



Transport demand evolution in Europe – factors of change, scenarios and challenges

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Abstract In the transport sector, where change comes with inertia and investments are made with a long term perspective, decision makers need to consider how the future may look like in the very long term. The work presented in this paper is a scenario analysis focusing on the evolution of transport demand towards 2050, aiming to identify related challenges for European industrial and policy players. It follows up on the work of other recent attempts to study the future of transport from a European perspective, integrating findings from these studies, updating new trends and applying a specific scenario analysis methodology relying also on expert consultation. The diversity of the scenarios created unfolds aspects of the future transport system with rather different outcomes on issues like the volume of transport, travel motives, the prevalent spatial scales of transport and logistics, people's preferences towards different

transport attributes, the relevancy of the State versus the private initiative in transport production, the level of competition, or the relative importance of environment and resource scarcity in setting an agenda for innovation and regulations. Beyond the subsequent challenges and opportunities identified in this work, the scenarios developed may be a useful basis for individual actors of distinct backgrounds to build their own specific futures, supporting them in defining strategies for the future.

Keywords Trends in passenger transport · Trends in freight transport · Transport futures · Scenario analysis

Introduction

The transport system changes slowly. Contrarily to other markets where disruptions may come quickly, structural changes in the transport system take decades or even centuries. The 19th century was dominated by the railway paradigm. The 20th century was dominated by the combustible engine private road vehicle. In the beginning of the 21st century, significant efforts are being put into reverting such a trend.

Indeed, strong lock-in effects are present in the transport system due to the high capital intensity and a lasting importance of social significance and habits in mobility choices. This reality shapes the choices regarding new capital investments and industrial innovation, which may have rigid impacts in the long-term. An example of this reality refers to the socio-economic and environmental aspects, which led to unanticipated negative impacts (like congestion, quality of the cities' space, or climate change) that feature inertia and are now difficult to reverse. The second refers to the expectations that the trend of car use growth would go on indeterminably and some countries continued to build infrastructure that would accommodate such growth, while a peak in car use in

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developed countries was already apparently taking place, even before the economic crisis [1].

The work presented in this paper is a scenario analysis focusing on the long-term evolution of transport demand with the aim of identifying related challenges for the European industrial and policy players. The work was realized under the project “FUTRE – Future prospects on transport evolution and innovation challenges for the competitiveness of Europe”¹, with the aim of identifying challenges for the competitiveness of Europe, in particular for industrial innovation, providing information for the definition of related EU programmes and for the industrial players themselves. In this sense, the European scope makes sense to the extent that there are policies (funding of research, regulation) which are appropriately addressed at European scale, under the subsidiarity principle.

This work follows up on recent attempts to study the future of transport from a European perspective [2–7] and other publicly available transport future studies from industrial players [8–11], integrating and incorporating some of the findings of these studies, updating on some of the most recently observed trends and applying a specific scenario analysis methodology.

The object of analysis of this work is the demand side of transport. Such a partial analysis allows to isolate the potential effects of specific factors contributing to the demand evolution. It should be recognized that on the side of supply, factors like technical evolution and new business models are also essential driving forces of the future. Furthermore, the evolution of supply and demand cannot be fully understood independently, as they deeply interact with each other. On the other hand, apart from this interrelation, isolating demand and supply is a useful way to simplify and modularise the analysis, as the basic factors contributing to the evolution of each side can be isolated in a comprehensive way. For the final purpose of this work, the partial demand analysis as a specific object of research is particularly useful when it is aimed at informing decisions taken at the supply side, under a context where the supply side should respond to the evolving independent needs or impacts of demand.

In this context, this work distinguishes and adds to the results available in the literature [2–11] in several ways:

- Its end focus was the industrial competitiveness of Europe
- It develops a partial analysis on the demand side of transport, clearly isolating its outcomes from potential influence from the supply side;
- It attempts to go beyond existing analyses by underpinning the analysis through the consideration of a wide range of transversal factors of change to transport demand.

A particularly distinguishing element is the consideration of megatrends with an extensive coverage of lifestyle issues;

- It applies an inductive scenario methodology characterized by an iterative process in the creation of global vs transport futures and in the definition of future insights vs factors of change. As a result of this method, contrarily to the common approach in future transport studies [2–7], each scenario is shaped by distinct dominant factors of change.

Although the analysis is performed from a European perspective, the object of analysis is the whole transport “world” which is interesting from a policy and industrial European perspective. The analysis includes both passenger and freight transport. The horizon is 2050. The broadness of the object of analysis makes the assessment necessarily abstract and aggregate.

Overall methodology

The main research question of the present paper is to identify and highlight potential trends and challenges for the transport sector, by providing insights into plausible alternative future transport demand ‘realities’ to policy makers. For doing so, three broad steps of work were conducted: 1) The development of global future scenarios, 2) the identification of key factors and issues that will affect future transport demand, and 3) the identification of trends and challenges for passenger and freight transport. Figure 1 shows a broad picture of these steps and how they are interlinked.

