes to use of transport modes**. Examples of these kind of mobility services are bike rental projects like Velib in Paris, public car rental projects (e.g. Greenwheels in the Netherlands), and providers of integrated mobility services for business travel that offer integrated mobility solutions instead of a company car, etc (Shaheen and Cohen, 2007).
- **From single-mode to multimodal transport services**. A good example of this trend is the introduction of smart travel cards, which provide travellers

the opportunity to pay for different kinds of public transport by one credit card-like card. The use of smart cards increases the flexibility of the traveller, because the destination need not be known in advance as with paper tickets. These smart cards may also increase the attractiveness of public transport (particularly for trips to and from railway stations) (Bak and Borkowski, 2010).

Traffic management

The identified trend in traffic management is from stand-alone systems to cooperative systems and finally new types of mobility (Dutch Ministry of Infrastructure and Environment, 2011). Prior to the mid-nineties traffic was mainly managed by stand-alone systems, like individual traffic signs. When the transport system became more complex, integration of the various stand-alone systems was needed and hence network solutions were created. At the beginning of this century so-called cooperative systems were introduced, which provide the opportunity for communication between vehicles or between vehicles and infrastructure. Between 2020 and 2030 these cooperative systems are expected to become the dominant system. However, in the meantime new types of mobility – e.g. fully autonomous private transport modes (see below) - are expected to be developed, which are expected to be mainstream around 2035-2040. At the moment these new types of mobility are still in the early phase of development.

In-vehicle technology

Closely related to traffic management options are in-vehicle technologies. Main identified trends are (Giannopoulos, 2004):

- **Towards autonomous vehicles**. Over the years, cars have been equipped with all kinds of driving assistance systems like cruise control, intelligent cruise control, collision warning and avoidance, lane-keeping support and all kind of navigation systems (Giannopoulos, 2004). This trend will continue and will probably end in completely autonomous vehicles. At the moment it is already technologically possible to let vehicles drive autonomously (without any intervention of a car driver). However, due to non-technical issues (e.g. consumer confidence and legal aspects) the introduction of autonomous driving will , in practice, take years.
- **Towards cooperative systems**. For decades, communication between car drivers was done by light signals, hooting or hand gestures, but there was no interaction between vehicles. However, interaction between vehicles and infrastructure can optimise individual driver assistances. With the help of ICT a car driver can be informed about vehicles approaching outside a driver's range of vision. We can identify the following types of communication within cooperative systems: infrastructure-to-infrastructure; vehicle-to-infrastructure; vehicle-to-vehicle.

2.4 Causal patterns

In this section the causal patterns identified by the analysis of sources are presented. Besides observing the trend of key factors, it is important to identify the interrelationships between key factors. This permits insight into how key factors affect each other, as well as into their impacts on passenger transport characteristics such as mobility patterns. This information is useful in the scenario building process.

As already pointed out, the analysis is limited to literature sources identified by project partners. Further information will be collected by asking experts' opinion in the Delphi survey which is an important step of the scenario building process. Therefore, in the next pages a preliminary picture of interrelationships between key factors and their impacts is provided. In annex 2 "Table of key factor causal patterns" there is a schematic summary of the interrelationships identified by project partners on the basis of the analysis of sources.

2.4.1 Infrastructure planning

Changes in infrastructure are strongly correlated with changes that can mostly be linked to either functional needs (land usage, transport intensity) or changing transport conditions (social or environmental changes). In itself, the availability of transport infrastructure can also have an effect on land usage (e.g. through enhancing urban sprawl), transport intensity (e.g. through the development of high capacity corridors), and transport conditions (e.g. through enhanced accessibility).

ICT for information society

As a result of the potential trip reduction effect of telework, positive effects on traffic and environmental problems are predicted. Direct impacts are expected to be seen in the reduction of commuting kilometres. Indirect impacts include wider consequences for total travel and travel behaviour as well as potential long-term impacts on household location and land use (Helman V. et al., 2007).

Another study (Rietveld P., 2011) has pointed out that a transition towards a large scale introduction of teleworking would involve the overcoming of various barriers by changes in the internal organisation of firms, changes in the social responsibility of firms, and changes in life styles and activity patterns of workers.

The most important aspects for working at home or out of home turned out to be the age and education and not, for example, the access to ICT (de Graaff T., 2007).

Mobile phone use was positively associated with activity and trip levels, while internet access was negatively associated. Mobile phone use is significantly and positively associated with activities that required an effort to pre-arrange timing, but neither technology associates with the frequency of temporally impulsive activities. (Lee-Gosselin M. et al., 2009).

There is a clear association between Internet use and an increase in activity participation and this suggests a clear role for virtual mobility in social and transport policy. Virtual mobility can provide a viable alternative to physical

mobility in reducing the aspects of mobility-related exclusion, by providing additional accessibility (virtual accessibility) without an increase in physical mobility (Kenyon S., 2010).

2.4.2 Spatial structure

Inefficient spatial land use distribution contributes to climate change and to increase mobility needs – a result of interacting factors which include policies with lack of horizontal coordination.

Around 75 % of the European population lives in urban areas. Following the EEA and JRC (2006) **sustainable urban planning strategies to combat urban sprawl can only be effective if the major driving forces are understood. The study identifies the following transport related driving forces: private car ownership, the availability of roads, low cost of fuel and poor public transport.**

Driving forces related to spatial and transport planning include: weak land use planning, poor enforcement of plans and lack of horizontal and vertical collaboration all which there identified as major drivers for urban sprawl.

An ESPON study (EU, 2010) shows a convergence of urban dynamic trends around spatial structure in most cities in the period post 1990s, this includes central and eastern countries (where there may be long-term stagnation or decline in demographic trends) which had a more centralized planning system. Overall, urban development can be related to changes in the main functions of urban regions: population, transport, tourism, manufacturing, and knowledge and decision making in the private and public sectors. **Major transport drivers contributed to the post 1990s urban sprawl: low cost of fuel, lower transport costs, private car ownership, low quality public transport and road infrastructure investment**.

