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Abbreviations

ANP	Analytic Network Process
EC	European Commission
INTEND	INtendify future Transport rEsearch NeedS
H2020	Horizon 2020 EU Research and Innovation Program
ETP	European Technological Platforms
WP	Work Package

Executive summary

Based on the existing knowledge and understanding, megatrends lead to serious challenges for the transportation systems. Therefore, there is a need for the transportation practice to adjust its developing routine to the current and future megatrends. This report gives a list of the global megatrends affecting both passenger and freight transportation and discusses the implications of the key megatrends for the future transport concepts.

Process of identifying megatrends affecting the future of transportation is based on the review of existing literature dealing with the megatrends in transport related reports and general foresight studies. This process included application of a literature review-based methodology and search on the term “megatrends” in both passenger and freight transportation reports, but also in foresight studies. We took into account relevant studies that consider megatrends with time perspective of up to 2050. The analysis of studies was performed particularly for passenger and particularly for freight transportation.

After thorough review of relevant and available literature, we defined consensus, across the reviewed sources, for selection of the key global megatrends, as well as megatrends that will be used for validation of obtained results. Therefore, in order to select any megatrend as the most important, it was necessary that at least 70% of the identified literature sources elaborate and describe the impact of that megatrend on passenger or freight transportation. On the other side, for the purpose of validation, we used a lower limit of 50% agreement for selecting certain megatrends for further analysis and elaboration through the application of the ANP (Analytical Network Process) methodology. Both lists were complemented with megatrends that have corresponding frequencies of occurrence in general foresight studies. In order to perform the required analysis, we prepared the matrixes listing sources against the megatrends identified in the reviewed literature. In total, 44 megatrends from all sources, which are related to passenger and freight transportation, as well as from foresight studies, have been separated and included in our analysis.

Obtained results indicate that the following four megatrends can be considered as the key among both groups of reviewed sources (transport-related and general foresight studies):

- **ageing society** (ageing world population; increased life expectancy)¹;
- **environmental challenges – climate change** (decrease in carbon emissions, global temperature increase, sea level rise, increased risk of flooding from melting glaciers, adaptation and mitigation policies, development of carbon markets);
- **key resources scarcity - shortages and consumption** (more constraints on consumptions - resource management; greater demands on scarce resources – fossil fuels; development of substitute materials, global privatization of resources; changes in ecosystems use);
- **urbanization and megacities** (higher population densities, improvements in cities infrastructure, environmental and health risks; PPP models; more sustainable cities).

Potential implications of these megatrends for the transportation practice are also explained.

The ageing of the population is one of the most important, particularly European, but also world trends of the 21st century. An environment that promotes ageing, supported by innovative technologies, is especially important as people are becoming old and less mobile. Easily accessible transport is essential to maintaining their independence, facilitating social contacts and enabling them to remain active in society. A network of affordable transport infrastructures and services needs to be expanded to include destinations that are not currently considered as accessible to the elderly population. Automated driving technologies may also provide capabilities to elderly to stay mobile according to their car-driving habits. Obviously, the existing and expected age structure of the population in many European countries indicates that

¹ The phrases in parentheses explain each megatrend more closely. The explanation of these phrases can be found in the analysis of transport-related (chapters 3 and 4) and general foresight studies (chapter 5), as well as in the tables 7 to 19.

transport systems have to be adapted to the needs of a larger number of people with travel disabilities.

Transportation also leads to the increased noise levels, GHG emissions and air pollution. Respecting environmental principles is, today, a very important element in the development of both passenger and freight transport. Since requirements and regulations regarding the establishment and maintaining of sustainable and green supply chains are constantly improving and increasing, it can be expected that GHG emissions will be one of the most significant characteristics of the competitiveness of the respective transportation chains. Transport companies that contribute significantly to environmental pollution will be obliged to bear the costs of removing the negative consequences of these processes. On the other side, technological achievements (e.g. natural gas propulsion, electromobility, hybrid solutions, using hydrogen as a power source) as well as better capacity utilization and improvement of transportation processes can contribute to reducing greenhouse gas emissions and impact of transport on the environment.

Fossil fuel consumption contributes to the exhaustion of existing supplies of this energy source. The type of fuel used in various transport means is very important for achieving the environmental sustainability of both passenger and freight transport sector. Forecasts indicate that the number of cars, around the world, will double by 2030, and that there will be an increase in oil prices (Clausen et al., 2014). Thus, the growing scarcity of oil reserves will be particularly reflected in the transport sector. It is obvious that transport companies will increasingly focus on using alternative energy sources in the future (electromobility, hybrid solutions and natural gas propulsion). In addition, due to expected high oil prices, large multinational manufacturing companies may tend to organize their production processes in less remote areas from the market. Obviously, changes in the price of renewable energy sources are not easy to predict, but they will have important impact on the future organization of supply chains.

Continuous urbanization and re-urbanization results in increasing demand for transport and energy. Interaction between urbanization and transport takes place in both directions. Urbanization impacts transport infrastructure and transport needs, while transport infrastructure could enhance urbanization, re-urbanization and help to rebalance the four modes of transport: road, river, air, and rail. The ultimate challenge of the transportation systems in the cities is to meet the needs of a population whose numbers are growing and whose average age is rising. Megacities are today leading examples of greater sustainable urban development through improving public transport that includes encouragement of non-motorized modes, creation of the pedestrian zones and limited use of private cars.

As megatrends, together with socio-technical shifts in the transport industry, are expected to change the whole sector in a fundamental way, they should be further validated in order to estimate their impact on defining the future transport research priorities. INTEND project, in its further steps (T3.2), will validate the megatrends by using the ANP. The aim of the validation process is to determine the prioritized megatrends (as well as technological advances and political imperatives) for successful implementation and realization of the key transport concepts of the future.

By combining the results related to passenger transportation and general foresight studies, the following megatrends are selected for further elaboration through ANP (task 3.2):

- **ageing society** (ageing world population; increased life expectancy);
- **bigger world economy** (growth of the world economic output; GDP growth; increase of international trade);
- **changing lifestyles** (changing reproduction and family lifestyle; generational shift - flexible and attractive works; global and greater connectivity; rise of lifestyle related illnesses; fitness trends; staying active; demand for experiences; loneliness and single person households; basic expectations from people; teleworking; shift towards individual - freelancing models; empowerment of women; online shopping; increased collaborative consumption - sharing economy);

- **energy demand and sources** (increased energy usage, energy investments, usage of renewable sources of energy and alternative fuels, fuel efficiency, global energy mix);
- **environmental challenges – climate change** (decrease in carbon emissions, global temperature increase, sea level rise, increased risk of flooding from melting glaciers, adaptation and mitigation policies, development of carbon markets);
- **key resources scarcity - shortages and consumption** (more constraints on consumptions - resource management; greater demands on scarce resources – fossil fuels; development of substitute materials, global privatization of resources; changes in ecosystems use);
- **shift of economic power** ("global south" as the engine for growth; emerging multi-polar world; center of gravity of the world economy, geographic hotspot of income generation, increasing commodity supply from developing countries);
- **urbanization and megacities** (higher population densities, improvements in cities infrastructure, environmental and health risks; PPP models; more sustainable cities).

Similarly, the following megatrends can be selected as the megatrends with significant influence on the future development of freight transportation:

- **ageing society** (ageing world population; increased life expectancy);
- **bigger world economy** (growth of the world economic output; GDP growth; increase of international trade);
- **changing lifestyles** (changing reproduction and family lifestyle; generational shift - flexible and attractive works; global and greater connectivity; rise of lifestyle related illnesses; fitness trends; staying active; demand for experiences; loneliness and single person households; basic expectations from people; teleworking; shift towards individual - freelancing models; empowerment of women; online shopping; increased collaborative consumption - sharing economy);
- **energy demand and sources** (increased energy usage, energy investments, usage of renewable sources of energy and alternative fuels, fuel efficiency, global energy mix);
- **environmental challenges – climate change** (decrease in carbon emissions, global temperature increase, sea level rise, increased risk of flooding from melting glaciers, adaptation and mitigation policies, development of carbon markets);
- **globalization 2.0** (global dissemination of production facilities, political and social integration);
- **key resources scarcity - shortages and consumption** (more constraints on consumptions - resource management; greater demands on scarce resources – fossil fuels; development of substitute materials, global privatization of resources; changes in ecosystems use);
- **security issues** (rising threat of cybercrime; crime rates; vulnerability of global supply chains).
- **shift of economic power** ("global south" as the engine for growth; emerging multi-polar world; center of gravity of the world economy, geographic hotspot of income generation, increasing commodity supply from developing countries).
- **urbanization and megacities** (higher population densities, improvements in cities infrastructure, environmental and health risks; PPP models; more sustainable cities).

In addition, in order to define streams of needed future researches in the fields of transport technologies, mobility concepts and research systems, INTEND project will also identify the gaps between technological advances in the transport sector and development prospects of the transport and mobility systems. This GAP analysis will be based on the perception of the impacts of various combinations of different technological advances and megatrends on specific characteristics of the future transport system. In addition, impact of megatrends on transport research needs will be visually presented by using the Transport Synopsis Tool.

1 Introduction

The overall objective of the INTEND project is to deliver an elaborated study of the research needs and priorities in the transport sector utilising a systematic data collection method. One of the main elements of the INTEND project is the review of pertinent literature (EU and international research projects including strategic research agendas, studies or roadmaps) in order to identify future technologies for each transport mode (road, aviation, rail, maritime) as well as infrastructure and transport systems which will be treated horizontally. The INTEND project will also review past futurology projects and recent futurology studies in order to present future mobility concepts. To ensure validity of the results, the Analytical Network Process will be used to determine the prioritized elements in all clusters (technological advances, megatrends and political imperatives) for successful implementation and realization of key transport concepts of the future. Finally, INTEND will develop a transport agenda that would pave the way to an innovative and competitive European Transport sector. The project is driven by three main objectives:

- to define the transport research landscape;
- to define the megatrends and their impact on research needs;
- to identify the main transport research needs and priorities.

In order to enable a wide range of stakeholders to gain access to the results, INTEND will develop an online platform, INTEND Synopsis tool, which will constitute a dynamic knowledge base repository on the major developments in the transport sector. This will provide a visualisation of the INTEND's main outcomes. The basis for the platform will be Transport Synopsis Tool which has already been developed under the project RACE2050 coordinated by TUB. The repository will be updated and integrated into the INTEND website to provide a comprehensive picture of all forward looking studies focusing on technological developments, megatrends and policies.

The main idea behind this deliverable is to draw attention to and identify key megatrends from the perspective of the future of transportation system. Based on the existing knowledge and understanding, it is obvious that megatrends lead to serious challenges for the transportation systems. Therefore, there is a need for the transportation practice to adjust its developing routine to the current and future megatrends. However, different economic, social and environmental characteristics of various regions all over Europe cause different impacts of these megatrends on corresponding transportation systems.

This process of identifying megatrends affecting the future transport system is based on the review of existing literature dealing with the megatrends in transport related reports and general foresight studies. Therefore, our goal is to reach consensus on the key megatrends for both passenger and freight transportation systems. Further, we also analyse potential implications of the key megatrends for the transportation practice.

1.1 The INTEND work structure

Figure 1 depicts the work flow of the INTEND project and the relationship between the process of identification of key megatrends affecting both passenger and freight transportation systems of WP3 with the rest of the WPs.

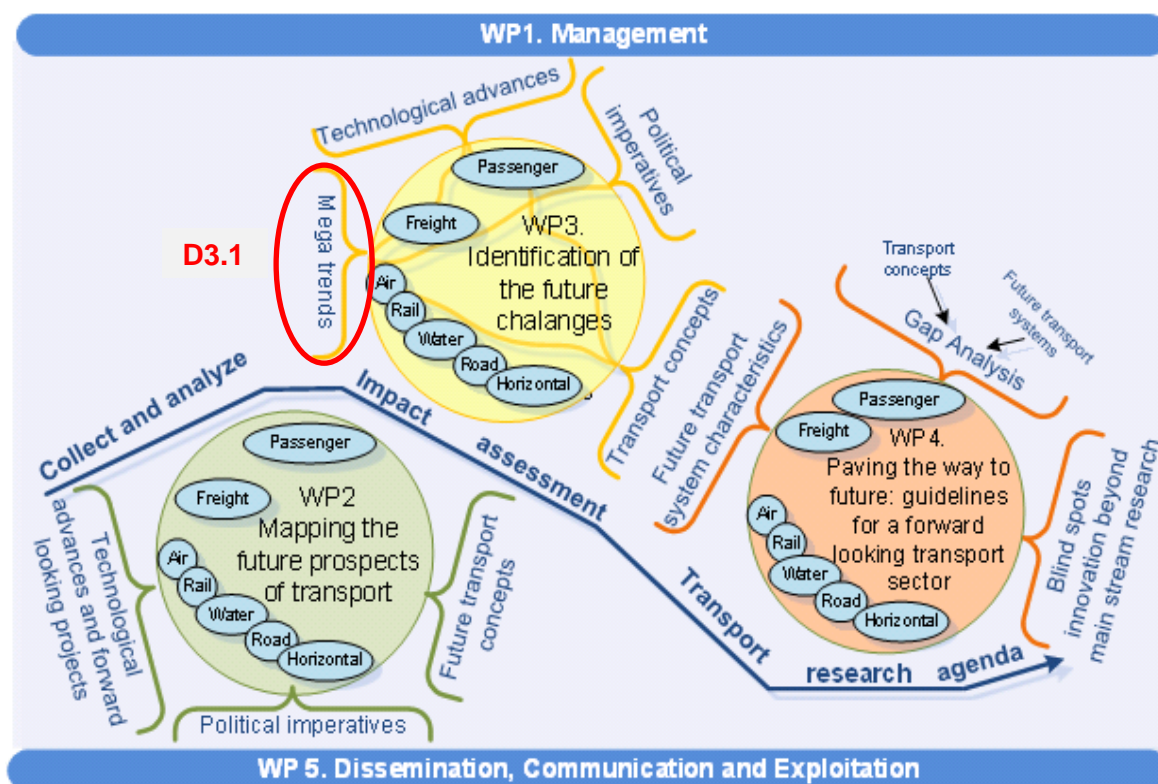


Figure 1. Workflow in INTEND and relations of task 3.1 with other WPs

1.2 The deliverable in the frame of INTEND work structure

D3.1 aims to identify the global megatrends affecting passenger and freight transportation and discusses the implications of the key megatrends for transport concepts of the future. We will also validate the megatrends within the WP3 by using the Analytical Network Process (ANP). The aim of the validation process is to determine the prioritized megatrends (as well as technological advances – task 2.1 and political imperatives – task 2.3) for successful implementation and realization of key transport concepts of the future (task 2.2).

As megatrends, together with socio-technical shifts in the transport industry, are expected to change the whole sector in a fundamental way, results of D3.1, i.e. ranking of megatrends, will be used in WP4, and therefore will constitute an important input for defining the future transport research priorities. In order to define streams of needed future researches in the fields of transport technologies, mobility concepts and research systems, we will identify the gaps between technological advances in the transport sector and development prospects of the transport and mobility systems (D4.2). This GAP analysis will be based on the perception of the impacts of various combinations of different technological advances and megatrends on specific characteristics of the future transport system. In addition, impact of megatrends on transport research needs will be visually presented by using the Transport Synopsis Tool (T5.3).

1.3 Task 3.1: Megatrends identification

The main aim of T3.1 is identification of potential megatrends, which are most likely to influence the transport concepts of the future. A literature review-based methodology and search on the term “megatrends” in both passenger and freight transportation reports, but also in foresight studies was applied. Particular emphasis was given to the EC, ETPs and worldwide projects,

which have studied the megatrends shaping the world we live, with emphasis on transportation studies.

After thorough review of relevant and available literature, a consensus on the selection of the key global megatrends that impact on future of freight and passenger transport was agreed and defined across the source literature. In that context, a matrix presenting megatrends and their respective sources, was prepared. By doing so, megatrends commonly elaborated in the majority of literature sources were identified suggesting us some level of consensus. This deliverable also reflects upon the implications of the key megatrends for the passenger and freight transportation. In order to validate the results from T3.1, selection of megatrends identified in D.3.1 will be further evaluated in task 3.2 by estimation of their relative importance for the realization of the transport concepts of the future. As we have already mentioned, this evaluation will be based on the application of ANP.

As a first step in the evaluation process and application of ANP, technological advances in freight and passenger transport, political imperatives and important key megatrends will be clustered. The ANP will develop a network structure based on these clusters, as well as a group of key transport concepts of the future. Further, relationships between elements in the network will be defined. This will enable validation and impact assessment of technological advances, megatrends, political imperatives on selected key transport concepts of the future from various perspectives. In addition, sensitivity analysis will be conducted in order to overcome the risk of an irreversible bad decision regarding future transport research priorities. Process of identification and evaluation of megatrends to be used in this project is visible on Figure 2.

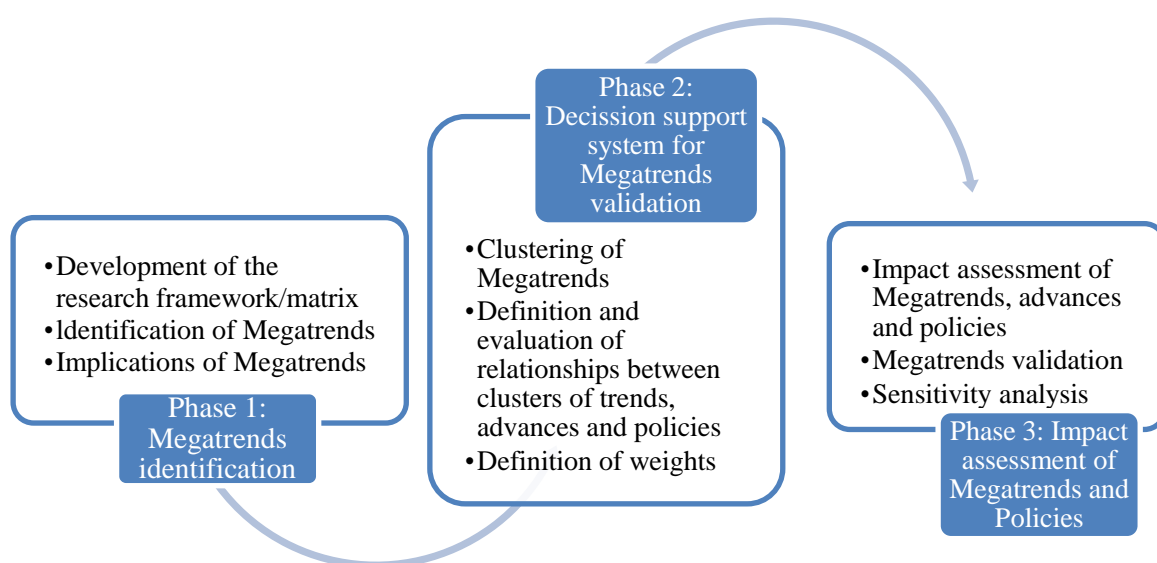


Figure 2. Identification and evaluation of key megatrends for successful implementation of the transport concepts of the future

2 Weak signals, trends and megatrends

Trend management, as a research discipline, arose from the concept of weak signals, introduced by Ansoff (1975) and Ansoff (1982). According to Ansoff (1982), weak signals are *“warnings (external or internal), events and developments that are still too incomplete to permit an accurate estimation of their impact and/or to determine their full-fledged responses.”* Over the years, Ansoff’s concept of weak signals has been accepted for what is now called a trend (von Groddeck and Schwatz, 2013). Accordingly, any trend can be analysed and understood by taking into account numerous indicators or warnings related to a particular phenomenon, which can lead to significant changes or discontinuities in a particular area, such as passenger or freight transportation. The aspect of changes clearly indicates that any trend must be considered as a new phenomenon, which is always complex and whose lifespan cannot be accurately measured. Therefore, studying trends implies research of something new, with the aim of understanding them and correctly perceiving the possible consequences in certain areas (von Groddeck and Schwatz, 2013). Liebl and Schwartz (2010) point out that innovation and diffusion are two perspectives from which trends should be observed in order to understand them. Innovation clearly points out the need for something new in every trend, while diffusion enables us to see to what level a certain trend influences the development of different areas, such as transport. Therefore, basic characteristics of every trend are the following (von Groddeck and Schwatz, 2013):

- It is a fundamental change over an extended period;
- Trends are phenomena that are always complex and whose lifespans can only be measured inaccurately;
- They represent associations that are defined by crossing contextual borders.

If the importance of certain transformation processes is to be emphasized, such changes are often called megatrends. Therefore, megatrends are one of the research disciplines in trend management. Vejlggaard (2008) points out two of the most significant characteristics of megatrends:

- megatrends represent cultural, economic, political and technological changes that have not yet happened;
- the effects or implications of megatrends are reflected on the whole or almost entire society.

The same author indicates the following differences between trends and megatrends:

- Megatrends last longer;
- Megatrends have a more pronounced impact on many areas;
- It is significantly easier to predict development patterns of certain trends in comparison with the prediction of future development of megatrends.

It is known that many internal and external factors influence both freight and passenger transportation system. This deliverable deals with general external factors or megatrends i.e. *“those variables, which are not specific to the transport system, but have impacts on it and contribute to shape its development”* (Anoyrkati et al., 2016). We will analyse these external factors from the socio-demographic, economic and environmental perspectives and put emphasis on those that are most often elaborated in the literature and relevant reports. In addition, these external factors or megatrends interact with policy actions within both freight and passenger transportation processes. It means that any policy action affects not just transportation systems but also development patterns of the megatrends.

Identification of technologies that require advancing or future technologies that will be used by the transport sector in the future is the main aim of the INTEND T2.1. Therefore, technological megatrends are not the main focus of this deliverable. Otherwise, we will elaborate technological changes relevant for the future of transportation in each reviewed source, but these megatrends will not be taken into account in the selection process. Selection and validation of all type of megatrends will be performed within INTEND T3.2.

3 Review of selected transport-related projects

The aim of this deliverable is to identify megatrends that may affect both passenger and freight transportation. The applied approach is based on a literature review of future studies, projects and papers. In this chapter, we took into account transport related studies that consider megatrends with time perspective of up to 2050. The analysis of studies was performed particularly for passenger and particularly for freight transport. Passenger transport related studies that we analysed for the purpose of identification of relevant megatrends are the following:

- European Commission (2009);
- OPTIMISM (2011);
- TOSCA (2011);
- World Energy Council (2011);
- Deutsche Post (2012);
- FORD (2012);
- The Future of Transport (2012);
- UNECE ITS (2012);
- FUTRE, D3.1 (2013);
- ERRAC (2014);
- Silva et al. (2014);
- CIPTEC, D1.1 (2015);
- Surrender (2015);
- UITP (2015);
- Anoyrkati et al. (2016);
- Future Transport 2056 (2016);
- Kautzsch et al. (2016);
- Mobility4EU, D2.1 (2016);
- WaterborneTP (2016);
- Aho et al. (2017);
- IATA (2017);
- Nissler and Guichard (2017);
- Megatrends Transportation (2017);
- US DOE (2017);
- US DOT (2017).

In an effort to identify most relevant megatrends for freight transportation, we have analysed all, to authors, available and known literature that deal with these two aspects (megatrends and freight transportation). This is a list of reviewed reports and studies:

- Jeschke (2011);
- TOSCA (2011);
- ALICE (2014a-e);
- ERRAC (2014);
- Clausen et al. (2014);
- DHL (2016);
- Future Transport 2056 (2016);
- Kautzsch et al. (2016);
- Mobility4EU, D2.1 (2016);
- WaterborneTP (2016);
- Aho et al. (2017);

- IATA (2017);
- Megatrends Transportation (2017);
- US DOT (2017).

Transport projects and studies examined and their specific findings on megatrends are characterized in detail in the following sections.

3.1 EC and TP reports and projects

European Commission (2009) identified the main trends in transport drivers and elaborated on challenges these trends could pose to the society. The report emphasized the following trends: **ageing, migration and internal mobility, environmental challenges, increasing scarcity of fossil fuels, urbanisation and global trends affecting European transport policy.**

The main objective of the TOSCA project was to “*identify promising technology and fuel pathways to reduce transportation-related greenhouse gas emissions through 2050*” (http://cordis.europa.eu/result/rcn/55384_it.html). The project concluded that **GDP growth** and **oil prices** are uncertain driving forces that will mostly affect both the passenger and freight transportation demand at the EU level.

OPTIMISM project aimed at development and elaboration of future mobility scenarios. Definition of OPTIMISM scenarios considered the process of identification of key factors and their trends affecting passenger transportation systems. Based on the analysis of literature on key factors and expert knowledge, the project also created a list of potential megatrends influencing transportation system and mobility behaviour. These megatrends are the following: **urbanisation, shortage of resources, globalization 2.0, climate change and environmental ethics, technology change, mobility and European policy reaction, world population growth, demographic and social change Europe, European market deregulation, increase of Inter-/ Intra-national social disparities and knowledge society and -economy Europe.**

FUTRE project (FP7, 2012-2014), in its deliverable D3.1, studied factors of evolution of transport demand behaviour. Scenario analysis was used as a methodology to identify the corresponding factors. The first step in this process was identification of possible megatrends with impacts on transport. Within this project, megatrends were defined as “*stable trends driven by global forces that impact several societal areas*”. From the perspective of transport needs and based on the literature review and inputs from expert consultation, 15 megatrends were identified as the most relevant to transport. Among them are **globalization**, as a pattern of economic, political and social integration at global level, **urbanization**, as a trend of appearance of numerous megacities, **global ageing of population**, knowledge society, as a process of increasing importance of education, know-how and information for economy and society, and **migration**. There are also a set of megatrends that may be grouped under **lifestyle changes**. These are:

- individualism,
- connectivity (people are online on a 24/7 basis with infinite information available),
- immediate needs (here & now – feeling of urgency and preference to short-term thinking),
- slow movement (counter-trend emphasizing quality of life and prioritizing health and mental health),

- empowerment of women (higher role of women at both political and professional level),
- awareness/ consciousness (reflecting the increased awareness of global social and environmental hazards),
- consumption 2.0 (use, not own – higher tendency to renting rather than buying),
- ever young (adventure, gaming and a strong desire for freedom as lifestyle of older people),
- seeking for experiences (strong preferences towards travelling, meeting other people and cultures), and
- do it yourself (people as consumers are involved in all phases of product and services development).

ERRAC (2014) identified the following megatrends:

- **urbanisation** (will lead to the increased market share in urban and regional markets of well-integrated public transport involving rail, metro, tram and bus transport (and even private modes like bike or electric car; rail passenger transport demand is strongly driven by demand growth in, to and between large cities and other urban areas);
- **aging of population** (the elderly population will grow significantly by 2050; elderly people will use trains more frequently, particular in urban areas and for long distance journeys);
- **lifestyle changes** (fewer car owners, preferences towards multimodal travel patterns including walking and cycling);
- **technological innovations** (expected to produce more energy and resource efficient systems for rolling stock and infrastructure; quality and safety and security management systems harmonized across Europe; interoperable European wide rail system by 2050; semi and fully autonomous and alternatively propelled car systems are expected to be a major competitor in 2050 to electrified rail mass transit);
- **sustainable mobility measures** (promote modal shift towards rail transport; enhance of the long distance rail services by making car travelling in cities relatively less convenient);
- **climate change** (more resilient infrastructure, with improved emergency maintenance services, is expected to be in place by 2050; comprehensive passenger information to provide advice in circumstances of service disruption);
- adopted **rail research and innovation policies at the European level** (driven by the need to strengthen European rail industries within competitive global rail markets; reflect a shift to rail strategy with more restrictions on road transport and the phasing out of conventionally fuelled vehicles in urban areas).