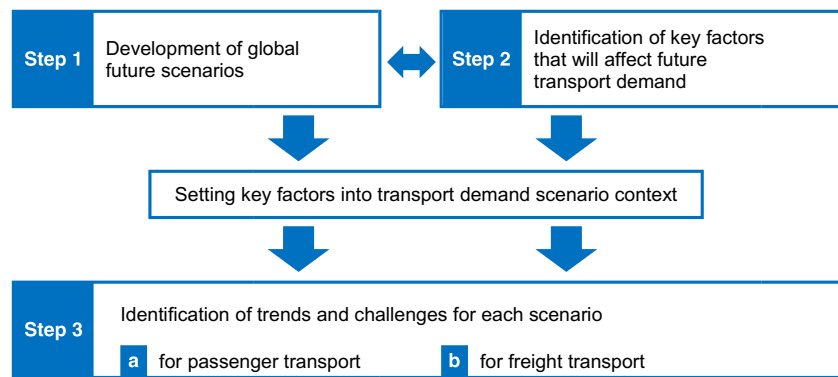
Steps (1) and (2) were interlinked and provided feedback to each other. A literature review gathering knowledge from other projects and studies was combined with a workshop and interviews with experts. Megatrends (not limited to the transport sector, but rather in a global sense) and derived insights on how these might affect future developments were analysed in order to extract four scenarios that outline four radically different ways of how the world may evolve. In parallel, the key factors that affect the future development of transport demand were identified. The development of global scenarios and the identification of key factors for transport were done in parallel and followed an iterative process following the analysis of the different sources of input and interactions of the project team. In step (3), the results from the two previous steps were interpreted in the context of key questions regarding the future of transport and transport trends and challenges were derived.

Development of global future scenarios and identification of factors affecting future transport demand

The formation of the global future scenarios is based on review of literature, stakeholder consultation and a consistency check following a systems thinking exercise. The general

¹ The project was funded under the 7th Framework Program of the European Commission (further information at www.futre.eu). For a synthesis of the methodology and results see [24] and for a full report on the work described in this paper see [21] and [23].

Fig. 1 Methodological steps for the analysis of future trends and challenges in the transport system



approach used was scenario analysis, where rather than foreseeing the most likely future, alternative future worlds are considered. The idea was to draw a space of plausible future scenarios in order to define strategies that accommodate different possible paths.

The choice of a scenario building method was framed by the following characteristics of the subject under analysis:

Wide spectrum of analysis Almost every major aspect of our society was under scope: politics, economy, urbanization, energy, environment, demographics, climate change, consumer behaviour and technology were all central aspects to be considered. This wideness made impossible to use any methodology that would focus on a limited number of uncertainties. The chosen method had to be able to embrace a large number of uncertainties.

Long time frame In more than 30 years, there is obviously a big level of uncertainty and lack of accuracy, but there are also sequences of paradigm shifts that can happen. Computer or algorithm based scenario methodologies would make the participants, from different academic and professional backgrounds, lose touch and understanding of the dynamics that was being analysed.

Complexity The Wide Spectrum and the Long Time Frame combined build up to an extremely complex subject. To approach this complexity, and gain some level of understanding the participants had to iterate through different levels of granularity (macro and micro perspectives), systematically creating and/or sorting out several insights, models and concepts.

Considering these characteristics, an inductive scenario method was applied with inspiration on the stepwise Manoa Approach [12, 13]. The applied approach was adapted to the fact that besides the technical requisites above, there were context and human constraints. Different experts were available for short periods of time, and it was imperative to extract all valuable information and insights. Instead of concentrating on different phases of the method, it was built more as an

iterative process. In each iteration, new scenarios were drawn replacing the old ones, adding and occasionally opting out of old insights. The early iterations (including the workshop) were focused on collecting as much insights as possible, with a creative approach. Towards the final iteration, the focus became more objective, concentrating on identifying dominant factors of change and building the coherence of the scenarios.

The steps carried out to come to a set of scenarios were the following:

1. Identification of possible **megatrends** with impacts on transport
2. Derivation of specific possible future **insights** on the world and transport demand
3. Identification of **key factors** of evolution of transport demand
4. Drawing of possible global **scenarios** with relevancy on transport

As mentioned, these steps were not linear and had several iterations. To conduct them, three sources of knowledge were applied:

- A literature review of future studies from transport sector and transversal sectors;
- A workshop on the future of transport needs and selected interviews;
- A systems thinking analysis of the factors of evolution of demand identified.

Future studies in the transport field and from other related fields were reviewed, covering megatrends and key elements for the development of demand and demand preferences in the transport system. All studies were completed within the last 5 years before the review. The selection comprised studies on global issues with no particular focus, as well as studies concerned with particular fields like economics, energy, environment, lifestyles, geopolitics and communications [14–20]. The identification of global issues and their analysis were based on [14] and [15], while issues related to geopolitics

are based on [16]. The issues of economy, energy and environment are addressed in [17] and [18]. Finally, issues concerning lifestyles and communications are adequately covered by [19] and [20]. The selected literature in the field of transport includes a variety of studies from the European Commission and relevant stakeholder groups, which offer different perspectives and interests [2–10].

Expert consultation

A workshop gathering eleven experts from distinct transport related fields from academia and the industry, gathered at a single event in an isolated location free from external stimuli². The workshop was conducted as a creativity exercise with the aim of identifying specific insights on transport futures and producing a first iteration on the creation of scenarios. The workshop covered all the steps referred in the former section and was structured in four exercises preceded by a quick presentation and fine tuning of basic mega trends, which provided the foundation for the construction of the following exercises. The experts, together with FUTRE project team elements, were grouped into four distinct groups which independently carried out the three exercises. In the first exercise, each group was asked to realize a *futures* wheel, i.e., to consider each mega-trend and, based on it, to derive a set of insights on the long-term future of transport (where *insights* were defined as specific trends or events). Each megatrend and respective insights were circulated by all groups, with each group building on top of the previous one. In the second exercise, the gathered insights were categorized into a STEP matrix: Social, Technological, Economic and Political. Each group was responsible for an element of the matrix. The third exercise was the categorization based on probability and impact, where each individual participant was given the chance to vote on the most important insights. The most voted insights were grouped by the facilitating team based on coherence criteria. In the final exercise, scenarios were created. The facilitating team firstly created four different sets of key insights. The criteria for choice of insights to include in each set had the aim that the various sets would create distinct, contrasting and exclusive future realities. Based on a set of insights, each expert group was asked to build a future scenario which would be consistent with the underlying insights. It was expected that the scenarios built would create a wide space of futures in line with contrasting underlying insights. Each group presented their scenario and a final discussion was realized on the final scenario results. A curious outcome which is worth to note is that the scenarios did not turn as contrasting as initially meant by the facilitating team, but rather the groups tended to

construct futures with significant similarities, closer to an “official” and/or normative future. The richness of the variety of the scenarios created came thus mostly from the pathways and internal balances described by the groups to reach their future, rather than the final futures achieved themselves.

