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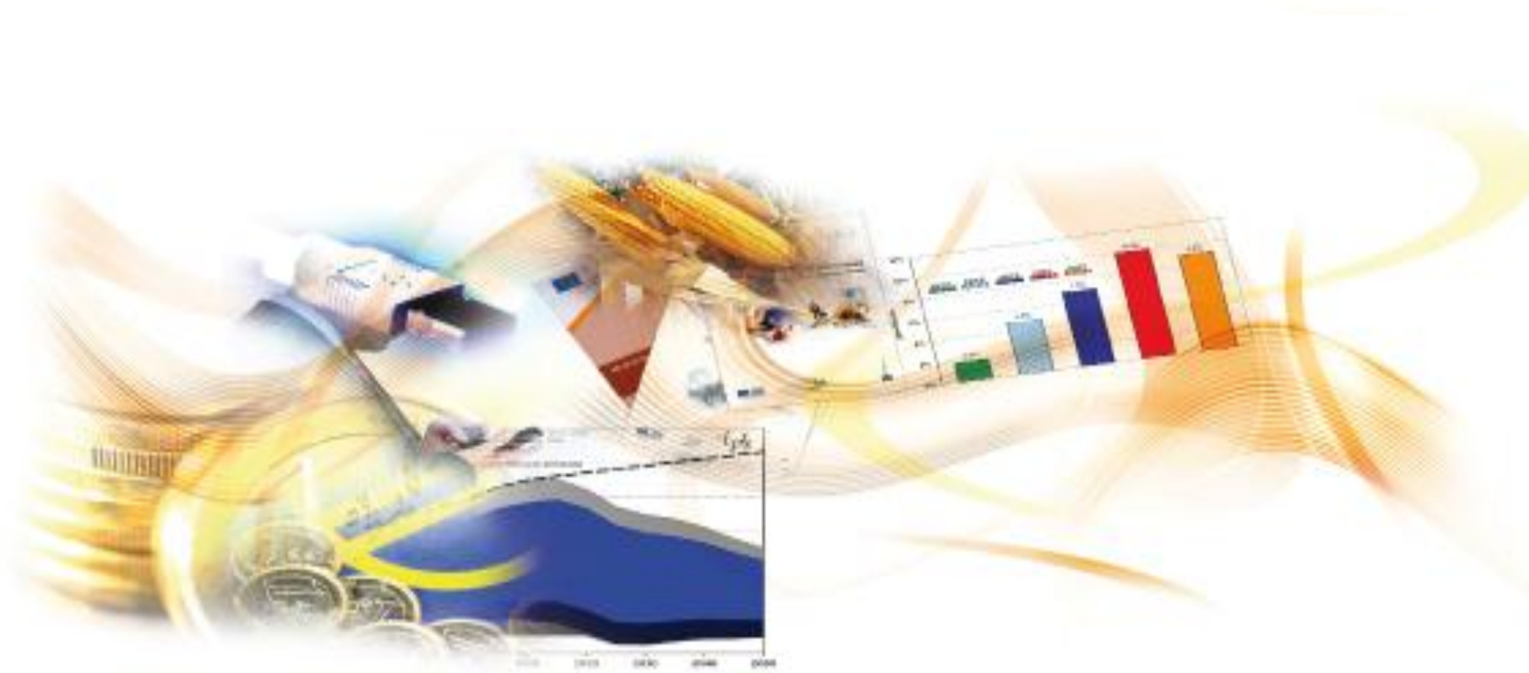

The Future of the Transport Industry

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Abstract

This publication aims to bridge the gap between the analysis of the trends in the European transport system and the evaluation of their impacts on competitiveness. Specifically, this report presents the future challenges, demand drivers and upcoming innovations which can have a considerable impact on the global demand patterns for the passenger and freight transport and how this might affect the competitiveness of related industries and service providers. Emphasis is given to targeted research strategies. The goal is to investigate the challenges for the European transport sector in the long term, in order to develop the suitable strategic options for European transport research policy.

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FOREWORD

This publication aims to bridge the gap between on the one hand manifold studies on the future of the European transport system and on the other hand, the issue of competitiveness, which needs to be supported through targeted research strategies. Specifically, this report presents the future challenges, demand drivers and upcoming innovations which can have a considerable impact on the global demand patterns for the passenger and freight transport and how this might affect the competitiveness of related industries and service providers.

In general the philosophy of this document is to investigate the challenges for the European transport sector in the long term, in order to develop the suitable strategic options for European transport research policy. The framework of this publication is based on the FUTRE project. This project has received funding from the European Union Seventh Framework Program under Grant Agreement n^{o} 314181. Its consortium consistes of five entities from four countries, which are:

1) Centre for Research and Technology Hellas, Hellenic Institute of Transport, Greece (Coordinator)
2) Fraunhofer-ISI, Institute Systems and Innovation Research, Germany
3) TIS, Consultores em Transportes, Inovacao e Sistemas, S.A., Portugal
4) Karlsruhe Institute of Technology, Institute for Technology Assessment and Systems Analysis, Germany
5) European Commission, Joint Research Centre, Institute for Prospective Technological Studies, Spain

A significant role to the successful compiling of this document played the input that came from: 1) three thematic workshops, which the FUTRE consortium organized during the two years of its duration (October 2012 – September 2014), 2) "Advisory Board (AB)" and 3) the "Expert Group (EG)". During these workshops, the AB, consisting of experts from the transport industry, with representatives from all the transport modes and research fields, was invited to contribute and share its ideas on the different topics discussed with the rest of the consortium. The AB members are listed in the next table.

Advisory Board list		
Expert	**Organization**	**Expertise**
Prof. Zissis Samaras	Aristotle University	Environment (mainly for road transport)
Prof. David Banister	Oxford University	Transport Policy, All modes
Prof. Werner Rothengatter	KIT Institute for Economic Policy Research	Transport Economist, Transport Policy, All modes
Paul Kompfner	ERTICO	Intelligent Transport Systems
Prof Rene Kemp	Maastricht	Transition Research
José Félix Ribeiro	International Future and Information Unit of the Department for Futurology and Planning of the International Relations office of the Ministry of Environment, Territorial Planning and Regional Development	Economist, futurologist (including transport studies and competitivenesss issues)
Maria da Graça Carvalho	European Parliament	MEP, Horizon 2020 raporteur
Prof. Barbara Lenz	DLR, Berlin	Transport Demand

The EG is composed of European stakeholders and was consisted of a more extensive list of people who were not directly involved with the FUTRE Project but contributed whenever required during the process of the project. Experts providing input and feedback in different stages of the project were acknowledged in all relevant project deliverables. Participants in the EG are listed in the following table.

Expert Group list

Expert	Organization	Expertise
Prof. P. Kapros	National Technical University of Athens (NTUA)	Energy and Environmental Economics, POLES model
Martin Burkhardt	UIRR, General Director	Rail Transport
Wolfgang Müller-Pietralla	Head of Future Development Volkswagen AG	Futurologist, Road Transport Innovations
John Cullen Simpson	Fraunhofer-LBF	Air Transport
Jonathan Köhler	Fraunhofer-ISI	Air and Maritime Transport
Moshe Givoni	Oxford / Tel Aviv	Integrated Transport
Luc Dechamps	Aerospace and Defense Industries Association of Europe (ASD)	Aviation
Klaus Rennings	ZEW Mannheim	Lead Markets
Yves Crozet	CNRS - National Center for Scientific Research	(High-Speed) Rail
Jonathan Gershuny	Centre for Time Use Research, University of Oxford	Economist, Time use research
Jeroen C.J.M. van den Bergh	Dept. of Economics & Economic History of Universitat Autònoma de Barcelona	Environmental economist, low growth economics and transitions
Birgitta Gatersleben	Research Group on Lifestyles, Values and Environment	Environmental psychologist - Sustainable consumer behaviour and energy use on travel and transport
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Joko Purwanto	TML	Demand, all modes
Davide Fiorello	TRT	Demand, all modes
Angel Aparicio	UPM	Transport Policy, All modes
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Prof. G. Giannopoulos	HIT, ETRA Chair	Transport Policy, All modes

Expert	Organization	Expertise
Sotirios Theofanis	Center for Advanced Infrastructure & Transportation (CAIT)	Freight Transportations, Port Management and Operations, Maritime Transportations
Thomas Wakeman	University Transportation Research Center	Navigation engineering, port development, maritime security and resilience, and freight transportation planning.
José Manuel Viegas	International Transport Forum	Transport Policy, All modes
Stephan Magnus	V-max GmbH	Specialist in prospective studies
Elena Tavlaki	Signosis Sprl.	Electromobility, Charging infrastructure
Massimo Moraglio	Technische Universität Berlin (TUB)	Futurologist, mobility effects on political, social and cultural fields
Caralampo Focas	University of Oxford	Transport Policy, All modes
Claudia de Stasio	TRT TRASPORTI E TERRITORIO SRL	Transport Policy, Transport Planning
Pelopidas Siskos	Energy-Environment-Modelling Laboratory (E3MLab) of National Technical University of Athens (NTUA)	Energy policy, energy economic analysis, economic of transports

We hope that the reader will find this publication interesting and useful to his/her work. Moreover, we believe that this document provides useful guidance material for the scientific society, in case the last wants to recognize and to evaluate the future prospects on transport sector.

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Table of acronyms

ASTRA	Assessment of Transport Strategies
BERD	Business Expenditure on R&D
BEV	Battery electric vehicle
CO2	Carbon dioxide
CNG	Compressed Natural Gas
REF	Reference Scenario
ERA	European Research Area
ETP	European Technology Platform
EU	European Union
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
FP7	Seventh Framework Programme of the EU for research and development
GBAORD	Government budget appropriations or outlays for R&D
GDP	Gross domestic product
GERD-GOV	Gross domestic expenditure on R-D by the Government sector
H2	Hydrogen
ICT	Information And Communication Technologies
ITS	Intelligent Transport Systems
IWW	Inland Water Ways
JTI	Joint Technology Initiatives
OEM	Original Equipment Manufacturers
LNG	Liquid Gas
NFC	Near Field Communication
PPP	Public Private Partnership
P2P	Peer-to-peer
R&D	Research and Development
RFID	Radio Frequency Identification
SME	Small and Medium Enterprises
STEEP	Social, Technological, Economical, Environmental and Political factors
V2X	Vehicle to X

1. *Introduction*

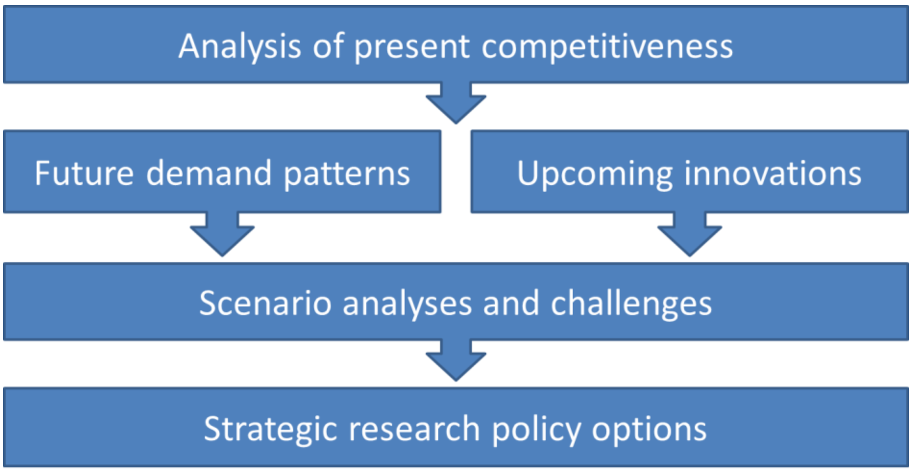
The transport sector is of utmost importance for economic growth and the quality of life in European countries. It is widely acknowledged, that innovations and targeted research activities are key factors for fostering global competitiveness of the transport sector. Innovation and related research agendas are targeted on the future, on challenges, market drivers and technologies that become effective in the future. Therefore, the design of research agendas needs to take into account potential future developments and challenges.