It was concluded that these megatrends are the keys to sustainable mobility in a low-carbon Europe and is also essential for the growth of the European economy and for social cohesion.

Alliance for logistics innovation through collaboration in Europe and ERTRAC Urban mobility WG made a report named *Sustainable, Safe and Secure Supply Chain* in 2014. The focus of the Report was to realize supply chain networks that are operated as a whole – in other words, full vertical and horizontal coordination and collaboration. Coordination and collaboration concern the full skull of supply chain operations from logistics and transportation planning to strategic network design choices. ALICE has identified five different areas that need to be specifically analyzed and addressed in terms of future research and innovation needs to achieve its mission. These areas are:

- Sustainable and Secure Supply Chains, ALICE (2014a);
- Corridors, Hubs and Synchromodality, ALICE (2014b);

- Information Systems for Interconnected Logistics, ALICE (2014c).
- Global Supply Network Coordination and Collaboration, ALICE (2014d).
- Urban Logistics, ALICE (2014e).

ALICE (2014a) gives the research roadmap in the field of sustainable, safe and secure supply chains. Supply chains depend on logistic systems, societal developments and challenges and the physical internet concept.

A supply chain concerns the entire production and distribution chain from raw materials to final customer and finally “reverse logistics”: taking back products and possible re-use of materials or components.

Logistics and supply chains put burdens on societal developments and environment. Their impacts are: 1) **reduction of the environmental impact**, including reduction of the “**carbon footprint**” and more local effects like stench, noise, unsafe and land use; 2) **reduction of demand for non-renewable resources**, including fossil fuels; 3) **improvement of external safety and labor conditions** and 4) addressing the **vulnerability of logistics activities for criminal interference**. Societal development as a part of supply chain include **shortage and sustainability, demographic trends** and **safety and security of supply chain**.

Future supply networks require a synchromodular transport system, in which shipments are to a large extent automatically routed in an optimal way. A possible way for designing the best networks to move goods is the **Physical internet**.

ALICE (2014b) presented the research roadmap in the field of Corridors, Hubs and Synchromodality. The innovation Roadmap for Corridors, Hubs and Synchromodality provided pathways towards improvements in the integrated European freight service network. The innovation includes combination of two layers: horizontal (stakeholders) and vertical (enablers).

The stakeholders will benefit from innovations at 3 levels:

- Supply chain level: Networks from the goods producing and trading sectors of industry towards the consumer, i.e. shippers and receivers of goods
- Service level: Transport service providers, per mode of transport, but also for intermodal transport and forwarding services.
- Infrastructure level: Network providers including hubs and corridor managers.

The enablers will benefit from innovations at 3 levels called the “enabling innovations”:

- Business Models innovation and governance/Orgware – Best collaborative practices and approaches for **fast deployment of innovations**.
- **ICT deployment of innovative technologies**/Software – Operational practices and standards for data, messages, software / digital divide
- New technology/Hardware – Modularized solutions, transport equipment, ICT devices.

It can be expected that technologies moving towards strong modularity, connectivity and self-organization will appear.

ALICE (2014c) provides the research roadmap in the field of Information Systems for Interconnected Logistics. A large number of **ITS technologies** (systems and services) are currently available to support or even manage specific aspects of goods movements. The implementation of the roadmap should contribute to supply chains that are fully integrated and

coordinated (supply networks) through the use of ICT. The roadmap focuses on solutions that can be made available to, and affordable for, all types of companies and participants, whether large or small. New business models, tools and standards that allow all participants to collaborate, share resources and rapidly setup and tear down supply networks are required.

Challenges for enabling ICT are: **sustainable safe and secure supply chains**, supply network coordination and collaboration, corridors hubs and synchromodality and urban freight. In order to achieve ALICE vision ICT Innovation, new business models and data governance are required.

In 2020, ALICE will have realized full horizontal collaboration over the sustainable and secure supply chains ALICE (2014d). Around 2030 integration of the manufacturing logistics should be realized. In 2040 ALICE will have realized open supply networks through Sustainable and Secure Supply Chains. In 2050 **physical internet** will become new reality.

The aim of the ALICE (2014e) was to achieve a full integration of freight flows in cities' operations and activities that could allow citizens to access the goods they require and the goods to reach the citizens. Identified research areas aimed to:

- increase **energy efficiency**, which can be achieved by improving the efficiency of the whole urban logistics system, and added to the expected gains in the energy efficiency of vehicles;
- improve the urban environment by increasing air quality and reducing noise;
- increase customer satisfaction by delivering the goods on time and improving the reliability of the systems;
- increase safety and security, reducing injuries and fatalities as well as cargo loss or damage.

CIPTEC project (H2020, 2015-2018) D1.1. reviewed the megatrends identified in the literature and run a brainstorming session to validate them. The major identified trends and their impact on transportation are the following (CIPTEC, 2015):

- **Enhancement of urban governance** (compliance with institutional and legislative frameworks; pressure to provide enhanced public services to citizens and business; competition among cities; city branding; local urban public transport systems are established within a framework of broader inter-urban service networks; increased needs to create Metropolitan Transport Authorities);
- **Globalization** (increased travel distances; more people work, study and travel abroad; increase of cross border travel; global outreach of ICT system lead to more efficient public transport system);
- **Internalization of transport external costs** (internalization measures will discourage the usage of individual vehicles and cars; enhanced public transport usage and share; reduced public transport operating costs; increased economic and effective operation of public transport services);
- **Shared economy** (young people change cars for bicycles, public transport and train; young people tend to share rather than owning the car; public transport slides from mobility to mobility as a service);
- **Flexible economy** (public transport system allows for flexibility and is more adjusted to the business needs);
- **Individual empowerment** (public transport service is becoming more aligned with the needs of more demanding customers; more personalized production; on-line services

bring on dramatic changes in consumer awareness, attitude and behaviour towards personal mobility; increase in flexibility of working hours);

- **Corporate social responsibility** (social innovation initiatives are enabling emerge of new innovative solutions; environmentally friendly production techniques, energy efficient vehicles or technologies reducing industrial carbon footprint correspond more efficiently to the expectations of the travelers);
- **Social innovation and social entrepreneurship** (car-sharing and car-pooling based on the shift from car ownership towards car-user groups; multi-modal mobility supported by social change through society digitalization; new ways of promoting walking; citizens' initiatives planning car-free city areas; improving the value of the immediate surroundings; voluntary public transport services in remote areas closing the gaps within the timetables or routes of public transport);
- **Ageing** (personal constraints leads to mobility decrease mainly after the age of 75 years; it lowers the average distances of trips made and inhibits change in travel purposes; selection of transport mode depends more on travel costs than on travel time; older people switch to walking when they can no longer drive);
- **Transforming families and household sizes** (household size decrease results in lower car occupancy leading to higher traffic densities, if motorization rate continue to increase; on the other side, car ownership rate among young people is decreasing and they are more oriented towards sharing, public transport, walking and cycling);
- **Urbanization and urban sprawl** (results in a higher demand for transport and mobility; development of peri-urban areas imposes huge problems related to traffic congestion; flexible working time eliminates traditional "peak time" situations; new "non-regular" mobility needs push people towards private travel modes requiring integration of public transport to other individual transport modes and mobility solutions);
- **Sustainable lifestyles** (popularization of sustainable transport systems and solutions, such as electric vehicles, advancement of crowdsourced and collaborative service consumption patterns, such as car-pooling and bike sharing; increase of transport related digital services, such as collaborative platforms with mapping and citizens reporting);
- **Innovation and technological development** (vehicle efficiency through new engines, materials and design; cleaner energy through new fuels and propulsion systems; more efficient operation, communication and marketing strategies through ITS);
- **Internet** (smart ticketing and real-time, customized, multimodal travel information make public transport more accessible and user-friendly; "internet of things" offer travelers the optimal transport solutions based on available and suitable transport means, traffic situation, personal preferences, weather conditions, etc.; fast development of new mobility services such as Uber, BlaBlaCar, Zipcar);
- **Environment** (covers climate change, pressure on natural resources and high oil prices; climate change can cause extreme events impacting transport infrastructures and disrupt supply chains, transport connectivity and services; pressure on natural resources means increased global demand for raw and other resources; oil prices will increase due to dwindling oil resources and unsustainable patterns in demand growth; developed initiatives – a) EU has mandated that, by 2020, 10 % of all fuel used in transport will come from renewable sources, b) e-mobility, c) smart cities and smart energy/smart grid);

- **Harmonization of legislation at EU level** (passenger safety and security have increased; EU legislation has strengthened passengers' rights; liberalization of international rail passenger transport; market opening measures in the transport sector; introduction of public procurement procedure by means of competitive tendering).

It is obvious that some of these trends can be grouped into wider categories. Urbanization clearly encompass development patterns of urban areas and appropriate governance models. Aspects of shared economy, individual empowerment, household sizes or sustainable consumption culture point out to the changes in the people lifestyles. On the other side, environment include trends that should be considered separately (climate change, energy sources or natural resources and oil prices). Various types of innovations and technological advancements could be considered as solutions to challenges imposed by the described trends.

Mobility4EU (H2020 project, 2016-2018) D2.1, 2016, conducted a literature review of societal, political, economic, technological and legal trends. These were also validated during a workshop session. The study revealed 29 trends organized in 9 larger trend categories (Mobility4EU, 2016). These include:

- **Distribution of wealth and labour market developments** (adaptation of Europe's economy in the global context of significant relative decline of GDP, telework and part-time work);
- **Inclusive society, personalization, accessibility** (increasing life expectancy of the population, migration trend generating long distance flows, inclusion of vulnerable to exclusion groups, less car use by younger generations, move towards more active and healthy lifestyles, acceleration and flexibility of liquid modern society and European integration facilitating flows);
- **Urbanization and smart cities** (rising and expanding urbanisation, the emergence of smart cities);
- **Environmental protection** (adoption of stricter regulations for environmental protection, increasing scarcity of available resources, increasing scarcity of available resources, impact of climate change on transport);
- **Digital society and internet of things** (rise of the Internet of Things, big data technologies and automation – supply side; expectation of customers and digitisation of mobility, new uses of travel-time – demand side);
- **Novel business models and innovation in transport** (new models challenging the individual vehicle ownership model; emergence of new business models in the batteries, data and freight sectors; emergence of co-development and co-creation of new systems by users and economic actors);
- **Safety in transport** (coexistence of automatic and non-automatic vehicles, promise of a decrease of road casualty through the introduction of automated cars, adjustments necessary in insurance and liability);
- **Security in transport** (security/accessibility issue: the provision of more security in transport by introducing controls/barriers reduces accessibility);
- **Legislative framework** (diversifying approaches of governance – more actors, including citizens, contribute to the governance of transport and mobility, legislative models adapts to new transport solutions and businesses – interaction between new business models and the legislative framework, trend toward harmonisation in

legislative frameworks – legislative framework in Europe has direct implications for transport such as in the area of interoperability of transport systems).

Trends in digitalization, business models, safety and security in transport obviously represent attempts of the transport sector to provide responses to the external megatrends identified in this, as well as other analyzed studies. Since these aspects will be taken into consideration in WP4, we have not elaborated them in details in this deliverable.

Waterborne^{TP} (2016) observed key global trends and their influence on the future of waterborne industries. It diversifies among societal trends, economic trends, climate disruptions and digitalization, or in more details:

- **population growth – urbanization** (the world population is predicted to increase to 8.5 billion in 2030; the share of people living in urban agglomerations will increase to about 60% in 2030; lead to the increased waterborne transport and increased use of ferries, cruise ship and leisure craft in particular; challenge is to build new and upgrade existing port infrastructure);
- **food and water demand** (increased food and water demand due to population growth, increasing urbanisation and industrialisation; increased need for water transport and aquatic food production, i.e. transport of fresh water, transport of food, food production at sea (fish farming, aqua farming), installation of desalination plants, need for specialised infrastructure);
- **health, safety and security reimaged** (civil society, consumers and workers will become less willing to accept negative social impacts of maritime sector such as, e.g. accidents and unsafe working conditions; need to improve working conditions due to scarcity of qualified personnel and for stricter safety and security standards in maritime sector);
- **increased environmental concerns** (stricter environmental regulations for shipping to reduce emissions to air and sea; stricter regulations for offshore activities, including renewable energy; stricter emission control in port areas);
- **global economic growth and trade increase** (low single digit number of GDP growth in OECD countries; higher growth rates of GDP in developing countries – China and India are predicted to at least double their GDP from 2015 to 2030; future economic growth driven by innovation instead of population growth; increase of middle class in developing countries will drive the consumption of technological products; challenges are increased need for waterborne transport of manufactured goods, increasing number of maritime jobs within Europe, increasing number of ships under European flags);
- **energy production and consumption** (world primary energy production grows at 1.5% p.a. from 2012 to 2030; developing countries will increase their energy consumption by approximately 75%; main energy sources will continue to be oil, gas and coal with similar share of fossil energy consumption; energy production on offshore locations; significant increase in production and transport of clean fuels – LNG, shale gas, hydrogen; need for exploration of reserves in deeper water, and harsher environments; need for port infrastructure for offloading; alternative fuel trade leads to transport of LNG, methanol or hydrogen);
- **climate changes** (climate will change dramatically, causing an increase in temperature extremes, more severe rainfall and flooding, higher frequency of storms and continuous and increasing polar ice melting; possibly severe operational disruptions; increased requirement for robustness of ships, ports and offshore structures for more severe weather conditions; increased use of weather routing; utilization of arctic routes – Northwest, Northeast; need for exploitation of arctic fossil fuel reserves; need for enforcement of coastal infrastructure – dikes, ship fairways);

- **digitalization** (significant increase of digitalization in all waterborne sectors is expected; higher degree of automation, automation of systems, autonomous operation; sea-based and shore-based operation: integration and transformation; need for secure connectivity against cyber-attacks; electronic data instead of legal paper documentation; data access issues, IPR).

3.2 Worldwide forward looking transport projects

World Energy Council (2011) created two global transport scenarios: “Freeway” in which market laws define a pathway for open global competition and “Tollway” where government interventions and common interests direct infrastructure and technology developments. These two scenarios deal with potential developments in transport fuels, technologies, and systems in the period of up to 2050. Some of the driving forces elaborated in this study are the following: **economic growth, demographic trends, urbanization and megacities, geopolitics, global oil reserve and supply, environmental and health concerns, policies and regulations, lifestyle changes, alternative fuels, fuel efficiencies, technological innovations.**

Study Clausen et al. (2014) took into account growing transport volumes to develop scenarios for the future, based on innovative and sustainable transportation systems. It identified five global megatrends and analyzed their future developments prospects with potential influences on road and rail freight transportation. These megatrends are the following: **globalization, demographic change, urbanization, sustainability and resource scarcity.**

Globalization, as the first megatrend, was analyzed from the perspective of global transport flows and developments, position of Germany as the logistics center of Europe and growth of freight flows in Germany. According to the presented findings, the traffic is expected to increase in the years ahead, especially in road, but also in rail transportation. In addition, congestion of infrastructure may lead towards the reducing of quality, a trend of merging individual logistics centers will occur and imbalance in the consumption and production of goods will cause a mismatched transport flows (level of incoming goods in some region is considerably different comparing to the outgoing freight flows).

The second identified megatrend in the same study is about demographic changes. Analysis of this trend took into account population trends in Germany, development of the labor force in the logistics industry and attractiveness of the workplace. The main identified challenges for the transport logistics industry in this area are skills shortage on the labor market, unattractive public image of the logistics industry and increased age of employees working in logistics.

Urbanization, as the third megatrend, was elaborated from the perspective of re-urbanization (increase of population in urban areas) and social development and individualization (diversity of different lifestyles). This megatrend will cause the following challenges for the freight transportation in cities:

- increase in transport volumes in the cities due to urbanization;
- reduction in space for traffic;
- individualization requiring customized solutions.

Sustainability is the fourth analyzed megatrend within the report of Clausen et al. (2014). It was considered from the usual three pillars, i.e. environmental, economic and social sustainability. According to predictions, “green supply chain” will become a decisive factor in the design of the future transportation chains. The basic pillar of economic sustainability are successful companies. They should aim to achieve maximization of profit by efficiently allocating resources and high level of customer satisfaction. Social sustainability is about responsibilities of companies to its employees and its wider duty to society. These sustainability issues are expected to create the following challenges to the transportation sector:

- working condition of the employees in the public and freight transportation companies will become a competitive factor in career choices;
- demands for “green logistics” will increase, so the companies will pay more attention to environmental concerns and efforts to reduce their carbon emissions;
- competition with other transportation companies will produce greater incentives towards increase of quality and efficiency.

Resource scarcity, as the fifth megatrend, deals with increasing shortage of certain commodities, such as oil. This megatrend was elaborated by taking into account needs for recycling economy, introduction of CO2 emissions rights trading, greater use of alternative energy sources, rising energy costs due to increase scarcity of fossil fuels and access to mineral commodities which are essential for the development of future technologies. All these aspects represent the challenges the transportation sector will face with in the future.

In addition to the identification and elaboration of megatrends, study of Clausen et al. (2014) suggested solution to the described challenges. These *solutions* are based on the trends of *digitization, flexible management and technological advances*.

Future Transport 2056 (2016) gives a strategy and vision for the next 40 years of transport in New South Wales, Australia. It identified and elaborated seven global megatrends that are expected to impact on how people, and the goods people need, will travel over such a long period. These megatrends are:

- **Rapid technology change;**
- **Customer demand** – “*Informed customers are demanding more ‘personalized’ transport services*”;
- **Live, work and study anywhere;**
- **Environmental sustainability and energy security;**
- **Growing international trade;**
- **Our growing and ageing population;**
- **The need for healthier lifestyles.**

Mohaddes and Sweatman (2016) elaborated a number transformational technology hot topics identified by TRB. The current state of the selected topics is considered to be represented by the nature of key technologies and their state of development, the key players involved, methods used to demonstrate the technologies to a national audience, methods used to publicize the technologies and convene their proponents and stakeholders, the economic significance of technologies and associated business models, and the possibilities for wider impact through synergies with other key technologies or other adjacent matters. At a high level, the hot topics can be characterized as follows:

- **Connected–automated vehicles (CAVs)** are a potential national ground transportation solution with high market, consumer, and societal significance; the realization of CAVs full potential will require sustained cooperation among many stakeholders.
- **Shared- use services** is a generational service economy concept that has extreme disruptive power in transportation and has a natural affinity with CAVs. It has a very high market potential, consumer, and societal significance.
- **Unmanned aerial systems (UASs)** are a national operations and mobility solution with significant market and consumer potential; the realization of UASs’ full potential will require government action and consumer acceptance.
- **IoT (Internet of things)** is a technological megatrend that will underpin many smart products and services.
- **Cybersecurity** is an essential, high-value process technology that underpins many fields of system operations and consumer services.

- **Smart cities** is a technological mega-trend that bundles related technologies including big data and IoT.
- **NextGen** is a new-generation national system for the control of aviation operations. It is led and operated by government and enables high market and societal value.
- **3-D printing** is a highly disruptive technology in manufacturing, logistics, and transportation. It has extremely high market value and flow-on effects, including the enterprises of IP, research and standards.
- **Big data** is an information technology that enables other transformational technologies, and game-changing advances in multiple fields of operation (including transportation).

It can be concluded that all these topics are technological. Therefore, their impact on future transportation concepts is analysed in INTEND T2.1 and will not be further studied herewith.

IATA (2017) report sets out the findings of a study exploring the forces shaping the future of aviation, and looks at the potential implications for the airline industry. Key drivers of change that IATA and airlines should be thinking about to prepare for future opportunities and challenges over the next 20 years are given on are the following.

1. **Alternative fuels and energy sources** – replacement of traditional fuels by energy sources such as bioenergy or fuel cells; the growth of renewables at a global level due to advances in energy storage;
2. **Cybersecurity** - in the future, increased connectivity between real-world devices including planes, cars and robots will blur the boundaries between virtual and physical security;
3. **Environmental activism** – may come from the public, the workforce, or even shareholders and governments; generational and societal shifts may lead to new tools; younger people are more likely to participate in online activism than older generations; technology and cyber activism provide new opportunities and threats;
4. **Extreme weather events** – due to **climate changes**, frequency and severity of extreme weather events (whether wildfires, droughts, extreme temperature, storms or snowfall) are expected to increase;
5. **Level of integration along air-industry supply chain** – an integrated supply chain allows manufacturers to look into business processes across multiple suppliers and disparate platforms to follow materials, components and people wherever they are; the importance of emerging markets, economic growth and the appetite of developing countries for natural resources may boost global prices and make it trickier to configure supply chain assets;
6. **New modes of consumption** – consumers seek greater value from products and services, redefining their relationship with ‘things’; sharing models grow and thrive; the concept of access over ownership; backlash against one-size fits all technology, increased demands for authenticity and personalized experiences, sustainable consumption and desire for face-to-face interaction;
7. **Price of oil** - future outlook of crude oil prices is uncertain; Persistent low prices may drive initial cost savings for transportation, but it has uncertain global economic impacts;
8. **Strength and volatility of global economy** – West to East economic shifts and an increase in South-South trade are likely to have a significant impact on international politics and governance, as well as other trends such as increasing inequality; as the economic influence of developing nations increases, new markets, competitors and demands will alter patterns of trade, changing what goods are transported where;
9. **Geopolitical (in)stability** – one in four people on the planet now live in fragile and conflict-affected areas; Increasingly, actors in these conflicts are not clearly defined; over the next 20 years, state fragility, religious and ethnic tensions, and mounting pressure on global resources may sow the seeds of conflict;

10. **Infectious disease and pandemics** – emergence of new threats such as HIV, SARS, Zika virus as well as animal diseases such as BSE have reacquainted the world with the risks;
11. **International regulation of emissions and noise pollution** – the airline industry contribution to overall CO2 emissions is relatively low compared to other transport sectors; forecasts to 2050 vary in optimism;
12. **Tensions between data privacy and surveillance** – advances in connectivity and sensor networks are likely to empower citizens by providing real-time accountability and transparency; privacy and surveillance are likely to be high on the list of military and government concerns over the next two decades; for corporations, data breaches and cybercrime may require new measures to protect data; privacy itself could become a valuable commodity;
13. **Terrorism** – terrorists adapt to the techniques and methods of counter-terror agencies and intelligence organizations; states with poor governance, ethnic, cultural, or religious tensions, weak economies, and porous borders have been breeding grounds for terrorism.

Megatrends Transportation (2017) deals with numerous issues related to the impact of passenger and freight transportation on individuals, businesses, communities, the environment, and the state. This publication explores the ways of using land use and transportation policies in shaping local communities. One section of the report addresses social aspects of transportation. It elaborates travel needs of different age groups and puts emphasis on “**age wave**” in Wisconsin, US. Another social aspect elaborated in the study relates to the increase of the **number of people living in the urban areas**. Urban areas in Wisconsin spread over only 4 % of all land, but contain 70 % of population. The report also covers the aspect of **climate change**, gives data about levels of emissions caused by transportation activities and suggests measures for reducing GHG emissions (by reducing vehicle miles travelled, using more efficient modes of transportation, and improving transportation network efficiency). Emerging trends is also one of the sections of this report. Two aspects contained in this section deal with **alternative fuels** and **fuel efficiency**. Since Wisconsin has no sources of petroleum or natural gas, propane, compressed natural gas, and electricity are widely used today and their popularity is growing. In addition, more efficient design, improvements to engines and tires, and weight reduction of vehicle contribute to the emerge of more efficient and less polluting vehicles.

Presentation of Nissler and Guichard (2017) identifies urbanization, aging of population, climate change, road safety and limited resources as global megatrends imposing challenges to the future mobility. It particularly elaborate the possibilities of intelligent transportation systems (ITS) to contribute to the reduction of improper and inefficient use of energy and existing capacity and infrastructure. More details about these issues are given in the UNECE ITS (2012) report. This report recognizes the following global trends creating limits to the future transport growth that can be tackled by using ITS:

- **population growth** (the world population is predicted to increase up to 9 billion by 2050; growth in population has created an unprecedented demand for personal mobility; growth of transport infrastructure and services is not adequate to meet the demand);
- **trade growth** (increase in the value of merchandise trade created a formidable demand for cargo mobility and freight transportation; growth of transport infrastructure and services is not adequate to meet the demand);
- **urbanization** (need for a fundamental transport policy changes and ultra-modern traffic management in order to provide supplies to people in mega-cities; need to solve traffic congestion problems; need for effective means of demand management;);

- **affordability** (availability of transport infrastructure and border crossing conditions; landlocked least developed countries can remain marginalized due to low-quality infrastructure both at home and at their transit neighbour; lack of available funds of investments in transport infrastructure; land availability may limit the expansion of transport infrastructure; challenge is to improve the throughput capacity of the existing infrastructure with ITS application);
- **vulnerability of global supply chains** (global supply chains can be severely disrupted by natural disasters, terrorist attacks, etc.; Japanese earthquake and tsunami caused the number of cars manufactured worldwide to have dropped up to 30 %; It may further decline GDP of many countries and income of transport companies; need to improve real-time information flow and the infrastructure and services resilience across the borders);
- **environmental protection** (mitigation of climate changes; In Europe, a quarter of the population lives less than 500 meters from a road carrying more than 3 million vehicles per year).

US DOE (2017) highlighted the impacts that the mobility system of the future will have on built environment, and how these interactions could change cityscapes, as well as suburban and rural areas. **Technologies** (energy-efficient future, including advancements in vehicle powertrains, movement to lightweight materials, integration of connected and automated vehicles, deeper applications of big data, and faster, cheaper processing speeds) are intersecting with key megatrends, such as **changing economics** (e.g., **increasing global energy demand; shifting population centres to mega-regions and cities**), **heightened user centricity** (e.g., **ubiquitous use of smart devices; people-focused business strategies**), **shifting demographics** (e.g., **growing and hyper-connective global population**), and **accelerated adoption of new technologies** (e.g., **shifting demands from new tech-savvy generations**). At the intersection of these trends are other critical factors **shaping mobility**. These include the rise of the “**shared economy**”, **increased urbanization**, increased societal and economic pressure to **reduce global GHG emissions**, and a rising strain on **resource allocation** to respond to a **growing population**.