Further expert input came from additional interviews that were conducted to further explore some issues which were subsequently identified as crucial. The specific topics covered were the relation between politics, energy and climate change, the impacts of a potential de-growth of developed countries and trends and possibilities in mobility consumer behaviour in the scope of a socio-political pressure for environmental sustainability³.

Relevant megatrends and insights into the future of transport

Megatrends are stable trends driven by global forces that impact several societal areas. Based on the literature review and inputs from the expert consultation, a set of megatrends was identified as potentially relevant to the scope of transport. These megatrends were applied in the development of global futures relevant to transport and comprised a building block in the identification of insights into the future of transport and key factors of change. The set that was considered in the analysis consisted of the following megatrends:

Globalization, urbanization, ageing, knowledge society, individualism, migration, connectivity, immediate needs, slow movement, empowerment of women, awareness / consciousness, consumption, ever young, seeking for experiences.

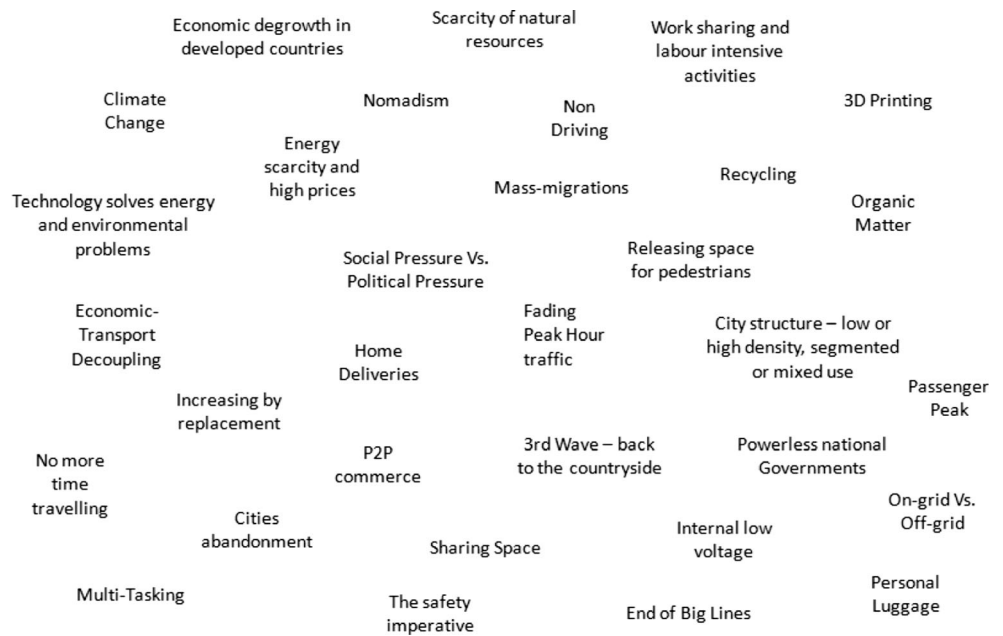
Insights were defined as specific trends or events that are somewhere between possible and likely to materialise in the future and are directly or indirectly relevant to transport. Their consideration as an intermediate step in the scenario building had the objectives of contributing to the validation of relevant megatrends, identification of the specific factors of change and preliminary identification of challenges.

The set of insights considered (Fig. 2) was based on the workshop results, the literature review and the systems thinking analysis. The exercise of identifying insights didn't aim to be an exhaustive, but rather an explorative exercise, feeding into the identification of factors and creation of scenarios. Their detailed description is available in [21].

² The workshop was held at the isolated Monastery of Arrábida (where the experts stayed for the night) during the evening of 7th March 2013 and the following day.

³ A more detailed description of the workshop and its final scenarios and the interviews is available in [21].

Fig. 2 Insights on possible trends and futures [21]



Key global factors that will affect future demand

Key factors were defined as being specific about a given phenomenon and the direction it may take, making them applicable in the systems thinking analysis. The key factors are related to different spheres of life. They were arranged in the areas defined by the STEEP approach: Social, Technological, Economical, Environmental and Political factors. Since the focus of the analysis was the demand side of transport, the technological sphere was considered at an abstract level only. These factors of evolution of transport demand, categorized within the five sections of the STEEP approach and in thematic areas include the following.

Social Demography (i.e., population growth, ageing, global migrations, living place flexibility); Education and social capital (i.e., level of education, equality of cultural capital); Preferences and awareness (i.e., 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)

Technological Ability to address energy, environmental and ageing challenges by technical developments

Economical Economic development (i.e., level of economic growth, economic stability, volume of international trade, economic equality); Production and consumption patterns (i.e., share of knowledge based work, purchasing channel paradigms, scale of production: mass vs. customized, paid work

time reduction); Energy (i.e., fossil energy scarcity – prices); Urban development (i.e., urbanisation, urban density, congestion);

Environmental Climate change; Biodiversity and other environmental issues; Local pollution (air, noise).