Furthermore, **globalisation is recognized as a major driver for urban sprawl**, fostered by the development of ICT along with increased accessibility (EC, 2011a).

Finally, **"*The observed substantial increase in personal mobility over the last couple of decades can be explained to a substantial part by a shift to faster transport means* *(high-speed trains, aircraft, higher car ownership resulting in more driving instead of walking or cycling, etc.). It is unclear whether the increase in general mobility is also due to longer distances which people have to cover to make their basic provisions. Urban sprawl, the rise of super- and hyper- markets and the loss of the grocery store around the corner may have contributed to such a situation*" (EC, 2009b).

2.4.3 Socio-demographic and cultural factors

Immigration seems to be the only structural variable that could soften the ageing process in European cities (EU, 2010).

Smaller household size has a connection with increased car ownership and reduced use of public transport, since people in small households take more trips

to manage their daily activities and rarely see public transport services as a viable option due to inflexibility (Rogge L., 2005).

Lifestyle, which is defined by personal characteristics, and also subjective attitudes towards mobility, travel modes and residential aspects, has an impact on mobility demand. The use of car or public modes is reflected by the situation in life, for example a typical European family lifestyle has a strong connection with car use (Van Acker, V., 2011).

The increasing mobility also has to do with international travelling, partly due to social connections or family members from different nationalities. Versatile activities in leisure time also lead to growing traffic volumes and complex travelling routes (InnoZ-Bausteine, 2008).

The private car offers a flexibility and ability to fullfil individual needs and routes, but the rising fuel costs and environmental issues will however make public transport a more attractive mode of transport. Especially in urban areas co-modal transport solutions will become more relevant (InnoZ-Bausteine, 2008).

According to the ESPON study (EU, 2010), **demographic trends and urban dynamics affect travel patterns and are a result of long-term structural variables such as: decline of fertility rate, increase of life expectancy, ageing process, growth share of single-household composition and immigration**.

2.4.4 Urban mobility

Current urban mobility patterns and changes in mobility predicted up until 2030 are understood to be the result of "*socio-demographic evolution (ageing and immigration), urbanisation, 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*" (ERTRAC, 2009).

2.4.5 Travel Behaviour

According to Zito and Salvo (2011) **trends in travel behaviour are related to city planning, planning and development of public transport, transport demand management, private transport supply, economy/law, externalities, and co-benefits**.

Following Zito and Salvo (2011), individual travel decisions are subjected daily to direct and indirect external factors. **Key factors influencing the development of transport can be classified using the following categories: 1) technological; 2) economic development 3) spatial and land use patterns; 4) government policy; 5) social and behavioural trends** (individual behaviour as a combination of habits, practical and emotional considerations).

A study for the Copenhagen Metropolitan Area, Naess (2011), compared the influences of macro-level and micro-level urban form characteristics on the respondents' travelling distance by car on weekdays. It was found that urban structural variables at the metropolitan scale (e.g. location of the residence relative to main city centre) generally exert stronger influences than neighbourhood-scale built

environment characteristics on the amount of car travel. At the micro-level scale, the local street structure in the neighbourhood was found to have no significant effect on car travel when controlling for the location of the dwelling relative to the city centre. The Naess (2011) study findings for Copenhagen are in line with several studies found in the literature that show that regional accessibility is more important than built-environment characteristics to explain the number of vehicles-km or vehicle-miles travelled. Therefore, allowing densification close to the main city centre of metropolitan areas would reduce travel distances and encourages using transport modes other than the private car. Therefore, from the perspective of sustainable mobility, metropolitan level centralisation is more favourable than decentralized development.

3 Megatrends

3.1 The concept of Megatrends

Despite the above described relations and trends affecting the transport system, there are fundamental changes in the framing conditions. Some of these changes have a character of fundamental, long lasting (more than 10 years), global or international transformation processes with a certain direction, including the economic and the socio-cultural dimension and affecting multiple aspects of life – so called Megatrends. Due to their long range those Megatrends are relevant for modelling the effects of the implementation of ICT-based co-modality strategies for the optimisation of the transport system with a time horizon 2030/2050. Therefore an important step is to identify those Megatrends.

Megatrends are comprehensive and dealing with different aspects of the environment, economy and society. They also affect each other, which can make the impacts of the Megatrends unclear and difficult to predict. Politics and society can find it challenging to steer and influence the Megatrends due to their comprehensive character (acting on different levels, cross-borders etc.). Due to these challenges it is even more important to take the Megatrends into consideration.

Megatrends are used when assessing future developments and challenges, which mobility and the transport system will be facing. For OPTIMISM two subclasses of Megatrends which may overlap have been identified:

- **Recent trends** with a historical background of some decades, supported by data;
- **Prospective trends** which became apparent in the last years and are likely to have future impact on passenger transport and mobility behaviour.

The latter contain forecast uncertainty while the existence and influence of the recent trends (e.g. world population growth) are documented.

For OPTIMISM, Megatrends have been identified within the literature research of key-factors combined with expert knowledge. Prospective trends are based on the observation of first (sometimes weak) signs that are uncertain and hence require critical evaluation. They still have to be verified as for some of them empirical evidence is difficult to find. Therefore the Megatrends were part of an impact analysis concerning their relevance for mobility and the future transport system – asking experts from the field of transportation to estimate importance and impact of the identified Megatrends.

The extent to which Megatrends have an impact strongly depends on the regional conditions. Megatrends develop and have influence globally, but the effects on national and regional level vary. Especially in the fields of mobility and energy these effects differ significantly. The spatial and functional correlations, economic structure of a country and the level of income strongly influence the supply and demand and impacts of Megatrends. This has to be taken into account when modelling the future scenarios.

3.2 Identified Megatrends

Some of the trends of the passenger transport key factors described in section 2 have the characteristics of Megatrends, such as population growth, population ageing, urbanisation, technological development and economic growth. Furthermore most of the Megatrends are interlinked and some of them (e.g. crisis on mobility) include changes inside the transport system, which affect other parts of the system.