Specifically, having a long term perspective in the transport sector is crucial, due to the implications of present decisions on future performance and the nature of the investments such as transport infrastructure that require forward planning and making educated decisions on future requirements. Moreover, it is important for the EU, as an entity, to identify and assess its competitive advantages as well as to examine how it positions itself in order to maintain its existing competitive advantages or enhance them.

In general, the European transport sector faces several challenges for which innovation may play an important role. The current economic downturn imposes a reduction of transport demand thus increasing the costs incurred by companies. Innovations that improve the cost efficiency and productivity of the transport sector may reduce the impact of the current economic situation. In terms of environmental challenges, national and international regulations such as the reduction of the transport sector's emissions have created potential markets to green innovations such as electric vehicles. On the other hand the increasing number of population living in urban areas constitutes a challenge for transportation system organisation and mobility management innovations.

Figure 1 below illustrates the steps that are followed within this publication

Figure 1: **Structure of the publication**



2. ***Analysis of present competitiveness***

The importance of the transport sector in the EU is widely acknowledged in many policy documents since it is considered an important pillar of economic growth and quality of life for European countries. The White Paper on Transport, which is the main policy document on transport policy for the European Commission, starts by saying:

"Transport is fundamental to our economy and society. Mobility is vital for the internal market and for the quality of life of citizens (…) enables economic growth and job creation (…)" (COM, 2011; 3).

Nowadays several threats are imposed to transport and these will probably get tougher in the future (Condeço-Melhorado, et al., 2013):

• Environmental constraints: the EU has set a target to reduce greenhouse gas emissions by 80-95% below the 1990 levels by 2050 and 60% of this reduction should come from the transport sector;

• Competition from fast developing world transport markets: the EU companies are world leaders in many transport sectors. However, other countries have launched coordinated and ambitious plans to promote certain transport sectors, causing the EU to loose competitiveness and face the delocalisation of major companies to more competitive markets.

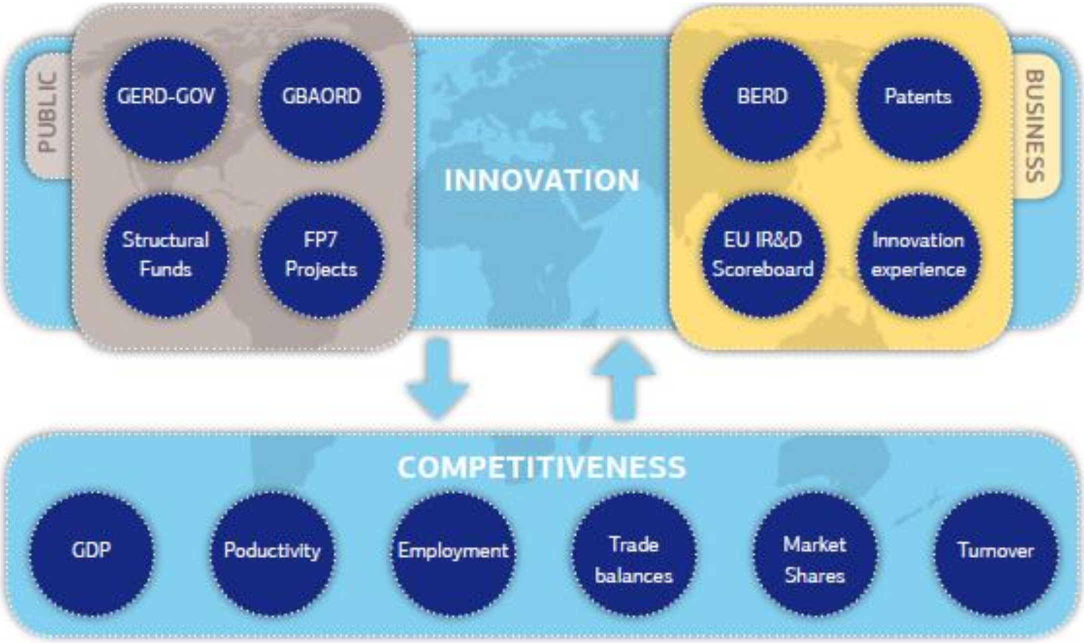
• Scarcity of resources: the EU transport sector depends on oil and oil products for 96% of its energy needs. Since oil will become scarcer in the future, transport will need to decarbonize in order to avoid oil price increase and deterioration of people's ability to travel.

• Security of passenger and goods.

• Congestion: certain transport infrastructures face important delays that represent a barrier to transport and lead to economic loss for companies and citizens.

Innovation in the form of new technologies or more efficient use of existing resources will be the key to address those threats without curving mobility. An innovative transport sector will become the pillar to sustain the economic competitiveness of European countries across the world. Therefore, there is a close correlation between innovation and competiveness in the transport sector, which is illustrated in the following figure.

Figure 2: Correlation between innovation and competitiveness



Source: FUTRE, 2013a

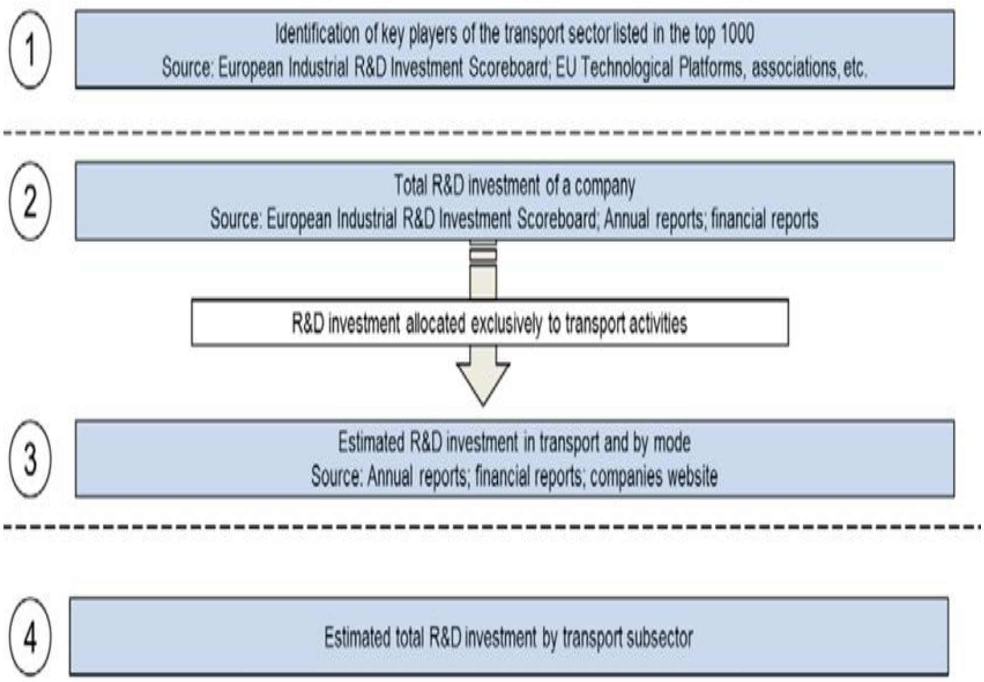
As depicted in the above figure, there are several indicators that can be used to illustrate the innovation effort made within the transport sector both by the public and business sector. From the public viewpoint, statistics on Gross Domestic Expenditure performed by the Government sector (GERD-GOV) show the R&D expenditure by the Government sector for a given year. Another type of indicator is the Government budget appropriations or outlays for R&D (GBAORD) which reflects the government intentions to commit money to R&D. On anEU level, statistics on Structural Funds and FP7 projects are also useful to characterise the innovation efforts in the transport sector.

For the business sector, there are several indicators showing the importance devoted to innovation in transport-related companies. The Business Expenditure on R&D (BERD) measures the national R&D expenditure performed by the business sector, while the EU Industrial R&D Scoreboard, contains the R&D expenditure of the most important companies. The Community Innovation Survey offers data on the Innovation Expenditures, which can be further disaggregated into intramural and extramural R&D, acquisition of innovative machinery, equipment and software and other external knowledge. Finally, patents are another important indicator to illustrate the innovativeness of the transport sector.

Regarding the competitiveness, there are specific indicators which can express the evaluation of this concept, such as GDP, employment, productivity, market shares, trade balances and turnover. Generally, there are several and different definitions about the meaning of this term. Two of the most prevalent are the following: The European Commission refers to competitiveness as "the ability of the economy to provide its population with high and rising standards of living and high rates of employment on a sustainable basis" (CEC, 2002; 2). Another definition comes from the World Economic Forum, which defines competitiveness as "a set of institutions,

policies and factors that determine the level of productivity of a country" (World Economic Forum, 2012; 4).
In this document, for a better understanding of the present innovation and competitiveness of the European transport sector, the following methodology is used, which is based on a bottom-up approach (Wissenthal, et al., 2011). Firstly, the EU transport sector competitiveness is characterized by comparing the differences among transport sectors. Then a similar analysis is performed at Member State level in order to draw conclusions about differences across countries in the EU. Finally, the competitiveness of the EU transport sectors is compared with major non-European regions, which will help to position the European transport sectors in the global context. Patent analysis was used to assess the competitiveness of the EU transport sector, looking at patent dynamics and specialisation, both at inter (global) and intra-European level., The Schematic overview of this methodology is given in the following figure (Condeço-Melhorado, et al., 2013).