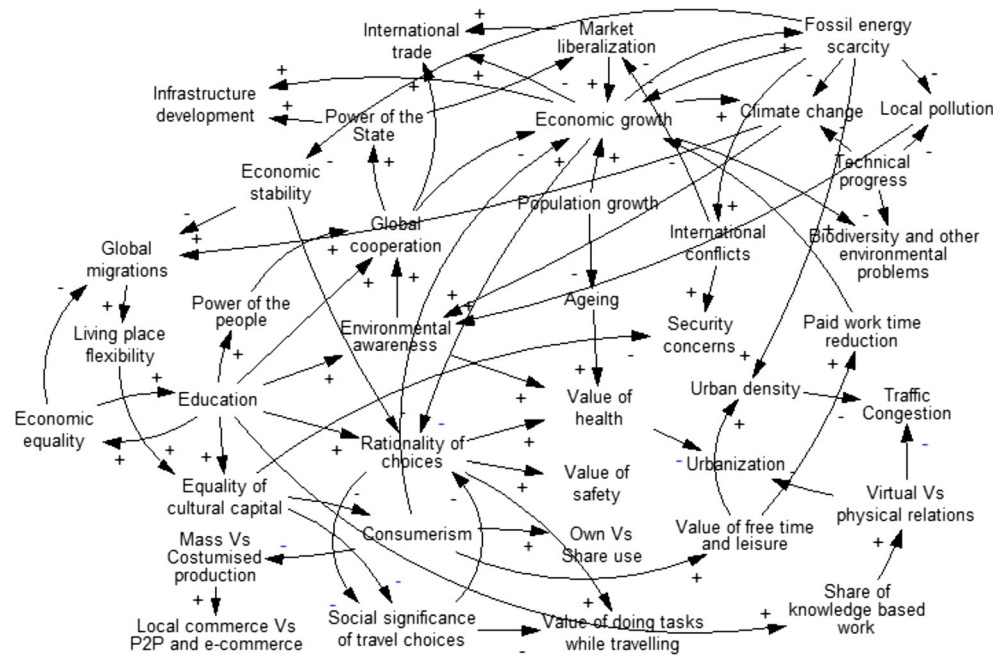
Political Global cooperation on global issues; Power of the State; Power of the people and civil organizations; International conflicts; Security concerns; Market liberalization;; Infrastructure development

Four global scenarios

The creation of scenarios was preceded by a **systems thinking analysis** based on the causal loop diagram approach [22], as shown in Fig. 3. Its application aimed to support the building and validation of coherent pathways considering the interrelations of the key factors of evolution of transport demand. The basic variables applied in the systems thinking analysis were the key factors of evolution of transport identified as noted in the previous section.

The systems thinking analysis was meant to take into account and obtain insights from the complexity shaped by the interrelations between those factors and to apply the derived information in the development of coherent and diverse scenarios. For example, it is expected in this analysis that socio-economic structures, like social equity, influence the evolution of values (e.g., towards status behaviour) and conversely values influence social equity by way of social behaviour and political action.

Fig. 3 Causal loop diagram of key factors [21]. Legend: arrows follow a System Dynamics notation. + (−) means a positive (negative) effect from the precedent to the pointed variable



Several observations were realized on interdependencies and structural patterns that set constraints on the co-evolution of factors that allowed assessing coherence and plausibility of different possible pathways. The following observations may be highlighted:

- Preferences are influenced and reinforced by external conditions. For example, consumerism is made possible when there is abundance (economic growth) and environmental awareness is reinforced by the manifestation of environmental problems. However, it may be assumed that preferences may have a certain degree of autonomy from external conditions in their evolution;
- The more constrained population growth is, the more resource scarcity and environmental problems there are. If these are solved, no limits are necessary on population growth. Increasing population growth reduces the population ageing phenomenon;
- The continuation of urbanization makes less sense in a world with more virtual relations and stronger preferences for health;
- The value given to health is increased by ageing, environmental awareness and rationality of choices;
- Increasing urban density makes sense in a world with scarce energy and more value given to free time;
- More equality of cultural capital tends to reduce the social significance of consumer (travel) choices and inherently the rationality of those choices;
- Rationality of choices also makes more sense in a world with economic constraints and instability. This may lead to a more long term thinking by people, who will for

example value more things like health, safety and multi-tasking while travelling;

- Connectivity enhances education and the political power of people, and contributes to environmental awareness and global cooperation on global issues;
- Less consumerism is related to more value given to time and leisure. Both factors lead to a willingness to work less time, contributing to a lower economic output and less environmental damage and natural resource scarcity;
- Security concerns are amplified by international conflicts and cultural inequality.

The **global scenarios** were built based on the pieces of information gathered, with a focus on the impact on the transport sector. The conceptual process taken in the development of scenarios was the following:

1. Identification of a short list of main driver factors;
2. Identification of pathways based on possible trends of a limited number of main driving factors;
3. Detailed definition of those pathways covering the remaining factors and considering their systemic consistency;
4. Assessment of the level of coverage of plausible outcomes by the set of pathways considered;
5. Back to step 2. Iterative development of pathways until a satisfactory range of plausibility with interest to transport demand futures is achieved.

Different pathways were iteratively developed and discussed. The final aim was to develop a set of scenarios

which better defined a range of plausibility with interest to the study of transport demand futures. To that purpose, they should differ as much as possible between each other within boundaries of plausibility.