US DOT (2017) analysed six major trends shaping future of transportation. These are:

1. How will we move? (**Increasing Population, Changing Driving Habits, Millennial Driving Patterns, Metropolitan Growth and Land Use, Regional Differences**)
 - America’s population will grow by 70 million by 2045.
 - By 2050, emerging megaregions could absorb 75 percent of the U.S. population; rural populations are expected to continue declining.
 - It is possible that Americans, particularly millennials, will continue—as a matter of preference—reducing trips by car in favor of more trips by transit and intercity passenger rail.
 - By 2045, there will be nearly twice as many older Americans as now; they will need quality connections to medical care and related services.
2. How will we move things? (**Population and Economic Growth, Increasing Congestion and Deteriorating Infrastructure Conditions, Urban Freight Challenges, Rural Freight Transportation: A Critical Link, Safety Effects, Environmental Impacts, Globalization, Freight Innovations, Workforce Challenges, Increasing Domestic Energy Production**)
 - By 2045, freight volume will increase by more than 40 percent.
 - Online shopping is driving up demand for small package home delivery, which could soon substitute for many household shopping trips

- Airline mergers and the consolidation of hubs may result in increased air traffic congestion.
 - International trade balances, due in part to low U.S. energy costs, could shift from imports toward exports, but overall globalization will increase both, straining ports and border crossings.
 - Strong domestic energy production may enable the U.S. to become a natural gas net exporter by 2020, but pipeline capacity may hamper growth and lead to greater movement of oil by rail.
3. How will we adapt? **(Impacts of Climate Change, Higher Temperatures, Severe Weather and Sea-Level Rise, Reducing Transportation Emissions, Fuel Efficiency, Alternative Energy for Transportation, Hybrid and Plug-In Electric Vehicles, Biofuels, Hydrogen, Liquid and Compressed Natural Gas, Reducing Dependency on Cars)**
- Predicted rises in global temperatures and mean sea levels, and more frequent and intense storm events, could drastically affect highways, bridges, public transportation, coastal ports, and waterways.
 - Federal fuel economy standards are slated to rise to the equivalent of 54.5 miles per gallon by 2025.
 - Sales of hybrid and plug-in electric vehicles are growing rapidly and have the potential to greatly reduce transportation emissions.
4. How will we move better? **(Breakthroughs in Tracking and Navigation, An Era of Big Data, Fast and Easy Payment, There's an App for That, Desktop Manufacturing, Robotics and Automation,)**
- Technological changes and innovation may transform vehicles, infrastructure, logistics, and the delivery of transportation services.
 - New sources of travel data have the potential to improve travelers' experiences, support more efficient management of transportation systems, and inform thoughtful investment decisions.
 - Automation and robotics will affect all modes of transportation, improving infrastructure maintenance and travel safety, and enabling the mainstream use of autonomous vehicles.
5. How will we grow opportunity for all **(The Widening Gap, A Legacy of Disenfranchisement and Underinvestment, A Lack of Affordable Transportation Options, Access to Opportunity in Rural and Tribal Communities, Accessibility Challenges, Growing Economic Segregation and Declining Social Mobility)?**
- The top 10 percent of income-earning families now earn as much income as the remaining 90 percent.
 - Middle- and low-income American households spend, on average, nearly 20 percent of their income on transportation and 40 percent on housing—higher shares than for wealthier Americans.
 - Between 2000 and 2012, the number of poor people living in suburbs increased from 10 million to 16.5 million. Today, more poor people live in the suburbs than in the cities or rural areas.
 - Sprawling urban development is increasing, as is economic segregation; economic opportunity and social mobility are decreasing.
6. How will we align decisions and dollars **(The Evolving Role of Government, Coordinating Decisions, Funding Scarcity, Declining Trust Funds, Policy Trends and Options, Focusing the Federal Role, Performance Management, Innovative Finance, Alternative Revenues, Value Capture, Mileage Fees, Tolling, International Cooperation)?** And invest the trillions of dollars our transportation system needs in the smartest way possible?
- Public revenues to support transportation are not keeping up with the rising costs of maintenance and capacity expansion.

- Nearly two-thirds of our roads are rated in less than good condition; a quarter of our bridges need significant repair.
- Federal gasoline-tax revenues have failed to keep up with our transportation needs and could decline further as vehicle fuel efficiency improves, and inflation further erodes purchasing power.
- Insufficient highway and transit revenues and the absence of reliable federal funding for rail, marine highways, and ports have created a need for new financing mechanisms.

3.3 National projects

Focus of The Future of Transport (2012) was on passengers' preferences in UK with a time horizon until 2025. The study aimed to look at the key future social, economic and technological trends with potential to influence the public transport system in the UK in terms of passenger needs and behaviours. The results of the study are general so they can be translated into circumstances of other European countries. The identified trends were analyzed on macro and micro levels. The first three macro trends are quite straightforward and they are about **ageing population, knowledge society and environmental concerns and awareness**. Other elaborated trends deal with **changes of lifestyles** (changes of values of purchasing with consideration for quality and longevity, impact of digital space to human connections, the empowerment of the individual and individual as consumer concept, feminization of society) leading to the **changes in mobility demands** in "smart cities". It was recognized that **technological advances and innovations** will significantly affect many aspects of day-to-day activities including travelling, shopping, social aspects, health issues, connections among people, working time, entertainment, etc. Cities and regions could increasingly become an amalgamated '**megalopolis**', where transport systems will be based on infrastructure which is able to meet future flexible working needs, strategies making them more resilient in coping with future congestion stresses, more efficient services or shared ownership models.

Deutsche Post (2012) used key factors and their projections to build future scenarios and elaborate their consequences for the logistics sector. The key factors and their future developments were compiled and estimated with the help of environmental analysis and after consultation with internal and external experts. The study considered a long term (up to 2050) and global perspective. In total, 14 key factors were selected, with different projections and influence on the logistic sector. These factors elaborated numerous trends such as various **household and countries income and growth, lifestyle changes** from the perspective of different purchasing preferences, **development of megacities** in developed world and in the emerging countries, **globalization of production facilities, energy sources or share of fossil and renewable fuels in the energy mix, availability and price of raw materials and resources** including oil prices and shortages and **environmental concerns** with focus on global warming and natural disasters. In addition, three key factors dealt with **regulatory aspects** (Regulatory and Spending Policies, Trade Regulation, Logistics and Transport Regulation) and therefore can be considered from the perspective European market regulation. **ICT systems, robotics or material technologies** clearly belong to the trend of technological changes and innovations.

Rohr et al. (2016) analyzed influence of new technologies on travel and possibilities to make transport more efficient in future. The study explored how transport demand may be satisfied with the help of new technologies, with a focus on 2035. It considers technologies that are currently under development, but does not elaborate any radically new technology. Otherwise, the report analyzed only technological megatrends, with no looking at the impact of other types of megatrends (social, operational, economical, political, etc.). Out of the list of 60 technologies that were identified from the review process, 6 were selected as key, i.e. as technologies with the greatest influence on efficiency and effectiveness of the transport network. These are:

- **Autonomous vehicles (AVs)** – Autonomous, automated, driverless and unmanned cars, but also unmanned aerial vehicles, surface and underwater maritime vehicles;
- **Next-generation connectivity** – 5G mobile networks, Li-Fi, fibre optic, low-cost satellites and UAV based Wi-Fi connectivity;
- **User apps and Big Data** – analysis, storage and visualization of vast amount of data with the use of use of data mining, predictive algorithms, machine learning and even artificial intelligence (AI);
- **Advanced manufacturing** – additive manufacturing (including 3D printing), robotics, novel materials (e.g. bio, nano, composite, smart), advanced equipment (e.g. lasers, plasma, waterjet), application of novel methods, digital tools, rapid prototyping and synthetic environments (e.g. virtual or augmented reality) to aid design and production processes;
- **Internet of things** – use of embedded chips, sensors and connectivity enabling real-time data gathering and machine to machine without need for human-to-computer interaction;
- **Novel materials and embedded sensors in infrastructure** – highly resilient materials reducing damage and wear-and-tear of road surfaces or improving friction as needed; self-healing automatically repairing ruptures or abrasions, without the need for work by a human crew; embedding sensors and actuators in roads, rails or runways provides continuous self-monitoring of their condition and repair needs.

Our summary results related to the identification of megatrends from the transport-focused literature will not take into account this report, since its outcomes correspond to the INTEND D2.1 findings.

Aho et al. (2017) concluded that “*global megatrends should be utilised in building the operating model and Finland’s future*”. Megatrends, which have potential to impact Finland transport and communication system, elaborated in this report are the following:

- **Technological development** breaking the traditional concept of mobility ("Digital revolution" i.e. development of information and communication technology, which will radically change established operating practices in society; enormous growth in data volumes (big data) and the significant boosting of its ability to understand through things like artificial intelligence);
- **Globalisation** connecting Finland ever more closely to the rest of the world (Globalisation leads to a structural change in the global economy and is thoroughly changing Finland; changes are taking place in global power relations due to cooperative structures and trading relations between countries);
- New solutions putting **climate and environmental questions** in the spotlight (change established operating practices and impose new solutions in the transport and communications sector; more than 90% of greenhouse gas emissions from Finnish transport are generated by road traffic and, in the European Union too, that figure is 73%; transport sector is responsible for almost 1/2 of all CO₂ emissions, so it will play an important role in achieving the reduction targets)
- An important platform for new transport solutions in cities - **Urbanisation** (the population is being concentrated on growing urban regions and the growth areas are expanding geographically. People, trade and industry are also being concentrated in growth corridors between urban regions; a shift in the focal point of the population will hamper the cost-effective organisation of transport and communication services in areas where the numbers of residents and users is declining);
- Demographic changes challenge Finland in the production of transport and communication services - **ageing population** (the population structure of the future will have a significant impact on the needs to develop transport and communications systems; according to the population forecast, the share of over-65s in Finland will be

26% in the 2030s, and more than 27% by 2050; increased demand for healthcare and social services and have an adverse effect on the dependency ratio; additional requirements for the organisation of individual door-to-door mobility services and easy-to-use electronic digital systems);

- **Values and attitudes** in transition (values and attitudes of consumers are changing; eco-friendliness of mobility, alongside price and speed, is becoming an increasingly important factor in mobility choices; new kind of culture of sharing is being born; owning goods is no longer necessarily);
- Preparedness to act in a changing and uncertain **security environment** (the security environment is in a constant state of change; geopolitical tensions have increased and their impact is also evident in the security situation in Finland and the Baltic Sea region; the cyber world is creating new kinds of security challenges; the significance of data protection and security is being heightened as operations and devices transfer to the web; when transport merges with communication, data system security will become the core of traffic safety).

4 Review of transport-related academic and business literature

4.1 Academic literature

Anoyrkati et al. (2016) identified key mega-trends or factors that are expected to influence the transport system in the short term (2030) and have a great impact on the mobility. The authors applied Delphi expert questionnaire in order to estimate the key megatrends on passenger mobility volumes and patterns. The Delphi approach consisted of a two-round online survey. In the first round, experts provided their opinions on the importance of the various megatrends and their impacts on mobility patterns. The second round of the survey provided authors with the concrete list of the most predominant megatrends. The questionnaire consisted of 10 groups of factors or megatrends, which relate to the following influential areas: demographics, behavior, spatial organization, economy, social structure, globalization, environment, institutional structures and policies, transport policies and information and communication technologies. Table 1 gives the twelve most important factors or mega-trends as identified by the experts, together with their scores on the scale from 1 to 5 and deviation levels.

Table 1 Most important factors affecting passenger transport system as identified in Anyorkati et al. (2016)

Trends	Factors	Score	Standard Deviation
Demographics	Ageing society	4.3	0.79
Spatial Organisation	Development of large metropolitan areas	4.41	0.9
	Urbanization	4.2	0.93
Economy	Financial recession	3.98	1
Social Structure	Unemployment rate	3.8	0.9
Globalisation	International Trade	3.75	1
Environment	Sustainable Development	3.86	0.96
	Renewable energy options	3.73	0.87
Transport policies	Charges (e.g. for congestion)	4.17	0.95
	Inadequate infrastructure investments	4	0.93
	Taxation of fuels	3.94	0.98
	Pricing	4	0.86

Source: Anoyrkati et al., 2016

Silva et al. (2014) analyzed the crucial driving forces and demand challenges that the European transport industry faces. Emphasis were put on the urban transportation systems. Authors suggested and elaborated the most influential societal, economic and technological driving forces or external trends that are expected to impact transport systems development up to 2030 and beyond. These trends are the following: **increase of world population, ageing society, gross domestic product (GDP), income growth and distribution, urbanization, changing lifestyles and mobility behaviours, environmental challenges – climate change and energy sources and technological innovations**. In addition, the authors paid particular attention to the issue of congestion, because the size of transport demand exceeds the available capacities of transport systems.

Discussion paper of Jeschke (2011) provided an analysis on how freight transportation will evolve up until 2030. It recognized and elaborated four socio-economic trends influencing the transport system of the future. These trends are **legislative frameworks and infrastructure constraints, oil price and supply** as a proponent of transport costs, **environmental awareness of society** and **changes in consumer behaviour** and **re-regionalization of**

production. The first trend deals with the need of establishing environmental zones of bigger cities, imposing congestion charging, promoting multimodal logistic chains, adaptation of the legislation on weight and dimension of transport means and impact of infrastructure constraints on dimensions of transport means and efficiency of transport flows. Oil price and supply, as the second trend, considers impact of the oil price level on the location of production sites and supply chains at the global level. Environmental awareness is a trend leading to the changes in consumer behaviour. Purchasing patterns of customers are shifting towards environmentally friendly products. Re-regionalization of production, as an aspect of globalization, notices a trend of re-regionalisation of production back from Asia due to long supply chains, corresponding increased vulnerability and induced risks, and a course towards locally manufactured products.

4.2 Reports from business sector and consultancy firms

Ford (2012) focused on consumer attitudes in passenger transport in Europe. This research took into account individual transport needs of consumers in six different markets (Denmark, France, Germany, Italy, Spain and the UK) to identify key drivers framing the sustainability of the future passenger transportation. The project elaborated nine such key drivers. “Economic pressure”, as the first driver, explains the impact of **economic crisis** on the transport industry. The second driver, named “**environmental anxieties**”, deals with the obligations of companies from transport sector to adopt their processes to the needs to minimize the environmental impacts. Next three drivers, i.e. “changing mobility demands”, “changing journeys” and “reframing ownership”, go in for the aspects of **urbanization** and **mobility behavior**. These drivers explain the impact of changes in consumer mobility needs, development of new types of urban mobility and changes of values of vehicle ownership on the passenger transport systems. “Market making”, “collaboration” and “People-to-machine interactions”, as drivers, are mostly concerned with the **technological innovations and developments** with focus on electric vehicles and related issues (e.g. potential markets for electric vehicles in the concept of “smart cities”, viability of electric vehicles). Impacts of new materials and **energy sources** are particularly analyzed within the “Vehicle development” driver.

PWC (2014a), analyzed impacts of major global megatrends on transport system in UK. These global megatrends, affecting cities throughout the world, are **rapid urbanisation**, **demographic and social change**, **technological breakthroughs** and **climate change**. All four are also impacting how UK cities councils plan their transport systems. **Urbanization** characterizes the major urban areas in Britain – up 8% over the last decade. **Demographic make-up of cities** is evident in e.g. Birmingham. This city has been experiencing fast growing young population – 40% of the city’s population is under 25. At the same time Birmingham and other cities have ageing population. Population increases in urban areas also make it more challenging to curb transport pollution, which accounts for around 21% of UK **greenhouse gas emissions**. **Advances in technology** are also important, not least in helping reduce vehicle emissions.

Stewart et al. (2014) dealt with the future of rail industry towards 2050. The report identified the following megatrends: **urbanization**, **population growth**, **technological advances**, **climate change**, **smart and integrated mobility** (passengers expect certainty in terms of time, so emphasis are on reliable and accurate real-time information) and **energy and resources** (economic growth may be limited by constraints on available resources and high and volatile prices; global consumption of resources will nearly triple to 140 billion tons per year by 2050). It was pointed out that these megatrends would particularly shape the rail and the world in the future. Changes will be driven by the evolving needs and expectations of future passengers.

The Report is focusing on the passenger experience and is setting out a forward-looking, inspiring vision for rail. Passenger experiences were canalised through four mentioned megatrends. The situations imagined by the users in the Report are intended to generate

conversation about the future and to provide context for future planning and decision making in rail industry.

Corwin et al. (2015) analyzed how transportation technology and social trends are creating a new business ecosystem. Industry-changing forces and mega-trends, analyzed in this report, transforming the future evolution of automotive transportation and mobility are the following:

- **Maturing powertrain technologies - Battery and fuel-cell electric vehicles-** higher energy efficiency, lower emissions, greater energy diversity, and new vehicle designs;
- **Lightweight materials - Stronger and lighter materials** - reducing vehicle weight without sacrificing passenger safety;
- **Rapid advances in connected vehicles - vehicle-to-infrastructure (V2I), (V2V vehicle-to-vehicle), communications technologies** - every car can know precisely where every other car is on the road;
- **Shifts in mobility preferences - pay-per-use mobility** - nearly 50% of Gen Y consumers like using a smartphone app for transport and already plan travel so they can multitask;
- **Emergence of autonomous vehicles - Autonomous-drive technology** - **Autonomous-drive technology** is no longer a case of science fiction; it is becoming more **mainstream and widely adopted**.

This report was based on impact analysis of different disruptive technologies for transportation. Since these technologies are elaborated in more details in D2.1, we will not consider them in the process of estimating the impact of key megatrends on future transport concepts.

Surrender (2015) identified the following two megatrends that are expected to affect the automotive industry and the future of mobility: **Future Mobility and Convergence in Mobility**.

It is expected that Future Mobility will cover the emerging urban mobility landscape, car-sharing to form an integral part of integrated mobility, ridesharing, autonomous driving, smart parking, roadmap towards integrated mobility and new mobility business models & partnerships. The emerging urban mobility landscape offers multiple modes and services and segment customer types using the same platform. Car-sharing to form an integral part of integrated mobility offers one way car-sharing, round trip car-sharing and P2P car-sharing. Ridesharing will be the next hot social transportation trend. It will work under the following systems: cloud-based systems, data-driven ridesharing and calendar syncing of rides. It is expected the revenue of 160,000 to 200,000 million \$ from autonomous driving by the end of 2025. Smart parking includes: parking analytics and big data, parking sensor integration, payment, apps and in car reservation, P2P parking. It is expected that smart parking revenue reach 45.00 billion \$ by the end of 2025. Roadmap towards integrated mobility includes journey planning (Multi Modal Planning of journeys via smartphone or web platforms), booking (booking of transportation modes via technology platforms, including referrals from third parties) and payment & reconciliation (Facilitating payment for transportation services and clearing). New mobility business models & partnerships will require cooperation between OEMs, Fleet & Leasing Companies, Travel Management Companies, Payment Platform Providers, Integrated Solution Provider, Public Transport Operators, Mobility Solution Providers and Car Rental Companies.

Megatrends leading to a convergence in mobility will cover mobility convergence and exciting new business models. Mobility convergence involves data security, safety, real-time maps, images & interpretation and automation. Exciting new business models involves car-sharing, ridesharing, ride hailing/taxis, parking, bike-sharing and dynamic minibuses.

UITP (2015) reported six main clusters of trends. These are:

- **Demographic trends and mobility** in urban areas

On a global scale, about 1,000 cities over 500,000 of the population are more confronted with major mobility problems, as almost inability provides adequate infrastructure to cope with the growing popularity of private cars. In this context, public transport has an important role to play. The debate about the relative merits of BRT, LRT and metro is sure to continue. Moreover, other less conventional ways such as cable cars, tram-trains and monorails are gaining momentum.

- Governing and providing **mobility in connected cities**

There seems to be a strong link between the increasing interconnection within society – of people, vehicles, and soon of pretty much all surrounding environment – and the demand for and provision of new mobility services. Connectivity creates an increasing number of available data for participants in the transport sector. Operators would like to gather faster and more individualised information on their customers in order to improve operations, as well as to maximise the profitability of commercial spaces in stations for instance. Enhancing connectivity also allows the rapid development of new mobility services, such as transaction removal platforms, with the rapid increase in services that have emerged in the last decade, such as car sharing.

- Funding **public transport**: the search for alternatives

Over the last decade, changes in public transport funding have been mostly influenced by three key trends:

1. Fares, supported by innovative technology;
2. Investment in infrastructure as one of the main challenges for many regions. Networks have begun to include the business community, linking commercial property development and transport or requesting the private sector to take the lead through PPPs;
3. Contribution of direct and indirect beneficiaries, such as land value capture, is increasingly being incorporated in public transport financing models.

- Market overview: **Globalisation** and emerging players

Globalisation of the economy has affected the business of public transport. BRICS nations are sure to lead growth in public transport. However, other world markets – such as Africa and ASEAN – are expected to become more important as they shift towards more economical and flexible urban transportation solutions.

- **Energy, climate change** and air pollution

Energy use and greenhouse gas (GHG) emissions from the land transport sector are expected to increase under a 'business as usual' scenario by nearly 50% by 2030 and more than 80% by 2050, compared with year-end 2009. Support to the public sector and greater recognition of its role in emission reduction will have to be supported by economic incentives, which could be in the form of carbon prices.

- Becoming attractive and **customer-oriented employers**

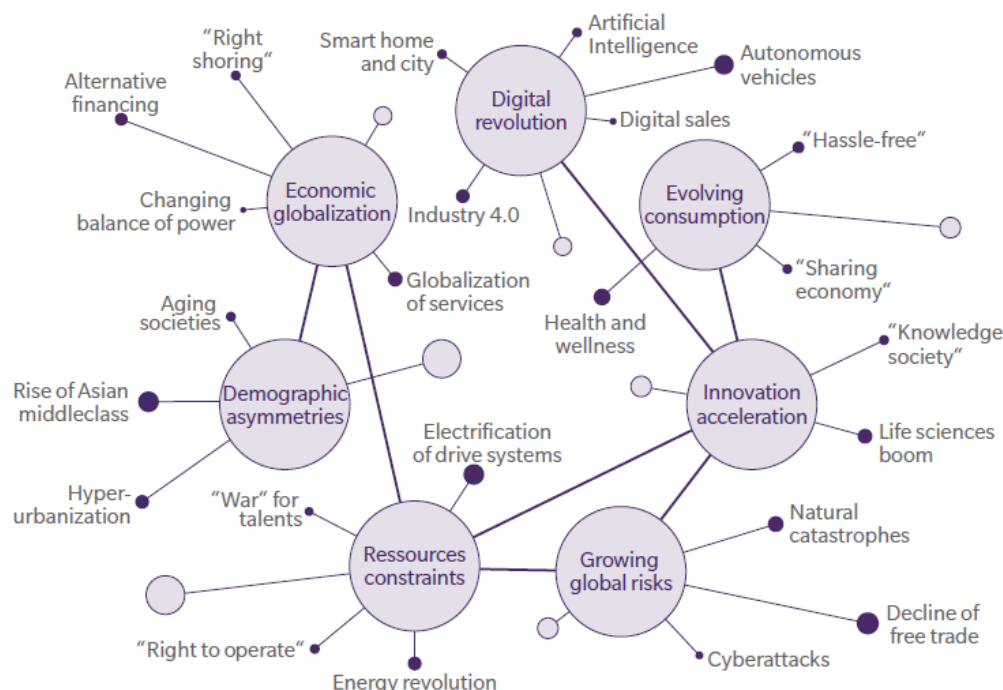
Some 13 million jobs are linked to the provision of public transport services and the public transport supply chain worldwide (all actors including operators, authorities and industry). In most European countries, jobs in the public transport sector offer a good level of remuneration compared to other jobs requiring similar qualifications; this is especially so in comparison to national minimum wages.

Focus of the DHL (2016) report was on four key sources of trend identification for the Logistic Trend Radar. The Logistics Trend Radar is a dynamic, living tool that changes over time through regular insights gathered from the following four key sources: megatrends, microtrends & startups, industry experts & research partners and customers.

This report determine megatrends as global, stable, long-term changes related to broader social, technological and economic frameworks. Microtrends & startups are defined as small trends that can grow into a major source of shaping the future of logistics. Industry experts & research partners present institutes and technology companies responsible for the next generation of logistics and technology research and development. Particular emphasis in this report are given to customers. It is recognized that open talks with customers can bring new ideas for the future of logistics and can anticipate trends related to logistics.

DHL (2016) identified the following three megatrends: **growing security awareness**, **new energy landscape** and **digitalization of logistics**. Growing security includes security awareness over the hacking of data system. To help raise the level of security and resiliency in logistics, innovative digital identifiers that allow unambiguous, tamper-proof identification of items and individuals could be deployed. New energy landscape targets limited availability of energy resources and the movement towards sustainable energy use. Regulations that require companies to adhere to these new targets will present challenges as well as opportunities in logistics in the coming years. Digitalization of Logistics refers to 3D printing big data analytics, Internet of Things, and self-learning systems. Physical transportation could be displaced by an exchange of bits and bytes with 3D printing and could act the same way as email impacted letters. Big data analytics, Internet of Things, and self-learning systems will continue to digitalize logistics processes, enabling new ways of increasing process efficiency, enhancing interaction with customers, and driving new business models.

Kautzsch et al. (2016) examined some of mega trends and gave examples of the impact of some of them on the auto industry. These megatrends (Figure 3) presents a combination of technological leaps and upheavals in global society and the environment that will reshape economies, businesses, and lifestyles. The megatrends will not all affect every manufacturer. But some of them will almost certainly have specific impacts on particular industries and corporations.



Source: Kautzsch et al. (2016)

Figure 3. Global megatrends shaping economies and societies

5 Review of megatrends in general foresight studies

This chapter provides an analysis of megatrends in general foresight studies or studies not exclusively related to the future of transportation. Therefore, these studies deal with the development patterns of science, innovation, education systems, economy and industry, development strategies of the societies, regions or countries. They take into account the implications of certain megatrends on future development trends in any of these areas. From each of the studies reviewed in this chapter, elaborated megatrends were identified and analysed. The results of the analysis of megatrends are given in Tables 7-19. So, each megatrend is presented in Tables 7-19 in the following way:

1. Title of the megatrend is given in the MT column (etc. climate change, urbanization, population growth);
2. Phrases describing a particular megatrend are given in the columns "Terms and phrases". In line with the definition of megatrends, "Terms and phrases" represent indicators or warnings related to each particular phenomenon. Two levels have been introduced because certain phrases may refer to several terms (e.g. for urbanization, as a megatrend, terms and phrases describing it could be "polycentric city structure", at level 1, and "localities around universities", "dense city centres", at level 2). If the titles of megatrends in the reviewed studies, given in the MT column, are too general or do not indicate clearly for certain fundamental changes over an extended period, the megatrends themselves are more closely explained in the "Terms and phrases" columns (e.g. Hajkowicz et al. (2012) define "forever young" as a megatrend; since this phrase is too general, it introduces "new demographic profile" (level 1) with e.g. ageing population (level 2) for better explanation of the general term; it is obvious that the phrase given at level 2 represents a megatrend in the context of megatrends definition given in Chapter 2).
3. Identified characteristics of a megatrend are given in "Explanation" columns.
4. Identified issues related to each megatrend are given in the "Challenges" columns.