Eleven Megatrends with relevance for future mobility and the transport system have been identified – based by the analysis of sources in combination with expert knowledge. In a further step the Megatrends and their potential impacts on different system parameters have been discussed with practitioners during an expert-workshop. The impact analysis helps getting an idea of how Megatrends are linked to the key factors of the transportation system and the challenges they might bring in the future. The results are qualitative as they are based on an expert survey providing input for the scenario building and modelling of the future transportation system.

These Megatrends have been grouped and presented according the two above-mentioned subclasses: recent Megatrends and prospective Megatrends.

3.2.1 Recent Megatrends

3.2.1.1 Globalisation 2.0

In general, global economic growth will be positive in the coming decades, even though the rate of growth seems to be more uncertain due to the 2008–2009 economic crisis. Emerging economies will experience higher rates (EEA, 2011a). Globalisation stands for increased international interactions and the integration of the economy and society and it is supported by the technological and political conditions. A global economic network is made possible by the market opening and the development of cross-border technologies. Globalisation 2.0 describes a new type of the development which has been going on in the western and industrialized countries during the past decades. With the economic boom going on in the BRIC (=Brazil, Russia, India, China) countries, a global change in economic and political power relations, in prosperity and economic specialisation are beginning to show, this is also called "Multi-Polarisation". Rising incomes and a worldwide redistribution of income will affect demand for mobility services, vehicle purchases as well as the development of transport technologies which will address needs from different cultural backgrounds as compared to the last decades.

In addition the international cross-linking of economies and societies leads to new areas where so far no international regulations exist. These so called free spaces (or regulation gaps) cannot be regulated through national laws. Legal questions concerning the Internet are an example of such regulatory issues. An international agreement would be needed to confront the issues, but it would slow down the processes of the Globalisation 2.0.

3.2.1.2 *World population growth*

The population growth is a determining factor significantly influencing the global economic, social and political developments during the next decades. The demand for goods and resources such as water, food, land and energy as well as scarce raw materials has rapidly increased during the past decades. Population growth together with a redistribution of prosperity increases the purchasing power and consumption in the emerging economies.

Population growth will be characterized by a slower rate of change than in the past and by major regional differences. In particular, in Europe, population is expected to decrease (EEA, 2011a). Within the booming economies there is an increase in demand, consumption and disposal but also a reallocation of the markets. Rising prices, growing exploitation of natural resources through production and disposal, as well as growing international trading are consequences of this development.

When it comes to mobility and transport, a growing demand for mobility and transport services, together with rising fuel prices and increased investments in alternative technologies and energy can be identified. Meanwhile some European regions have to face decreases in population which may lead to an inefficient public transport infrastructure with unused capacities.

3.2.1.3 *Urbanisation*

The trend of urbanisation has been going on for decades and still continues uninterrupted, especially in the emerging markets.

Even in Europe the level of urbanisation is expected to grow even though at a slower rate (EEA, 2011a). The spatial structures created by urbanisation are determining factors for the mobility and transport sectors. The concentration of people and regional labour markets in a few large centres allows an increasing efficiency of transport for commuters. A sufficient supply of mobility services is essential for these densely populated commercial centres with high production and service levels. Problems arise from the concentration of commuter flows during traffic peaks; new solutions such as teleworking or shifting working hours could address those problems. Appropriate infrastructure also needs to be available, as well as good connections from the centres to the ever more sparsely populated peripheries needing supplies. The trends of centralisation and the deserting of peripheries are leading to contradictions where the profitability, infrastructure and operations of transport need to fulfil conflicting requirements. Enabling equality in accessibility and achieving true cost in traffic at the same time is one of the main challenges for the future. Even though the costs for transport and traffic are rising, spatial structures have the greatest influence on the mobility sector and urban sprawl is still increasing in many European agglomerations.

3.2.1.4 *Increase of inter-/intra-national social disparities*

Together with the increasing wealth and income levels the prosperity gaps have also intensified in the past decades, especially in the emerging economies (Mici, 2007). These prosperity gaps are accompanied by other social disparities which have an

influence on several social and economic areas. Access to the employment market, housing, education and health care often depend on the income. This is still, or again, the case in industrialized countries (for example access to education in Germany or health care in the United States). The transport system is more or less accessible or exclusive, depending on the pricing for mobility services. Increases in the lower income segments also increases the medium-term demand for mobility services.

3.2.1.5 *Demographic and social change in Europe*

In general people will live longer, be better educated and emigrate more (EEA, 2011a). An increase in the share of the population over 65 is expected in future, especially in the European Union (Lisiankova, 2005). Ageing will have a significant impact on mobility needs and services. Current and future seniors, compared with previous generations, are healthier, wealthier and have a more active life style including travelling and leisure mobility. It is difficult to interpret how the more individual and flexible mobility will affect the transport and traffic sectors.

Changes in demographic and household structures are also reflected in the demand for mobility. A decreasing household size requires more apartments and has an influence on the housing settlements' structure. A smaller household size works against a high housing density, which is often seen as a way to prohibit increasing traffic volumes.

Other important aspects influencing mobility are the use of new ICT solutions and social internet applications. More distinct mobility can prompt a demand for new roads since individuals may not adapt their routes and use; also it is not clear if possible synergies, such as combining modes or pooling cars, will be used. The physical mobility can partly be reduced and replaced by contacts, discussions and activities on the internet. The effect of the internet on behaviour changes and physical mobility depends on the quality of the internet applications, the acceptability and use. A reliable assessment of the impacts can only be made when statistics from generations of digital natives and active seniors exist.