Each scenario is driven by certain key factors with primary importance in the development of the correspondent pathway. Contrarily to a common approach in futures studies, the main key factors which define the scenarios are not fixed. Each scenario is driven by particular factors which, in other scenarios, have a secondary role. This approach was followed under the belief that the uncertainty about the future relates not only with the direction that some factors will take, but that it is also about which factors will play the most decisive role. In other words, the factors' weight is variable in the definition of course of each pathway. To a great extent, the scenarios were characterized by this choice of core factors.

The short list of factors which were more persistently referred to as crucial in the development of future pathways consisted of the following five factors: *Climate change; Energy scarcity and price; Economic performance; Global cooperation; Social preferences – consumerism Vs spiritual needs*. It was assumed that a reduced number of factors (one to three) would be the main driving forces of each pathway, and that the direction of the remaining factors would develop around that course in a systemically consistent way. Technology is an external input which changes the importance of these factors; for example, in the first scenario climate change and resource scarcity are not relevant factors because it is assumed that technology has solved them.

The pathways selected were developed and discussed within the project team iteratively until the purpose of capturing the range of plausibility of global futures was considered to be met. They were developed on the basis of systemically consistent combinations of factors according to the systems thinking analysis described above, both for the main driver factors and for the remaining factors.

The four global scenarios developed were [21]:

Unlimited Society has overcome the biggest limits to growth i.e., environment (global warming) and technology. Technology is able to solve the crucial environmental and energy problems. Current social practices may continue and even follow a path of increased consumerism and thirst for travel. Economic prosperity and green growth are evident across the world. Global economic competition is the most important driver for societies.

Passivity and collapse Describes a world where society was not able to address the impending environmental and energy problems and presents the effects of climate change and environmental degradation caused by human activities. Societies ultimately fail economically and politically. The scenario

emphasizes the consequences of a collapse, the inherent uncertainty and the need for quick adaptation in an unstable world.

Cooperation and de-growth Describes a world where governments have realized the importance of the environment and cooperate to properly manage the global commons, preserve energy and resources. The Western world decides to turn away from consumerism and adopt less materialistic lifestyles, drawing back the economic output to a level consistent with sustainability. People consume and travel less.

Smart and spiritual Describes a world where societies have turned away from materialism and consumption to focus on spirituality, values and quality of life. It emphasises the consequences of a shift of social preferences and culture towards different values. It presents a more rational world, where people highly value long-term issues like health and safety. Decisions are made based on environmental concerns, while free of traffic city centres become widespread. Different lifestyles emerge and teleworking allows people to work from long distances. The full description of each scenario in terms of the evolution of each factor is summarised in Table 1.

The marks in the table indicate the positive (+) or negative (–) evolution of each factor within the context of each scenario. Shaded cells indicate decisive factors in the development of the scenario

Trends in transport demand

Key questions and issues on the future of transport were listed. In the passenger sector, these questions covered four areas: macro transport flows, land-use patterns, social attitudes and preferences and purpose of trips. In the freight sector, macro transport flows, political issues and behavioural issues were considered.

The key issues were embedded into the four scenarios, allowing an understanding of how the four different futures described in these scenarios might affect transport demand. The main trends under each scenario for both passenger and freight transport, include the following.

Unlimited

Market driven development of land-use patterns together with “nomadism” and extreme globalisation maximise passenger travel demand. In terms of emissions this is not too much of a problem since green technologies are available. Being fast and/or the option of making more use of travel time is a key-factor for transport related choices. “Commuting” as it was done in the older days nearly disappeared. Schools and universities are increasingly organised in a virtual way.

Table 1 Direction and importance of key factors within each scenario

	Unlimited	Passivity and chaotic collapse	Cooperation and de-growth	Smart & spiritual
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	+		-	

Highly efficient zero-emission cars are seen as a fast and convenient way of transport, in particular for shorter distances; new forms of mixtures between cars and e-bike are gaining market shares; leasing schemes are common since the nomads frequently change their residence; taxis and to a lesser extent also car-sharing is used; in rural areas, many people still like to have their own car.

In urban areas, apart from cars and e-bikes, underground systems are very popular; younger people are very open for different transport options and their combinations, older people have a stronger tendency to use their own (leased) car.

Differences between continuously growing urbanised areas and shrinking regions are large; public money goes mainly into the growth centres; still, a significant number of people like to live in the countryside, but they have to accept a lower level of infrastructures since investments hardly pay off in sparsely populated areas.

In freight transport, emerging economies catch up with the rest of the world and play a significant role creating extra demand as new consumer markets but also become producers. The emergence of mega corporations drives the creation of highly efficient global supply chains. Nomadism creates big dispersion of consumer markets and creates additional demand for freight transport of construction equipment and raw materials. New manufacturing processes allow new materials to become mainstream. 3D printing takes over specific segments of product markets creating a need for specialised logistics services [23].

Passivity and collapse

Compared to the beginning of the century, overall passenger transport volumes are reduced in Europe. There is not much international transport and many longer distance business trips are substituted by virtual meetings. The tourism sector and related travel is shrinking. Most daily trips are work-related and for getting things done, they are mainly short-distance, with cheap transport options being available (busses, bikes). There is a significant decline in leisure trips.

At a European policy level flexibility and resilience are the only policy strategies that find broader support. There is no commitment to clear long-term targets. Together with the general high degree in uncertainty this is an environment, which is not attractive for investments. Budgets for R&D are cut and there is not much openness for any kind of innovation. Most striking development in the transport sector is the new dominance of all kinds of bus service for longer and for short trips. Busses, bikes and shared cars dominate urban modal split.