Figure 3: Schematic Overview of the Methodology



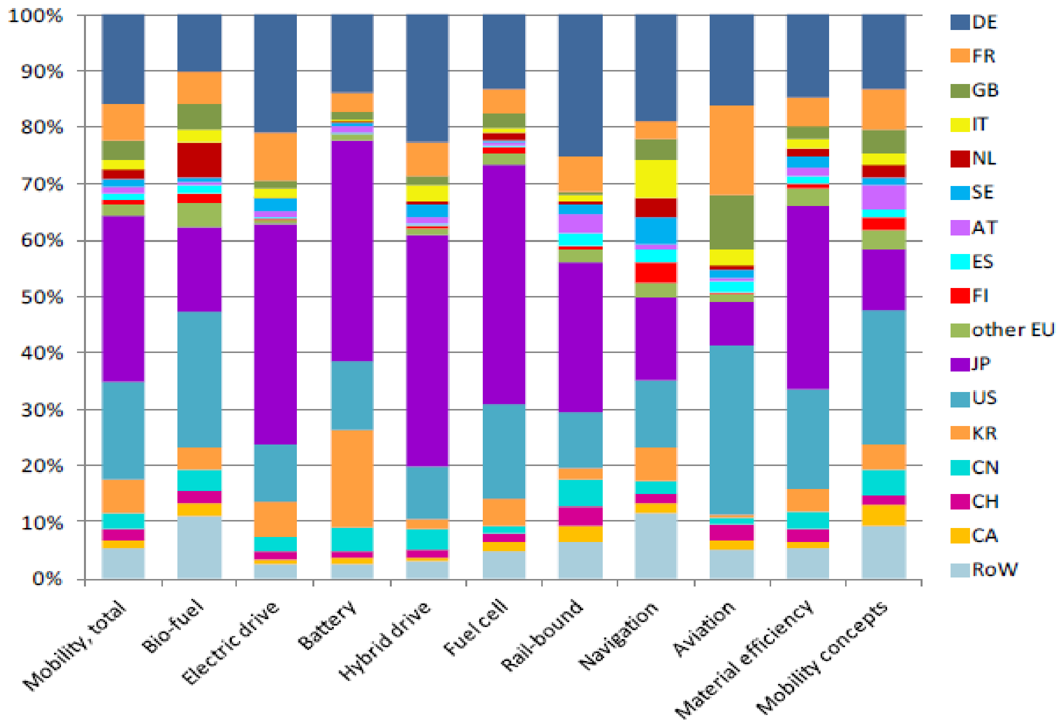
Source: Condeço-Melhorado, et al., 2013

The key results from the above methodology are the following (Figure 4, 5):

- Germany shows disproportionally (with respect to mobility in total) large shares in rail-bound, hybrid-drive, electric drive and navigation (in decreasing order)
- For France, aviation and, to a lesser extent, electric drive are above average

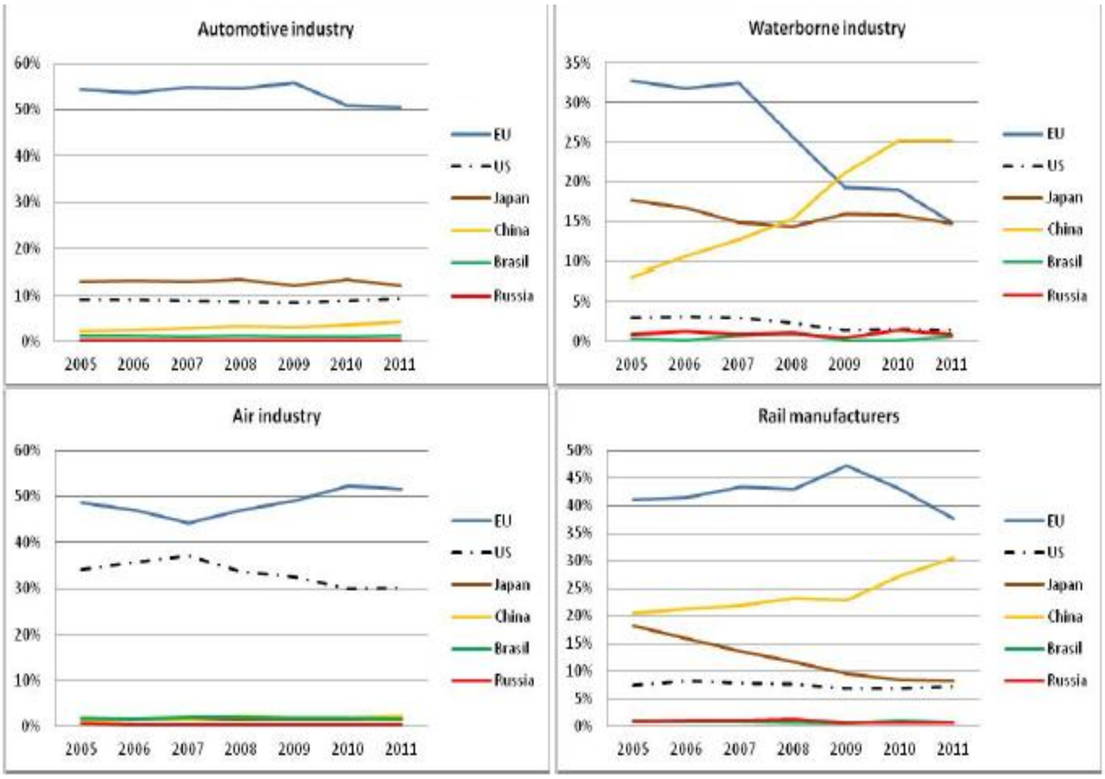
- Prominent areas with respect to patent shares: Bio-fuel for the Netherlands, navigation for Italy, Sweden and Finland, aviation for Great Britain and mobility concepts for Austria
- On the global level, by contrast, especially strong players in battery technology are Japan and Korea and in fuel cell Japan alone. Japan additionally takes the lead in electric and hybrid drive; so it dominates alternative drive technologies altogether
- The US dominates the areas of bio-fuel, aviation and mobility concepts. The fact that Japan hardly plays a role in aviation well reflects the almost complete division of the global market between the EU (Airbus) and the US (Boeing)

Figure 4: Patent shares of the most relevant applicant countries (share >= 1%) for different mobility-relevant technology areas in 2008 to 2010



Source: Condeço-Melhorado, et al., 2013

Figure 5: World market shares[1]



Source: Condeço-Melhorado, et al., 2013

In most transport modes the European industry has a global competitive position to defend and there is a clear sense that the best way to do so is by investing in research and innovation. The key challenge for European Transport Policy is twofold: Ensure competitiveness of the European industry while reducing the societal impacts (especially environmental) of that mode of transport. These two objectives are not contradictory in nature: if legislation and regulation is properly designed at European and international level, then addressing societal challenges will pay-off in terms of competitiveness.

3. ***Future demand patterns***

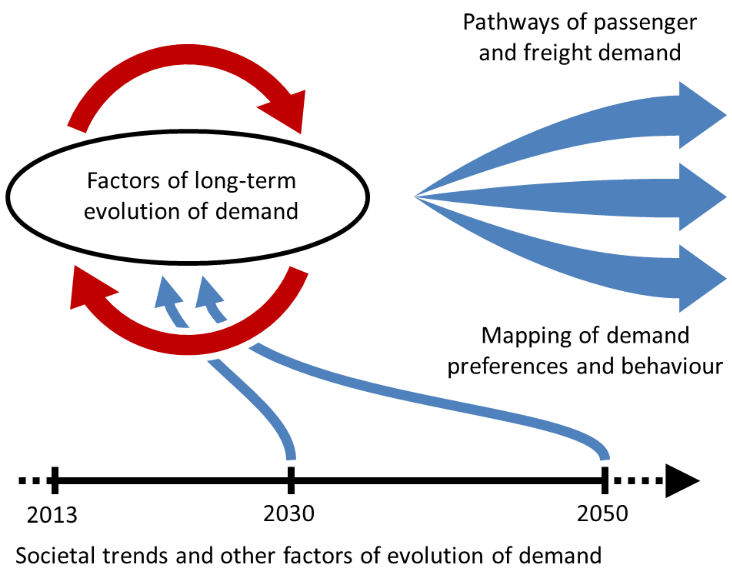
In order to identify long-term challenges for the EU transport industry, there is a question which must be answered and it is: "What will be the needs for transport in 2050?". The answer is not easy and requires a general approach which based on scenario analysis. Given the high level of uncertainty associated with the long-term prediction, it is useful to consider alternative future worlds. The idea is to draw a space of plausible possibilities in order to define strategies that accommodate different possible paths. More specifically, the method of pathway/scenario building departs from the consideration of possible global demand patterns, trends and converged to specific needs and importance of attributes on transport systems.

The identification of future demand patterns is a procedure which has as a necessary prerequisite the identification of the factors affecting future demand. The main features of these patterns included inputs from the literature review on future studies on transport and related fields, the stakeholder consultation and the consistency check based on a systems thinking approach. More specifically, this identification was based on the following steps (Bernardino, et al., 2013):

- ✓ Identification of possible **mega-trends** with impacts on transport
- ✓ Identification of key **factors** of evolution of transport demand
- ✓ Derivation of specific possible future **insights** on the world and transport demand
- ✓ Drawing of possible **global pathways** with relevancy on transport
- ✓ Identification of possible **key issues** that affect passenger and freight transport demand
- ✓ Assessment of **derived trends and challenges** and evaluation of challenges the EU will face

The following figure illustrates the methodological approach of the identification of the future demand patterns.

Figure 6: Identification of future demand patterns



Source: Reichenbach, et al., 2013

Megatrends are stable trends driven by global forces that impact several societal areas. By considering megatrends it is possible to try to assess how they will influence aspects of transport needs. The following megatrends were selected as the most relevant in the scope of transport (Bernardino, et al., 2013):

1. Globalization
2. Urbanization
3. Ageing
4. Knowledge society
5. Individualism
6. Migration
7. Connectivity
8. Immediate needs: here & now
9. Slow Movement
10. Empowerment of Women
11. Awareness / consciousness
12. Consumption 2.0 – use, not own
13. Ever Young
14. Seeking for experiences
15. Do it yourself

Based on the megatrends, related insights and the identification of aspects relevant for mobility systems, a set of key factors for the evolution of transport demand was identified. The **key factors** are related to different spheres of life and where arranged in the areas defined by the STEEP approach: Social, Technological, Economical, Environmental and Political factors. The factors are outlined in the table below:

Table 1: Key factors of evolution of transport demand

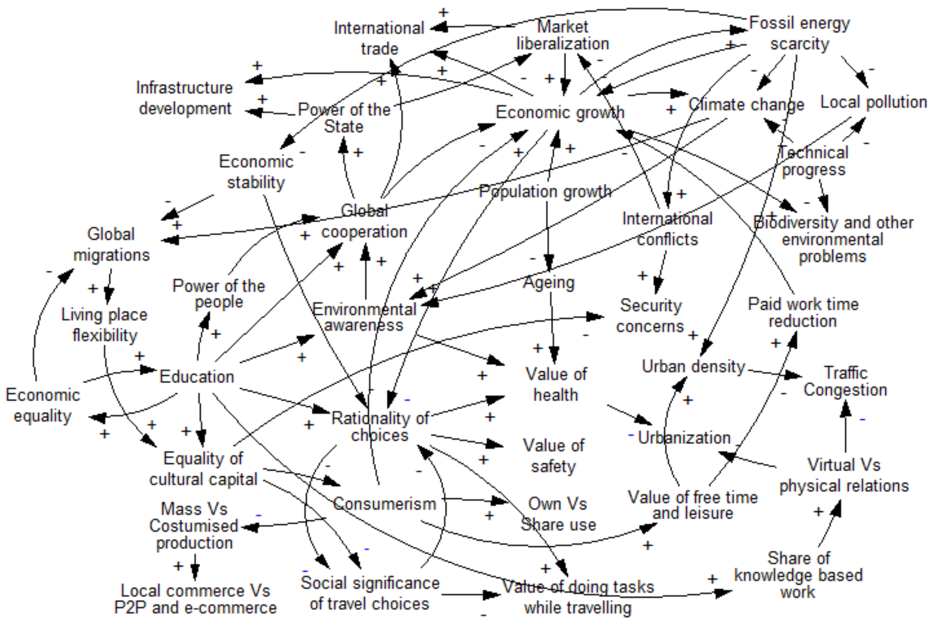
Social
Demography:
Population growth
Ageing
Global migrations
Living place flexibility
Education and social capital:
Level of education
Equality of cultural capital
Preferences and awareness:
Consumerism (VS spiritual needs)
Environmental awareness
Propensity to own VS share use
Social significance of travel choices (status)
Value of doing tasks while travelling
Rationality of choices
Value of safety
Value of health
Value of free time and leisure
More virtual than physical relations / communication
Technological
Ability to address energy, environmental and ageing challenges by technical developments
Economical
Economic development:
Level of economic growth
Economic stability
Volume of international trade
Economic equality
Production and consumption patterns:
Share of knowledge based work
Purchasing channel paradigms (P2P and e-commerce VS local commerce...)
Scale of production: mass VS customised
Paid work time reduction
Energy:
Fossil energy scarcity – prices
Urban development:
Urbanisation
Urban density
Congestion
Environmental (perceived problem of...)
Climate change
Biodiversity and other environmental issues
Local pollution (air, noise)

Political
Global cooperation on global issues
Power of the State
Power of the people and civil organizations
International conflicts
Security concerns
Market liberalization
Infrastructure development

Source: Bernardino, et al., 2013

The next step before the development of global pathways was the analysis of interrelations and systemic behaviour of the set of key factors. To this end, a system thinking approach framed the analysis. The development of causal loop diagrams allowed showing the main relations between the factors in question and the direction of those relations. It also showed the existence of several relevant feedback loops. For example, it was seen that people's preferences are influenced and reinforced by external conditions, whereby e.g. consumerism is made possible when there is abundance (economic growth) and environmental awareness is reinforced by the manifestation of environmental problems.

Figure 7: Causal loop diagram of key factors



Legend: arrows follow a System Dynamics notation. + (-) means a positive (negative) effect from the precedent to the pointed variable

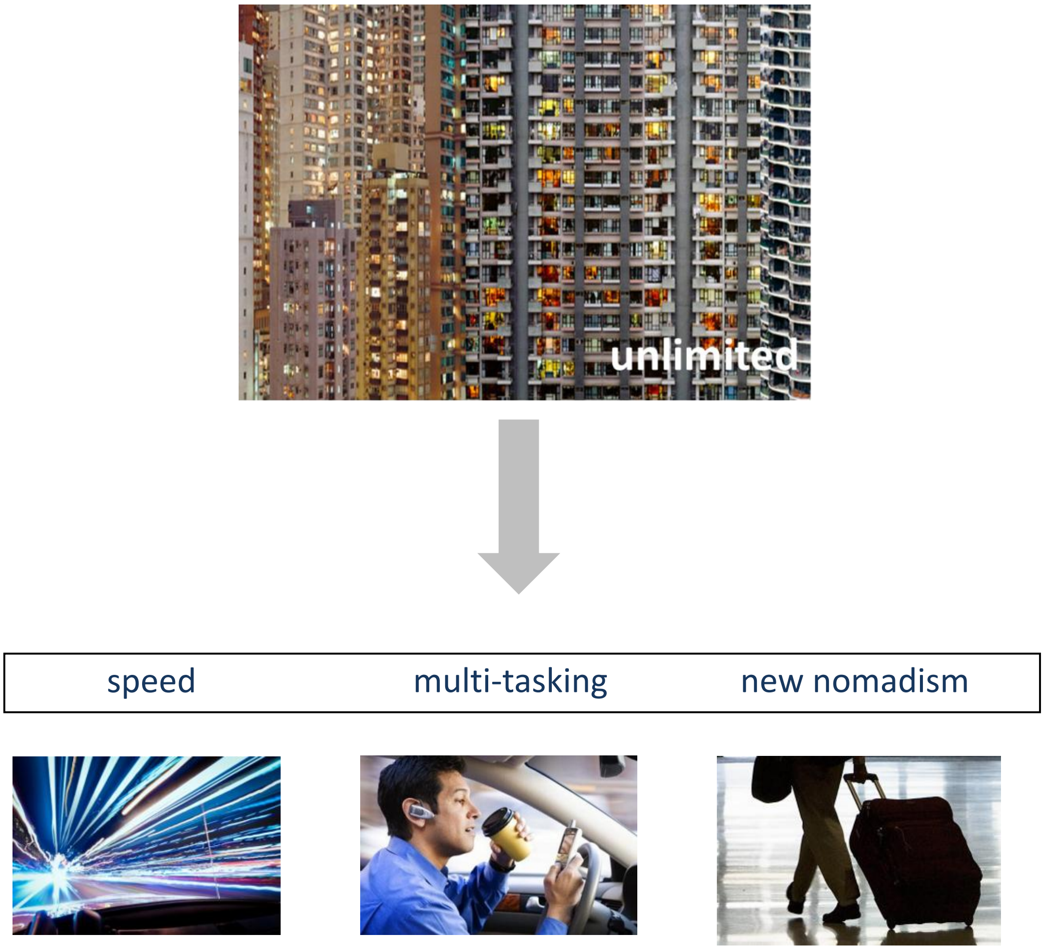
Source: Bernardino, et al., 2013

The steps taken in the development of scenarios included the identification of a short list of main driving factors. This list was composed of climate change, energy scarcity and price, economic performance, global cooperation and social preferences. The three final scenarios are the following:

1. **Unlimited:** This is the scenario where technology is able to solve the crucial environmental and energy problems. Without any constraint on them, current social practises may continue and even follow a path of **increased consumerism and thirst for travel.** Global economic competition is the most important driver of societies (Bernardino, et al., 2013).

   Main features: *Breakthrough technologies for green growth, little poverty, fast-running lives and 'experientalism', mix of work and private life, mainstream 3D printing*

Figure 8: Unlimited scenario characteristics



Source: Bernardino, 2014

1. **Passivity and chaotic collapse:** This scenario describes a world where societies are not able to address the impending environmental and energy problems. Societies ultimately fall economically and politically. There is a collapse of every type (energy, environment, political), with **uncertainty and need to adaption** in an unstable world (Bernardino, et al., 2013).

Main features: *Climatic and environmental crisis, severe climate change consequences, mass migration and protectionism, unpreparedness and chaotic change*

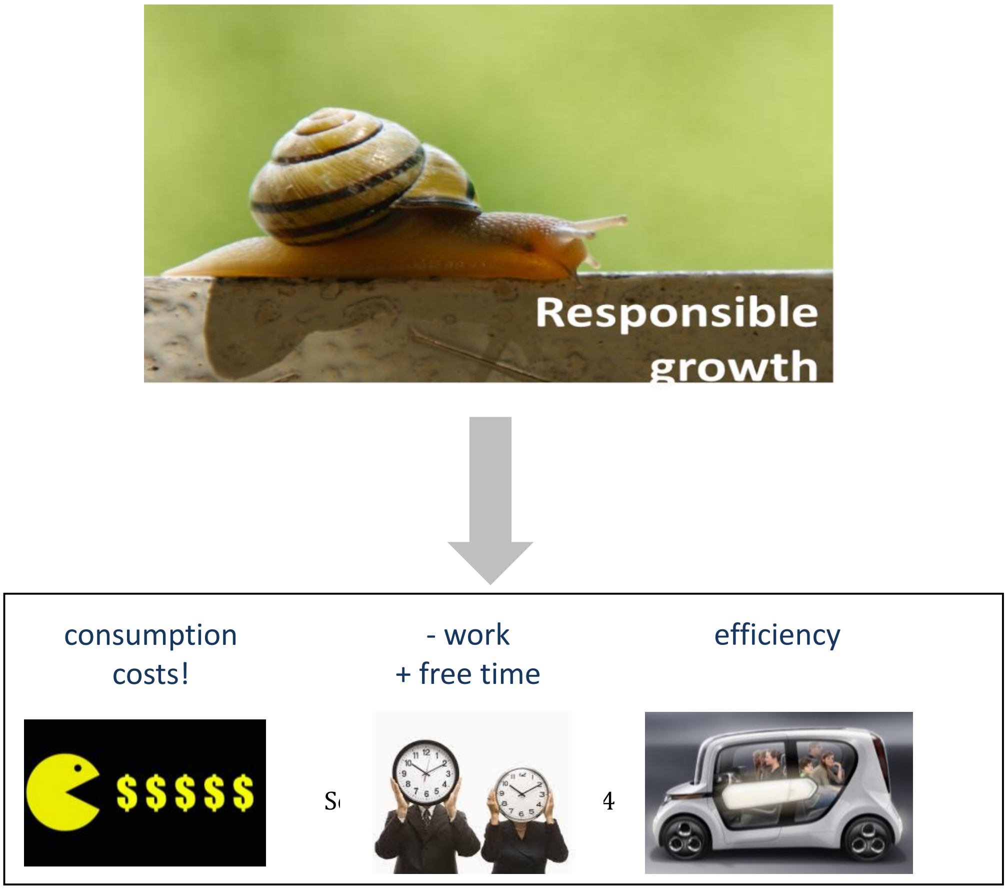
Figure 9: Passivity scenario characteristics

Source: Bernardino, 2014

2. **Responsible growth:** In this scenario the prospect of environmental and economic collapse leads people and countries to cooperation, in order to properly manage the global commons in a responsible way. Since the pace in (responsible) innovation is not high enough to cope with the grand challenges, this necessarily involves drawing back the economic output to a level consistent with sustainability. **People consume and travel less,** incentivised by various policy incentives concerted at an international level. Sustainability and also safety become overriding paradigms (Krail, et al., 2014).

   <u>Main features:</u> Internalization of external costs, restricted resource use, less resource-intensive restructured economy, sustainability, solidarity, less consumptive lifestyles, new social paradigm, responsible and conscious choices.

Figure 10: Responsible growth scenario characteristics



The identification of potential challenges for the transport sector was carried out by providing insights of alternative future transport 'realities'. The methodological approach of this identification is based on the correlation between a list of issues, which are expected to affect the process in which the transport system evolves and the main characteristics of each scenario (that were mentioned above). These issues are the results of an extensive literature review which took into consideration the key recognized issues - factors that have been previously used in other future passenger and freight demand work.