3.2.1.6 *Knowledge Society and -economy Europe*

During the past decades the economy in Europe has gone through a structural change from production to services. The process differs regionally and nationally and also within the production and service sectors a structural change can be identified. The remaining branches of the production sector are strongly specialized in order to stay competitive despite the relatively high salaries when globally compared. The orientation towards research and development, high quality products and manufacturing is made possible by a high level of education and a know-how being built over time. Knowledge acquisition and use, capacity for innovation and further development of products and services are characteristic of the knowledge economy. This is based on a high level of education which can be further developed. The emergence of the knowledge economy as a megatrend has made the acquisition and further development of knowledge necessary for corporations and individuals. This is also shown in the attitudes, preferences and in the demand on the market. How this megatrend is going to affect demand on mobility is hard to say: Green or at least less

car-dependent urban lifestyles may occur and the awareness of ICT-solutions in mobility within this group may increase the demand for public transport and/or car-sharing, E-Mobility or social-media based and self-organised mobility.

3.2.1.7 Climate change, environmental pollution and environmental ethics

Climate change has a great impact on the environment, economy and society. Besides the changing temperatures and rainfall, extreme weather or regional climate shifts, climate change also has influence on a secondary level in the world. It has a direct impact on the land use and affects agriculture, industries, service sector, housing development and infrastructures.

Climate change is a global pressure issue that poses significant negative externalities on society. There is no effective policy tool to internalize the long-term international costs of climate change and policy should tend for a global-term carbon price (Zachmann, G. et al. 2012).

The costs of climate change through damages and necessary adaptation measures will affect society permanently and new political models and decisions are needed to cover these costs. Political and social reactions to the development will have a significant impact also on the requirements for mobility and logistics. Environmental and energy related political measures, like taxes on the CO2 emissions and use of fossil energy, are some of these impacts. Studies on carbon pricing show that the pathway for economic efficiency is complex as carbon price needs to be aligned across sectors, over time and across regions.

Also the environmental pollution load is growing heavier in terms of complex mix pollutants threatening Earth's regulatory mechanisms. In particular particulate matter, nitrogen and ground-level ozone are most dangerous for their complex and potentially far-reaching effects on ecosystem (EEA, 2011a).

Guidelines regulating vehicles' emissions are influencing technical developments and are also a part of the measures for tackling climate change. When it comes to individuals, especially in the welfare states, an increased awareness of environmental issues can be identified; policy could support this change of behaviour (see OECD, 2011). If the economy reacts to this trend by creating corresponding business models and relevant supplies of products and services are developed, behavioural change can be achieved. One reason for the lack of behavioural change is the low number of suitable, more sustainable mobility and transport services on the market.

3.2.2 Prospective Megatrends

3.2.2.1 Shortage of resources

Economic growth, on the one hand, accelerates consumption and resource use, on the other hand, stimulates technological innovation, which permits us to better address environmental problems and increase resource efficiency (EEA, 2011a). To meet its growing energy needs Europe relies on foreign resources. Increasing scarcity of fossil fuels may stimulate greater efforts to shift to other energy sources that can be found domestically.

The growing demand in the past decades has already led to temporary shortages of resources like crude oil, precious metals and food products. The increasing demand has not been the only reason for supply shortfalls. Political conflicts, financial crisis and speculations have also contributed to them. The shortfalls of several resources are intensified by a growing global economy and by the export controls of the exporting countries. Rising prices for oil and energy especially, will increasingly affect the European transport system.

As rare soils are also critical resources facing the previously mentioned challenges, transport technologies based on regenerative energy (e.g. electro-mobility) may partly lose their potential as alternatives. Resource shortages are accompanied by increasing prices, but the impacts of a temporary or partial outage of certain raw materials are also unpredictable. Besides economic and social consequences, political conflicts would occur.

3.2.2.2 *Technology change*

Technological development will continue, in particular nanotechnology, biotechnology and information and communication technology. Innovation is a key driver of economic growth and can contribute directly and indirectly to damaging or improving the environment. In general, R&D efforts have increased globally but environmental R&D retains a low share of the total (Johnstone et al., 2010. Quoted in EEA, 2011a). Lighter materials, new battery technology or ICT-solutions for intelligent transport organisation are only a few examples of more energy efficient technologies.

These new technical developments are leading to a paradigm shift. Nanotechnologies are opening up new possibilities in the fields of medicine, electric engineering and material technology, just to name a few. The comprehensive nature of this technical shift makes it difficult to predict its impacts. The technologic convergence also has an impact on the paradigm shift. Technological progress in specific fields has impacts outside the own boundaries and can create synergies (MIT, 2011). Through these synergies new approaches and ways of thinking are created. The consequences will be revolutionary and can be compared with the industrialisation or digitisation. Due to the unpredictable impacts associated with the technological change, it is characterised as a prospective megatrend; the impacts on transport and mobility are difficult to estimate.

Another influencing aspect is the increasing digitisation of everyday life, in other words the ambient intelligence. The economy, society, living habits and consumer behaviour have already gone through a fundamental change due to internet, smart-phones and social media services. The changes in the future will most likely be as dramatic. Digital natives will be introduced to new technologies and decision makers who are against the reorganisation of the everyday life towards home offices and online services will lose their influence. The familiar use of new technologies leads to paradigm shift, which enables new ways of life, working methods and the organisation of mobility.

3.2.2.3 *Crisis of Mobility and European policy reaction*

The term crisis should not be understood as a negative trend only. It is more a period of radical changes creating a need for adjustments. The factors driving a crisis are often negative developments, but during the crisis also positive effects can occur. Decisions are made and new opportunities created for improving an old system. The trend towards a mobility crisis is defined by growing demand and rising costs, which are specifically important for the fields of mobility and transport. Infrastructural developments cannot keep up with the growth rate, which is partly due to insufficient financing. Generally this leads to a lacking infrastructure. The diminishing of low-cost fossil fuels in the future is making investments in traditional modes of transport questionable. Restructuring of future taxation systems in Europe (e.g. for passenger vehicles) may encompass different approaches and encourage innovation.

Growing demand is defined by spatial structures created by existing transport services and the distribution of working places and housing areas. The existing infrastructures are strongly connected with the functional structures, which all require mobility. It is challenging to substitute mobility which is steered by spatial structures.