EC (2012) analyzed three key scenarios which describe different possible pathways that Europe could choose to follow over the decades to come. These scenarios are presented to some of Europe's leading foresight and macro-economic modelling experts. Their work not only demonstrated the power of forward-looking exercises but lights the path to a better future. The study, along with a variety of other sources on distant future forward looking, pointed to a number of, at that moment, unfolding trends at the global level in each of the following six dimensions (Table 7):

1. **Global demographic and societal challenges;**
2. **Energy and natural resource security and efficiency, environment and climate change;**
3. **Economy and technology prospects;**
4. **Geopolitics and governance:** EU frontiers, integration and role on the global scale;
5. **Territorial and mobility dynamics;**
6. **Research, education and innovation.**

Report from Hajkowicz et al. (2012) presented six interlinked megatrends given on Figure 4. The indicative time frame adopted for the analysis was 20 years ahead. Detailed elaboration of the identified megatrends is provided in Table 8.



Source: Hajkowicz et al. (2012)

Figure 4. Interlined megatrends as seen by Hajkowicz et al. (2012)

KPMG (2012) presented a system of 10 sustainable megatrends that would have strong effect on business over the next 20 years. Megatrends, explained in

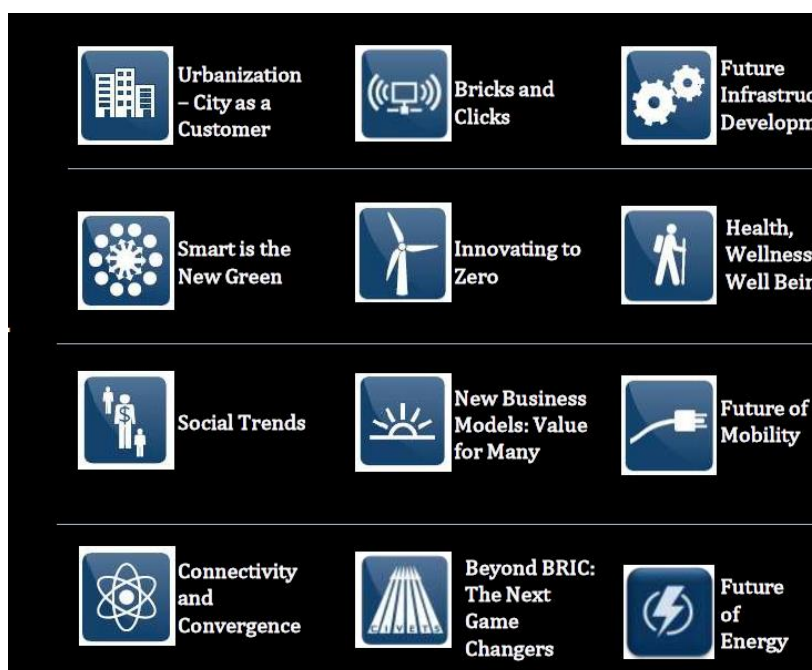
Table 9, are connected with each other and do not act alone in predictable ways. They are: **climate change, energy & fuel, material resource scarcity, water scarcity, population growth, wealth, urbanization, food security, ecosystem decline and deforestation.**

KPGM (2014) is a report impacting government policy in the segment of creating conditions for business doing. It identified the following nine megatrends: **Demographics, Rise of the individual, Enabling technology, Economic interconnectedness, Public debt, Economic power shift, Climate change, Resource stress and Urbanization.** Details about identified megatrends in this report are given in Table 10.

Lorenz and Haraldsson (2014) overviews how global megatrends can influence topics on regional and local level. The report demonstrates how qualitative modelling and system thinking approach can be applied to analyse the possible impact of global megatrends to the

regional topic of resource scarcity, demonstrated in two case studies. Elaborated megatrends are given in Table 11.

Singh (2014) examined some of mega trends and gave examples of the impact of some of them on the auto industry. It defines megatrends as “*transformative, global forces that define the future world with their far reaching impact on business, societies, economies, cultures and personal lives*”. Figure 5 shows megatrends elaborated in this report, while Table 12 gives more details about them.



Source: Singh (2014)

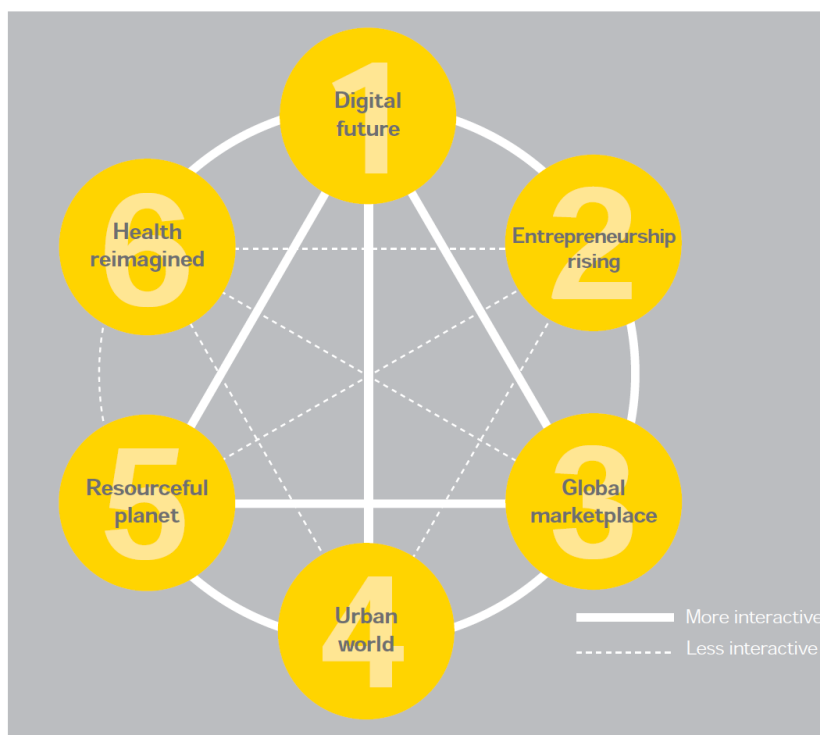
Figure 5. Interlined megatrends as seen by Singh (2014)

Sweden 2050 (2014) identified four megatrends in paper elaborating vision for Sweden 2025. Megatrends named **Climate Change**, **Globalization**, **Urbanization** and **Digitalization** are integral part in the development of modern society and will be backbone for a sustainable society by 2050 at the latest. Table 13 gives details about these megatrends.

EC (2015) aimed to support the implementation of Horizon 2020, and in particular the preparation of its third strategic programme, which covers the period 2018-2020, with foresight. The study reviewed existing foresight evidence and used it to develop a perspective of future change relevant to Horizon 2020. Changes encompassed: **Hyper-connectivity and Big Data** driving accelerated change and innovation, **Falling cost of energy**: a potential game changer, **Migration and changing demographics**: important changes for innovation in Europe, **Health as a major driver**: key aspirations shaping attitudes to research and innovation, **Facing climate change**, oceans and space as pacifying/unifying projects, Primary sector innovation: strategic and key for **sustainability and well-being**, **Biotechnology** as the next wave of disrupting technologies, and A state of **instability** as the new norm in **global society**. Explanations of these trends are given in Table 14.

Ernest and Young (2015) identified six megatrends that, they think, illustrate the world in motion and possess the capacity to change the world in which we live in an unexpected and surprising way. These megatrends, as well as their interconnectivities, are given in Figure 6.

In addition, Table 15 gives terms and phrase that describe the megatrends, as well as their explanations together with challenges they are raising nowadays.



Source: Ernest and Young (2015)

Figure 6. Six megatrends and their interconnectivities as identified by Ernest and Young (2015)

Lindekugel (2015) elaborated impact of megatrends on the future of innovation. It was emphasized that “*megatrends serve as our starting point to create insights and foresights*”. The report distinguishes between two megatrends whose details are given in Table 16.

PWC (2015) presents economic growth projections for 32 of the largest economies in the world, accounting for around 84% of global GDP. Their projections are based on a model that takes account of projected megatrends in **demographics**, **capital investment**, **education levels** and **technological progress**. Table 17 gives terms and phrases that describe the megatrends, as well as explanation of these keywords together with challenges they are raising nowadays.

OECD (2016) identified several megatrends affecting science, technology and innovation. It expected that these megatrends will have strong impact on science, technology and innovation over the next 10-15 years. Table 18 describes the megatrends clustered into eight thematic areas as follows: **Demography**, **Natural resources and energy**, **Climate change and environment**, **Globalisation**, **Role of government**, **Economy, jobs and productivity**, **Society**, and **Health, inequality and well-being**.

European Parliament (2017) considered eight economic, societal, and political global trends that have the potential to shape the world to 2035. These are an **ageing population**, **fragile globalisation**, **technological revolution**, **climate change**, **shifting power relations**, **new areas of state competition**, **politics of the information age** and **ecological threats**. Major findings related to these megatrends are given in Table 19.

6 Reaching a consensus

After evaluation of all selected sources, it may be concluded that most of the studies had a long-term perspective of up to 2050. Therefore, our results suggest those megatrends, whose influence on transport systems will be very important in the same period.

Reaching a consensus, in this case, means defining the criteria that will allow for the identification of megatrends that have the most significant impact on the future development of passenger and freight transportation. Literature usually recommends that consensus should represent 50 to 70 % agreements. This range is usually adopted and used for reaching a consensus in the Delphi method. Numerous exercises, performed so far, required an agreement among 70 % of the sources, experts or panellists to reach the consensus (Ashton Acton, 2013; Kleynen et al., 2014; Kelly et al., 2016). In this deliverable, we have adopted the upper limit for selection of any megatrend as a key. Otherwise, in order to select any megatrend as the most important, it is necessary that at least 70% of the identified literature sources elaborate and describe the impact of that megatrend on passenger or freight transportation.

On the other side, in order to validate the obtained results, we will apply an approach of selection of the key megatrends based on the experts' opinions. For that purpose, we will use a lower limit of 50% agreement for selecting certain megatrends for further analysis and elaboration through the application of the ANP methodology. Experts will, through ANP questionnaires, select those megatrends, which they consider to be the most important for the future development of passenger and freight transportation.

Our analysis will, therefore, include selection and listing of two groups of megatrends both for passenger and freight transportation. These are:

1. A list of **key megatrends** determined based on high frequency of occurrence in reviewed sources (> 70%);
2. A list of megatrends that have a lower frequencies of occurrence in reviewed literature sources (> 50%), which will be used to validate the selection of **key megatrends** (task 3.2).

Both lists will be complemented with megatrends that have corresponding frequencies of occurrence in general foresight studies.

6.1 Matrix of megatrends over sources

In order to perform the required analysis, we prepared the matrix, shown in Tables 2, 3 and 4, listing sources against the megatrends identified in the reviewed literature. As it can be seen, a total of 44 megatrends from all sources, which are related to passenger and freight transportation, as well as general foresight studies, have been separated and included in our analysis. The goal of this matrix analysis is to determine the megatrends that are processed in most of the analysed sources, indicating a certain level of consensus or convergence to those that are most important for the future development of transportation processes. Some of the megatrends, given in Tables 2, 3 and 4, are in the same way labelled and described in a number of sources, while in certain cases, there are differences in that respect. For this reason, the labels and descriptions of the megatrends applied in various studies, projects, papers and reports have been harmonized herewith. Similar approach for identification of key global

megatrends and their implication for environmental assessment practice was applied in Retief et al, 2016.

6.2 Key global megatrends in passenger transportation

Table 2 gives a matrix of megatrends over sources for passenger transportation. In order to select a megatrend as the key it should be elaborated in at least 19 out of 26 analysed sources (> 70 %). Our approach has enabled us to identify the following megatrends as the most important for the development of passenger transport:

- **urbanization and megacities;**
- **environmental challenges – climate change.**

On the other hand, the process of validating the selection of the key megatrends from the passenger transportation point of view will include further elaboration of the following megatrends, whose frequency of occurrence in the reviewed literature is > 50%:

- **urbanization and megacities** (higher population densities, improvements in cities infrastructure, environmental and health risks; PPP models; more sustainable cities);
- **environmental challenges – climate change** (decrease in carbon emissions, global temperature increase, sea level rise, increased risk of flooding from melting glaciers, adaptation and mitigation policies, development of carbon markets);
- *ageing society* (ageing world population; increased life expectancy);
- *changing lifestyles* (changing reproduction and family lifestyle; generational shift - flexible and attractive works; global and greater connectivity; rise of lifestyle related illnesses; fitness trends; staying active; demand for experiences; loneliness and single person households; basic expectations from people; teleworking; shift towards individual - freelancing models; empowerment of women; online shopping; increased collaborative consumption - sharing economy);
- *energy demand and sources* (increased energy usage, energy investments, usage of renewable sources of energy and alternative fuels, fuel efficiency, global energy mix);
- *key resources scarcity - shortages and consumption* (more constraints on consumptions - resource management; greater demands on scarce resources – fossil fuels; development of substitute materials, global privatization of resources; changes in ecosystems use).



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Table 2 Global megatrends in passenger transportation

Source Megatrend	EC, 2009	OPTIMISM, 2011	TOSCA, 2011	World Energy Council, 2011	Deutsche Post, 2012	FORD, 2012	The Future of Transport, 2012	UNECE ITS, 2012	FUTRE, D3.1, 2013	ERRAC, 2014	Silva et al., 2014	Stewart et al., 2014	CIPTEC D1.1., 2015	Surrender (2015)	UITP, 2015	Anoyrkati et al., 2016	Future Transport 2056, 2016	Kautzsch et al. (2016)	Mobility4EU D2.1., 2016	WaterborneTP, 2016	Aho et al., 2017	IATA, 2017	Nissler and Guichard, 2017	US DOE, 2017	US DOT, 2017	Megatrends Transport, 2017	Total
increase of world population	-	+	-	-	-	-	-	+	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	+	+	-	7
ageing society	+	+	-	+	-	-	+	-	+	+	+	-	+	-	-	+	+	+	+	-	+	-	+	-	+	+	16
gross domestic product (GDP), income growth and distribution, economy growth	-	-	+	+	+	-	-	-	-	-	+	-	+	-	-	-	-	-	+	+	-	+	-	-	+	-	9
economic pressures and crisis	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	2
increase of Inter-/Intra-national social disparities	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
urbanization and megacities	+	+	-	+	+	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	-	+	+	+	+	22
changing lifestyles	-	+	-	+	+	-	+	-	+	+	+	-	+	-	-	-	+	+	+	-	+	+	-	+	+	-	15
changing mobility behaviours (crisis of mobility, mobility demands, mobility measuers)	-	+	-	-	-	+	+	-	-	+	+	+	+	+	+	-	+	-	+	-	-	-	-	+	+	-	13
environmental challenges – climate change	+	+	-	+	+	+	+	+	-	+	+	+	+	-	+	+	+	-	+	+	+	+	+	+	+	+	22
energy demand and sources	-	-	-	+	+	+	-	-	-	-	+	+	+	-	+	+	-	+	+	+	-	+	-	+	+	+	15
key resources scarcity - shortages and consumption	+	+	+	-	+	+	-	-	-	-	-	+	+	-	-	-	+	+	+	+	-	+	+	+	+	-	15
Globalization 2.0 (Global dissemination of production facilities, political and social integration)	-	+	-	-	+	-	-	-	+	-	-	-	+	-	+	+	+	+	+	-	+	-	-	-	+	-	11
migration and internal mobility	+	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	4

D3.1 Report on main Megatrends

Source Megatrend	EC, 2009	OPTIMISM, 2011	TOSCA, 2011	World Energy Council, 2011	Deutsche Post, 2012	FORD, 2012	The Future of Transport, 2012	UNECE ITS, 2012	FUTRE, D3.1, 2013	ERRAC, 2014	Silva et al., 2014	Stewart et al., 2014	CIPTEC D1.1., 2015	Surrender (2015)	UITP, 2015	Anoyrkati et al., 2016	Future Transport 2056, 2016	Kautzsch et al. (2016)	Mobility4EU D2.1., 2016	WaterborneTP, 2016	Aho et al., 2017	IATA, 2017	Nissler and Guichard, 2017	US DOE, 2017	US DOT, 2017	Megatrends Transport., 2017	Total
European market regulation (regulatory and spending policies, trade regulations, logistics and transport regulations)	-	+	-	-	+	-	-	-	-	+	-	-	+	-	+	+	-	-	+	-	-	+	-	-	+	-	9
knowledge society and knowledge economy	-	+	-	-	-	+	+	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	5
trade growth (value of merchandise trade; demand for cargo mobility and freight transportation)	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	+	-	+	-	-	+	-	5
land availability (availability of transport infrastructure and border crossing conditions)	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	2
natural disasters, safety and security issues (cybersecurity, vulnerability of global supply chains, terrorism)	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	+	+	+	-	-	+	-	7
increased food and water demand	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	1
becoming customer-oriented employers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	1
infectious disease and pandemics	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	1
geopolitical (in)stability	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	1



6.3 Key global megatrends in freight transportation

Table 3 presents our matrix of megatrends over sources for freight transportation. In this case, consensus is reached if a megatrend is elaborated in at least 10 out of 14 identified sources (> 70 %). By applying the described approach, the following megatrends can be selected as the megatrends with the most significant influence on the future development of freight transportation:

- **environmental challenges – climate change;**
- **key resources scarcity - shortages and consumption.**

After adding all megatrends whose frequency of occurrence is > 50%, the following list of megatrends relevant for freight transportation is obtained, which will be further validated through the ANP network:

- **environmental challenges – climate change** (decrease in carbon emissions, global temperature increase, sea level rise, increased risk of flooding from melting glaciers, adaptation and mitigation policies, development of carbon markets);
- **key resources scarcity - shortages and consumption** (more constraints on consumptions - resource management; greater demands on scarce resources – fossil fuels; development of substitute materials, global privatization of resources; changes in ecosystems use);
- *ageing society* (ageing world population; increased life expectancy);
- *changing lifestyles* (changing reproduction and family lifestyle; generational shift - flexible and attractive works; global and greater connectivity; rise of lifestyle related illnesses; fitness trends; staying active; demand for experiences; loneliness and single person households; basic expectations from people; teleworking; shift towards individual - freelancing models; empowerment of women; online shopping; increased collaborative consumption - sharing economy);
- *energy demand and sources* (increased energy usage, energy investments, usage of renewable sources of energy and alternative fuels, fuel efficiency, global energy mix);
- *urbanization and megacities* (higher population densities, improvements in cities infrastructure, environmental and health risks; PPP models; more sustainable cities);
- *globalization 2.0* (global dissemination of production facilities, political and social integration);
- *security issues* (rising threat of cybercrime; crime rates; vulnerability of global supply chains).



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Table 3 Global megatrends in freight transportation

Source Megatrend	TOSCA, 2011	Jeschke, 2011	ERRAC, 2014	ALICE, 2014a-e	Clausen et al., 2014	DHL, 2016	Mobility4EU D2.1., 2016	Future Transport 2056, 2016	Kautzsch et al. (2016)	WaterborneTP, 2016	Aho et al., 2017	IATA, 2017	Megatrends Transportation, 2017	US DOT, 2017	TOTAL
increase of world population	-	-	-	-	-	-	-	-	-	+	-	-	-	+	2
ageing society	-	-	+	+	+	-	+	+	+	-	+	-	+	+	9
gross domestic product (GDP), income growth and distribution, economy growth	+	-	-	-	-	-	+	-	-	+	-	+	-	+	5
urbanization and megacities	-	-	+	-	+	-	+	-	+	+	+	-	+	+	8
changing lifestyles	-	-	+	-	+	-	+	+	+	-	+	+	-	+	8
changing mobility behaviours (crisis of mobility, mobility demands)	-	-	+	-	-	-	+	+	-	-	-	-	-	+	4
environmental challenges – climate change	-	+	+	+	+	-	+	+	-	+	+	+	+	+	11
energy demand and sources	-	-	-	+	+	+	+	-	+	+	-	+	+	+	9
key resources scarcity - shortages and consumption	+	+	-	+	+	+	+	+	+	+	-	+	-	+	11
Globalization 2.0 (Global dissemination of production facilities, political and social integration)	-	+	-	-	+	-	+	+	+	-	+	-	-	+	7
Migration and internal mobility	-	-	-	-	-	-	+	-	-	-	-	-	-	-	1
European market regulation (regulatory and spending policies, trade regulations, logistics and transport regulations)	-	+	+	-	-	-	+	-	-	-	-	+	-	+	5

D3.1 Report on main Megatrends

Source Megatrend	TOSCA, 2011	Jeschke, 2011	ERRAC, 2014	ALICE, 2014a-e	Clausen et al., 2014	DHL, 2016	Mobility4EU D2.1., 2016	Future Transport 2056, 2016	Kautzsch et al. (2016)	WaterborneTP, 2016	Aho et al., 2017	IATA, 2017	Megatrends Transportation, 2017	US DOT, 2017	TOTAL
trade growth (value of merchandise trade; demand for cargo mobility and freight transportation)	-	-	-	-	-	-	-	-	+	+	-	+	-	+	4
security issues (rising threat of cybercrime; crime rates; vulnerability of global supply chains)	-	-	-	+	-	+	-	-	+	+	+	+	-	+	7
increased food and water demand	-	-	-	-	-	-	-	-	-	+	-	-	-	-	1
infectious disease and pandemics	-	-	-	-	-	-	-	-	-	-	-	+	-	-	1
geopolitical (in)stability	-	-	-	-	-	-	-	-	-	-	-	+	-	-	1



6.4 Key global megatrends from general foresight studies

Many authors define and describe megatrends in different ways in the reviewed sources. Under the term megatrend, some authors introduce unclearly defined phrases (e.g. “More from less” or “Going, going, ... gone”). These phrases are then explained through terms related to social, economic, or technological phenomena, which are merely megatrends from the point of view described in Chapter 2. Then, some authors under megatrends introduce terms that are rather broad and do not clearly indicate changes whose influence is to be analysed (e.g. “global demographic and societal challenges”, “R & I and education”, etc.). These authors explain such broadly defined terms through relevant phenomena or changes that we call megatrends. Tables 7 to 19, which are used for presentation of results related to the search for megatrends in all reviewed foresight studies, are such structured to encompass all noticed ways of megatrends elaboration in the literature. Therefore, identification of megatrends from Tables 7 to 19 requires previous analyses and understanding of terms and phrases in the first columns of these tables (MT), but also phrases in the second (“Terms and phrases” - level1) and the third columns (“Terms and phrases” - level 2) of these tables. Obviously, relevant megatrends can be found in any of these three columns of Tables 7 to 19, depending on the way individual authors have elaborated this research topic. Bearing this in mind, identification of megatrends in the general foresight studies involved analyses of the terms given in the first three columns of the Tables 7 to 19. Analysis of these tables has enabled us to identify megatrends, as well as the frequency of their occurrence in the literature.

Since we have analysed 13 various reports and studies, consensus on the key megatrends is reached if a megatrend is elaborated in at least 9 sources. Therefore, the following megatrends could be identified as the key among the reviewed general foresight studies:

- **ageing society** (ageing world population; increased life expectancy);
- **environmental challenges – climate change** (decrease in carbon emissions, global temperature increase, sea level rise, increased risk of flooding from melting glaciers, adaptation and mitigation policies, development of carbon markets);
- **urbanization and megacities** (higher population densities, improvements in cities infrastructure, environmental and health risks; PPP models; more sustainable cities).

As with passenger and freight transportation, 50 % agreement among reviewed literature has also been adopted as a lower limit for selecting certain megatrend for its further elaboration through the application of the ANP methodology. Based on the results in Table 4, the following megatrends have been selected:

- **ageing society** (ageing world population; increased life expectancy);
- **environmental challenges – climate change** (decrease in carbon emissions, global temperature increase, sea level rise, increased risk of flooding from melting glaciers, adaptation and mitigation policies, development of carbon markets);
- **urbanization and megacities** (higher population densities, improvements in cities infrastructure, environmental and health risks; PPP models; more sustainable cities);
- *changing lifestyles* (changing reproduction and family lifestyle; generational shift - flexible and attractive works; global and greater connectivity; rise of lifestyle related illnesses; fitness trends; staying active; demand for experiences; loneliness and single person households; basic expectations from people; teleworking; shift towards

individual - freelancing models; empowerment of women; online shopping; increased collaborative consumption - sharing economy);

- *key resources scarcity - shortages and consumption* (more constraints on consumptions - resource management; greater demands on scarce resources – fossil fuels; development of substitute materials, global privatization of resources; changes in ecosystems use);
- *bigger world economy* (growth of the world economic output; GDP growth; increase of international trade);
- *globalization 2.0* (global dissemination of production facilities, political and social integration);
- *shift of economic power* ("global south" as the engine for growth; emerging multi-polar world; center of gravity of the world economy, geographic hotspot of income generation, increasing commodity supply from developing countries).