Specifically, the main issues from passenger side are: Globalization, growth in passenger transport, urbanization, change in factors influencing modal choice, openness for innovation. As regards to the main issues from freight side, these are the following: Freight volumes in relation to global economy, openness of global international trade markets, consumption behaviour in relation to ethical values, switch from "ownership" to "sharing", innovative technologies for logistics and new technologies for energy saving and environmental awareness.

Furthermore, the key challenges and trends that the transport sector will face in relation to each scenario are outlined in the table below:

Table 2: Overall challenges for passenger & freight transport

Scenario / **Issue**	**Unlimited**	**Passivity and chaotic collapse**	**Responsible growth**
Globalisation	Corresponding infrastructure is needed, in particular for aviation.	Significant reduction in air transport and an increase in shorter distances needs different kinds of infrastructure	Demand for sustainable products that meet society's needs.
Growth in passenger transport	Capacity of infrastructure will constrain passenger transport growth. Also, there is a huge demand for efficient zero-emission vehicles.	Energy efficiency of transport modes. High demand for smart and cheap and small cars.	People expect resource efficient innovations to be politically fostered. Efficient busses for smaller cities needed.
Urbanisation	Congestion is a problem. The travel preferences of city and countryside residents are different.	Financing of infrastructures is a major challenge. PPP schemes are needed.	Many smaller cities require cost and energy efficient solution for urban transport. Rail linkages between cities are extended.
Change in factors influencing modal choice	Difficult to provide the appropriate amount of capacities.	Not much demand for expensive high quality transport products and services.	Re-allocation of public funding; much more goes into small-medium cities.
Openness for innovation	High demand for vehicle designs between e-bikes and e-cars.	Challenge of getting funds for new developments and difficulties in bringing them to the market .	Innovations offering new and/or more efficient and saver mobility options are expected by the public.
Freight side	**Unlimited**	**Passivity and chaotic collapse**	**Responsible growth**
Issues	**Key challenges**		
Freight volumes in relation to global economy	Depletion of natural resources. Demand for new warehousing management technologies. Creation of customised logistics	Overcoming the ageing condition of transport infrastructure with limited resources and lack of investment.	Achieving more environmentally friendly means of transport.

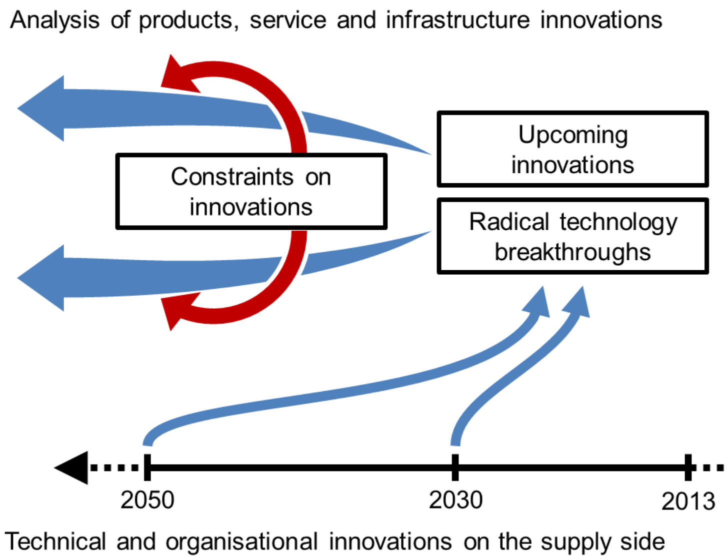
Scenario / Issue	Unlimited	Passivity and chaotic collapse	Responsible growth
	for 3D printing.		
Openess of global international trade markets	Development of quick and reliable freight services. Protection of natural resources of small developing economies from globalised markets.	Difficulty in border crossing for freight services.	Development of quick, reliable, safe and environmentally friendly services.
Consumption behaviour in relation to ethical values	Customer demand for on time delivery will require flexible logistics systems.	Coping with demand based on migration patterns in an environment with limited infrastructure and resources.	Survival of small companies is going to be difficult due to the increased responsibilities of the full product life cycle.
Switch from "Ownership" to "Sharing"	Nomadism will cause housing demand and freight related to construction equipment and materials.	The cost for infrastructure will have to be absorbed by producers/shippers/ energy companies that use the transport network.	Demand for better planning techniques that will help freight transport companies to cope with serving multiple customers that need products delivered on time.
Innovative technologies for logistics	Large production of new advanced technological materials.	Investments on technologies by few people will create two gear societies: technologically advanced or deprived.	Investments on green & reverse logistics.
New technologies for Energy saving and environmental awareness	Achieve the dual objective of cost effective and environmental friendly freight transport.	Achieving these sustainable technologies and start re-using and recycling more of existing materials.	Shift towards green sources of energy.

Source: Papanikolaou, et al., 2014

4. *Upcoming innovations*

The identification of the most relevant innovations (emerging or anticipated technical and organisational innovations) is a procedure which has a focus on radical innovations that are expected to lead to significant improvements of global relevance and to have systemic effects on the transport system. The following figure illustrates the methodological approach of the identification of the upcoming innovations, which is described in details below.

Figure 11: Identification of upcoming innovations



Source: Reichenbach, et al., 2013

The first step involved the separation and the definition of three types of transport-related innovations, which are (Reichenbach, et al., 2014):

- ✓ Product innovations include fuel efficiency, use of ICT, new materials or new design
- ✓ Service innovations imply for example innovative mobility or logistics concepts controlled by ICT
- ✓ Infrastructure innovations include innovations in constructing of transport networks as well as energy production and distribution innovations relevant for increasing the share of renewable energy carriers for transport

The next step included desk research on upcoming innovations, which is based mainly on the results of several studies in the transport sector, from the recent years were analysed with regard to innovations that they assume to important in the future. These studies are mostly settled in the European context and being carried out within other FP7 research projects such as

GHG-TransPoRD, Market-Up, REACT, EU Transport GHG: Routes to 2050, TOSCA, U-STIR, TRANSvisions, FREIGHTVISION and INNOSUTRA.

The result of the above desk research was the identification of a long list of relevant upcoming transport-related products, service and infrastructure innovations until 2030 and beyond on a global scale (approximately 400 innovations). Innovations were then categorized into **Innovation Fields** and the most important technologies were selected for further evaluation based on their impact (Table 3 below).

Table 3: Identification of innovation fields and technologies

Innovation Field	Innovation or technology
Automation of road transport	Advanced driver assistance systems
	Full autonomous driving
	Intelligent transport communication Systems (e.g. inter-vehicle communication, vehicle-infrastructure communication, intelligent signaling
Fuels and propulsion technologies	Battery electric vehicles
	Hybrid technology (allowing pure electric drive for a certain distance)
	Fuel cell Electric Vehicles
	Second Generation biofuels
	Improvements in conventional internal combustion engines (e.g. downsizing)
	Liquid Gas (LNG) for shipping
Improving the means of transport	Lightweight materials (e.g. carbon fibers)
	Improved aerodynamics
Intelligent transportation systems	Ubiquitous (internet) access to harmonized traveller information (passenger) and tracking information (freight)
	Personal Rapid Transport (small automated vehicles operating on a network of specially built guide ways)
	RFID (Radio Frequency Identification) /NFC (Near Field Communication) applications for seamless user interfaces
	Autonomous supply chain management for more efficient use of logistics services
Services /organizational innovations	Innovative sharing services (car sharing, bike-sharing etc.)
	Tele-working, video-conferencing and holographic conferencing
	Smart ticketing schemes
Infrastructures	Innovative new types of transport infrastructure (e.g. CargoTube, Hyperloop)
	Innovative transshipment technologies for seamless intermodal freight transport
	Inductive charging infrastructure for electric vehicles

Source: FUTRE, 2013b

The next step involved an evaluation of identified innovation fields which aimed at gaining an understanding on emerging transport innovations/technologies, on how these are expected to affect transport system efficiency in Europe and the competitiveness of the European transport sector. The following aspects were taken into consideration in this procedure (Reichenbach, et al., 2014):

- ✓ the likeliness of technological breakthroughs in the corresponding field
- ✓ crucial constraints and barriers
- ✓ the potential impacts on the transport system
- ✓ the potential impacts on global competitiveness of the European transport sector

The main conclusions of this evaluation are the following (Reichenbach, et al., 2014):

- The importance of ICT technologies as a key enabler for all transport services. As ICT systems will be part of the infrastructure, transport experience will be transformed completely
- Full autonomous driving is expected to be mainstream in the next 20-30 years and it will change the way we perceive and understand transportation. In the core urban area there will be fierce competition against advanced transit system while there is no market for this in the non-urban area.
- Technologies related to energy (e.g. renewable energy technologies) and materials (e.g nano-materials, rare earth materials etc.). These technologies will have a significant impact on transport systems

  Focus on materials: Since the EU is implementing the "Pay per use" philosophy for the road transport sector, it is essential to find more resistant materials for roads, so that the maintenance shall be cheaper in long term.

5. *Scenario analyses and challenges*

The need of understanding of how the market reacts on major upcoming transport-related innovations under the framework of changing demand needs on a European scale, led to the use of the modelling toolset consisting of ASTRA-EC and Trans-Tools. The System Dynamics model, ASTRA-EC (Assessment of Transport Strategies), is a tool enabling Integrated Assessment of transport policy strategies. Hence, it is able to link the systems of transport, society, economy and environment.
The ASTRA-EC model is based on System Dynamics methodology. In brief, a System Dynamics model consists of a set of hypotheses on the relationship between causes and resulting effects. Hypotheses may be based on theory or only informed by theory, but empirical inputs from statistics, surveys or other observations may also be used (Krail, et al., 2014).
ASTRA-EC consists of different modules, each one related to a specific aspect, such as the economy, the transport demand, the vehicle fleet. The main modules cover the following aspects (Fermi, et al., 2012):

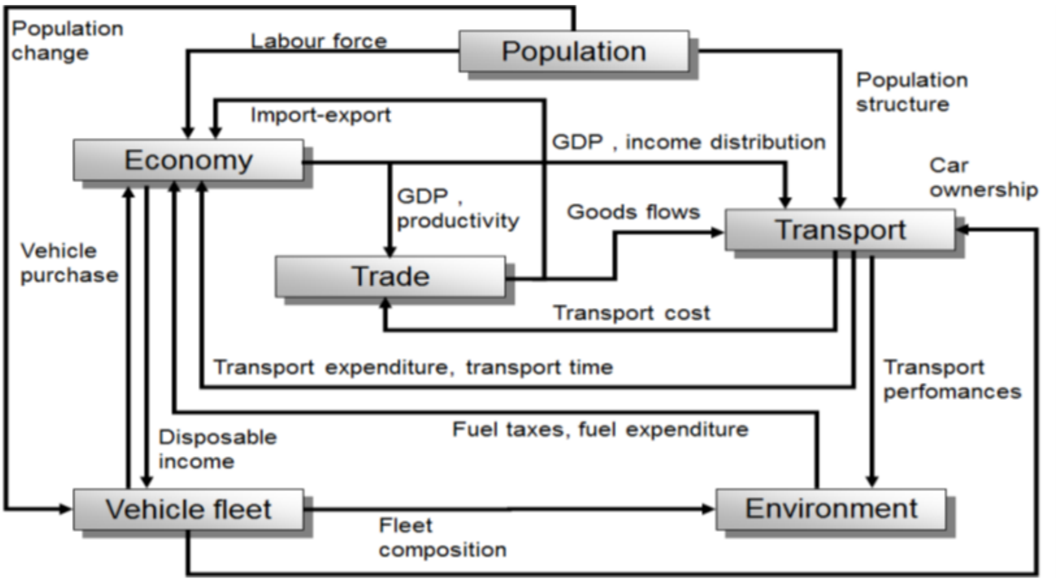
- ✓ Population and social structure (household types and income groups)
- ✓ Economy (including input-output tables, government, employment and investment)
- ✓ Foreign trade (inside EU and to partners from outside EU)
- ✓ Transport (including demand estimation, modal split, transport cost and infrastructure networks)
- ✓ Vehicle fleet (passenger and freight road vehicles)