The private motorised urban vehicle kilometres in world cities increased due to population growth, urban sprawl and increased car ownership for the last decades (Cameron, 2004). These challenges has been shown not only by control measures such as true cost pricing, privatisation or driving restrictions in urban areas, but also by the requirements for new vehicles and mobility concepts. At the same time it shows how comprehensive the change to a future mobility could be. Similar dimensions with the invention of the internet or the automobiles could be reached.

Policy has started to address these issues; there is increasing policy awareness of the importance for the integration of transport and land use (spatial) planning (EC 2011a and EC 2011b). On transport integration, Potter and Skinner (2000) already provided an interesting framework. Transport and land use are part of a complex system as the urban and metropolitan one, that is subject to external influences and each component constantly evolves (Zito and Salvo 2011).

As Stead and Banister (2003) note, long-term planning decisions must be as robust as possible to cover all future challenges in the policy-making environment. This calls for a new approach for identifying ex ante (and ex post on a regular basis) all impacts of policies under different types of conditions, aiming to identify which policies are cost-effective and robust (as opposed to no-regret transport policies that lead to unsustainable transport, as recognized in 2011 by the Transport White Paper from the European Commission). This would represent a change in the planning paradigm and an inflection point from past EU transport policy to a more sustainable future.

Furthermore, for inter- and intra-urban transport, public transport modes are increasingly supported, requiring enhancements to public transport infrastructures. (EC, 2011a; EC, 2011c). Concerning the integration of the European transport network, a tendency also exists to enhance mobility between (urban) regions. In the case of roadways and railways this is reflected most strongly by the TEN-T projects (with an investment of just over 7.2 billion € over 327 projects between 2007 and 2013) for different modes. A pan-European network is created allowing for the usage

of all modes of transport. In the case of the road and rail mode, this is mostly through enhancing existing (highway or railway) infrastructure, or through the filling of missing links (UN, 2011; TEN-T, 2008).

3.3 Links between Megatrends and key factors

3.3.1 Impact Analysis

Since the modelling horizon is 2030 and 2050, it is important to focus on factors which have long lasting effects on passenger transport systems. Therefore Megatrends have been used as they are continuing, long term flows influencing multiple aspects like economy, society and policy – shaping the determining factors of the transport system. To get an idea how Megatrends will influence the transport system an impact analysis has been done. Experts were asked to link Megatrends with key factors (related to them) and to estimate the impact. These links are important for determining "priority" factors in the scenario building process. Table 2 shows the results of the impact analysis based on the results of the expert workshop. The participants were asked to rate the impact of the respective Megatrend on the key factors by 1 for low, 2 for medium and 3 for high impact. The table shows the results of those ratings.

Table 2 – Links between Megatrends and selected key factors

Rating of Impact		Megatrends										
External Key Factors	1 = low 2 = medium 3 = high	Globalization 2.0	World population growth	Urbanisation	Increase of inter- / intra-national social disparities	Demographic and social change Europe	Knowledge Society and - economy Europe	Climate change and environmental ethics	Shortage of resources	Technology change	European market deregualtion	Crisis of Mobility and European policy reaction
Competition	Market structures											
	Regulation/deregulation of transport markets											
Transport policy and planning	Definition of aims in strategic transport planning											
	Taxes (in general)											
	Pricing and charges											
	Internalization of externalities											
	Priorities in infrastructure investment policy											
	Subsidies and incentives											
	Traffic law											
	Institutional structures											
	Integrated (urban) mobility plans											
	Analysis and implementation of transport measures											
	Infrastructure planning											
	Privatisation of planning and PPP											
Cohesion	Regional differences in economies											
	Peripheral regions and accessibility											
Passenger characteristics	Driving license											
	Vehicle ownership											
ICT for transport applications	Technology development and innovation diffusion											
	ITS (relevant to inter- and co-modality)											
Legend	Total of ratings in points		10-20		21-30		31-40		41-50		51-60	

Rating of Impact		Megatrends										
External Key Factors	1 = low 2 = medium 3 = high	Globalization 2.0	World population growth	Urbanisation	Increase of inter- / intra-national social disparities	Demographic and social change Europe	Knowledge Society and - economy Europe	Climate change and environmental ethics	Shortage of resources	Technology change	European market deregualtion	Crisis of Mobility and European policy reaction
Transport	Urban public transport											
	Individual public transport services											
	Railway and coach services											
	Freight logistics											
	Intermodality and co-modality services											
	Air transport services											
	Seaways and inland waterways services											
	Mobility needs, daily activities and leisure											
	Mobility needs of disable and ageing population											
	Type of vehicle purchase decision											
	Door-to-door travel time											
	Transport behaviour											
	Urban streets and public transport infrastructures											
	Roads infrastructure											
	Railways infrastructure											
	Seaways and inland waterways infrastructure											
	Airports infrastructure											
	Global trends in mobility patterns and in impacts on sustainability criteria											
Legend	Total of ratings in points		10-20		21-30		31-40		41-50		51-60	

3.3.2 Relevance of Megatrends

The impact analysis gives insight on how important experts regard the impact of the identified Megatrends are supposed to be. The list of Megatrends ranked by the summarized estimations of the experts shows, that recent Megatrends, such as Urbanization and Climate Change, as well as prospective ones, e.g. Shortage of Resources, Globalization 2.0 and Technology Change, are expected to have great impact.

1. Urbanisation
2. Shortage of Resources
3. Globalization 2.0
4. Climate Change and Environmental Ethics
5. Technology Change
6. Crisis of Mobility and European Policy Reaction
7. World Population Growth
8. Demographic and Social Change Europe
9. European Market Deregualtion
10. Increase of Inter- / Intra-national Social Disparities
11. Knowledge Society and -Economy Europe

Megatrends describing social change, such as Knowledge Society, Social Change and Disparities are not expected to have a great impact on the key factors of the transport system. Partially this contradicts results elaborated in the same expert-workshop, where the important role of income development and disparities has been stressed.