Regional economies focus on the primary sector i.e., agriculture, livestock breeding, fishing and some limited extraction of last energy reserves. Countries that still have energy and natural reserves will drive demand and production leading to the creation of regional hubs that will influence the few

global supply chains. Demand for freight services will be reduced, while transport costs will increase. The reduction of product demand and scarcity for energy and natural resources will create the need for more efficient stockless manufacturing that will be based on the make to order principle. Re-use and recycling will play a considerable role in overcoming materials' scarcity [23].

Co-operation and de-growth

Because of scarcity in resources, there is a high increase in efficiency. The world is characterised by "harmonic globalisation" with a free flow of goods and services. GDP and consumption are restrained by high cost for energy and other resources as well as by a reduction of labour time.

Small and medium sized cities are perceived as the most sustainable urban structure. They minimise distances and reduce the high cost for transport. The car ownership rate is low. People use public transport, car sharing and e-bikes. Rail linkages between the cities flourish. Less passenger kilometres are travelled by the Europeans compared to a business-as-usual situation, with a strong reduction in trip length but increase in the number of trips. Travel patterns are dominated by leisure trips to local or regional destinations. A significant number of trips are induced by voluntary engagements.

In terms of freight transport, the main trend of this pathway is based on global government cooperation in managing the existing natural and energy resources by introducing strict environmental legislation. Natural resources and energy reserves are monitored globally by governments, ensuring sustainable usage and extraction. New business models for sharing transport freight services will emerge, in order to bring down energy and environmental compliance costs. Technology will focus towards efficient means of transport based on energy efficiency, new lightweight & stronger materials, improved aerodynamics & propulsion methods and more environmentally friendly manufacturing processes. The advent of 3D printing will increase the demand for printed products that can become a cheaper alternative to conventionally produced ones while saving resources. The use of 3D printing will only achieve to capture a specific segment of the overall market, while conventionally manufactured products will still dominate [23].

Smart and spiritual

People live very conscious and reflexive; they work less and spend more time for leisure and spiritual exercise. Sustainability and safety are highly important in daily life and for transport related choices. Slowing down in all fields of daily life is characteristic for this pathway. Being fast is not the highest priority and travel time should not be "wasted", it should be used to work or relax.

In most urban areas private cars are banned. Integrated solutions of public transport, car-sharing, cycling and walking are the backbone of urban transport systems. Urban areas are attractive and are growing – but there is some interest in rural areas where there are not much alternatives to privately owned cars and e-bikes. Not many people own a car and the number of cars strongly decreases. Sharing schemes are ubiquitous and widespread standards for mobility services exist.

Societies become anti-materialistic and demand from governments to cooperate and have better monitoring of natural resources and energy reserves, ensuring sustainable usage and extraction. Mixed passenger and freight solutions become mainstream in order to compensate the smaller volumes of transported goods, fully utilising the existing infrastructure. Shared freight services play a considerable role in keeping costs low. Alternative lifestyles will emerge that will show preference for local products. The demand for open spaces and free from traffic city centres, will give rise to city logistics [23].

Implications – how these scenarios could be applied

Rather than a final exercise, the scenarios should be perceived as a tool for thinking about the future. The general transport scenarios achieved may provide a basis for assessment of potential future implications and strategic analysis in the scope of specific topics. From the overall and transport futures drawn, it becomes relatively straightforward to draw specific implications for a concrete topic. The following section presents develops some implications in the scope of the European transport industry and policy, the main topic of this work. But this possibility to assess implications is not exclusive to this field and may be applied in other areas. An application in a different topic has also been tested in the scope of urban mobility management at a local level⁴.

Applications of these scenarios should consider their scope and limitations:

Long time frame – they are relevant in the scope of long time frame

Contrasting – they are, to a significant extent, mutually exclusive

Defining a range of plausibility – the scenarios are intended to present relatively radical futures which define the boundaries of plausible futures. The real future should be somewhere in the middle. If the future is coincident or farther from a scenario, this analysis would have failed towards its aim of defining such a range.

⁴ A presentation was held at ECOMM 2104 (European Conference on Mobility Management) with the title “Four future pathways on mobility needs. Think about implications for mobility management”, covering a specific analysis on the futures for urban mobility management originated from the present general scenarios.

Powerful – the scenarios are spontaneously desired or feared in order to engage decision making.

The wide scope of analysis as a strength – by considering multiple aspects of life interfering with the transport system, these scenarios may be considered robust.

The wide scope of analysis as a weakness – because it makes the analysis more complex (which has been addressed through the application of a systems thinking approach) and because it becomes more difficult to consider every detail of the available information on the multiple factors considered.

Varying dominant explanatory factors – each scenario was shaped by distinct dominant driving forces which were considered the most promising ones, with different emphases on economic, environmental, political and social factors. The choice of such dominant factors is questionable.

Focused on demand – the scenarios have arisen from a partial analysis of the demand side of transport. If the object of the analysis in question requires the consideration of transport supply futures, the application of these scenarios should be extended to include also supply effects.

Storylines on some potential challenges for the EU transport policy and industry

In the scope of the European transport industry, a set of specific challenges was derived from the transport demand trends above. This is an exploratory exercise to identify potential challenges, which is in no way exhaustive and that would justify more specific analysis and validation of each specific challenge. The identification of challenges is made per scenario:

Regarding the **Unlimited Scenario** and specifically the passenger sector, European manufacturers should get prepared for a significant increase in demand for efficient zero-emission vehicles (e-bikes and e-cars). For governments of strong economies it will become necessary to implement sustainable land-use planning and to enhance the capacity of infrastructure, in particular for aviation. Finally, due to the phenomenon of nomadism (by which people become less attached to a fixed place of residence and work), there will be a need for a legislative framework on work and taxation. With regard to the freight sector, the European governments and manufacturers will need to create cooperative agreements in order to develop business models that will compete against global corporations. The focus will be on creating strong non-competitive relationships at European level and simultaneously utilizing geographical, technological and environmental advantages of EU member states/corporations against global competitors. Furthermore, it will be crucial for the EU to provide economic

incentives to European corporations for remaining on EU territory as well as for those willing to move their manufacturing activities inside the EU. In general, there will be a focus on creating strong bonds between suppliers, shippers and manufacturers within the EU in an effort to create fast and flexible regional supply chains.