1. Environment (including pollutant emissions, CO2 emissions, fuel consumption)

A key feature of ASTRA-EC as an integrated assessment model is that the modules are linked together. Changes in one system are thus transmitted to other systems and can feed-back to the original source of variation. For instance, changes in the economic system immediately feed into changes of the transport behaviour and alter origins, destinations and volumes of European transport flows.
The original Trans-Tools model is designed as a support tool, tailored to the main priorities of EU transport policy. It covers the networks of all main modes in both passenger travel and freight transport. Its features have been selected in order to best simulate and analyse the impacts of different policy measures affecting a large number of drivers of transport demand, transport volume, costs and the performance of the transport system as a whole. TRANSTOOLS-S is a simplified version of the Trans-Tools model that has been developed by the JRC-IPTS to overcome certain difficulties encountered in the original model, especially as regards the model's precision, transparency and reaction to policy shocks.
In this publication the usefulness of ASTRA-EC model was to simulate changing travel patterns in a bottom-up approach following the first three

stages of the classical four stage passenger and freight transport modelling approach consisting of generation, distribution, modal split and assignment. For the last stage, a detailed transport network is required which can only be provided by a network-based transport model like Trans-Tools (Krail, et al., 2014).

Figure 12: Overview of the linkages between the modules in ASTRA-EC



Source: Fermi, et al., 2012

The key elements of each scenario that were used as input to the ASTRA-EC model are presented at the table below. These were derived from the analysis and the work that was carried out in the previous stages based on the long-term perspective on the transport demand and supply side.

Table 4: Key elements of the scenarios

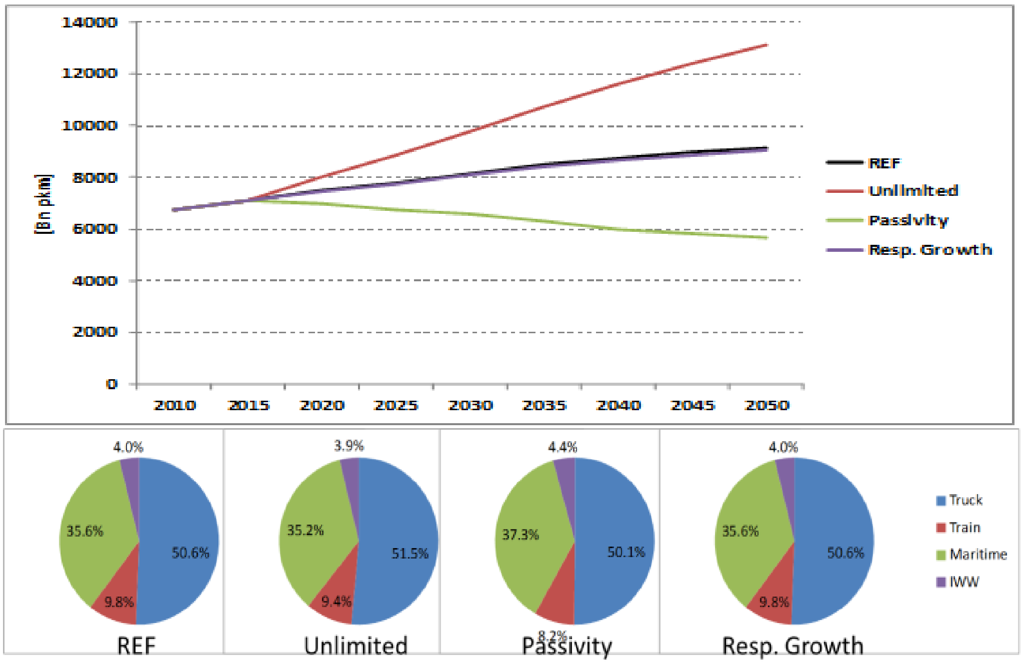
	Unlimited	Passivity & chaotic collapse	Responsible Growth
Economy	Globalised, +2.0%	National, +0.2%	Control, +1.0%
Climate	Small problem	Huge problem	Challenging
Lifestyle	Nomadic	Working	Leisure
Innovation	Extreme progress	Slow progress	Responsible Innovation
Land use	Megacities	Urban sprawl	Medium-sized cities
Passenger volumes	Increase	Decrease	Like business as usual

	Unlimited	Passivity & chaotic collapse	Responsible Growth
Freight	Increase	Decrease	More regional
Cars/1000 inhabitants in the EU15	650	400	250
Fuels for cars	Non-fossil	Fossil (some BEVs)	Mixtures
Long-distance trucks	CNG/LNG	Diesel	Methane/diesel/H2
Car usage	Owning/leasing	Owning/sharin g	Sharing
Urban transport	Cars	Buses	No cars
Energy price	Low	Medium (oil: 200$/barrel)	High (oil: 300$/barrel)

Source: Krail, et al., 2014

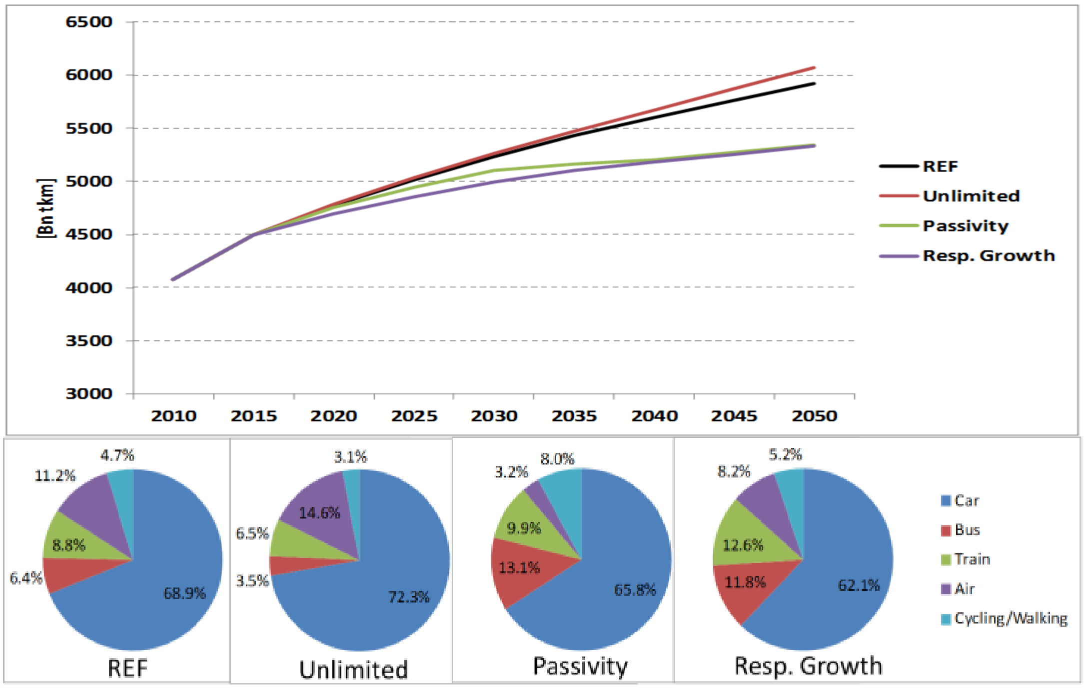
Some of the indicative results, which came from the analysis with the ASTRA-EC model, are the following:

Figure 13: EU27 passenger transport -pkm and modal share in 2050



Source: Krail, et al., 2014

Figure 14: EU27 freight transport -pkm and modal share in 2050



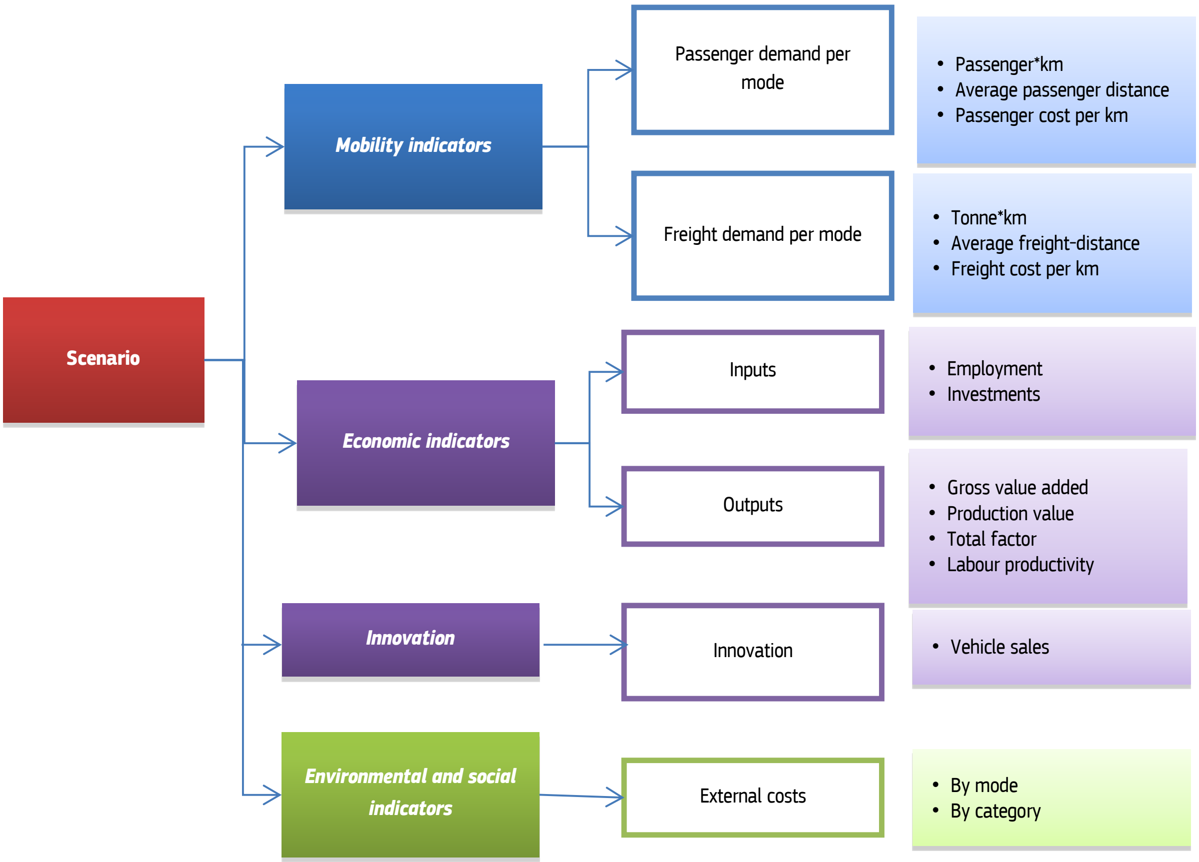
Source: Krail, et al., 2014

As illustrated in the above figures, the existence of the fourth scenario (reference scenario – REF) was based on providing a baseline so it could be used as a baseline for comparison in relation to the other future scenarios. A general rule for the Reference scenario was that it included the legislative status and the quantitative approval of the European policy.