3.3.3 Vulnerability of Key Factors

Which key factors will be mainly affected by the Megatrends? Table 3 shows the key factors ranked by their vulnerability to Megatrends – based on the experts ratings. All parts of the transport system, "urban" and "individual public transport" as well as "air transport", seem to be vulnerable to the developments described by the most important Megatrends. This means Urbanisation, Shortage of Resources or Globalization 2.0 are supposed to influence those sectors. A large impact on the transport system may also occur through effects on "regional differences in economies", which has been ranked highest.

The impact of the megatrends will also affect the policy reaction in different fields, such as "definition of aims in strategic transport planning", "priorities in infrastructure investment policies" and "infrastructure planning". Also "technology development and innovation diffusion" and "transport behaviour" are supposed to be highly affected by Megatrends.

External Key Factors	Rated by deviation from average rating of all factors
Cohesion	Regional differences in economies
Competition	Market structures
Transport	Urban public transport
Transport	Individual public transport services
Transport	Air transport services
Transport policy and planning	Definition of aims in strategic transport planning
Transport policy and planning	Priorities in infrastructure investment policy
Transport policy and planning	Infrastructure planning
ICT for transport applications	Technology development and innovation diffusion
Transport	Transport behaviour
Transport	Airports infrastructure
Transport	Intermodality and co-modality services
Transport policy and planning	Pricing and charges
Cohesion	Peripheral regions and accessibility
Transport	Railway and coach services
ICT for transport applications	ITS (relevant to inter- and co-modality)
Transport policy and planning	Integrated (urban) mobility plans
Transport	Freight logistics
Transport	Mobility needs, daily activities and leisure
Transport	Type of vehicle purchase decision
Transport policy and planning	Internalization of externalities
Transport	Railways infrastructure
Transport policy and planning	Analysis and implementation of transport measures
Passenger characteristics	Vehicle ownership
Transport	Roads infrastructure
Competition	Regulation/deregulation of transport markets
Transport policy and planning	Taxes (in general)
Transport	Urban streets and public transport infrastructures
Transport	Seaways and inland waterways services
Transport policy and planning	Subsidies and incentives
Transport	Mobility needs of disable and ageing population
Transport	Door-to-door travel time
Transport	Seaways and inland waterways infrastructure
Transport policy and planning	Institutional structures
Transport policy and planning	Privatisation of planning and PPP
Transport policy and planning	Traffic law
Passenger characteristics	Driving license
Transport	Global trends in mobility patterns and in impacts on sustainability criteria

Table 3 – Key factors ranked by rating concerning impact from Megatrends (key factors marked in grey are around the average of rating)

4 Conclusions

This deliverable reports on the literature review identifying key factors, their trends and causal patterns of the passenger transport system. It also provides a list of the potential Megatrends affecting the transport systems and which are likely to impact the system in the future.

The identification of key factors and their trends is of fundamental importance for the definition of scenarios for the modelling the implementation of co-modality ICT-based strategies aiming to optimise the passenger transport systems, which is the objective of OPTIMISM WP3.

The deliverable provides results of a meta-study based on literature research showing a complex system. It provides an overall picture of the collected information on key factors, their trends and causal patterns which will serve as an input for building scenarios and modelling the future transport system.

In this respect, the information collected by analysing literature sources mainly provides qualitative trends and in some cases quantitative forecasts. Furthermore, the collected information does not cover the entire list of key factors identified in D3.1. The gaps will be partly filled by a Delphi survey involving experts from all over Europe, including two online inquiries combined with an expert-workshop.

Megatrends have been identified as large dynamics not only affecting the transport system directly, but also having indirect impact on the system through changes in technology, economy, society and policy. The identified Megatrends permit OPTIMISM to include factors with long lasting direct or indirect effects on transport systems, since the modelling horizon is 2030 and 2050.

The 11 Megatrends identified on the basis of the analysis of sources and on the basis of project partners' experience covers all dimensions of sustainability: economic, social and environmental. They also include issues related to technology, cohesion and mobility. The Megatrends have been discussed by experts and ranked with regard to their potential impact for the future transportation system:

1. Urbanisation
2. Shortage of Resources
3. Globalization 2.0
4. Climate Change and Environmental Ethics
5. Technology Change
6. Crisis of Mobility and European Policy Reaction
7. World Population Growth
8. Demographic and Social Change Europe
9. European Market Deregualtion

10. Increase of Inter- / Intra-national Social Disparities
11. Knowledge Society and -Economy Europe

The information included in this report will be used as input for the expert workshop which is a main step of the Delphi survey. The final output of the workshop will be the definition of scenarios for modelling the impacts of co-modality ICT-based strategies for the optimisation of passenger transport systems.

The results of the Delphi survey, and in particular of the expert workshop, will be the subject of the next deliverable of WP3: D3.3 "Delphi expert report on the future scenarios of transport and mobility".

References

Bak, M. and Borkowski, P. (2010). Integrated ticketing in passenger transport as a chance to improve interconnectivity, 12th WCTR, July 11-15, 2010 – Lisbon, Portugal (DELFT_T_22)

Brög, W., Barta, F. and Erl, E. (2005) Societal Megatrends: like it or not, the framework is set. 56th UITP World Congress. (TML_T_2).

Cameron, I., Lyons, T. J. and Kenworthy, J. R. (2004) Trends in vehicle kilometres of travel in world cities, 1960-1990: underlying drivers and policy responses. Transport Policy 11(3): 287-298 (ZHAW_T_51).

CEC (2008) "Directive relating to the assessment and management of environmental noise", Directive 2002/49/EC of the European Parliament and of the Council, Brussels.

Christidis P. and Ibanez N. (2010) European transport policy: methodology to assess impact on accessibility, Paper presented at 57th Annual North American Meetings of the Regional Science Association International, Denver, Colorado, 10-13 November 2010. (JRC_T_26).