In the **Passivity and Collapse Scenario**, there will be an increase in shorter distance trips, so it will be necessary to create different kinds of infrastructure, which will serve the new needs. Furthermore, the states will depend on public private partnerships for the financing of infrastructures. European manufacturers will cope with a higher demand for smart, cheap and small vehicles. Due to the disaggregation of the power of states, the lead may come from the private sector for example in the form of a union of regional supply chains within the EU, transforming the continent into a global supply hub. The EU will have to focus on creating political stability within the union and EU wide policies against terrorism and crime as well as better disaster management and planning.

Regarding the **Cooperation and De-growth Scenario**, the re-location of public funding is necessary, especially into small- to medium-sized cities, which require cost- and energy-efficient solutions for urban transport. Moreover, EU policy will give priority to the sharing economy, including the adjustment of regulatory frameworks to allow car-sharing systems become the mainstream. Generally, there will be a shift towards resource efficient innovations which will involve customers in the co-design of them. Environmental campaigns focusing on reduction at source, re-use and recycling both on manufacturing and consumer level will be a constant, as will be the application of high environmental taxes in a coherent way throughout all the transport system. Infrastructure capacity will not require expansions overall due to the stagnating flows of people and goods, but a shift from road to rail will take place. The governments and manufacturers will need to cooperate in order to create an environmental policy and legislative framework for a much more radical environmental protection and preservation of energy and natural resources. For example, there might be a need for the creation of a platform that will focus on exchange of technology and innovation within EU in an effort to quickly comply with increasing global environmental legislation.

In the **Smart and Spiritual Scenario**, the EU will need to get prepared for coping with the huge demand for sustainable products that meet the society's needs. There will be a need for new types of car-sharing schemes (such as PUC – public urban car). Moreover, there will be a development of an EU policy restructure to enable teleworking (e.g., taxation issues, infrastructure, company initiatives for the promotion of teleworking). Generally, under this scenario the societal values will need to be addressed in order to enable successful innovations in the transport sector that meet the needs of rationalization and health. New policy frameworks and

infrastructure for the development of city logistics that promote open spaces and traffic-free city centres will be created. New types of means of transport that can carry both freight and passengers might appear. The use of the car is gradually phased out [23].

Conclusions and outlook

This research developed an inductive scenario analysis on long-term futures of transport demand with a focus on the challenges put at a European level, with a focus on the competitiveness of the transport industry.

The four scenarios were developed following an iterative inductive scenario approach, which is a distinct approach from the commonly applied deductive approaches in European transport futures research projects. They were built on an extensive literature review and a consultation with experts in an iterative process between the identification of relevant megatrends, future transport insights (trends or events), factors of change, systemic effects and scenarios. The scenarios 'Unlimited', 'Passivity and collapse', 'Cooperation and de-growth' and 'Smart and Spiritual' are shaped by distinct trends and weights including environmental, resources, economic performance, international cooperation and social preferences, which systemically influence all other factors considered in the system.

The diversity of the scenarios unfolds aspects of the future of the transport system which show rather different outcomes. The evolution of the volume of transport, the relative importance of travel motives, the predominance of regional versus international transport and logistics as well as urban (mega or small scale cities) to rural, the preferences of people towards different transport attributes (fast, status, efficient, multitasking or experience rich), the relevancy of the State versus the private initiative in transport production, the level of competition, or the relative importance of environmental or resource scarcity in setting an agenda for innovation and regulations, are aspects with very significant variations in the scenarios conceived. Several challenges and opportunities in the scope of transport industrial competitiveness were explored in each scenario.

Rather than a final exercise, the scenarios developed are be a useful basis for individual actors of distinct backgrounds to build their own specific futures, supporting them in defining strategies for the future. From the overall and transport futures developed, it is possible to draw specific implications for concrete topics. The scenarios incorporate different levels of detail from global, to transport, to specific topic, where the later layer may be developed by the analysis or policy maker based on the former.

This approach goes beyond the existing literature both by considering a wider range of topics and by the specific iterative methodology applied which was based on building on

creative insights and developing internally consistent futures. The scenarios are intended to provide a range of plausibility on what the real future could be, but their ability to do so depends on the underlying assumptions. Particularly, these futures were shaped each by distinct dominant driving forces which were deemed by the project team as the most promising ones, with different emphases on economic, environmental, political and social factors. Their choice is questionable and there is a chance that other surprising factors will dominate.

Further research in the scope of this work could go in several directions. One of them is more deeply validating and updating the assumptions of each underlying factor. In this area, while tangible factors like for example energy or demography have been subject to numerous assessments and are commonly taken into consideration in transport future analyses, a field which seems to be less approached and which could have a considerable impact (see scenarios Unlimited and Smart & Spiritual) is social preferences. Another direction of research and improvement of the results could be in the area of methodological development, comparing the outcomes and insights of this study with other future studies. A third area of further research could be, as argued above, to apply the results of the current scenarios to study the implications and build related specific scenarios focusing on concrete topics.