A set of indicators was developed and used to carry out the competitiveness assessment of the EU transport sector. The selected indicators, which are listed in figure 13, were used in the ASTRA-EC model for each of the main three scenarios. These competitiveness indicators referred to mobility patterns, economic factors and environmental and social impacts.

These indicators revealed the drivers for the competitiveness of the sector which are related with mobility patterns and the innovation capacity of the different transport subsectors. Other indicators show the outcomes of each scenario in terms of economic performances and environmental and social costs (Krail, et al., 2014).

Figure 15: Indicators selected for the analysis of competitiveness of the European transport sector



Source: Krail, et al., 2014

This assessment of the different scenarios, based on the indicators mentioned above, revealed several opportunities and barriers for the competitiveness of the European transport sector (Table 5 below).

Table 5: Opportunities and barriers for the competitiveness of the European transport sector in each scenario

Unlimited

- Increasing competition from emerging countries, especially in the automotive and maritime sectors;
- Weak competitiveness of European transport industry in most promising technologies in this scenario: Hybrids, FCEV, EV;
- Decreasing modal share for collective means of transport (i.e. rail sector, especially freight);
- Alternative fuels for aviation

Passivity

- Reduced mobility
- Decreasing modal share for the rail sector, especially freight.
- Loss of high skill jobs in the transport sector (i.e. aviation and automotive)
- Increasing competition from emerging countries (automotive and maritime sectors)
- 'conventionally-fuelled' cars
- High European dependence from most external sources of fuel, including E85 and CNG
- Scarcity of raw materials
- Lack of financial resources to improve transport infrastructure
- Lack of political will to deal with

Responsible growth

- New business models (i.e. shared economy)
- Strong competition from developing countries, particularly from shipbuilders and automotive sector (EV, FCEV, hybrids)
- Managing increased demand for public transport
- Low carbon and sustainable fuels, especially in for the air mode
- Scarcity of raw materials

6. *Strategic research policy options*

The key aim of this publication is to use all the information, which were gathered in the previous sections, as a basis to develop strategic options for transport-related research activities. For this reason each European transport subsector (automotive, rail, aircraft manufacturers and the maritime sector) is analysed for each scenario in terms of its current global competitiveness and its future prospects of sales. Specifically, a framework was created, which classifies the transport subsectors into 4 categories with different challenges and specific policy needs (Condeço-Melhorado, et al., 2014):

2. *Strong industry with low prospects of sales:* This is a negative situation that will evolve towards a declining industry if no strategic options are taken. The industry benefits from a good competitive position in international markets, but new demand preferences will move away from traditional products and services offered by the industry, forcing it to adapt. In this situation public policy should support an industrial transformation by focusing on the most competitive innovation fields and on the promotion of cross-fertilization between different sectors. Demand-side instruments focusing on the most competitive innovation fields will drive innovation efforts of the transport sector.

3. *Strong industry with high prospects of sales:* This ideal situation is related with high innovation capacity of the private sector. The industry has the available funds for innovation and the capacity to fulfil future demand preferences, which are in line with its core-business. In this case public support should follow the industry's priorities, providing a mix of demand-side and supply-side innovation measures, but rather in a complementary way. Public support should try to fill the innovation gaps that are caused by market failures associated with the innovation process.

4. *Weak industry with low prospects of sales:* This is the worst case scenario from the industrial viewpoint. It reflects a situation of a declining industry that was not able to adapt to current demand preferences and will need to struggle further with new demand shifts that will put additional pressure into traditional business models. Public policy should focus on providing extensive support to innovation, both with demand-side and supply-side innovation measures. This will support the competitiveness of the industry at the time it promotes a profound industrial transformation by improving the skills and specialization, focusing in the most promising innovation fields.

5. *Weak industry with high prospects of sales:* This is the case of low industrial specialization in promising markets. Public support should focus on strengthening the innovation capacity and the competitiveness of those industries that are well positioned in those innovation fields with higher

prospects of sales. Supply-side measures, such as financing of innovation activities will help companies facing the most important challenges pointed in each scenario.

The outcomes of applying the current framework to the competitiveness prospects of European transport subsectors are presented in Table 6.

Table 6: The competitiveness prospects of European transport sector under each scenario

		Low prospects of sales	High prospects of sales
Strong industry	*Unlimited*	Rail	Private cars Aviation
Strong industry	*Passivity*	Aviation Private cars Rail	Buses
Strong industry	*Responsible growth*	Private cars Aviation	Buses Rail
Weak industry	*Unlimited*		Private cars: alternative fuels Commercial vehicles Maritime
Weak industry	*Passivity*	Commercial vehicles Maritime	Cheap and slower modes
Weak industry	*Responsible growth*	Commercial vehicles Maritime	

Source: Condeço-Melhorado, et al., 2014

The rationale for establishing the European transport research policy measures was built using this categorization of the industries. A set of EU transport research policy measures is proposed in order to help each sector become more competitive by the year 2050 and overcome the limitations of each scenario. Moreover, the proposed policy measures will focus on the role of EU transport research as a mean to improve competitiveness and increase sales for the industry. Specifically, these policy measures consist of recommendations of how EU transport research could help the industry through mechanisms such as funding, promotion of legislation and technologies, provision of support services for companies such as coaching and mentoring, excellence in education as well as access to information and technology for companies (Condeço-Melhorado, et al., 2014).

These mechanisms were based on action plans that the EU currently uses within the framework of innovation (Innovation policy platform, 2014; EC- Innovation union, 2014) as well as company support (EC—DGRU, 2013). The following tables present the policy measures that have been formulated for each scenario:

Table 7: EU transport research policy measures related to Unlimited Scenario

	Low prospects of sales	High prospects of sales
Strong industry	**Rail** - Financial investment for companies developing innovative high speed infrastructure through direct funds, competitive R&D grants or credit guarantees (in order to make the rail mode more attractive through journey time minimisation). - Investment in research for design and development of innovative systems that will enable intermodal/ comodal integration of the rail mode into seamless transport systems in order to create sales by making the mode more attractive (ITS and integrating ticketing). - European vision and roadmap for door-to-door intermodal information passenger travel service. - Development of legislation allowing information sharing between companies/ countries in order to allow integrated ticketing. - Development of innovative legislation schemes that allows revenue sharing between companies. - Establishment of cooperative platform & single European standards with the aim of cross border interoperability throughout Europe. - Development of a single safety legislation platform allowing the improvement of safety across the EU rail network.	**Automotive (private cars)- small support** - Financial support (competitive R&D support or credit guarantees) to innovative companies that will develop solution on alternative fuels. - Introduction of regulatory regimes and standards for the use of autonomous control technologies, V2X and ITS. - Introduction of cooperative platforms for the creation of single innovation market in order to create a common line for the choice of technologies made by the EU companies. - Promoting excellence and educational skills for in promising innovation areas (i.e. electromobility). Vocational training schemes and research initiatives related to this area. - Financial and coaching support to cluster that promote technology exchange between companies in order to create a strong competitive EU industry against rivals. **Aviation- small support** - Promotion and support to aviation special interest groups with the focus on bringing in together customers (airlines), consumers (passengers) and policy makers in order to design future aircrafts meeting everyone's needs. - Financial support through direct funding or competitive R&D grants for manufacturers with the aim of innovative design for green and lighter aircrafts - Introduction of regulations/ legislation promoting the use of alternative propulsion and fuels.

	Low prospects of sales	High prospects of sales
Weak industry		**Automotive (alternative fuel technologies)** - Financial support to innovative companies that are related to the manufacturing side of alternative fuel technologies. Direct funding, competitive R&D grants or credit guarantees. - Support in the improvement of refuelling infrastructure taking in consideration sustainable production and storage (i.e. for hydrogen). - Research support for the exploration of alternative funding schemes that can be used by private companies for the creation of alternative fuel refuelling infrastructure. - Standardisation for refuelling infrastructure through restrictive regulations. - Creation of an EU Platform for battery technology platform bringing in all industry stakeholders (i.e. working groups from mining, manufacturing, systems, standardisation, recycling and overall framework). - Promoting excellence and educational skills for production of fuel cells and electric batteries. Vocational training schemes and research initiatives related to this area. **Automotive (commercial vehicles)** - Creation of support services for commercial vehicles automakers such as: Financial support and risk sharing for innovative companies creating joint ventures in non EU countries i.e. competitive grants, direct support. EU support through technology showcases and exhibitions for EU commercial vehicles manufacturers. Consultancy services and coaching for identifying foreign market needs. Support of the industry through networking services with foreign markets. - EU to assist OEMs by creating technology platforms for information sharing across the EU between research centres, universities and the industry in the field of alternative fuels and other energy saving technologies. **Maritime** - Support clusters offering information exchange between companies and countries. - Direct financial support to companies through the creation of pool funds between member states or credit guarantees. - Enhance the awareness among SMEs and inclusion of SMEs into national support frameworks and schemes such as coaching / mentoring. - Improve resource efficiency through the creation of quality assessment scheme for shipyards at world-wide level. - Promote openness and capitalise on Europe's creative potential by sharing the results of EU research across the industry including SMEs where currently only the larger companies tend to benefit from.