De Graaff, T. and Rietveld, P. (2007) Substitution between working at home and out-of.home: The role of ICT and commuting costs. Transport Research Part A 41, pp. 142-160. (DLR_T_26) (CUE_T_32).

Dejoux, V., Bussiere, Y., Madre, J., and Armoogum, J. (2010) Projection of the Daily Travel of an Ageing Population: The Paris and Montreal Case, 1975-2020. Transport Reviews 30(4), pp. 495-515. (ZHAW_T_62).

Donaghy, K., Rudinger, G. and Poppelreuter, S. (2004) Societal trends, mobility behaviour and sustainable transport in Europe and North America. Transport Reviews 24(6), pp 679-690. (LNEC_T_45).

Duchene, C. (2011) Discussion Paper No. 2011-11. Gender and Transport project. (DLR_G_1).

Dutch Ministry of Infrastructure and Environment (2011) ITS in the Netherlands. (DELFT_G_36).

EC – European Commission (2008), EU energy trends to 2030 - UPDATE 2007. Office for Official Publications of the European Communities. Luxembourg. (SIGNOSIS_T_10).

EC – European Communities (2009a) A Sustainable Future for Transport - Towards an Integrated, Technology-led and User-friendly System. Publications Office of the European Union. Luxembourg. (CTL_T_10).

EC – European Commission (2009b) The Future of Transport – Focus Group's Report. (CTL_G_2).

EC – European Commission (2010), EU energy trends to 2030 - UPDATE 2009. Publications Office of the European Union. Luxembourg. (DLR_T_39).

EC – European Commission (2011a) WHITE PAPER Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system , COM (2011) 144 final, Brussels.

EC – European Commission (2011b) IMPACT ASSESSMENT Accompanying document to the WHITE PAPER Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, SEC(2011) 358 final, Brussels.

EC - European Commission (2011c). Commission Staff Working Paper : Roadmap to a Single Transport Area – Towards a competitive and resource efficient transport system. SEC(2011) 391 Final.

EEA – European Environmental Agency (2011a) The European Environment - State and Outlook 2010: Assessment of Global Megatrends. EEA, Copenhagen. (CTL_T_3).

EEA and JRC (2006) Urban sprawl in Europe - The ignored challenge, EEA report n10/2006, Copenhagen. (JRC_G_8).

Egenhofer, C. (2011) The EU should not shy away from setting CO2-related targets for transport, Centre for European Policy Studies (CEPS) Policy Brief 229, January 2011. (JRC_T_2).

EIA - U.S. Energy Information Administration (2011) International Energy Outlook 2011. Washington. (DLR_T_38).

ERTRAC (2004) Vision 2020 and Challenges. European Road Transport Research Advisory Council, www.ertrac.org. (CTL_G_19).

ERTRAC – European Road Transport Research Advisory Council (2009) ERTRAC Road Transport Scenario 2030+ Road to Implementation, Brussels. (CTL_G_9).

ESPON (2007), ESPON 2013 PROGRAMME - European Spatial Planning Observation Network. Structural Funds 2007-2013, Objective 3 Interregional Cooperation Networks. (JRC_G_16).

EU (2010) Future Orientations for Cities: Final Report, ESPON ERDF, Luxembourg. (JRC_G_4).

EU (2011) European Land Use Patterns, ESPON &Tecnalia,Luxembourg. (JRC_G_5).

FORESIGHT for TRANSPORT (2004) Final Report. Foresight for Transport (A Foresight Exercise to Help Forward Thinking in Transport and Sectoral Integration) project. Fifth Framework Programme - Competitive and Sustainable Growth Programme. (CTL_G_5).

Frändberg, L., and Vilhelmson, B. (2011) Population change and accessibility by road and rail networks: GIS and statistical approach to Finland 1970–2007. Journal of Transport Geography 19(4), pp. 926-935. (ZHAW_T_60, LNEC_T_19).

Harms, L., Jorritsma, P., Hoen, A. and van de Riet, O. (2011) Blik op de personenmobiliteit. KiM project. (DELFT_G_3)

Helman, V. and Mika Ristimaki, M. (2007), Relationships between communting distance, frequency and teleworking in Finland. Journal of Transport Geography, 15 (5), pp. 331-342. (CUE_T_1).

IMF (2012) World Economic Outlook. Growth Resuming, Dangers Remain. April 2012. "http://www.imf.org/external/pubs/ft/weo/2012/01/pdf/text.pdf" (Signosis_T_9).

InnoZ-Bausteine (2008) Megatrends und Verkehrsmarkt - Langfristige Auswirkungen auf den Personenverkehr. Innovationszentrum für Mobilität und gesellschaftlichen Wandel. (DLR_G_3).

Jorritsma, P. and Olde Kalter, M. (2008) Grijs op reis Over de mobiliteit van ouderen. KiM project. (DELFT_G_7).

Kenyon, S. (2010), The impacts of internet use upon activity participation and travel: Results form a longitudinal diary-based panel study. Transport Research Part C: Emerging Technologies: 18(1), pp. 21-35. (CUE_T_9)-

Kotavaara, O., Antikainen, H. and Rusanen, J. (2011) Population change and accessibility by road and rail networks: GIS and statistical approach to Finland 1970–2007. Journal of Transport Geography 19(4), pp. 926-935. (ZHAW_T_57).

Kunert, U. and Kuhfeld, H. (2007) The diverse structures of passenger car taxation in Europe and the EU Commissions proposal for reform, Transport Policy 14, pp. 306–316 (LNEC_T_56).

Lanzendorf, M. and Gather, M. (2005) Special issue: Institutional, economic and demographic transition and its impact on the transport system. EJTIR 5(3), pp. 135-138. (DELFT_T_10).

Lee-Gosselin, M., and Miranda-Moreno, L.F. (2009), What is different about urban activities of those with access to ICT? Some early evidence from Quebec, Canada. Journal of Transport Geography: 17(2), pp. 104-114. (CUE_T_8).