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Table 4 Global megatrends identified in general foresight studies

Source \ Megatrend	EC, 2012	Hajkowicz et al., 2012	KPGM, 2012	KPGM, 2014	Lorenz and Haraldsson, 2014	Singh, 2014	Sweden 2025, 2014	EC, 2015	Ernest and Young, 2015	Lindekugel, 2015	PWC, 2015	OECD, 2016	European Parliament, 2017	Total
ageing society (ageing world population)	+	+	+	+	+	+	-	+	+	+	+	+	+	12
migration and internal mobility	+	-	-	-	+	-	-	+	-	-	-	+	+	5
urbanization and megacities	+	-	+	+	+	+	+	-	+	+	-	+	+	10
increase of world population	+	+	-	+	+	-	-	-	-	-	+	+	-	6
advances in medical sciences and healthcare (prospects of personalized medicine; Big data in healthcare)	-	+	-	-	-	-	-	+	+	+	-	+	-	5
changing lifestyles	+	+	-	+	-	+	-	-	+	+	-	+	+	8
offshoring (sourcing labour from abroad)	-	+	-	-	-	-	-	-	-	-	-	-	-	1
rise of recycling (waste generation, resource-rich "non-waste")	-	+	-	-	-	+	-	-	-	-	-	-	-	2
energy demand and sources	-	+	+	-	-	-	-	+	+	-	-	+	-	5
key resources scarcity - shortages and consumption	+	-	+	+	+	-	-	+	+	-	-	+	+	8
global water scarcity	-	+	+	-	+	-	-	-	+	-	-	+	-	5
increased food demand	-	+	+	-	+	-	-	-	-	-	-	+	-	4
biodiversity decline (biodiversity loss, genes, species and ecosystem, protection of critical biodiversity)	-	+	+	-	-	-	-	-	-	-	-	-	-	2
increase of deforestation	-	-	+	-	-	-	-	-	-	-	-	-	-	1
bigger world economy	-	+	-	+	+	-	+	-	+	-	+	-	+	7
shift of economic power	+	+	-	+	+	-	-	-	+	-	-	+	+	7

D3.1 Report on main Megatrends

Source	EC, 2012	Hajkowicz et al., 2012	KPGM, 2012	KPGM, 2014	Lorenz and Haraldsson, 2014	Singh, 2014	Sweden 2025, 2014	EC, 2015	Ernest and Young, 2015	Lindekugel, 2015	PWC, 2015	OECD, 2016	European Parliament, 2017	Total
Megatrend														
building a new world economy with BRICS	-	+	-	-	-	-	-	-	-	-	-	-	-	1
rising middle class (transition out of poverty; developing markets)	-	+	+	-	-	-	-	-	+	+	-	+	-	5
slowing economic growth in China (rate of industrialization and steel use to slow)	-	+	-	-	-	-	-	-	-	-	-	-	-	1
rapid phase of industrialization in India	-	+	-	-	-	-	-	-	-	-	-	-	-	1
shrinking workforce (fiercer competition for skilled workers; war for talents; quality of labour)	-	+	+	-	-	-	-	-	+	-	+	+	-	5
smaller retail formats (retail store size, multi-channel shoppers)	-	-	-	-	-	+	-	-	-	-	-	-	-	1
innovative personalization (personalized products and services, consumers higher expectations)	-	+	+	-	-	-	-	-	+	+	-	-	-	4
rising importance of moral and ethical dimensions for consumers (products labelled as environmentally and socially responsible, "fair trade" logo)	-	+	-	-	-	-	-	-	-	-	-	-	-	1
increased public spending (pension, social protection, healthcare; redefined retirement model) due to ageing society	+	+	+	-	-	-	-	-	+	-	-	+	-	5
risk of new pandemics and increase of chronic disease	-	-	-	-	+	-	-	-	+	-	-	-	-	2
changing geopolitics (geopolitical (in)stability, resource conflicts, unpredictable international politics, global governance)	+	+	-	-	-	-	-	+	-	-	-	-	+	4
globalization 2.0 (global dissemination of production facilities, political and social integration)	+	-	-	+	-	-	+	+	+	-	-	+	+	7
sustainable prosperity (measuring growth in terms of quality rather than quantity, income stability, environmental quality, social mobility, well-being)	+	-	-	-	-	-	+	-	-	-	-	-	-	2

D3.1 Report on main Megatrends

Source	EC, 2012	Hajkowicz et al., 2012	KPGM, 2012	KPGM, 2014	Lorenz and Haraldsson, 2014	Singh, 2014	Sweden 2025, 2014	EC, 2015	Ernest and Young, 2015	Lindekugel, 2015	PWC, 2015	OECD, 2016	European Parliament, 2017	Total
Megatrend														
increased role of citizens in policy landscape (e-voting, new societal initiatives)	+	-	-	+	-	+	-	-	-	-	-	-	-	3
territorial dynamics	+	-	-	-	-	-	-	-	-	-	-	-	-	1
EU innovation gap (weak R&I governance, under-financing, complex R&I system in EU)	+	-	-	-	-	-	-	-	-	-	-	+	-	2
rise of spending on education	-	+	-	-	+	+	-	-	-	-	+	+	-	5
environmental challenges – climate change	-	+	+	+	+	+	+	+	+	-	-	+	+	10
increase of extreme weather events	-	+	+	+	-	-	-	-	+	-	-	+	-	5
security issues (rising threat of cybercrime; crime rates; security of supply of food, water and materials)	-	+	-	-	-	+	-	+	+	-	-	+	-	5
European market regulation (regulatory and spending policies, energy regulatory interventions, trade regulations, logistics and transport regulations)	-	-	+	-	+	-	-	-	-	-	-	-	-	2



7 Implications of the key megatrends for passenger and freight transportation

Results from Chapter 6 indicate that the following four megatrends can be considered as the key among both groups of reviewed sources (transport-related and general foresight studies):

- **ageing society** (ageing world population; increased life expectancy);
- **environmental challenges – climate change** (decrease in carbon emissions, global temperature increase, sea level rise, increased risk of flooding from melting glaciers, adaptation and mitigation policies, development of carbon markets);
- **key resources scarcity - shortages and consumption** (more constraints on consumptions - resource management; greater demands on scarce resources – fossil fuels; development of substitute materials, global privatization of resources; changes in ecosystems use);
- **urbanization and megacities** (higher population densities, improvements in cities infrastructure, environmental and health risks; PPP models; more sustainable cities).

Potential implications of these megatrends for the transportation practice are also explained.

7.1 Ageing society

The ageing of the population is one of the most important, particularly European, but also world trends of the 21st century. The projected number of persons aged 60 or over will increase to 1 billion in less than 10 years and double by 2050 and reach 2 billion (UNFPA, 2012). Europe today has the oldest population in the world. The average age is 41 years, and it is expected to rise up to 46 years until 2050. It is also forecasted that by 2050 about 60 countries worldwide will have more than 30% of the population over 60 years of age.

Increasing longevity - due to improved nutrition, better health care, medical advancement and economic development - is one of the greatest achievements of humanity. On the other hand, population ageing is a source of great opportunities for society and businesses if properly managed. An environment that promotes ageing, supported by innovative technologies, is especially important as people are becoming old and less mobile. Easily accessible transport is essential to maintaining their independence, facilitating social contacts and enabling them to remain active in society.

In order to make progress towards a transport system that guarantees access to key destinations for all population groups it is necessary to set priorities. The existing infrastructure must be subsequently equipped and adapted to persons whose abilities differ from the 'normal' spectrum of abilities. Also, a network of affordable transport infrastructures and services needs to be expanded to include destinations that are not currently considered as accessible to the elderly population. Examples of interventions to improve the situation of persons experiencing travel-related impairments, organized by type are given in

Table 5 (Martens, 2018).

Table 5 Interventions for improving the travel experience

Type of intervention	Example of measures
Universally accessible transport system: adapting existing mainstream transport sub-systems	<ul style="list-style-type: none"> ➤ adding elevators to stations ➤ introduction of low-floor buses ➤ curb cuts at pedestrian crossings ➤ sound devices at traffic lights ➤ spoken announcements at public transport stops and in public transport vehicles ➤ general introduction of full driving ➤ automation for private cars, including suitable infrastructure
Inclusive transport system: extending mainstream transport sub-systems	<ul style="list-style-type: none"> ➤ extension of pavement network to previously not-served areas ➤ paved roads to all build-up areas ➤ extension of bicycle network to previously not-served areas ➤ provision of regular public transport services to previously not-served areas ➤ provision of on-demand public transparency ➤ improvement of public transport services on poorly served routes
Supplementary measures	<ul style="list-style-type: none"> ➤ subsidized wheelchair ➤ subsidized mobility scooter ➤ subsidized walking aid ➤ subsidized bicycle with balance support ➤ subsidized fully autonomous vehicles for persons with travel-impairments ➤ provision of dedicated bus services for persons with travel-impairments ➤ provision of dial-a-ride services for persons with travel-impairments ➤ travel companion services for persons with travel-impairments ➤ dedicated parking places for persons with travel-impairments

Source: Martens, 2018

Reduced mobility of older people imposes different travel characteristics in comparison with younger people. Generally, older people belong to the generations which were highly dependent on the car usage. Therefore, it is not an easy task to shift active older people to sustainable transport modes and innovative mobility schemes (walking, cycling, public transport, car-sharing, etc.). Since most of older people will have driving licenses and would like to stay active, they will maintain their car-driving habits and choose driving as their primary transport mode. It is obvious that automated driving technologies may provide capabilities to elderly to stay mobile according to their habits.

Johnson et al. (2017) identified 11 qualities that help to promote mobility, and hence independence and social/economic inclusion, for older people (

Table 6). They analysed national-level government documents across the EU, Norway and Switzerland to determine how far they address each quality and concluded that disproportionate emphasis is currently being placed on the tangible and easily understood aspects of safety, barrier freedom and affordability.

Table 6 Qualities of an “age-friendly” transport system

System quality	Explanation
Affordable	Use (of the transport and mobility system) should be possible within the financial means of older people
Available	The transport and mobility system should exist in a way that makes it capable of facilitating a required journey for an older person
Barrier-free	Facilities that can be used by disabled without any specific difficulty and without assistance from third persons. It should be possible to use (the transport and mobility system) by taking into account the physical, sensory and cognitive impairments more likely to be experienced by older people.
Comfortable	The transport and mobility system should be designed or adopted to ensure that older people can use it without experiencing undue discomfort, pain, stress or anxiety.
Comprehensible	Information about the transport and mobility system should be communicated in a number of ways that make it easy for older people to understand about transport and mobility services.
Efficient	It should be possible to travel to the required destination within a reasonable and suitable amount of time.
Friendly	The transport and mobility system should be approachable for older people. Where applicable staff who are involved should be available in a number of way (phone, face to face) and should be aware of the particular needs of older people.
Reliable	The transport and mobility system should be delivered and should perform as it could reasonably be expected to allowing for an element of unpredictability caused by unforeseen events, for example, by extreme weather.
Safe	The transport and mobility system should not be dangerous for older people, with their specific needs, to use. The risk of accidents on the system should be limited as much as possible.
Secure	Older people should feel confident when using the transport and mobility system and should not feel exposed to reasonable (real or perceived) risks from others.
Transparent	Older people should be aware of the existence of the transport and mobility options available to them, and understand how to use them.

Source: Johnson et al. (2017)

In many countries, the age structure of the population indicates that transport systems have to be adapted to the needs of a larger number of people with travel disabilities (Martens, 2018). This challenge does not need only the adaptation of existing transport systems, but also the expansion of these systems in order to allow people with travel disabilities access to the transport systems.

7.2 Environmental challenges – climate change

Z punkt, as a foresight company, regularly update their report on megatrends. In these reports, climate changes and environmental concerns are regularly considered among the 20 identified long-term transformation processes with a broad scope and a dramatic impact known as megatrends. According to this report, trends relevant for describing and understanding the climate change are the following (Z punkt, 2013):

- rising temperatures and CO2 emissions;
- growing risks posed by environmental problems in newly-industrialised and developing countries;
- increased food shortages;
- stricter regulations;
- cleantech investments;
- strategies for mitigating and adapting to climate change.

Respecting environmental principles is today, a very important element in the development of both passenger and freight transport. Transport, as an industry, participates with around 18% in total CO2 emissions on the global level (Clausen et al., 2014). Since requirements and regulations regarding the establishment and maintaining of sustainable and green supply chains are constantly improving and increasing, it can be expected that GHG emissions will be one of the most significant characteristics of the competitiveness of the respective transportation chains.

Transportation leads to the increased noise levels, GHG emissions and air pollution. Consequently, transport companies that contribute significantly to environmental pollution will be obliged to bear the costs of removing the negative consequences of these processes. The costs of both passenger and freight transportation will inevitably increase, resulting in the enhanced attention the companies in both transport sectors will give to environmental protection.

Obviously, there are numerous problems that can arise due to climate change. With today's level of knowledge, it is extremely difficult to predict whether humankind will be able to overcome the challenges that climate change can bring. FUTRE D3.2 (2014) identified the following four possible outcome of these processes:

- catastrophes and adaptation – humankind fail to reach agreements, successive catastrophes, causing mass migrations, conflicts and strong social problems;
- limitation – progress, as we know it, is stopped and society turns to low consumption ways of life;
- replacement – techniques like alternative sources of energy and organic materials allow us to keep developing in an environmental friendly way;
- end-of-line solutions: finding ways (conscious or spontaneous) to invert or control global warming (e.g. Carbon sequestration).

End-of-line transport solutions, as ways of overcoming challenges caused by climate change, can be viewed from two perspectives. First, technological achievements (e.g. natural gas propulsion, electromobility, hybrid solutions, using hydrogen as a power source) can contribute to reducing greenhouse gas emissions. Furthermore, better capacity utilization and improvement of transportation processes have a significant potential to reduce the impact of transport on the environment. This can be achieved through optimized planning based on real-time data, integration of transport modes in both passenger and freight transportation,

consolidation of transport volumes, deceleration and avoidance of transport. Such solutions, without other measures in all other areas, may not lead to the elimination of negative effects of climate change (such as extreme weather events and mass migrations), but will certainly reduce the impact of transport activities on their occurrence.

7.3 Key resources scarcity - shortages and consumption

Energy consumption at the global level, as well as the impact of these processes on the environment, are domains that are increasingly analyzed at social, business and political levels. In the global energy market, fossil fuels are the most important source of energy production and consumption (Brutschin and Fleig, 2016). However, fossil fuels, like all minerals, are the finite and non-renewable source, whose supplies are unequally distributed throughout the world. Obviously, fossil fuel consumption contributes to the exhaustion of existing supplies of this energy source. The number of new oil fields discovered reached its peak in the 1960s. From that period, any increase in oil prices on the global market could not have led to an increase in the number of new discoveries of this energy product at an annual level (Capellán-Pérez et al., 2016). During 2012, the share of oil in global energy consumption has reached its minimum in the last 50 years (BP, 2013).

Capellán-Pérez et al. (2016) notes, based on the previous literature, a pessimistic and optimistic perspective of the fossil fuel consumption. A pessimistic or geological approach emphasizes that geological factors are the ones that decisively influence the peak in the consumption of any source and that technology, regardless of the degree of its development, can not significantly change it. On the other hand, the optimistic or "conventional economists" approach comes from the fact that market mechanisms and technological advancements, or human ingenuity, are enough to turn "*resources into reservoirs*", and to find alternative energy sources that will replace existing in such a way as to avoid any restrictions in the energy supply. In this case, the consumption of non-renewable energy sources would not affect the growth of gross domestic product (GDP). Obviously, the key instrument for achieving long-term energy security, from the optimistic perspective, is the discovery of viable substitutes or enhancing the existing system of energy sources consumption. It can be concluded that technological advances in this area are very important for designing many other technological processes in a sustainable and efficient way.

The type of fuel used in various transport means is very important for achieving the environmental sustainability of both passenger and freight transport sector. Currently, most of the 700 million cars around the world use gasoline and diesel engines. Forecasts indicate that the number of cars will double by 2030, and that there will be an increase in oil prices (Clausen et al., 2014). Thus, the growing scarcity of oil reserves will be particularly reflected in the transport sector. Bearing this in mind, it is obvious that transport companies will increasingly focus on using alternative energy sources in the future. In addition, scarce resources, cost increases, negative environmental impacts and legislation have caused significant research on alternative sources of propulsion, so the progress is seen in areas of electromobility, hybrid solutions and natural gas propulsion (Clausen et al., 2014).

As already pointed out, in addition to fossil fuel consumption, the future of the transport industry is highly dependent on oil prices. However, Jeschke (2011) emphasizes the researches indicating that the expected increase in oil prices will not significantly affect conventional transport. The EIA (2008) predicts that the price of oil will reach \$200/barrel in 2030. It should also be pointed out that the price of oil will significantly influence the organization of supply

chains and the location of the production sites of big manufacturing companies. If the price of oil exceeds \$1000/barrel, it can be expected that large multinational manufacturing companies will tend to organize their production processes in less remote areas from the market. However, if the price of oil is below this limit, large companies will want to take advantage of globalization and not so expensive transport services (Jeschke, 2011). Changes in the price of renewable energy sources are not easy to predict.

7.4 Urbanization and megacities

Urbanization makes and changes places globally. Populations in urban areas are expected to grow substantially up to 2050. However, the biggest growth is estimated in developed countries where increase of the capacity of transport infrastructure does not follow urban expansion (May and Marsden, 2010).

Continuous urbanization and re-urbanization results in increasing demand for transport and energy. Urban areas are often large entities with no clear boundaries that make difference between urban areas and nonurban areas. Such boundaries are usually rivers or transport infrastructure and are representing certain properties of urban areas. Urbanization and re-urbanization are usually connected to demographic trends, housing preferences, social aspects and transportation. All these elements act and interact at different scale. Within the transportation, transport networks are an important factor for urbanization (European Environment Agency, 2017).

The main questions generated from urban expansion are (May and Marsden, 2010):

1. What are the socio-economic characteristics of people in urban areas?
2. Which are the major modes of transport that people in urban areas use in accessing socio-economic opportunities and why?

Interaction between urbanization and transport takes place in both directions. Urbanization impacts transport infrastructure and transport needs, while transport infrastructure could enhance urbanization, re-urbanization and help to rebalance the four modes of transport: road, river, air, and rail (Kamga, 2015).

One of the most important effects of the interaction between urbanization and transport is the shift in use of transport modes toward urbanization. This is especially evident on the example of megacities or cities of over 100,000 inhabitants. More than half of inhabitants does not live in city centres (Mather et al., 2011). However, as their neighbours in the city centres, they use private cars in order to meet their transport needs (Campbell, 1997). On the other side, in order to meet transport needs that include travelling to the centre of the city, they use different modes of transport. In that way, urban density is decreased and transit systems grow.

Together, the trend of urbanization and the shift from one mode of transport to another mode, including the transit systems, can help to begin deal with the sustainability challenges the transportation systems face in the cities. The ultimate challenge of the transportation systems in the cities is to meet the needs of a population whose numbers are growing and whose average age is rising.

The size of megacities allows flexibility of urban expansion, adoption of “green” travel modes and gives the opportunity for environmental protection. In contrast, smaller and medium-sized

cities often have fewer resources to implement new transport modes and can be more vulnerable to fluctuations in the world economy. Megacities are today leading examples of greater sustainable urban development through improving public transport that includes encouragement of non-motorized modes, creation of the pedestrian zones and limited use of private cars (Pojani and Stead, 2015).

8 Conclusion

This deliverable lists the global megatrends affecting passenger and freight transportation. We applied a literature review-based methodology and search on the term “megatrends” in transport related and general foresight studies. Particular emphasis was given to the EC, ETPs and worldwide projects that have studied the megatrends affecting transportation sector and roles of megatrends in forward looking projects. After thorough review of relevant and available literature, a consensus on the selection of the key global megatrends that impact on freight and passenger transport was agreed and defined across the source literature. The same analysis was performed for general foresight studies. In that context, a matrix giving megatrends over sources was prepared. By doing so, megatrends commonly elaborated in the majority of literature sources were identified suggesting some level of consensus.

As megatrends, together with socio-technical shifts in the transport industry, are expected to change the whole sector in a fundamental way, they should be further validated in order to estimate their impact on defining the future transport research priorities. INTEND project, in its further steps (T3.2), will validate the megatrends by using the Analytical Network Process (ANP). The aim of the validation process is to determine the prioritized megatrends (as well as technological advances and political imperatives) for successful implementation and realization of the key transport concepts of the future.

By combining the results related to passenger transportation and general foresight studies, the following megatrends are selected for further elaboration through ANP (task 3.2):

- **ageing society** (ageing world population; increased life expectancy);
- **bigger world economy** (growth of the world economic output; GDP growth; increase of international trade);
- **changing lifestyles** (changing reproduction and family lifestyle; generational shift - flexible and attractive works; global and greater connectivity; rise of lifestyle related illnesses; fitness trends; staying active; demand for experiences; loneliness and single person households; basic expectations from people; teleworking; shift towards individual - freelancing models; empowerment of women; online shopping; increased collaborative consumption - sharing economy);
- **energy demand and sources** (increased energy usage, energy investments, usage of renewable sources of energy and alternative fuels, fuel efficiency, global energy mix);

- **environmental challenges – climate change** (decrease in carbon emissions, global temperature increase, sea level rise, increased risk of flooding from melting glaciers, adaptation and mitigation policies, development of carbon markets);
- **key resources scarcity - shortages and consumption** (more constraints on consumptions - resource management; greater demands on scarce resources – fossil fuels; development of substitute materials, global privatization of resources; changes in ecosystems use);
- **shift of economic power** ("global south" as the engine for growth; emerging multi-polar world; center of gravity of the world economy, geographic hotspot of income generation, increasing commodity supply from developing countries);
- **urbanization and megacities** (higher population densities, improvements in cities infrastructure, environmental and health risks; PPP models; more sustainable cities).

Similarly, the following megatrends can be selected as the megatrends with significant influence on the future development of freight transportation:

- **ageing society** (ageing world population; increased life expectancy);
- **bigger world economy** (growth of the world economic output; GDP growth; increase of international trade);
- **changing lifestyles** (changing reproduction and family lifestyle; generational shift - flexible and attractive works; global and greater connectivity; rise of lifestyle related illnesses; fitness trends; staying active; demand for experiences; loneliness and single person households; basic expectations from people; teleworking; shift towards individual - freelancing models; empowerment of women; online shopping; increased collaborative consumption - sharing economy);
- **energy demand and sources** (increased energy usage, energy investments, usage of renewable sources of energy and alternative fuels, fuel efficiency, global energy mix);
- **environmental challenges – climate change** (decrease in carbon emissions, global temperature increase, sea level rise, increased risk of flooding from melting glaciers, adaptation and mitigation policies, development of carbon markets);
- **globalization 2.0** (global dissemination of production facilities, political and social integration);
- **key resources scarcity - shortages and consumption** (more constraints on consumptions - resource management; greater demands on scarce resources – fossil fuels; development of substitute materials, global privatization of resources; changes in ecosystems use);
- **security issues** (rising threat of cybercrime; crime rates; vulnerability of global supply chains).
- **shift of economic power** ("global south" as the engine for growth; emerging multi-polar world; center of gravity of the world economy, geographic hotspot of income generation, increasing commodity supply from developing countries).
- **urbanization and megacities** (higher population densities, improvements in cities infrastructure, environmental and health risks; PPP models; more sustainable cities).

In addition, in order to define streams of needed future researches in the fields of transport technologies, mobility concepts and research systems, INTEND project will also identify the gaps between technological advances in the transport sector and development prospects of the transport and mobility systems. This GAP analysis will be based on the perception of the impacts of various combinations of different technological advances and megatrends on specific characteristics of the future transport system. In addition, impact

of megatrends on transport research needs will be visually presented by using the Transport Synopsis Tool.

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Appendix 1 Megatrends in general foresight studies

Table 7 Megatrends identified in EC (2012)

M T	Terms and phrases		Explanations / Results / introduction	Challenges
	Level 1	Level 2		
Global demographic and societal challenges	imbalance in population growth	increased life expectancy	Regional differences in growth rates and life expectancy at the world level will result in a larger proportion of people living in Asia. Accelerated population ageing will occur also in China as a result of increased longevity, from the current average age of 74 to 79.3 years of age. Continued migration from rural areas means that a greater number of people will live in cities than ever before (urbanisation).	Are people in the right places? Do we have the right skills? Can we reduce child mortality in emerging economies? Do we have enough people of working age to support economic growth? As the population ages, are there enough people to support the old? How can we close the gap between the 'haves' and the 'have-nots'?
		ageing population		
		Migration		
		Urbanisation		
	Facts	the world population will reach around 9 billion people in 2050 and peak at around 9.2 billion in 2075 (UN and OECD estimate) our children can expect to live on average to celebrate 97 years, and from 2030 onwards it will be not surprising if life expectancy reaches 106;		
	Changing reproduction and family lifestyle	fertility rate	An increased quality of life in Europe may help to partially overcome the present incompatibility between work and parenthood, as well as advances in technologies may help to enhance the probability of late motherhood, leading to a recovery of fertility among richer and higher educated women – a trend presently becoming visible in some parts of Europe. The nature and role of families is also changing.	
		family lifestyle		
	Facts	Taking typical averages into account, the natural replacement rate by which a population stays is 2.1 children per woman.		
	Generational shifts	young generation	The young generation (sometimes called 'digital natives') increasingly search for more flexible and attractive works to better fit with life aspirations, flexibility will not only be imposed by the employers. The education of EU young people is high: more than half of all students are in upper secondary education attending vocational programs.	When more than half (65 %) of employed 15-24 year olds have used to work on a temporary contracts or in a part-time jobs their work attitudes have already changed.
flexible and attractive works				
Facts	In the EU there are currently 96 million 15-24 year olds – in 2030 this generation will be 35-44 years old and in 2050 their cohort from 55 to 64 will still be in working life.			
resource	more constraints on key resources	resource consumption	Economic growth is coupled with resource consumption – as people become wealthier they use more energy (e.g. for air conditioning, heating, computing, mobility), eat and waste more food.	Countries will no longer be concerned just about energy security but also about resource security – land, food, water and raw materials. This is particularly true because resources tend to be geographically concentrated – often in areas that are difficult in terms of physical accessibility or ease of doing business.
		global privatization		
		resource security		
	Facts			

D3.1 Report on main Megatrends

Energy and natural	Facts	climate change		Climate change plus a shortage of resources will also be a catalyst for innovation, but there will be an increasing need of systemic governance of innovation to successfully tackle climate change and sustainability challenges.
		sustainability challenges		
		systemic governance		
	changes in eco-systems use	ecosystem services	Often the global trends of the energy and environment dimension considered in the scenarios are mainly linear extrapolations of today. ICT technologies will be able to calculate how to use ecosystem services without destroying them. Production ecosystems may be created to meet specific needs.	Agricultural productivity is expected to double in this way and waste could be reduced by at least 1/3rd.
Facts				
economy and technology prospects	shift of economic power to Asia	Asian economic power	Asian consumers are clearly growing richer, with average earnings in many countries doubling over the past five years. Asians are now able to use their newly acquired disposable incomes to buy everything from mobile phones (43 % of all sales are now to Asian consumers) to cars (35 % of all car sales in 2009 were in Asia). China is already well on the way to becoming the world's biggest market for pretty much anything you can think of.	As prosperity spreads and the middle classes become big spenders, there is the expectation that the region's emerging economies could soon grow enough to offset falling consumption in the US and the EU. Asian economic growth will continue to outpace that of the West.
		Asian economic growth		
		Asian emerging economies		
	Facts	Today China has 55 million middle- class households: by 2025, this is expected to more than quadruple to nearly 280 million. Three billion Asians currently spend a little less than US\$ 7 trillion on consumer goods; in comparison, 300 million Americans spend up to US\$ 10 trillion.		
	Pressure of ageing population on public spending	ageing population	UN statistics suggest that pensioners in the 'rich world' will comprise one-third of the population and one-tenth will be over 80. Many governments now have to contemplate the prospect of slowing growth and low productivity, rising public spending – particularly on healthcare – and labour shortages Many agree that getting people to work for a few more years – either full or part time – would solve a lot of the problems associated with ageing populations; a retirement age of 70 in the future is already considered highly likely by many in the EU.	From an economic perspective, this mass ageing is already producing a significant pressure and, going forward, many see it as a time bomb for healthcare, pensions, taxation and wider social dynamics. The Stockholm European summit has defined a 3 pronged strategy: reducing the public debt, increasing the employment rate, especially for older workers, and reforming the pension and health care sector. More must be done to improve the efficiency and viability of pension schemes, otherwise the situation may even lead to a collapse of the current European model of social protection and health care
		pension schemes		
		public spending on social protection		
		public spending on health care		
		labour shortages		
	Facts	In the OECD as a whole, health expenditures are likely to rise from an average of 6.7 % of GDP in 2005 to double-digit figures by 2050, and pensions could climb on average by around 3 to 4 percentage points of GDP over the same period		
	Global connectivity	greater connectivity	Greater connectivity, brought about by technology, deregulation, globalization, low-cost travel and migration, is changing how people live, how they work and how they think. ICT, the Internet and new mobile devices will continue to play a pervasive and transformational role.	Mobile devices are becoming a key technology to access the internet and promise to continue heavily transform our way of living.
		new mobile devices		
		lifestyle changes		
	Facts			

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geopolitics and governance dimension	enabling general purpose technologies <i>Facts</i>	artificial intelligence	Machines will be a dominant feature of the future.	More concretely, as machines get smarter and artificial intelligence takes over many repetitive jobs that can be reduced to a set of formal rules that an intelligent and emotionally aware machine can learn, displacing entire layers of workers, humans will increasingly face the risk of becoming more stupid and useless.
		robotics and nanotechnology		
	Changing geopolitics <i>Facts</i>	unpredictable international politics	Political developments are inherently unpredictable, given the wide scope for human agency in shaping the course of events. First, in the absence of a clear and established international political system, globalization itself will be the most influential factor shaping international politics. Second, multipolarity will be a fact of life. The relationship between old and new powers will determine the future of global governance.	The ways in which the new economic powers will be willing and able to translate their weight into some form of political influence will be key to the future political and security system.
		economic power		
		globalization		
		global governance		
	happiness beyond GDP? <i>Facts</i>	GDP growth paths	Today and in the decades ahead it will remain crucial to compare the standard of living of the different regions of the world by measuring their GDP per capita, and the convergence (or divergence) of GDP growth paths. However, in Europe and elsewhere – also in the emerging economies when the currently huge investment opportunities (e.g. in new energy, transport, etc. infrastructures) will be saturated and the growth rates reduced – the criteria for success will not be simply the raw GDP growth rates. There will be a world-wide political reframing of growth in terms of its quality rather than simply its quantity. It should be underpinned by meaningful measures of sustainable prosperity such as well-being, income stability, environmental quality and social mobility.	The need for a different way to measure progress is already evident and is part of the scientific, cultural and (partially) policy debate in the affluent societies of today, and can be coupled with the need to better measure capabilities and freedoms for the population living in less developed countries.
		standard of living of the different regions		
		well-being		
		income stability		
		environmental quality		
		social mobility		
	e- Action and the future of democracy <i>Facts</i>	E-voting	E-voting will expand in the future to cover a wide set of policy issues, allowing citizens to check policy actions and express their opinion more frequently. Social media and various forms of e-Action may change the future policy landscape, in Europe and elsewhere, by allowing an increasing share of citizens from all ages and way of life to participate, exchange new ideas and support – with a sometime surprising speed – new societal initiatives and policy actions outside the traditional parties' pathways.	If voters can connect directly with the issues, do we need politicians in their current form? The answer will be different depending on the future scenarios of democracy.
new societal initiatives				
Economist Intelligence Unit's measure of democracy – one-half of the world's population now lives in a democracy of some sort; the number of 'full democracies' is low, at only 26 countries; 53 countries are rated as 'flawed democracies'; of the remaining 88 countries considered in the index, 55 are authoritarian and 33 are considered to be 'hybrid regimes'.				