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References

- Goodwin P (2012) Three views on peak car. *World Transp Policy Pract* 17:8–17
- Petersen M.S, Sessa C, Enei R, Ulied A, Larrea E, Obisco O, Timms PM, Hansen CO (2009) Report on transport scenarios with a 20 and 40 year Horizon. Final report, TRANSvisions. European Commission. DG TREN
- European Road Transport Research Advisory Council (ERTRAC) (2009) ERTRAC road transport scenario 2030+ “Road to implementation”. ERTRAC road transport scenario. http://www.ertrac.org/uploads/documentsearch/id23/ERTRAC_Scenario_2030_Summary.pdf. Accessed Apr 2015
- FREIGHTVISION (2009) Management summary II – forecasts, preliminary vision, conflicts and measures. doi: 10.2768/13118. http://www.transport-research.info/Upload/Documents/201208/20120823_190815_53417_Management_Summary_II_FinalVersion.pdf. Accessed Apr 2015
- World Energy Council (2011) Global transport scenarios 2050, ISBN: 978-0-946121-14-4
- Kok R, Laparidou K, Rahman A, Dray LM (2011) TOSCA project, deliverable D8 - scenarios of European transport futures in a global context. http://www.transport-research.info/Upload/Documents/201204/20120406_000752_78369_TOSCA_WP6_Scenarios.pdf. Accessed Apr 2013
- Delle Site P, Salucci MV, Hoppe M, Seppanen T, Christ A, Arsenio E, Van Grinsven A, Morris D, Anoyrkati E, Brooks R, Hepting M, Kompil M, Tavlaki E, Micharikopoulos D, Akkermans L (2012) Deliverable 3.2 - list of potential megatrends influencing transport system and mobility behaviour. OPTIMISM project. <http://www.tmleuven.be/project/optimism/Deliverable-3.2-List-of-potential-megatrends.pdf>. Accessed Apr 2013
- FORD (2012) The future of sustainable transport in europe, the futures company, curry A, Hughes C. http://uk.kantar.com/media/122799/ford_the_future_of_sustainable_transport_in_europe_november2012.pdf. Accessed Apr 2013
- Go-Ahead Group and Passenger Focus. (2012). The future of transport. <http://www.transportfocus.org.uk/research/publications/the-future-of-transport-overview>. Accessed Apr 2013
- Deutsche Post AG (2012) Delivering tomorrow -logistics 2050. A scenario study. ISBN 978-3-920269-54-2
- Shell. (2013). New lens scenarios - a shift in perspective for a world in transition. <https://www.shell.com/global/future-energy/scenarios/new-lens-scenarios.html>. Accessed Apr 2013
- Dator J (2009) Alternative futures at the manoa school. *J Futur Stud* 14.2 (2009): 1–18
- Schultz W (1993) Scenario building: the manoa approach, “maximizing difference”. <http://www.infinitefutures.com/tools/sbmanoa.shtml>. Accessed 9 Sept 2015
- Punkt Z (2013) Megatrends update, online September 2009, <http://www.z-punkt.de/megatrends-update-en.html>. Accessed Apr 2013
- Hajkowicz SA, Cook H, Littleboy A (2012) Our future world: global megatrends that will change the way we live. The 2012 revision. CSIRO, Australia. <https://publications.csiro.au/rpr/download?pid=csiro:EP126135&dsid=DS2>. Accessed Apr 2013
- National Intelligence Council USA (2012) Global trends 2030 - alternative worlds. ISBN 978-1-929667-21-5
- Johansson A, Guillemette Y, Murtin F, Turner D, Nicoletti G, Maisonneuve C, Bagnoli P, Bousquet G, Spinelli F (2012) Looking to 2060: Long-term global growth prospects. OECD Econ Policy Pap, No. 03. doi: 10.1787/2226583x
- European Environmental Agency (2011) The European environment — state and outlook 2010: assessment of global megatrends. Eur Environ Agency Copenhagen. doi: 10.2800/76887
- Leppänen J et al. (2012) Scenarios for sustainable lifestyles 2050: from global champions to local loops. SPREAD sustainable lifestyles 2050, European commission
- Alcatel-Lucent (2013) Megatrends - A wave of change impacting the future - market analysis. http://www2.alcatel-lucent.com/knowledge-center/public_files/megatrends/Megatrends_EN_MarketAnalysis.pdf. Accessed Apr 2013
- Bernardino J, Vieira J, Hugo G (2013) FUTRE project, deliverable 3.1 - factors of evolution, global pathways and approach to identify transport demand pathways. <http://www.futre.eu/Portals/0/Documents/Deliverables/Factors%20of%20evolution%20of%20demand%20and%20methodological%20approach%20to%20identify%20pathways.pdf>. Accessed Jan 2014
- Sterman JD (2000) Business dynamics: systems thinking and modeling for a complex world, vol 19. Irwin/McGraw-Hill, Boston
- Papanikolaou A, Boile M, Reichenbach M, Schipll J (2014) FUTRE project, deliverable 3.2 - long-term future analysis on

- transport demand market and drivers. <http://www.futre.eu/Portals/0/Documents/Deliverables/D3-2-Final.pdf>. Accessed Jan 2014
24. Aggelakakis A, Bernardino J, Boile M, Christidis P, Condeço A, Krail M, Papanikolaou A, Reichenbach M, Schippl J (2015) The future of the transport industry. JRC Technical reports. Report EUR 27085 EN. Luxemburg: European Union. doi: 10.2791/904866, [http://publications.jrc.ec.europa.eu/repository/bitstream/JRC93544/future of tansport industry report final3.pdf](http://publications.jrc.ec.europa.eu/repository/bitstream/JRC93544/future%20of%20transport%20industry%20report%20final3.pdf). Accessed 24 Jun 2015