Lisiankova, K. and R. E. Wright (2005). Demographic Change and the European Union Labour Market. National Institute Economic Review 194(1): 74-81.

Mici, P., Ed. (2007). Das ZukunftsRadar. Die wichtigsten Trends, Technologien und Themen für die Zukunft. Megatrend. Offenbach.

MIT Massachusetts Institute of Technology (2011). The Third Revolution: The Convergence of the Life Sciences, Physical Sciences, and Engineering.

Mobil 2030 (2011) Mobil 2030 - Mobilitätskultur in einer alternden Gesellschaft: Szenarien für das Jahr 2030. Zentrum für Alternskulturen (DLR_G_5).

Mota Borges, I. (2007) The Added Value of Accessible Public Transport for All in The Context of Demographic Ageing.

Naess, P. (2011) 'New urbanism' or metropolitan-level centralisation? A comparison of the influences of metropolitan-level and neighborhood-level urban form characteristics on travel behavior, Journal of Transport and Land Use 4(1), pp. 25-44. (JRC_T_23).

OECD - Organisation for Economic Co-operation and Development (2001) Ageing and Transport - Mobility Needs and Safety Issues. (CTL_T_22).

OECD (2011). Greening Household Behaviour. The Role of Public Policy. OECD.

OECD/ITF - Organisation for Economic Co-operation and Development/ International Transport Forum (2009) Reducing Transport GHG Emissions - Opportunities and Costs. Paris. (DELFT_G_15).

PBL - Netherlands Environmental Assessment Agency, and SRC - Stockholm Resilience Centre of Stockholm University (2009), Getting into the Right Lane for 2050, Bilthoven. 2009. (CTL_T_2).

Rietveld, P. (2011) Telework and the transition to lower energy use in transport: On the relevance of rebound effects. Environmental Innovation and Societal Transitions: 1(1), pp. 146-151. (CUE_T_6).

Rogge, L. (2005) Working Group (WG) 4 "Seamless intermodal networks and services" - Final Report. Voyager project. FP5. (TML_G_9).

Rosenbloom, S. and Ståhl, A. (2002) Automobility among the Elderly: The Convergence of Environmental, Safety, Mobility and Community Design Issues. EJTIR 2(3/4), pp. 197-213. (DELFT_T_5).

Rothengatter W. (2009) European Transport in a Competitive Economy. Report for Netherlands Environmental Assessment Agency. (JRC_G_18).

Rudinger, G., Donaghy, K. and Poppelreuter, S. (2006) Societal trends, mobility behaviour and sustainable transport in Europe and North America. EJTIR 6(1), pp. 61-76. (DELFT_T_11).

Scheiner, J. (2006) Does the car make elderly people happy and mobile? Settlement structures, car availability and leisure mobility of the elderly. EJTIR 6(2), pp. 151-172. (DELFT_T_13).

Sessa C., Andersen P.B., Enei R., Fiedler, R., Fischer D., Larrea E., Timms P.M., and Ulied A. (2009) Report on Transport Scenarios with a 20 and 40 year Horizon, Final report, Funded by DG TREN, Rome, Italy. (Signosis_G_1)

Shaheen, S. A. and Cohen, A. P. (2006) Worldwide Carsharing Growth: An International Comparison. Transport Research Record, UCD-ITS-RR-06-22, USA. (CTL_T_17).

Shell (2009) Shell Pkw-Szenarien bis 2030 - Fakten, Trends und Handlungsoptionen für nachhaltige Auto-Mobilität. Shell Deutschland Oil GmbH.

Short,J. and Kopp, A. (2005) Transport infrastructure: investment and planning. Policy and research aspects. Transport Policy 12(4), pp. 360–367. (LNEC_T_15).

Simma, A. and Axhausen, K.W. (2003) Interactions between Travel Behaviour, Accessibility and Personal Characteristics: The Case of Upper Austria. EJTIR 3(2), pp. 179-197. (DELFT_T_9).

Spruijtenburg (2009). The Road to Personal Intelligent Travel Assistance; How to Bundle Public Interests to Private Opportunities? Baarn/Delft, 07/12/2009 (DELFT_G_41).

Stead, D. and Banister, D. (2003) Transport policy scenario-building, Transport Planning and Technology 26(6), pp. 513-536. (JRC_T_10).

Su, F., Schmöcker, J.D. and Bell, M.G.H. (2009) Mode Choice of Older People Before and After Shopping: A Study with London Data. Journal of Transport and Land Use 2(1), pp. 29-46. (JRC_T_25).

TEN-T (2008). Ex post evaluation of cohesion policy programmes 2000-2006.

UN - United Nations, Department of Economic and Social Affairs/Population Division (2011). World urbanisation prospects – The 2011 revision. http://esa.un.org/unpd/wup/pdf/WUP2011_Highlights.pdf

USEmobility (2011) Deliverable 2.2: National trends in passenger transport regarding the choice of transport mode (Final Draft). USEmobility (Understanding Social behaviour for Eco-friendly multimodal mobility) project. Seventh Framework Programme. (CTL_G_7)

Van Acker, V., Mokhtaria, P. L. and Witlox F. (2011) Going soft: on how Subjective Variables Explain Modal Choices for Leisure Travel. EJTIR 11(2), pp. 115-146. (DELFT_T_18).

WEC – World Energy Council (2007) Deciding the Future: Energy Policy Scenarios to 2050. London. (LNEC_G_16)

WEC – World Energy Council (2011) Global Transport Scenarios 2050. London. (LNEC_G_17).

Zachmann, G., Holtermann, M., Radeke, J., Tam, M., Huberty, M., Naumenko, M., and Faye, A. (2012) The great transformation: decarbonising Europe's energy and transport systems, Bruegel Brueprint 16, Brussels, Belgium. (JRC_T_1).

Zito, P. and Salvo, G. (2011) Toward an urban transport sustainability index: an European comparison, European Transport Research Review 3(4), pp. 179-195. (LNEC_T_3).