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territorial and mobility dynamics	territorial dynamics	the urban settlement system (hierarchy and networks)	The basic structural elements of territorial dynamics include: the urban settlement system (hierarchy and networks), the semi-urban areas (suburban, peri-urban, diffuse city patterns), the more rural areas (including also areas with a high natural heritage value), systems of transport and communication networks. Territorial dynamics are highly complex, as they depend on a number of long-term heavy trends – population ageing, social mobility, globalization, resource shortages, diffusion of ICT in society and economy, growing knowledge-based production, progressing climate change, etc. – as well as uncertainties – the level of international migrations from outside Europe, the flows of Foreign Direct Investments towards central and eastern Europe, possible departure from nuclear energy production and accelerated promotion of renewable energy sources, also to name a few.	Smart growth (fostering knowledge, innovation, education and digital society), sustainable growth (making production more resource-efficient while boosting competitiveness) and inclusive growth (raising participation in the labor market, acquisition of skills and fight against poverty) remain until 2050 the leitmotifs of EU policies, and these will have important territorial impacts.
		the semi-urban areas (suburban, peri-urban, diffuse city patterns)		
		the more rural areas (including also areas with a high natural heritage value),		
		systems of transport and communication networks.		
		Facts		
	sustainable transport	car-sharing schemes	Climate change, urbanization and resource shortages – most notably oil – will fuel a shift away from large petrol-engine cars to small electric and hybrid vehicles. There will be also a boom in cheap cars and bikes in emerging countries. Tax rates, license charges, road charging and parking fees will increasingly be linked to vehicle type and we will see even more anti-car and anti-driver sentiment and regulation. This will be a catalyst for car-sharing schemes, green car loans, green car insurance and bicycles. From a sustainability point of view the future must see the reinvention of mass public transport, but people would not embrace the idea until the governments start thinking long term and build safe, clean, convenient and affordable networks. Embedded intelligence and remote monitoring will allow to support travelling and to combine the travelling experience with a number of other services, increasing the efficiency of our journeys.	Cars will also become mobile technology platforms linking data to other services, such as healthcare. Obviously privacy issues abound, but cars could become useful data-collection and delivery points. Indeed, in the future all cars will be automatically tracked from space, making no journey entirely private. The good news in all this is that real-time data on where a car is and what it is doing will revolutionize the auto theft recovery and insurance industries and will foster various location-based services such as pay-as-you-go insurance. Embedded intelligence may evolve creating driverless cars. We cannot expect this any time soon, but by about 2040 we will see around cars capable of driving themselves with minimal interference from the driver. Cars will also be able to travel automatically in platoons and correspond with other vehicles and the infrastructure about conditions ahead or alternative routes. Speed regularity – a feature of automated driving – will help to relief congestion on busy highways.
		green car loans		
		green car insurance		
		mass public transport		
		small electric and hybrid vehicles		
		embedded intelligence – driverless cars		
		cheap cars and bikes in emerging countries		
	Facts			
R&I, Education	EU innovation gap	under-performance of the EU research and innovation system	under-performance of the EU research and innovation system as whole and the related productivity gaps; innovative solutions need to be safe, accepted by society and sustainable.	reasons: the under-financing of various activities across research and innovations systems; weaknesses in the operation of specific components of these systems at EU, national and regional levels; the failure of many system components to function or link effectively together; and weak research and innovation governance systems and resulting policy portfolios.
		weak research and innovation governance systems		
	Facts			

Table 8 Megatrends identified in Hajkowicz et al. (2012)

M T	Terms and phrases		Explanations / Results / introduction	Challenges
	Level 1	Level 2		
More from less	More people <i>Facts</i>	population growth	The global population is forecast to level-off at over 10 billion people.	
	By the year 2025 there will be 8 billion people and by the year 2043 there will be 9 billion people.			
	A bigger world economy <i>Facts</i>	growth of the world economic output		Growth of the world economic output will place pressure on scarce natural resources due to the increasing demand from the rising middle class of emerging and developing countries.
		rising middle class		
	Global water scarcity <i>Facts</i>	climate change	Climate change presents additional concerns about water scarcity over coming decades.	The increased demand for water is likely to be associated with price rises.
		Increased water consumption		
		water scarcity		
		global water demand is forecast to increase by 55 % between 2000 and 2050 (largest increases comes from manufacturing, electricity and domestic use) total water consumption in Australia is forecast to rise by 42 % by the year 2026 and 76 % by the year 2056 compared to 2009 levels		
	Increasing global energy demand <i>Facts</i>	worldwide energy usage	All sources of energy are forecast to experience growth. Oil demand increases by 18 percent, coal by 25 percent and nuclear by 70 percent. Despite a rapid growth rate, renewable energy is starting from a small base and will still make only a minor contribution to world energy use by the year 2035.	
		growth of energy consumption		
		renewable energy		
		Worldwide energy usage is forecast to rise by 40 percent between the years 2009 and 2035 by the International Energy Agency.		
	Energy investments <i>Facts</i>	investments in energy supply infrastructure	During the period 2011 to 2035 the world is forecast to spend some US\$38 trillion on energy supply infrastructure to meet growing demand. Two-thirds of this expenditure occurs in the developing world. Over 90 percent of the growth in energy demanded occurs in developing countries.	
		China is forecast to consume 70 percent more energy than the United States by 2035.		
	Increasing carbon emissions and new markets <i>Facts</i>	increase in carbon emissions	Rising energy consumption is associated with a 20 percent global increase in carbon emissions. This is forecast to cause a long term average global temperature increase of 3.5 degrees Celsius. Carbon markets currently exist in Europe and New Zealand. It is possible that coming decades will see rapidly emerging economies such as Brazil, Russia, India and China introduce carbon pricing of some form.	
		global temperature increase		
		rising energy consumption		
		development of carbon markets		

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Going, going...gone?	Global food demand and supply challenges	increase food production	Based on assumptions about population growth, changing diets and agricultural systems the Food and Agriculture Organisation (FAO) forecast that food production needs to increase by 70 percent by the year 2050 to meet demand. In addition to rising food demand, diets are shifting.	The world loses 12 million hectares of productive agricultural land, capable of producing 20 million tonnes of grain, each year to land degradation resulting from human activities such as over-cultivation and deforestation.
		increasing meat consumption		
		land degradation (over-cultivation and deforestation)		
		Facts		
	volatile food prices	higher and more volatile food prices	Today some one billion people are considered hungry. Factors such as income growth, biofuel production, climate variability, trade distortions, rising oil prices and urbanisation are considered likely to push up food prices into the future.	
		Facts		
	Increased biofuel production		Currently one percent of the world's arable land area is devoted to biofuel production. While biofuel may help achieve energy security and climate mitigation outcomes it may also place upward pressure on food prices.	
		Facts		
	Resource conflicts		As water and other resource become scarce relative to demand the risk of conflict is heightened.	Statistical analyses have revealed that countries which share rivers have a statistically higher probability of military disputes.
		Facts		
	Declining mineral ore grades and the rise of recycling	waste generation	Waste generation is forecast to continue to rise into the future on a local and global scale. As a consequence waste is increasingly being viewed as resource-rich 'nonwaste' from which commodities can be 'mined'. Swedish mining company Boliden has identified that a growing share of the metal production will originate from recycling in the future.	Mining in the future may happen above the ground (i.e. recycling) more than below the ground.
		metal production originating from recycling		
		Facts		
	Biodiversity decline	genes, species and ecosystems	There are indications that the three main components of biodiversity - that is genes, species and ecosystems - are all continuing to show signs of decline. Habitat damage, overexploitation, pollution, invasive alien species and climate change are the five principal pressures that are directly driving biodiversity loss.	Given the current context and state of biodiversity actions made in coming decades will determine the fate of biological diversity for coming millennia.
		signs of decline		
		biodiversity loss		
Facts				
increased protection of critical biodiversity sites	critical to species survival	The Alliance for Zero Extinction has identified 595 sites worldwide that are critical to species survival, including sites that collectively contain the entire global population of 794 critically endangered or endangered species.		
	Facts			

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the silk highway	climate change impact Facts	extreme weather events	The impacts of climate change on humans will also be far reaching. They will occur through extreme weather events, sea level arise, higher temperatures and changed environmental conditions.	Warming of the climate is now considered unequivocal given increases of global average air and ocean temperatures, widespread melting of snow and ice and rising average sea levels.
		sea level arise		
		higher air and ocean temperatures		
		changed environmental conditions		
	shifting hotspot of world economic activity Facts	centre of gravity of the world economy	The centre of gravity of the world economy is the geographic hotspot of income generation based on the distance weighted gross domestic product of 700 locations. In 1980 the hotspot was in the Atlantic Ocean midway between the economic powerhouses of Europe and the United States. However, today the hotspot is over Saudi Arabia and by 2030 the hotspot is forecast to shift to a location firmly between India and China.	Rapid economic growth in Asia is pulling the whole world economy eastwards.
		geographic hotspot of income generation		
	building a new world economy with BRICS Facts		China and India have contributed to 20 percent of world GDP over the past 10 years. When combined with Brazil and Russia (to form the BRIC nations), these four countries will have higher economic output than the United States by end of 2018.	By 2030 the bulk of global GDP will be generated from non OECD countries. This is a major shift for the world economy.
	growing middle-class Facts	transition out of poverty	Coming decades will see over one billion people in Asia transition out of poverty and into the middle income bracket between US\$6,000 and US\$30,000 per year.	
	Slow economic growth in China Facts	domestic consumption and services economy	The growth slowdown may mark the transition from an export-led and investment-driven economy to a domestic consumption and services economy. Soft landing is likely. Declining Chinese infrastructure investment will see a slowdown in resource consumption, sourced largely from Australia and thus decreasing demand for Australian mineral exports.	
	rate of industrialisation and steel use to slow in China Facts	steel intensity per GDP unit	Steel intensity per GDP unit is a lead indicator of the construction cycle and industrialisation. While Chinese demand for steel is still expected to grow, the rate of steel consumption per unit of GDP is expected to decrease by 2020-2025. This means that China may be moving beyond the phase of rapid industrialisation and into a more services-oriented phase of economic development.	
		services-oriented phase of economic development		

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Forever young	Will India pick up the slack?	rapid phase of industrialisation in India	There is a possibility that India will enter a rapid phase of industrialisation as China slows down thus ensuring strong sustained demand for commodities on global markets. However, an analysis of refined metal consumption rates in India suggests that India's commodity demand will not be high enough to replace China. The industrialisation of India has barely begun.	
		Facts		
	Increasing commodity supply from developing countries	vast mineral reserves	The developing world has vast mineral reserves which are not yet competing to supply global markets because the infrastructure has not yet been developed.	Coming decades may see infrastructure put in place with subsequent supply putting downward pressure on prices.
		developing world		
		supplying global markets		
	Facts			
	new demographic profile	ageing population in OECD countries	In 1950, 8 percent of the world's people were over 65 years old. This grew to 11.2 percent by 2011 and is forecast to reach 22 percent by 2050. The ageing population is even more pronounced in OECD countries. Demographic forecasts reveal the extent of change in the nation's age profile. In 2011, 14 percent of the Australian population was aged 65 years and over. By 2056 this proportion is predicted to have risen to between 23 and 25 percent. The relative population engaged in the workforce will also shrink. Japan has the fastest speed of ageing amongst the world's countries. In 1950, 4.5 % of Japan's population was over 70 years old. By 2010 it was 23 %. By 2050 it is forecast to increase to 40 %.	
		shrink of population engaged in the workforce		
		the world population as a whole is ageing		
		Facts	the world will contain more than 2 billion people over the age of 60 years by the year 2050	
	longer life spans	longer life expectancy	One of the reasons the world population is ageing is because of longer life expectancy. Advances in medical sciences and healthcare over time mean that people will live longer in the future.	
		advances in medical sciences and healthcare		
	Facts			
	Redefining retirement model	ageing population	When the ageing population is combined with longer life expectancy we identify an additional challenge – the retirement savings gap. This is the shortfall in savings for the current workforce to have a “comfortable” retirement. The combined pressures of ageing and the retirement savings gap might redefine the concept of retirement into the future.	
		retirement savings gap		
		“comfortable” retirement		
		Facts		

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	Rise of lifestyle related illnesses	Lifestyle related illnesses	Lifestyle related illnesses and worldwide are on the rise. A global analysis finds that the portion of deaths from non-communicable diseases, including cancer and cardiovascular diseases, will increase from 59 percent of total deaths in 2002 to 69 percent of total deaths in 2030. The same study finds that deaths from car accidents will rise from 2 percent to 3 percent of total deaths over the same time period. It also forecasts that deaths from tobacco-attributable causes will increase from 5.4 million persons in 2005 to 8.3 million persons in 2030.	
		Increase of deaths from non-communicable diseases		
		rise of deaths from car accidents		
		Increase of deaths from tobacco-attributable causes		
		Facts		
	Fitness trend	investing more in fitness	The diabetes and obesity trend is being countered by a fitness trend. People are more aware of health issues and are investing more in fitness. For example, there has been a significant growth in the number of fitness centres and their income.	
		growth in the number of fitness centres		
		Facts		
	healthcare expenditure	growing healthcare expenditure	The ageing population and lifestyle illnesses are drivers of growing healthcare expenditure. Over the medium term there is growth in spending on all areas of healthcare: hospitals, medical benefits, pharmaceuticals and private health insurance.	
		Facts		
	Staying active		People are physically active and participate in sport.	
		Facts		
	Virtually here	rise of the digital world	disruptive technologies	Authors suggest that company should act quickly enough to benefit from the disruptive technologies. The challenging question is how much bigger will it get in the next 5, 10 or 20 years? It will be too late to respond if and when, the answer is obvious.
change business models				
Facts				
retail sector fuelled by online competition		growing online sales	Changing consumer preferences, shifting expenditure patterns and growing online sales are all contributing to a structural shift within the world economy.	
		changing consumer preferences		
		rise of internet enabled micro-transactions		
		Facts		

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	Increased collaborative consumption <i>Facts</i>	many consumers use the same product	Collaborative consumption occurs when many consumers use the same product via some type of sharing arrangement. This can lead to more efficient resource use and cost savings. An example is car sharing. Car sharing is considered to use less street parking, reduces city greenhouse emissions and reduces congestion.	Collaborative consumption may increasingly spread into other areas (e.g. music, books, bicycles, apartments). It will be boosted by continued development of innovative online transaction platforms.
		more efficient resource use		
		car sharing		
		innovative online transaction platforms		
	increasing demand for teleworking <i>Facts</i>	teleworkers	Modern information and communication technology will increasingly remove the necessity for many workers to visit a physical location. People can increasingly work from home, cafes, parks, libraries or other public spaces. Teleworking is well positioned to grow with advancements reliant upon technologies such as cloud computing and the ever-growing connectivity and information flows within networks. By 2020, the Australian Government plans to double the number of teleworkers in Australia so that at least 12 percent of employees have teleworking arrangements.	Given these workers make up the bulk of employees within major cities urban design and transportation systems may change.
		cloud computing		
		ever-growing connectivity		
	Activity based layouts in offices <i>Facts</i>	docking stations for lap-top computers	In activity based layouts staff may be seated anywhere within the building on any given day. The desks have docking stations for lap-top computers and, upon login, the phone and/ or video communications lines are connected to the individual. This reduces the number of vacant desks. Activity based layouts have been tried in previous decades with varying degrees of success. They are likely to succeed in coming decades due to the availability and social acceptance of communications and portable computing technology.	
		phone and/ or video communications lines		
		reduced number of vacant desks		
		social acceptance of communications		
	growth of online commerce <i>Facts</i>	online web service	Every time somebody presses "buy" on an online web service a background supply chain is triggered. The growth in logistics is evidenced by parcel delivery rates and supporting industry data.	The growth of online commerce is likely to be accompanied by a growth in background logistics operations.
		background logistics operations		
	Grow of freelancing models <i>Facts</i>	online transactions	Online transactions are enabling domestic and international freelancing models to grow rapidly. Portfolio workers supply their services to a range of companies.	The rise of freelancing may be associated with the emergence of the portfolio worker which sees a shift away from the corporation and towards an individual.
		portfolio workers		
		shift towards an individual		
	Offshoring <i>Facts</i>	sourcing of labour	Offshoring is the sourcing of labour from other countries.	The offshoring pressure is likely to intensify into the future as the labour force of the developing world becomes more skilled, technology enables more jobs to be done remotely and the labour cost differential remains high.

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Great expectations	rising threat of cybercrime <i>Facts</i>	virtual crime and	Individuals, organised groups and nation states are increasingly using sophisticated online tools for illegal purposes.	An inevitable consequence of society's movement into the digital world is the rising threat of cybercrime.
		cybersecurity threats		
	declining relative material consumption <i>Facts</i>	rising absolute material consumption	Whilst absolute material consumption is rising in line with economic growth, relative material consumption is decreasing. Relative to population and income growth material consumption is declining in countries with advanced economies.	
		decreasing relative material consumption		
	Education spending is on the rise <i>Facts</i>		People and countries often redirect discretionary income towards education services as they become wealthier and grow national income.	
	Innovative personalisation <i>Facts</i>	personalise products and services	Additive manufacturing allows the printing and fabrication of three dimensional objects based on electronic designs. Another example comes from recent software tools designed to make new recommendations based on a person's existing music library.	Marketers have long sought to personalise products and services to increase sales.
	rising importance of moral and ethical dimensions for consumers <i>Facts</i>	products labelled as environmentally and socially responsible	Recent decades have seen a growth in the number of products labelled as environmentally and socially responsible. The "fair trade" logo is an example.	Although fair trade products still comprise a relatively minor share of all consumer products they are growing rapidly.
		"fair trade" logo		
	rising consumer and societal demand for experiences <i>Facts</i>	Great expectations	Many of the trends presented under Great expectations give the impression of more desirable behaviours as incomes grow. But there is a negative side to income growth and class ascendancy. Class ascendancy allows people to seek new experiences but scientific studies have revealed that people's motivations and behaviours are not always more honest or desirable. Therefore the rising consumer and societal demand for experiences, partly fuelled by income growth, should not be seen as strictly positive or negative. It will have both dimensions.	Humans are complex and income growth and class ascendancy can be associated with negative behaviours.
		income growth		
		class ascendancy		
		seeking new experiences		

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	Loneliness and single person households	population living alone	Population living alone is associated with delayed partnering, divorce and declining fertility. Loneliness is also more common amongst older people, who will comprise a greater proportion of the workforce in coming years. The office and shopping centre will hold increasing importance as places for social interaction.	
		loneliness		
		office and shopping centre		
		Facts		
	preference for face to face interaction	face to face communication	Despite the high participation rates in social media, there is still a preference for face to face interaction.	
		Facts	In a consumer survey forty-nine percent of American teenagers aged 13 to 17 prefer face to face communication with their friends.	
	Basic (not great) expectations of people	expectation for the basic necessities	Much of the world's population has an expectation for the basic necessities of life. Even though the situation is improving many of the world's people live in survival mode. They have an expectation not for higher-order experiences but for basic necessities (food, water, shelter, clothing, personal safety).	Basic expectations are unfulfilled for far too many of the world's people
		live in survival mode		
		unfulfilled basic expectations		
		Facts		
	Poverty reduction		The datasets reveal the severity and extent of global poverty is reducing over time.	Poverty reduction is an objective for the twenty-first century.
		Facts		

Table 9 Megatrends identified in KPGM (2012)

MT	Terms and phrases		Explanations / Results / introduction	Challenges
	Level 1	Level 2		
Climate change		global temperature rise	Risks include new laws and government initiatives to tackle climate change such as energy efficiency requirements and standards, carbon taxes, emissions cap and trade systems and fuel tariffs.	Global temperature rise could cause 'irreversible' impacts including near-total deglaciation in the long term, contamination of groundwater supplies, water shortages for hundreds of millions of people, lower agricultural yields in many places and more malnutrition, infectious diseases and deaths from heat waves, as well as increasingly severe floods, droughts and storms. Extreme weather events are set to become more frequent. Agriculture is expected to rise in northern Europe while in Africa it could leave hundreds of millions of people without enough food.
		frequent extreme weather events		
		disruption to water supplies		
		increased risk of flooding from melting glaciers		
	Facts	One sixth of the world's population could face disruption to water supplies and an increased risk of flooding from melting glaciers.		
Energy & Fuel		higher global energy demand	Fossil fuel markets are set to become more volatile and unpredictable because of higher global energy demand. Most renewable energy companies depend heavily on oil, coal and gas for power, fuel and raw materials. Renewable energy sources, led by hydropower and wind, should grow faster than other energy forms Energy businesses must prepare for shifts in fuel mix due to policy, supply, and fuel prices. Demand for natural gas is expected to rise most strongly.	Need to increase regulatory interventions related to climate change. Companies will find it difficult to plan for and manage energy costs. Vehicle and electrical appliance suppliers, manufacturers, and retailers must prepare for increased demand for their products. Fossil fuel-dependent transportation industries such as aviation, shipping and manufacturers that use petroleum as a process input, such as plastic or chemical producers, will need robust strategies and plans to address fuel price volatility and potential shortages.
		grow of renewable sources of energy		
		shifts in fuel mix		
		increase regulatory interventions		
		robust strategies and plans to address fuel price volatility and shortages		
	Facts	The price of crude oil will rise to US\$120/barrel by 2035. World oil production is predicted to reach 96 million barrels per day in 2035. Nuclear energy is likely to grow by about 70 percent to 2035.		
Material Resource Scarcity		increase of demand for material resources	Demand for material resources looks likely to continue to increase dramatically. Over the next 20 years, demand for material resource will soar while supplies will become increasingly difficult to obtain.	Business is likely to face global competition for a wide range of material resources that become less easily available. Resource shortages create opportunities for developing substitute materials and for recycling and recovering resources from waste products. The uneven global distribution of material resources, from oil to land to fresh water, makes planning for the future even more complex
		less easily available material resources		
		development of substitute materials		
	Facts	In 2030 it is predicted that some 83 billion tons of minerals, metals and biomass will be extracted from the earth.		

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Water Scarcity		water shortages	Potential water shortages pose a threat to business growth and expansion, and conflicts over water supplies may create a security risk to both business operations and markets. Climate change puts further pressure on water availability and quality. Lack of clean water in rural areas could reduce the amount of viable agricultural land, which would add to the pressure for people to migrate to cities.	The projection for freshwater availability in 2030 bears potential for crisis and conflict, since water lies at the heart of everything that is important for human life: food, sanitation, energy, production of goods, transport and the biosphere. Increasing stress on the world's water supplies threatens to affect food and energy systems around the world due to the interlinked nature of the global economy. Water-intensive sectors are at the greatest risk from water scarcity include clothing, automobile, food and beverage, biotech/pharmaceutical, chemical, forest products, electronics, mining, refining and electric utilities
		conflicts over water supplies		
		lack of clean water in rural areas		
		water-intensive sectors are at the greatest risk		
	Facts	The global demand for freshwater will exceed supply by 40 percent by 2030 assuming average economic growth and no efficiency gains.		
Population growth		growing young populations	intense pressures on ecosystems and the supply of natural resources such as food, water, energy and materials; lack of employment opportunities for growing young populations;	Financial challenges related to employee retirement benefits and pension funding will become more common as smaller workforces struggle to support the rising costs of ageing populations. As people live longer, conventions around working life, retirement and personal finance will be challenged. In developed countries with stable populations but a growing proportion of elderly and retired citizens, businesses will face a shrinking workforce and fiercer competition for skilled workers.
		the rising costs of ageing populations		
		changes in retirement and personal finance		
		shrinking workforce		
		fiercer competition for skilled workers		
	Facts	The number of people on our planet is predicted to increase to 8.4 billion by 2032 in a moderate growth scenario. Almost two thirds (58 percent) of people will live in Asia and around one fifth (19 percent) in Africa.		
Wealth		workers developing higher expectations	Disparities between working conditions and wages in different countries are likely to become increasingly apparent as workers develop higher expectations. The advantages that many companies have experienced from cheap labor in developing nations are likely to be eroded by the growth and new power of the global middle class.	The challenge for businesses is to serve new markets at a time when resources will become scarcer and more price-volatile. The greatest opportunity awaits those businesses that can provide products and services for a more resource-constrained world.
		growth of the global middle class		
		businesses to serve new markets		
		more resource-constrained world		
	Facts	Global population is predicted to grow 172 percent between 2010 and 2030 resulting in a rise in overall global wealth over the next 20 years.		
Urbanization	Urban centres	improvements in cities infrastructure	Cities will require vast improvements in infrastructure including construction, water and sanitation, electricity, waste, transport, health, public safety and internet and cell phone connectivity. Higher population densities in urban centres are likely to change economic and political dynamics. Cities also provide potential for business in terms of the number and diversity of available human resources	IT could allow resources to be used more efficiently. Moving people and goods safely and efficiently through larger, densely populated urban areas will become more challenging and expensive. As cities grow there will be greater demands on scarce resources such as clean water and open green space.
		higher population densities		
		available human resources		
		moving people and goods safely and efficiently		
		greater demands on scarce resources		
	Facts	In 2009, for the first time ever, more people lived in cities than in the countryside. By 2030 all developing regions including Asia and Africa are expected to have the majority of their citizens living in urban areas.		