Source: Condeço-Melhorado, et al., 2014

Table 8. EU transport research policy measures related to Passivity Scenario

	Low prospects of sales	High prospects of sales
Strong industry	**Aviation** - Support research that will promote alternative fuels, energy and emissions efficiency in order to reduce cost and dependency on conventional fossil fuels. - Research support to alternative solution for scarce raw materials and environmental friendly practices in the industry through competitive R&D grants and EU support services such as coaching. - Financial support for the improvement of on board safety and airport security. - Support of aerospace clusters with the aim of sharing technology, information or even patents. - Support services for SMEs in order to reduce the cost of accessing knowledge, research & innovation and technology through participation in networks, joint research as well as mentoring/coaching. - Promotion of standardisation in terms of technologies that will be used by the aviation industry in order to reduce development and manufacturing costs. - Creation of PPPs calls as a tool to bring in investors (governments, airlines, aircraft manufacturers and others) in order to design new aircrafts that meet current needs. **Automotive (private cars)** - Support through financing and coaching for the creation of platforms for car pooling and sharing, with the automotive industry taking considerable part as an added value services provider. - Financial support for companies researching on improving energy efficiency of ICE as well as on fuel blends & multifuel engines. - EU support in the creation of design & development centres aiming at the collaboration of consumers, universities, research centres and automakers aiming at finding optimum solutions for the design and manufacturing of new vehicles. - The creation of a single innovation market in terms of vehicles design and propulsion technologies. - Creation of technology exchange & information platforms between EU automakers with the aim of reducing R&D as well as operational costs. **Rail** - Investment in research for design and development of innovative systems that will enable multimodal/intermodal integration of the rail mode with buses and other modes - Support integrating ticketing focusing on cost reduction between train mode and car sharing/pooling. - Development of legislation allowing information sharing between companies/ countries in order to	**Automotive (buses)- small support** - Promotion of integration of buses into intermodal/ multimodal traveling. - Public procurement of more efficient ICE, fuel blends & multifuel engines. - EU support in the creation of design & development centres aiming at the collaboration of consumers, universities and automakers aiming at finding optimum solutions for the design and manufacturing of new buses. - Calls for exploring alternative funding schemes with the aim of maintaining road infrastructure at certain areas that have been affected by climate change or wars using pool funds.

	Low prospects of sales	High prospects of sales
	allow integrated ticketing. - New legislation that allows revenue sharing between companies. - Development of a single safety legislation platform allowing the improvement of safety across the EU rail network. - Promote alternative fuel technologies that will reduce fuel costs for the rail industry (i.e. through European Innovation partnerships). - Alternative funding schemes for infrastructure such as PPPs.	
Weak industry	**Automotive (commercial vehicles)- high support** - Financial support through direct funds or credit guarantees for companies researching on efficiency of ICE, fuel blends and multifuel engines or any other energy efficient technologies. - Creation of support services for commercial vehicles automakers such as: Consultancy services and coaching for identifying foreign market needs. Support of the industry through networking services with foreign markets. Promote adoption of environmental friendly practices in the industry through EU support services such as coaching or small financial support such as tax incentives. - Assist the industry in creating cooperative platforms to improve competitiveness towards Asian and US markets **Maritime - high support** - Financial support for companies that research on alternative fuels and more energy efficient and larger vessels. - EU support on the creation of design and development centres aiming at the collaboration of experts, universities, research centres and ship builders aiming at finding optimum solutions for the design and manufacturing of new vessels that will meet the scenario's needs. - Financial support on research for port side operations in order to make the connection between truck/rail and maritime more efficient. - Support clusters offering information exchange between companies and countries (i.e. creation of pool fund between member states) - Promotion of short sea shipping within the EU member states that are easily accessible by sea or IWW. - Appropriate political and economic framework conditions and creation of port hubs at strategic locations. - Improve resource efficiency through the creation of quality assessment scheme for shipyards at world-wide level.	**Automotive (cheap and slower modes)** - Financial support for research related to the design of new or adaptation of existing infrastructure to the needs of slower modes i.e. bike lanes, rest and parking areas. - Promote integration of slower modes into public transport.

Source: Condeço-Melhorado, et al., 2014

Table 9. EU transport research policy measures for Responsible Growth Scenario

	Low prospects of sales	High prospects of sales
Strong industry	**Automotive (private cars)** - Research on new business models for sharing economy such as carpooling and car sharing. - EU support in the creation of design & development centres aiming at the collaboration of consumers, universities, research centres and automakers aiming at redesigning vehicles to be: bigger, more economical and ecological than the conventional types. - Financial support for joint ventures between OEMs and leasing companies. - Financial support to innovative companies that will adopt and introduce alternative fuel technologies into their vehicles. - EU platforms that will prepare the environment for new technologies involving regulations, verification and standardisation related to safety and operation of autonomous control technologies, V2X and ITS. - Promoting excellence and educational skills in promising innovation areas (i.e. electromobility). Vocational training schemes and research initiatives related to this area. - Mechanisms of generating consumer demand through incentives or innovative marketing techniques for the purchase of new vehicles utilising alternative propulsion systems. **Aviation** - Investment in research for design and development of innovative systems that will enable comodal/intermodal integration of the aviation mode into seamless transport systems in order to create sales by making the mode more attractive. - Platforms to promote commercial agreements between air and rail carriers for intermodal/comodal services. - Promotion and support to aviation special interest groups with the focus on bringing in together customers (airlines), consumers (passengers) and policy makers in order to design future aircrafts meeting everyone's needs. - Direct funding through competitive R&D grants and credit guaranties for companies developing i.e. greener, lighter aircrafts offering amenities that enhance the flight experience. - Aerospace clusters and special interest groups can be made with the aid of the EU, in an effort of technology and information transfer in terms of sustainable manufacturing and to assist companies dealing with heavier environmental regulations while still being competitive against non EU rivals. - Introduction of regulations/ legislation promoting the use of alternative propulsion and fuels in aviation.	**Automotive (buses)- small support** - Promotion of integration of buses into comodal/intermodal traveling. - Public procurement of more efficient buses utilising alternative fuel technologies and propulsion. - EU support in the creation of design and development centres aiming at the collaboration of consumers, universities and automakers aiming at finding optimum solutions for the design and manufacturing of new buses. - EU financial support for R&D of inductive charging at bus stops or en route charging for public buses. - Promotion and use of ITS to assist in creating demand responsive transport and help improving efficiency of public transport operations. **Rail- small support** - Promotion of the development of high speed electric rail, making this mode more attractive and generating sales. - Investment in research for design and development of innovative systems that will enable comodal/ intermodal integration of the rail mode into seamless transport systems in order to create sales by making the mode more attractive (ITS and integrating ticketing). Strong focus on efficiency will be required. - European vision and roadmap for door-to-door intermodal information passenger travel service. - Development of legislation allowing information sharing between companies/ countries in order to allow integrated ticketing. - Development of innovative legislation schemes that allows revenue sharing between companies. - Promotion and financial support for companies that develop energy efficient locomotives either by looking at electric or hybrid propulsion with alternative fuels. Hence, lightweight rolling stock. - EU support in the creation of design and development centres aiming at the collaboration of consumers, universities and locomotive and rolling stock manufacturers aiming at finding optimum solutions for the design and manufacturing of new trains. - Development of a single safety legislation platform allowing the improvement of safety across the EU rail network.

	Low prospects of sales	High prospects of sales
Weak industry	**<u>Automotive (commercial vehicles)- high support</u>** - EU promotion of alternative fuels, energy and emissions efficiency of vehicles, lighter materials and heavy integration of ITS. - Financial support for OEMs developing new innovative technologies (see above) and incentives for companies that will integrate such technologies into their products. - Promotion of V2X and ITS systems in conjunction with green city logistics in order to reduce operative costs. - EU platforms that will prepare the environment for new technologies involving regulations, verification and standardisation related to safety and operation of autonomous control technologies, V2X and ITS. - Creation of support services for commercial vehicles automakers such as: Financial support and risk sharing for innovative companies creating joint ventures in non EU countries i.e. competitive grants, direct support. EU support through technology showcases and exhibitions for EU commercial vehicles manufacturers. Consultancy services and coaching for identifying foreign market needs. Support of the industry through networking services with foreign markets. - EU to assist OEMs by creating technology platforms for information sharing across the EU between research centres, universities and the industry in the field of alternative fuels and other energy saving technologies. **<u>Maritime- high support</u>** - Direct financial support to companies through the creation of pool funds between member states or credit guarantees. - EU support on the creation of design and development centres aiming at the collaboration of experts, universities, research centres and ship builders aiming at finding optimum solutions for the design and manufacturing of new vessels that will meet the scenario's needs. - Enhance the awareness among SMEs and inclusion of SMEs into national support frameworks and schemes such as coaching / mentoring. - Improve resource efficiency through the creation of quality assessment scheme for shipyards at world-wide level. - Promote openness and capitalise on Europe's creative potential by sharing the results of EU research across the industry including SMEs where currently only the larger companies tend to benefit from. - Promotion of short sea shipping within the EU member states that are easily accessible by sea or	

	Low prospects of sales	High prospects of sales
	IWW. - Financial support on research for port side operations in order to make the connection between truck/rail and maritime more efficient. - Appropriate political and economic framework conditions and creation of port hubs at strategic locations.	

Source: Condeço-Melhorado, et al., 2014

Suggestions for a future R&D strategy are presented in chapter 5 and are based on the competitiveness prospects of the European transport sector and on the strategic options for European transport research policy. Specific R&D needs are pointed for different transport subsectors depending on their specific needs in each analysed scenario. Furthermore innovation areas that should receive public R&D support were also pointed out, as determinants for the promotion of competitiveness of different transport sectors:

ITS technologies rank high in all analysed scenarios. Applications in the field of multimodality and improving the efficiency and security of transport operations will be determinant for the future of all transport means. Applications to autonomous driving on the other hand, seams more feasible in the Unlimited scenario, characterized by high economic growth and high demand for private cars.

Fuel and propulsion technologies will remain a key priority for the competitiveness of the transport sector. Nonetheless high economic growth will be determinant for the success of more advanced technologies such as fuel cell electric vehicles, as more investments and higher living standards are needed to create the necessary conditions for the uptake of more expensive technologies.

New materials (i.e. lightweight materials) constitute another area where public authorities should provide additional support, especially focusing on suitable alternatives for critical raw materials used for the production of vehicles (Reichenbach,M., 2013).

R&D devoted to transport infrastructure and land-use policies will be determinant to solve societal challenges such as climate change, security, congestion or accessibility to services and economic activities. This innovation area is of particular interest for public authorities, which are responsible to provide adequate policies and coordinate efforts to effectively tackle societal needs.

Improving the range of transport offers will also be a priority for all transport sectors. R&D support in this field should be directed towards the search of new technological concepts and understanding the mobility needs of future societies. This will guarantee that the European industry will remain competitive at the time it provides innovative solutions that will fulfil the demand expectations of citizens.

Understanding the opportunities and the risks of new business models, such as those based on the 'sharing economy' and the profound transformation this may bring for more traditional transport sectors, should also be explored in future research. The appearance of such models will be expected especially in a context of lower living standards and in societies that are more environmentally concerned. Public support is most needed in this innovation area, since particular resistance from private lobbies will be expected, while social benefits are expected to be high.

Finally increasing the focus on societal innovation is an area where public funding should be directed in the future. This innovation area is characterized for its wide social and long term benefits, market failures that will limit the participation of private investments. Examples of research topics within this area are the demographic evolution of future societies and the appearance of new life-styles that will determine the evolution of transport demand. Further research is also needed on behavioural aspects of transport actors and how they interact and react to certain policies such as congestion charging or land-use policies. R&D funds to improve the data sources, taking advantage of new technologies such as those coming from ITS or ICT, together with new models, will favour the quality of future research. Furthermore, research on societal innovations that increase the participation of citizens in future policy actions related with private and public innovation strategies could promote the acceptance and the deployment of such initiatives.

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