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Food security		increase of demand for food	Demand for food will increase most in developing countries with their fast-growing populations.	In water-scarce regions, agricultural producers will compete for supplies with other water-intensive industries such as electric utilities and mining and with consumers. Modernizing agricultural techniques in the developing world, particularly Africa, may provide opportunity for producers of fertilizers and other agricultural inputs. Patterns of production are likely to be driven by crop yields, water availability, governance and consumer preferences
		modernizing agricultural techniques		
		governance and consumer preferences		
	Facts	Global food prices could rise by 70–90 percent by 2030. Effects of Climate Change could trigger prices rise even higher.		
Ecosystem Decline		damage to ecosystems	Food producers and retailers in particular have been targeted over the damage to ecosystems. The decline in biodiversity and ecosystems is making natural resources scarcer, more expensive and less diverse. Costs of water are rising. Healthy ecosystems and diverse species are essential to many valuable and difficult-to-replace services ranging from fresh water and food to pollution filtration, carbon storage and pollination. Exact biodiversity tipping points are uncertain.	Continued degradation of global biodiversity and ecosystem services could increase the pressure on agriculture, fishing, food and beverages, pharmaceuticals and tourism.
		decline in biodiversity and ecosystems		
		rise of cost of water		
	Facts	The benefits of ecosystem services are increasingly recognized – the UN estimates that the value of avoided greenhouse gas emissions from conserving forests is US\$3.7 trillion, for example, while insect pollinators contribute US\$190 billion a year to agricultural output.		
Deforestation		forests supply essential resources	Forests supply essential resources to local communities and the global economy, including timber, fruits and medicinal products. Deforestation is increasingly being driven by the consumption needs of developed economies and rapidly expanding developing economies The timber industry and downstream industries such as pulp and paper are vulnerable to potential future regulation and market-based mechanisms such as Payments for Ecosystem Services.	Cutting down forests – for agriculture, commerce or housing – directly reduces the supply of valuable natural resources and ecosystems services for business and the global community. It also removes a vital carbon sink and reduces the world’s ability to contain climate change. Reforestation with plantation forests is encouraged. Primary forests in developing countries are uprooted to support the cattle, timber and paper, and palm oil industries.
		increase of deforestation		
		supply of valuable natural resources		
		need for reforestation		
	Facts	Forests cover 31 percent of the world’s land surface. The area covered by primary forests – those undisturbed by human activity – has fallen by more than 40 million hectares		

Table 10 Megatrends identified in KPGM (2014)

MT	Terms and phrases		Explanations / Results / introduction	Challenges
	Level 1	Level 2		
Demographics	Individuals	Increases in the general population	Higher life expectancy Falling birth rates Increasing the proportion of elderly people across the world	Solvency of social welfare systems, including pensions and healthcare are challenged. Challenge of integrating large youth populations into saturated labour markets.
		Increased proportion of elderly people		
	Facts	With expected increases in the general population and a growing middle class, a 50 percent jump in food production will likely be necessary to meet this demand, requiring additional water and energy consumption		
Rise of the individual	Lifestyles	empowerment of individuals	Global education, health and technology have helped empower individuals like never before, leading to increased demands for transparency and participation in government and public decision-making.	Government action to improve services for citizens. The ways for better informing of citizens. Protection of privacy and security in the information age by government.
		participation in government and public decision-making		
		improved services for citizens		
	Facts	By 2022, more people will be middle class than poor		
Enabling technology	Evolution of skills	Information and communication technology	A new wave of technological advances is now creating novel opportunities, while testing governments' ability to harness their benefits and provide prudent oversight. Society transformation over the last 30 years by information and communication technology and by technological advances	Unknown works for this days children by 2030. Evolving skills that can ensure relevancy for the future work.
		technological advances		
		society transformation		
	Facts			
Economic interconnectedness	Increase of global economy	increase of international trade	Global economy is interconnected. Continued increase in the levels of international trade and capital flows.	Unless international conventions can be strengthened, progress and optimum economic benefits may not be realized. Ability of government to help citizens compete on the markets. Needed actions of government to ensure safety of the banks.
		increase of capital flows		
		strengthening international conventions		
		safety of the banks		
	Facts	The trend toward further economic interconnectedness brings significant potential and a major push toward global free trade could shift 650 million people out of poverty over a 10-20-year period		

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Public debt	Facts	Fiscal options	Mounting public debt is limiting the scope of governments to act in a range of policy areas. Public debt is expected to operate as a significant constraint on fiscal and policy options.	Governments' ability to bring debt under control and find new ways of delivering public services will affect their capacity to respond to major social, economic and environmental challenges. Restoring budgets and paying down debt in times of slow growth in developed countries. Balance between the need to reduce debt and the need to stimulate growth.
		Policy options		
Economic power shift	economic opportunities	'global south' as the engine for growth	Emerging economies are lifting millions out of poverty. The consequences of economic power shift: the 'global south' as the engine for growth, emerging multi-polar world order, innovation as the source of sustaining growth and increased consumption base driving economic opportunities.	International institutions and national governments will need a greater focus on maintaining their transparency and inclusiveness. Government actions for foreign ownership of corporations to ensure all benefits are received.
		emerging multi-polar world order		
		innovation as the source of sustaining growth		
		increased consumption		
	Facts			
Climate change	Physical Environment	unpredictable changes to the environment	Climate change is increasing the frequency and magnitude of extreme weather events. GHGs are driving a complex mix of unpredictable changes to the environment.	Achieving the right combination of adaptation and mitigation policies. Maintaining affordable insurances and assenting protection of homes and businesses as weather gets more extreme.
		magnitude of extreme weather events		
		adaptation and mitigation policies		
	Facts			
Resource stress	consumption of natural resources	stress on essential natural resources	By 2030, significant changes in global production and consumption, along with the cumulative effects of climate change, are expected to create further stress on already limited global resources. Population growth, economic growth and climate change will place increased stress on essential natural resources (including water, food, arable land and energy).	Government have to make certain that sufficient water for citizen future needs will be enough as demand exceeds supply. Sustainable resource management will be placed at the centre of government agendas.
		resource management		
	Facts			
Urbanization		social development	Significant opportunities for social and economic development and more sustainable living. Pressure on infrastructure and resources, particularly energy.	Government plans for infrastructure have to be timely, effective and sustainable. Poverty in the cities.
		economic development		
		pressure on infrastructure and resources		
	Facts	almost two-thirds of the world's population will reside in cities by 2030.		

Table 11 Megatrends identified in Lorenz and Haraldsson (2014)

MT	Terms and phrases		Explanations / Results / introduction	Challenges
	Level 1	Level 2		
global divergence in population trends	population trends	global population growth	The global population will still be growing midway through the 21 st century, but at a slower rate than in the past. People will live longer, be better educated and migrate more. Some populations will increase as others shrink. Migration is only one of the unpredictable prospects for Europe and the world.	
		people will live longer		
		People will be better educated		
		People will migrate more		
	Facts			
Living in an urban world	urbanization	increasingly urban world	An increasingly urban world will probably mean spiralling consumption and greater affluence for many. But it also means greater poverty for the urban underprivileged.	Poor urban living conditions and environmental and health risks associated with this could have an impact on all parts of the world, including Europe.
		poor urban living conditions		
		environmental and health risks		
	Facts			
risk of new pandemics		emerging and re-emerging diseases	The risk of exposure to new, emerging and re-emerging diseases, to accidents and new pandemics, will grow with the increasing mobility of people and goods, climate change and poverty. Vulnerable Europeans could be severely affected.	
		emerging accidents		
	Facts			
technological change	racing into the unknown	nanotechnology	The breakneck pace of technological change brings risks and opportunities, not least for developed regions such as Europe. These include, in particular, the emerging cluster of nanotechnology, biotechnology, and information and communication technology.	Innovations offer immense opportunities for the environment, but can also cause enormous problems if risks are not regulated adequately.
		biotechnology		
		information and communication technology		
	Facts			

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Continued economic growth	economic growth	consumption and resource use	Rapid growth accelerates consumption and resource use. But it also creates economic dynamism that fuels technological innovation, potentially offering new approaches to addressing environmental problems and increasing resource efficiency.	
		environmental problems		
		resource efficiency		
	Facts			
from a unipolar to a multipolar world	shifting global power	global interdependence	Global power is shifting. One superpower no longer holds sway and regional power blocs are increasingly important, both economically and diplomatically.	As global interdependence and trade expands, Europe may benefit from improving its resource efficiency and knowledge-based economy.
		resource efficiency		
		knowledge-based economy		
	Facts			
global competition for resources		efficient production and resource use	How will Europe survive in the intensifying scramble for scarce resources? The answer may lie in more efficient production and resource use, new technologies, innovation and increasing cooperation with foreign partners.	
		new technologies, innovation		
		increasing cooperation with foreign partners		
	Facts			
Decreasing natural resources		natural systems for food, water and energy	A larger and richer global population with expanding consumption needs will place growing demands on natural systems for food, water and energy. European resource stocks may likewise face increasing pressures.	
		resource stocks		
	Facts			

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climate change	Facts	food and water supplies	The speed at which climate change has an impact on the environment will threaten food and water supplies, human health, and terrestrial and marine life.	Europe may also see more human migration and aggravated pressure on resources supplies.
		human health		
		terrestrial and marine life		
		human migration		
environmental pollution load	Facts	complex mix of pollutants	An increasingly complex mix of pollutants threatens the Earth's regulatory mechanisms.	Particulates, nitrogen and ground-level ozone merit particular attention because of their complex and potentially far-reaching effects on ecosystem functioning, climate regulation and human health. In addition, many other chemical substances are released into the environment, with effects – in isolation or combined – that are still poorly understood.
		poor understanding of effects		
Environmental regulation and governance	Facts	governance models	The world is devising new governance models, including multilateral agreements, on numerous issues and public-private ventures. In the absence of global regulations, high European standards and procedures are often adopted worldwide.	
		global regulations		
		high European standards and procedures		

Table 12 Megatrends identified in Singh (2014)

M T	Terms and phrases		Explanations / Results / introduction	Challenges
	Level 1	Level 2		
Connectivity & Convergence	Future connected living ecosystem	Home Automation Home Energy Home Health Home Entertainment	Connected life contains three important aspects of connected home, connected city, and connected work	Connectivity will accelerate convergence of industries, products, technologies and competition shorter design and product development cycles
		Mobility – Mobile email, Unified Communication Mobile Working Enterprise Social Networking		
		eGovernance eCitizens Personal and Freight Mobility E-learning Mobile banking		
	Facts	connected living total market: \$730 billion in 2020; 80 billion connected devices globally by 2020; connected devices for every household by 2020; 5 connected devices for every user by 2020; 5 billion internet users by 2020; 500 devices with unique digital ids (internet of things) per square kilometre by 2020;		
Bricks and clicks		smaller retail formats	retail formats are becoming smaller and unique with more emphasis being placed on the concept and urban location of the store;	urbanization will compel retailers to shrink store sizes – retailer store size to be 15-20% less than the current average store size by 2020; technology converting buyers into multi-channel shoppers;
		retailer store size		
		multi-channel shoppers		
	Facts	global online retail sales to reach \$4.3 trillion by 2025 accounting for 19% of total retail \$11.8		

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Smart is the new		Smart Cities		
		Smart Technology		
		Smart Infrastructure		
		Smart Energy		
		Smart Mobility		
		Smart Buildings		
		Smart Windows		
		Smart Clouds		
		Smart Materials		
		Smart Bandages		
		Smart Factory		
		Smart Meters		
	Fact			
Urbanisation	City as a Customer	Mega Cities	cities, and not countries, will drive wealth creation in the future;	high economic power of cities; hub and spoke business model; transit oriented development; new mobility solutions;
		Mega Corridor		
		Mega Regions		
		Smart and Sustainable Cities		
	Facts	Cities like Seoul account for 50% of the South Korea's GDP; Budapest (Hungary) and Brussels (Belgium) each for roughly 45%. Top 4 Metropolitan Cities (Rhine-Rur (15% GDP), Munich, Frankfurt, Berlin) to account for 57% of Germany's GDP by 2025.		
Social Trends		Geo socialization	Demographic shifts are driving the empowerment of women; In Nordic countries women could soon have equal political power. Women are the routers and amplifiers of the social web. Certain societies are leading in the closing of gender parity (personalised vehicles: driving dynamics personalization, mood lighting; high quality materials: non wearable materials, sustainable and natural fabric; seamless connectivity: touchscreens and gesture control, NFC enabled, integration with personal devices)	
		Gen Y		
		She - economy		
		Ageing population		
		Heterogeneous Society		
		Middle Bulge		
		Reverse Brain Drain		
		Halal economy		
		Surge in Asian Work poll		
		Generational Political Shift		
	Facts	there are 117 female directors of FTSE 100 companies; by 2020 over half of millionaires in the UK will be female;		

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Innovating to Zero		Zero Waste/Emissions		Off-the-Grid Buildings; On-site Energy Harvest; Use of Intelligent Systems; Increase use of renewable energy; Net Zero Hospitals; Zero faults and zero errors in manufacturing; Highly Strict Quality; Control; Cutting Edge IT; Infrastructure and Services that convert Ideas to implementation on real-time; Instant File Sharing; Networking Interfaces; Zero Management Gaps; Zero Processing Time; Zero Learning Gaps; Energy efficient buildings; Greener Transport; Waste Reduction and Waste Recycling; Increase use of Renewable; Energy; Strong Health and Safety Measures; Safety Days (eg. Shell); Life-Saving Rules within facilities; Active safety systems in vehicles that over-ride drivers; In-house design, cutting, finishing; Continuous, speedy deliveries; Direct point-of-sale data collection; Daily analysis of product sales and customer feedback using software analytics;
		Zero Defects and Zero Faults		
		Carbon Neutral Cities		
		Complete Recyclability from Households (Cradle to Cradle Concept)		
		Zero Corporate Debts		
		Zero Emails		
		Carbon Neutral Factories and Retail Stores		
		Zero Breaches of Security		
		Zero Emissions from Cars		
		Zero Accidents		
		Zero Crime Rates		
		Facts		
	New Business Models	Value for Many	Personalization & Customization	
Co-Creation				
Pay as you go				
One-off Experience				
Facts				

Table 13 Megatrends identified in Sweden 2025 (2014)

MT	Terms and phrases		Explanations / Results / introduction	Challenges
	Level 1	Level 2		
Climate change	Sustainable social development <i>Facts</i>	social planning	great influence on how the growth of urban areas and regions takes place; contribute to potential energy in a water;	it will be necessary for social planning to be used as a tool to achieve zero net emissions by the year 2050 and to be able to respond to the changes that follow in the wake of the changed climate; protecting green areas in the cities from building development; water quality and quantity;
		assessment of planned protective inputs for water catchments, watercourses and reservoirs		
	Climate adaptive planning <i>Facts</i>	guidelines for construction near the beach or shoreline	through knowledge of the increased risks in building too near the shoreline or beachfront, the number of requests for building within the shoreline protection areas has declined; energy use and other environmental considerations have stimulated research and development; new buildings are now located in more sheltered positions;	all municipalities should have climate-change adaptation plans;
		climate-change adaptation plans		
	Development of agricultural land <i>Facts</i>	high quality agricultural land	Swedish agriculture becomes increasingly important; cultivation of crops will become profitable ever farther north;	There are areas where the agricultural land is of very high quality, at the same time as the pressure for building is very high. In these areas a careful weighing up of the interests is crucial to minimise the utilization of agricultural land as a result of pressure for social development.
		high pressure for building		
		utilization of agricultural land		
		pressure for social development		
Globalization <i>Facts</i>	Foreign trade	Swedish export sector	Iron ore and forest products will continue to be important for the Swedish export sector. Advanced technology products will be the backbone of economic development in future.	Sweden economy currently losing ground in relation to other economies. In order for Swedish and European enterprises to retain their competitive edge, continued investments in R&D are necessary
		advanced technology products		
		investments in R&D		
Urbanization <i>Facts</i>	Polycentric city structures	development of metropolitan regions	In total, Sweden has a population of more than 10 million, of whom about 6 million live in our three metropolitan regions. The population along the Norrland coast is also increasing. The high population density contributes to the favourable economic development of the entire region.	the metropolitan regions expand geographically and acquire more inhabitants; high population density contributes to the favourable economic development of the entire region; more regions are in the process of merging one with another;
		localities surrounding universities		
		multi-core urbanised regions		
		dense city centres		
		By about 2050, the growing together of the various regions will proceed to the point at which most parts of Sweden belong to one of four, multi-core urbanised regions		
Digitisation <i>Facts</i>	Internet links	Access to first-class Internet links is taken for granted and online communications are a precondition of retaining and developing living standards. Information moves around the world at lightning speed.	Society must adjust to the new needs for rapid connection and new forms of integrating and being together that shape the way we work, study and live our lives.	
		By 2025, Sweden will be a clear frontrunner in exploiting the opportunities opened up by digitisation		

Table 14 Megatrends identified in EC (2015)

MT	Terms and phrases		Explanations / Results / introduction	Challenges
	Level 1	Level 2		
hyper-connectivity and Big Data innovation	Key drivers of change	cognitive computing	Cognitive computing and artificial intelligence (AI), automation and robotics, Big Data and data mining, are key drivers of change. Data are collected from many sources and merges information from across the web, to generate a single database of facts about the world and the people in it.	Better prediction and modeling via algorithms is likely to provide huge opportunities. The Internet of Things will raise issues of data storage and access, and citizen access to analytics will be a developing area of business opportunity. In transport, expert systems will combine with automation (autonomous vehicles continuously communicating with other vehicles and the infrastructure) and big-data techniques, to optimise not only traffic flows but also the design of transport systems, and infrastructure investment and management.
		artificial intelligence		
		automation and robotics		
		The Internet of Things		
		Big Data and data mining		
	Facts			
falling cost of energy	Key drivers of change	reliable and robust infrastructure	Solar and wind energy are becoming competitive with fossil fuels, even though current prices for the latter are low. Energy and transport are inextricably linked – transport is one of the major uses of energy and shares with it the requirement for a reliable and robust infrastructure. In the field of energy there is likely to be a significant shift towards renewable energy – but the pace and extent of change will depend on the ability to achieve reliable and secure supplies of energy. Renewable energy is an important component of the efforts to mitigate climate change.	In both energy and transport, smart cities will seek to develop cleaner, more sustainable services provision, and there is likely to be a move to more efficient energy trading as batteries decrease the reliance of individuals on the grid, and enable individual energy provision. Fossil fuels may well become cheaper, as demand falls in developed countries, and as new sources emerge – for example shale oil and gas. In transport, the move towards automatic vehicles, non-carbon fuels and materials, and smarter logistics will all lead to major changes in the transport infrastructure. Alongside the development of cleaner vehicles, there will need to be the development of a transport infrastructure to support these vehicles.
		renewable energy		
		reliable and secure supplies of energy		
		move to more efficient energy trading		
		move towards automatic vehicles		
		move towards non-carbon fuels and materials		
	Facts			
migration & changing demographics	Key drivers of change	globalisation	vastly increased availability of information; increasing facility to travel; decline in the power of nation states over corporate and individual actors; states fail and wars, environmental and humanitarian catastrophes form people's everyday reality; Waves of migrants and refugees will bring predominantly young people, talented and eager to work, to Europe. Migration will alleviate environmental pressures in other parts of the planet.	It will be a challenge for Europe to make positive use of the increasing diversity in order to benefit from advancing globalisation. The challenge is the arrival of people from outside the EU. Migration will become a bigger challenge in Europe, as incoming populations need to be included in environmental impact calculations and in sustainable local societal practices. Migration to the cities from rural areas, and immigration from outside Europe, will change the nature of cities.
		waves of migrants and refugees		
		environmental impact		
	Facts			

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health as a major driver	Key drivers of change	higher expectations for health	Demographic trends (ageing, migration), climate change and natural disasters, anti-microbial resistance, higher expectations for health in a context of increasing health costs per se, will all put high pressure on health systems. Sustainable environment is a healthy environment, one which preserves the health of current and future generations. Developments in ICT offer the prospect of personalised medicine, in which there is faster prevention and diagnosis. Data availability and Big Data analytics are driving the understanding of the influence of genetic and environmental factors and their combinations, raising individual aspirations and demands for healthy longevity.	<p>Developments in preventive medicine will have three potential effects:</p> <ul style="list-style-type: none">potentially valuable source of economic activity and innovationdemand for (and the cost of) improved health services and health outcomeschange the relationship between clinicians and patients <p>Human enhancement and robotic (assisted) care are two radical opportunity spaces that are driven by health considerations.</p>
		healthy environment		
		prospect of personalised medicine		
		Data availability and Big Data analytics		
		Human enhancement and robotic		
	Facts			
facing climate change	Key drivers of change	adaptation to climate change	Innovation is likely to be increasingly shaped by the needs for mitigation and adaptation to climate change, as climate models provide estimations on the likely future environmental conditions. The governance of space science and technology has been shifting from an exclusive state affair to a business model where states, private companies and billionaires interplay. Climate services are seen as an emerging business sector with high potential.	<p>The increasing demand from users creates a need to “manage” space and the oceans better. The drive to explore unexplored places, in space as well as in the ocean, will continue to be strong. Dramatic climatic or geological events will accentuate the sense of urgency for more monitoring services and research. Projects of taming outer space will face important technical barriers.</p>
		governance of space science and technology		
	Facts			
sustainability and well-being	Key drivers of change	Demographic and economic development	The primary sectors and their rural-urban landscapes, city-scapes and ecological assets are the physical basis for Europe's future. Each of these sectors is under growing pressure from demographic change, economic restructuring, technological innovation and in particular from climate change. Demographic and economic development are combined with resource scarcities.	<p>Development of new societal models for science, policy, enterprise and development could involve transformations of the rural landscapes. Establishing security of supply of food and materials is driving geo-engineering pursuits as much as, or more than, climate change. The challenge is to support a vibrant environment of innovative small businesses taking advantage of streams of innovations coming from biotechnology, materials science and ICT and from their combinations, an example is in water treatment.</p>
		resource scarcities		
		involve transformations of the rural landscapes		
		security of supply of food and materials		
		vibrant environment of innovative small businesses		
	Facts			

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Biotechnology	Key drivers of change	acceleration of biotechnology	The acceleration of Biotechnology, driven by developments such as gene editing, will be transformative. Biotechnology will revolutionise nearly all aspects of healthcare. Genetic engineering modifies or introduces new metabolic processes into bacteria, yeasts and higher organisms. ICT with data techniques and the increasing availability of genetic information accelerate biotechnological advances. Earlier diagnosis and prevention of ill-health is likely to accelerate demand for healthcare.	development of new food varieties; creation of biological sensors to detect and measure a wide range of conditions, with environmental or medical applications; biotechnology can be used to promote other sustainability traits in a range of production processes.
		new metabolic processes		
		Increased availability of genetic information		
		accelerated demand for healthcare		
		new food varieties		
	Facts	more than 80% of the total soybean meal use - one of the biggest ingredients in the EU livestock and poultry feed - by EU member states is estimated to be GM;		
instability – new norm in global society	Key drivers of change	economic and political instability	Economic and political instability combine with an accumulation of problems related to climate change, desertification, and severe perturbations of the water/energy/food nexus to produce rising migration and social unrest, potentially including in the EU.	The need for the design of systems able to be resilient against instability. Securing food and water supply chains against environmental catastrophes. Essential hyper-connectivity should be resilient to system breakages.
		rising migration and social unrest		
		resilient system against instability		
		securing food and water supply		
	Facts			

Table 15 Megatrends identified in Ernest and Young (2015)

M T	Terms and phrases		Explanations / Results / introduction	Challenges
	Level 1	Level 2		
Digital future	Digital transformation	cloud computing	distribution of goods and services via digital channels (cloud); Subscription-based revenue models; micropayments such as “freemium” and pay-per-use models	companies reassess and adapt their pricing strategies, sales processes and distribution models; issues related to for revenue recognition and customer privacy; changing customer engagement and business models;
		connected devices - “Internet of Things”		
		Mobile		
		social media		
		Big data analytics		
	Facts	80% of companies see changes in how their customers access goods and services; 51 % of these companies are changing their pricing and delivery models		
	“mobile first” world		Interaction between customers and brands through mobile devices; Mobile devices are also becoming preferred tools for work and communication; companies are building applications and interfaces on a mobile platform first, not for the desktop or web browser	IT infrastructure of companies need to support the latest mobile technologies;
	Facts	Webpage views from mobile phones are gaining share — from 17% in 2013 to nearly 29% in 2014; Consumer spending via mobile will increase from US\$204b in 2014 to US\$626b in 2018;		
	Proliferation of data	Data from social media	Companies that can extract value from this information using data analytics will gain a more precise understanding of customer segments; Products and services can be tailored to the level of the individual; consumers' expectations are growing	Issues related to the possibilities of companies to control messages about themselves; companies need to increase transparency, while proactively cultivating and managing relationships with their stakeholders and customers
		Online shopping behavior		
		Geo-location information		
		Individual “prosumers”		
	Facts	Companies are failing to use approximately 80% of customer data now generated		
	Digital disruption	best-of-breed platforms	companies are pricing and delivering their products as a service via the cloud; companies develop their own digital platforms providing innovative solutions to meet the unique needs of their customers and partners;	Companies in digital ecosystem may be partners in one market segment and competitors in another - buying and implementing digital technologies from their competitors, as well as competing with their existing technology business partners in the market offering similar vertical solutions
	Facts	one-third of the top-20 companies in most industries will be disrupted by industry-specific data platforms n 2018		
	cyber threats	data breaches	organizations' data are more accessible and vulnerable due to greater use of the internet, smartphones and tablets; more access points to company and personal data as digital connections between entities and people increase.	companies, organizations and governments will need secure digital assets and protect confidential information
		cybercrime – theft of data		
bring your-own-device policies				
Facts	In 2013, cyber attacks compromised 800+ million record; Digital crime and IP theft currently costs between \$375b and \$575b per year — eclipsing the annual GDP of most nations			
Work-styles	virtual workforce	Workforce connected to work anytime, from anywhere, and on any device	skills and resources on demand (rather than owning) hampers efforts to keep widely distributed workforces motivated, productive and satisfied	
	online “crowdsourcing”	workstyles will be matched		
	freelance platforms	by new means of engaging with talent		
	Facts	By 2020, 50% of the workforce will be Generation Y and Z members — and they have grown up connected, collaborative and mobile		

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	robotic technologies	artificial intelligence machine learning computer processing power sophisticated mobile robotics	Automation impacts on all work categories, not just those that require routine; New opportunities to develop, service or operate the next generation of software and machines will arise requiring advanced skills	large number of individuals will be relegated to lower-skilled service occupations that cannot easily be mechanized, or to the unemployment line; governments and educational system will be under pressure to develop and retool workers to operate in the new environment
	Facts	47 % of occupations in advanced economies are at “high risk” of being automated in the next 20 years		
Entrepreneurship rising	rapid-growth markets	High TEA (Total Early Stage Entrepreneurial Activity) Index	the percentage of individuals aged 18 to 64 in an economy who are in the process of starting or are already running new businesses;	entrepreneurs launch businesses out of necessity
		innovative rapid-growth market startups	creating a product, service or process that represents a significant commercial opportunity	
	High-impact entrepreneurs	transformative businesses	start-ups making high impact on mature markets (Google, Facebook, Twitter, Virgin Airlines, andGoPro);	
		frugal innovation	offering lower-cost products and services tailored to unmet and local market needs.	
	Young entrepreneurships	Youth unemployment	young people are increasingly turning to entrepreneurship;	along with training, young entrepreneurs across the G20 need additional support to launch and scale their enterprises
		entrepreneurial education		
		ILO reports that globally, almost 13% of young people (close to 75 million people) are unemployed; more than 5,000 entrepreneurship courses are offered in the US today, compared with 100 in 1975; nearly 50% of the world’s entrepreneurs are between the ages of 25 and 44.		
	Women entrepreneurs	Women’s entrepreneurial ventures	increasingly important source of new jobs	Access to finance remains a hurdle for female entrepreneurs; Policy-makers and other stakeholders to create enabling environments for female entrepreneurs across the globe
		women-run SMEs		
		today, roughly 126 million women are launching or operating brand new businesses in 67 economies around the world; at least 48 million female entrepreneurs and 64 million female business owners currently employ one or more people in their businesses; across the globe, there are roughly 8 million to 10 million formal SMEs with at least one woman owner.		
	Entrepreneurial growth	supportive environments	essential to successful entrepreneurship and these are evolving across the world.	urgent action needed to improve support for their entrepreneurs Elimination of tax on capital gains Relaxation of rules preventing foreign investment
		access to funding;		
		entrepreneurial culture;		
	supportive regulatory and tax regimes			
educational systems				
Facts	entrepreneurial ventures are currently responsible for 75% of new jobs each year and 68% of exports – focus on improving the regulatory and tax environment for new ventures and SMEs;			
Access to funding	lack of funding	Smart governments are creating a range of mechanisms and institutions to provide entrepreneurs with financing options to meet these changing requirements; CGSs used by banks, often with public sector support, to ease the constraints SMEs face in accessing finance	primary reason for business discontinuance around the world; private sector investors to focus more on startups through improved taxes’; crowdfunding and microfinance require regulatory support to achieve scale.	
	crowdfunding market			
	microfinance			
	tax incentives			
	credit guarantee schemes - CGSs			
Facts	Crowdfunding market for developing countries – which was US\$5b in 2013 — could rise to US\$96b by 2025, since there are 344 million households in rapid-growth economies capable of making crowd funding investments in their local communities			

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Global marketplace	rapid-growth economies		Shifting of global economic power the east and south	shift in economic power will force major adjustments in strategy of all companies with global ambitions
	Facts	By 2030, rapid-growth markets will comprise 63% of global GDP, up from 38% today and amounting to US\$223t.		
	Trade-off patterns	continued transformation	world's fastest-growing trade routes are Asia-MENA, Asia-Latin America and Asia-Africa; Middle East and Africa will become new trade hubs, driven by economic integration with Asia, proximity to Europe, capacity for low-cost production and growing domestic markets;	economies will remain highly interdependent through trade and financial system linkages, need for stronger global policy coordination among nations need for resilient supply chains for companies
		fragmentation of supply chains		
		high levels of market integration		
	Facts	Global merchandise trade is forecast to grow 8% annually to 2030, and should outpace GDP growth		
	share of capital inflows and outflows	gross capital inflows and outflows	including foreign investment, equity and debt portfolio investment, bank loans and other investment	national policy-makers to create more businessfriendly investment environments in rapidgrowth markets; volatility, particularly political, could also continue to deter FDI inflows in rapidgrowth markets
		foreign direct investment (FDI)	developing countries more attractive sources and destinations for capital flows	
		greenfield investment		
	Facts	By 2030, rapid-growth markets will account for 47% of gross global inflows up from 23% in 2010.		
	growing global middle class	emergence of lucrative new markets	fast-growing countries are becoming prime markets for global and home-grown companies	competition is increasing
		middle income consumers	Rapidly growing, young populations combined with strong economic growth; new Asian middle class;	companies need to carefully position their brands and portfolios to meet the needs of increasingly empowered and diverse consumer bases
		Facts	The World Bank projects that 50% of the total global stock of capital will reside in the developing world by 2030 (up from 33% in 2010) Two-thirds of the global middle residents by 2030, up from just under one-third in 2009	
	new knowledge world order	shift in knowledge production	rapid-growth markets are steadily increasing their academic and research output, particularly in Asia (China); Chinese companies have begun to outsource manufacturing to Africa, South America and the Middle East;	
		homegrown innovation		
		outsourcing of services		
	Facts	By 2022, China is expected to overtake the US as the largest global spender on research and development (R&D)		
	war for talents	worldwide competition for qualified talents	Many emerging market invest more in education have rapidly expanded the number of college graduates that they produce; By 2025, the South rather than the North may become the major source of technical talent in the global economy;	Difficulties of employers when trying to find employees skilled in science, technology, engineering and mathematics
		labor market pressures		
		multicultural workforce		
	Facts	gender-balanced workforce	In 2015, 54% of college graduates were from leading emerging market countries — in 10 years it will be 60%.	
	Global cities	Global urbanization	Asia and Africa are urbanizing at the fastest rate among regions; urbanization will drive the world's future economic growth; shift in spending power to urban areas	
		Facts	By 2030, the world's 750 biggest cities will contribute 61% of total world GDP — close to US\$80t (in 2012 prices) and will gain 220 million additional middle-class consumers.	

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Urban world	Aging populations	“old” and “new” cities	Young populations create large and productive labour forces	young populations drive unrest in countries with underemployment and other social ills; aging populations leave the workforce without an adequate younger cohort to replace them, depressing growth and straining public resources;	
	Facts	a full 90% of the 0–14 age group residing in cities on the top 750 cities list will live in Africa in 2030			
	economic order of cities	shift eastward	balance of economic power held by cities will shift eastward;	mid-sized cities will be the fastest-growing urban economies over the next 15 years; mid-sized cities will be potential new markets of global companies; mature markets will retain some of the largest and most important urban centers in the world	
		mid-sized cities			
	Facts	by 2030, 40% of the 50 largest cities in the world in terms of constant-prices GDP will be in China; five of the top six cities in 2030 will be traditional centers of business and commerce: Tokyo, New York, Los Angeles, London and Paris.			
	Urbanization	sector shifts	shift from agriculture to manufacturing (Africa) jobs growth in the industrial sector (Asian cities) high land and labor costs (mature market cities) manufacturing expansion (rapid-growth market cities)	need to build new infrastructure in emerging cities; upgrading infrastructure in mature market cities;	
		change of employment patterns			
	Facts	Beijing, Lagos and Mumbai are all expected to create more financial service sector jobs than London from 2013 to 2030.			
	investment in infrastructure	high-quality infrastructure	financing infrastructure projects using PPP models	many emerging nations builds new urban infrastructure from scratch; many developed nations face the problem of aging infrastructure; recommendations for actions of G20 nations: <ul style="list-style-type: none">• setting specific targets for infrastructure in their national growth plans;• establishing a Global Infrastructure Hub and• increasing the availability of long-term financing for investment	
		Public-private partnership (PPP) models			
	Facts				
	Sustainable and resilient urbanization	resource risks	energy-efficient buildings, reduced waste relying heavily on renewable energy sources and energy efficient transportation systems use of state-of-the-art ICT to build smart mobility solutions, smart grids		
		global resource depletion			
		more sustainable cities			
		“Green” cities			
		“smart” cities			
		“smart” mobility solutions			
		“smart” grids			
	Facts	Roughly 50% of the urban population being monitored (12% of the total global urban population) exposed to air pollution – at least 2.5 times > WHO recommended levels; 70% of primary energy consumption and 80% of global GhG emissions are derived from cities, while up to 80% of the US\$100b per year in climate-adaptation costs will be assumed by urban areas.			
	Reducing urban poverty and margin. populations	social problems	not all citizens are reaping the positive aspects of urbanization	municipal governments struggle to provide the basic requirements — adequate food, water, health care, and shelter — to slums and informal settlements; crime; traffic congestion; air pollution; unsafe food and water supplies;	
		unplanned growth			
Facts	nearly 1 billion people currently live in slums; over the next 15 years, the number of global slum dwellers is expected to double to 2 billion people.				

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Resourceful planet	limited resources	energy, commodities food and water	increase the demand for energy, commodities food and water; technological developments have allowed for access to resources previously thought impractical or impossible to recover;	accessing new sources of supply will be increasingly difficult and expensive governments to put a price on resource security through taxes and regulations;	
		finite limits of resources			
		technological developments			
		new sources of supply			
		competition for natural resources			
	Facts	1.2b increase in world population by 2030; 33 % increase in global energy demand by 2035;			
	global energy mix	shale formations	Natural gas released from shale formations Oil produced from tight formations; shift away from traditional suppliers in Eurasia and the Middle East to suppliers in North America, Australia, Brazil and Africa; renewable energy will grow rapidly as clean technologies become more cost competitive;	Oil and gas companies will need to adjust their production and spending plans to meet the demands of shifting price environments; countries to develop expertise, sign technology transfer agreements and find cost-efficient ways to unleash the potential of unconventional resources; new models and sources of financing significant infrastructure demands due to changing energy mix and empowerment of consumers;	
		tight formations			
		shift in global energy production			
		newly found or exploitable unconventional energy sources			
		renewable sources			
		clean technologies			
	Facts	Over the next 20 years, unconventional sources of oil will contribute to 70% of oil supply growth, while unconventional sources of gas will account for almost 50 % of increases in global gas production; By 2030 the share of electricity generated by renewable energy could reach 50 %.			
	water scarcity	water usage	water usage has been growing at more than twice the rate of population growth in the last century;	Rise of the need to reconcile the demands of food production; accessing dwindling water supplies for energy production or private consumption will become harder;	
		water shortage			
		water withdrawals			
		energy and food production			
		Facts			The UN estimates that by 2030 demand for water may be 40% more than supply, and water shortages could affect almost 50% of the world's population; by 2030, freshwater shortages could cause a 30% reduction in grain production; by 2025, water withdrawals will increase by 50% in emerging countries and 18% in developed countries;
	climate changes	extreme weather events	climate change impacts are already accelerating instability in vulnerable areas of the world and are serving as catalysts for conflict; incidence of extreme weather events has increased	need to create resilient infrastructure due to grow of urban population; need for new funding models; move toward lower-carbon economies (carbon taxes and emission trading programs) need to include carbon costs into decision-making processes of companies;	
		resiliency			
		Impact on urban centers			
		Facts			The UN forecasts that the number of people in large cities who are exposed to cyclonic winds, earthquakes and flooding will more than double in the first half of this century;
	transparency and security of global supply chains	supply chain risk management	systemic disruptions to global supply chains due to environmental, geopolitical, economic and technological triggers;	companies are at risk of suffering serious reputational damage in real time if their social and environmental performances is below average level; companies are at need to apply with more powerful means of communication	
		systemic disruptions to global supply chains			
		raw material traceability			
		transparency of sourcing strategies			
		Facts			

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Health reimaged	health care reform initiative	new delivery and payment models		need for new delivery and payment models based on outcomes and value; need to increase the transparency of information on quality, price and other metrics — enabling patients and others to make better decisions	
		transparency of information			
	Facts	13% of adults in France and 6% in the UK have serious problems in paying medical bills			
	incidence of chronic disease	global chronic disease epidemic	ageing population contributes to the increase of global chronic disease epidemic; number of chronically ill individuals across the globe will also swell due to increasing incomes, changed diets and increasingly sedentary lifestyles in rapid-growth markets;	new approaches to driving desirable behavioral change (tobacco use, harmful use of alcohol, physical inactivity and poor diet) are required;	
		ageing population			
	Facts	non-communicable diseases account for 75% of health care spending and will cause a loss of US\$47 trillion to world GDP by 2030			
	mobile and social health solutions	mobile health technologies	empowerment of patients with more transparent information and more control over their health; creation of real-time data and provision of real-time interventions;	need to integrate mobile health technologies into our everyday life	
		smartphone apps			
		wirelessly connected medical devices			
		social media			
	Facts	global mobile health and fitness sensor market will grow at 40% CAGR between 2013 and 2018 social media channels will generate significant health care data – from 50 petabytes today to 25,000 petabytes by 2020			
	Big data in health care	electronic health records	utilization of “big data” technologies and analytics in the service of health care (from drug R&D to care-coordination)		
		payer claims			
		pharmacy data			
		mobile health technologies			
		“big data” technologies			
	Facts				
	Genetic/genomic info	drug development		New drug discovering programs based on genes and gene products	
		new therapies			
		denes; gene products			
	Facts				
	personalized medicine	personal genome sequencing	price of personal genome sequencing has failed significantly, so manufacturers are increasingly focused on personalized medicine approaches;		
		targeted therapeutics			
Facts					
entrants from non-traditional fields	telecommunications firms	Companies from sectors once far removed from health care are developing approaches to empower patients with their personal health management;			
	ICT				
	data analytics				
	Retailers and food manufacturers				
Facts					

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Table 16 Megatrends identified in Lindekugel (2015)

M T	Terms and phrases		Explanations / Results / introduction	Challenges
	Level 1	Level 2		
Shifting Demographics	Urbanizing Populations	infrastructure challenges	Massive movement toward cities is leading to infrastructure challenges for governments	Urban infrastructure solutions need to be smart and sustainable to absorb additional 2.6B people by 2050
		movement toward cities		
		urban infrastructure solutions		
	Facts	Fertility rates have been dropping across the world while life expectancy continues to rise. By 2050 over 21% of people worldwide are projected to be above the age of 60.		
	Burgeoning Middle Class	migration to cities	Migration to cities and industrialization of developing markets will grow the middle class.	
		industrialization		
		developing markets		
		grow the middle class		
	Facts			
	Evolving Face of Healthcare	increased life expectancy	Increased life expectancy and a global push for access to healthcare are driving businesses to reengineer offerings	
		access to healthcare		
	Facts			
	Rising Workforce Burden	workers support more dependents	Fewer workers must support more dependents as the graying population retires and ages	
		population retires and ages		
	Facts			

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Expanding Digital Economy	Collaborative Economy	sharing assets	Knowledge, capital, labor and other assets are shared in new ways through digital platforms	
		digital platforms		
	Facts			
	Omni-Channel Experience	consistent messaging	Customers expect consistent messaging, information and experiences through integrated channels	
		integrated channels		
	Facts			
	Big Data and Advanced Analytics	storage, aggregation and analysis of data	Storage, aggregation and analysis of data create insights, and ultimately, foresights.	
	Facts			
	Internet of Things (IoT)	changing decision making process	Physical objects that sense and communicate are changing how and where decisions are made.	
Facts				
Evolved Manufacturing	Digitization	Digitization is transforming not only the products around us, but also the way they are made		
Facts	by 2020 there will be over 4 billion Internet users and 80 billion connected devices worldwide; B2B online retail market is expected to be worth \$12 trillion by 2020 (<i>six times the size of the B2C market</i>);			

Table 17 Megatrends identified in PWC (2015)

MT	Terms and phrases		Explanations / Results / introduction	Challenges
	Level 1	Level 2		
Demographics		population growth	Most of the developed economies are expected to experience low levels of population growth. The impact of a declining, ageing population is significant in restricting any country's ability to increase its share of world GDP in a similar way to other large emerging economies.	Importance of structural reforms and institution building aimed at boosting the productivity element of growth. Increases in labor productivity will account for all of its economic growth. An ageing population also acts as a drag on country growth in the longer term relative to that of country with big growth of population.
		ageing population		
	Facts	All of the countries, with the exception of India, are projected by the UN to see a declining share of their total populations in the prime 15-59 working age group between 2014 and 2050.		
Education level	education levels in the workforce	quality of labour	Growth in the quality of labour ('human capital') is assumed to be related to current and projected average education levels in the workforce. Must be a strong commitment to developing human capital and entrepreneurship through improving education and rising education levels.	Downside risks are associated with shrinking workforces in some countries being impaired by insufficient competition in, or resource allocation to, or staff incentives in, education. Economy grow requires sustained economic reforms and increased investment in infrastructure, institutions and mass education.
		education levels		
		human capital		
	Facts	The fastest educational catch-up rates are assumed to be seen in Asian countries such as India and Indonesia, which is consistent with trends in recent periods and is an important factor in their relatively strong projected growth performance.		
Capital investment		physical capital stock	Growth in the physical capital stock is driven by new capital investment. With declining marginal returns on new investment over time, the very high investment/GDP ratios in developing countries will tend to decline in the long run as these economies mature.	Downside risks associated with shrinking workforces in some countries being impaired by capital investment
		investment/GDP ratios		
	Facts	Initial average annual investment/GDP ratios, which vary from around 6% in Nigeria to around 36% in China, will adjust gradually to long run investment levels after 2025 that vary more narrowly from 8% in Nigeria to around 25-30% in some Asian emerging economies.		
Technological progress		technology transfer	Technological progress is assumed to be related to the extent to which a country lags behind the technological leader and so has the potential for 'catch-up' through technology transfer, conditional upon levels of physical and human capital investment and other more institutional factors such as political stability, openness to trade and foreign investment, the strength of the rule of law, the strength of the financial system and cultural attitudes to entrepreneurship. An appropriate degree of intellectual property rights protection can stimulate technological progress and other forms of innovation.	Economy growth through technological progress is only intended to produce projections for long-term trend growth. It ignores cyclical fluctuations around this long-term trend, which history suggests could be significant in the short term for emerging economies in particular, but which we cannot hope to predict more than a year or two ahead at most. It also ignores the possibility of major adverse shocks (e.g. political revolutions, natural disasters or military conflicts) that could throw countries off their equilibrium growth paths for longer periods of time, but which are inherently impossible to predict. GDP growth is driven by technological progress, which drives improvements in total factor productivity
		human capital investment		
		factor productivity growth		
		degree of intellectual property rights		
		GDP growth		
	Facts			

Table 18 Megatrends identified in OECD (2016)

MT	Terms and phrases		Explanations / Results / introduction	Challenges
	Level 1	Level 2		
Demography	growing global population	larger global population	more consumers; innovators and researchers at a global level; increase importance of innovation agendas;	need to manage the multiple development challenges this trend creates;
		demands and needs of the centers		
		technology transfer		
	Facts	from 7.4 billion in 2015, the global population will reach 8.5 billion by 2030 and 9.7 billion by 2050; Africa's population will more than double by 2050 and account for more than half the global population increase;		
	aging societies	social and health spending	slower economic growth and resources diverted to social and health spending; influence the types of products and services in demand and the direction of innovation; could help the elderly live longer, healthier and more autonomously;	This could draw resources away from science, technology and information (STI) spending
		lifestyles and consumption patterns		
		direction of innovation		
	Facts	The older population (80+) will be predominantly female in 2050.		
	labour / international migration	ageing research workforce	fewer people of working age will affect the labour market for STI skills and could lead to an ageing research workforce in OECD countries; robotics and artificial intelligence, could alleviate expected labour shortages in the wider economy;	the flow of highly skilled migrants into OECD countries is likely to intensify, further contributing to the STI labour force;
		robotics and artificial intelligence		
labour shortages				
highly skilled migrants				
Facts	Migrant workers will be an important factor to mitigate the effects of ageing in most OECD countries.			
Natural resources and energy	promise of innovation	new STI knowledge	new STI knowledge could improve the monitoring, management and productivity of natural resources and, ultimately, decouple economic growth from their depletion;	technology diffusion efforts will be as important as developing new technologies and should promote wide adoption of best available technologies for efficient resource use;
		technology diffusion		
		efficient resource use		
	Facts	Price increases for most agricultural commodities will likely affect the poorest populations the most.		
	Agriculture, food and water	water-food-land resources	growing tensions on water-food-land resources; new innovative agricultural technologies and methods could help increase land productivity in a more sustainable way; new technologies will play a central role in adapting agricultural practices to climate change and more extreme weather-related conditions; improvements in irrigation technologies and new agricultural practices should help better monitor water use and slow groundwater depletion;	South and East Asian countries will continue dominating overall aquaculture production, with China, India, Indonesia and Viet Nam accounting for the majority of projected growth; new generation of wastewater treatment plants using advanced technologies will be needed to deal with the challenge of micro-pollutants from medicines, cosmetics, etc.
		innovative agricultural technologies		
		adapting agricultural practices to climate change		
		improvements in irrigation technologies		
		new generation of wastewater treatment plants		
	Facts			

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	Energy	onshore wind and solar photovoltaics	onshore wind and solar photovoltaics are ready to be mainstreamed, but high levels of deployment will require further innovation in energy storage and smart grid infrastructure to increase their adaptability to weather variability;	Cities could play a leading role in deploying these smart innovative approaches.
		advanced energy storage technologies	The Internet of Things and advanced energy storage technologies offer opportunities to better monitor and manage energy systems.	
	Facts	economic growth in non-OECD will drive further increases in global energy consumption; Asia will account for around 60% of the total increase;		
Climate change and environment	International coordination	climate change mitigation and adaptation	require greater international co-operation on solutions; GHG emissions by 2050, mostly driven by energy demand and economic growth in key emerging economies;	climate change mitigation and adaptation will depend on technology transfer to less advanced countries, which are set to account for the largest increases in GHG emissions over the next few decades due to their rapid development;
		environmental degradation		
	Facts	CO2 emissions account for 75% of global GHG emissions, with most coming from energy production;		
	Multi-actor perspective	governments play a leading role to low carbon societies	governments are expected to play a leading role in enabling the transition to low carbon societies; the private sector leads innovation efforts in enabling the transition to low carbon societies;	Biodiversity losses will include Asia, Europe and southern Africa.
		private sector leads innovation		
		Internet of Things	smart apps and sensors will enable a closer monitoring of climate change, ecosystems and biodiversity;	
	Facts	Big data monitoring	big data will generate large amounts of novel data that could support new research practices;	
60% of the world's biocapacity is held by only ten countries that suffer most from heavy land and forest degradation				
Globalisation	International R&D cooperation	answer to the global economy	R&D cooperation appears in this context as a strategic answer to the global economy, allowing enterprises to seek partners who provide the best opportunities for learning and innovating, regardless of their location; globalisation will continue to facilitate the wide diffusion of knowledge, technologies and new business practices and will itself be deepened by this diffusion;	crime increasingly globalized; tax evasion has turned global; international agreements and Initiatives will further international co-operation in research and direct it towards global grand challenges; national STI policy could be framed increasingly in global terms, reflecting the global nature of many problems and issues, and the globalisation of markets and production;
		diffusion of knowledge, technologies and new business practices		
		globalisation of markets and production		
	Facts			
	Business R&D	internationalization of R&D	business R&D and innovation are increasingly global; multinational enterprises could internationalise their R&D at a faster pace and on a larger scale than before;	in a globalised economy, compatibility and interface across borders are ever more important; global value chains could further encourage national industrial specialisation and an increasing concentration of innovation capacities;
encouragement of national industrial specialisation				
concentration of innovation capacities				
Facts	USD 100-240 billion could be lost annually due to tax avoidance. This is 4% to 10% of global corporate income tax revenues.			

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	Human mobility	Highly educated individuals	knowledge circulation worldwide between highly educated individuals at different stages of their professional careers; digital technologies enables individuals to maintain regular contact with friends and families for example;	countries and institutions will be engaged in a global competition for talent to build their own centres of global scientific excellence;
		Digital technologies		
		International mobility		
Facts		by 2020, some 940 million (M) online shoppers are expected to spend almost USD 1 trillion on cross-border e-commerce transactions;		
Role of governments	Relations with S&I	governments guarantees scientific autonomy;	governments will continue to play an essential role in guaranteeing scientific autonomy and supporting fundamental science; governments will continue to collect and increasingly make open large amounts of data that are useful for research and innovation;	the shift to a more multipolar world may increase security uncertainties and possibly spark new arms races, which would likely influence government spending on STI; governments will likely become increasingly proactive in promoting green innovation, using funding for R&D, tax incentives, innovative procurement, standards and regulation;
		governments to make open large amounts of data		
		shift to a more multipolar world		
		Facts		
	Government capacity	governments largest investors in public R&D;	governments will remain the largest investors in public R&D; mounting debt burdens, dwindling tax revenues and rising expenditures on pensions and healthcare could compromise their capacity to fund STI activities at current levels. Governments innovate, conduct experiments and rely on digital technologies for policy formulation, delivery and evaluation.	technological change will present governments with new challenges to manage innovation rents, e.g. through competition policy, and workforce re-skilling, e.g. through education;
		expenditures on pensions and healthcare could compromise funding of STI activities		
		digital technologies for policy formulation		
		technological change		
	Facts	pensions are to grow from 9.5% of GDP in 2015 to 11.7% in 2050; health and long-term care are to grow from 6% of GDP in 2010 to 14% in 2060 without policy action;		
	Non-state actors	rise of megacities	megacities may become the epicenter of social, economic and political development, displacing national states in some instances; cities and regions will become increasingly significant public funders of research and innovation;	rise of megacities is a challenge to nation states; governments will increasingly partner with businesses, NGOs and philanthropists to support STI, which will influence public research agendas;
		significant public funders of research and innovation		
		Facts		
Economy, jobs and productivity	Future productivity	world economy is shifting southeast	the centre of gravity of the world economy is shifting southeast; given population ageing, future income growth will be increasingly driven by innovation and investment in skills;	declines in knowledge-based capital accumulation, together with “winner-take-all” business dynamics, could slow the arrival of breakthrough innovations and their diffusion across economies; Asian economies are expected to climb up the global value-addedLadder; these changes will be accompanied and, in part, driven by big investments in STI;
		innovation and investment in skills		
		slow of the arrival of breakthrough innovations		
		Facts		
	Digital technologies	digital platform economy	digital technologies will further disrupt all sectors; a digital platform economy is fast emerging, creating greater opportunity for entrants – including individuals, outsider firms and entrepreneurs – to succeed in new markets;	the growing maturity and convergence of digital technologies are likely to have far-reaching impacts on productivity and income distribution;
		far-reaching impacts on productivity and income distribution		
		Facts		

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	Future jobs	advances in machine learning	advances in machine learning and artificial intelligence and digital platforms are likely to create new jobs for non-standard workers that, as yet, have not even been imagined;	advances in machine learning and artificial intelligence are expected to expand the capabilities of task automation and could lead to a further hollowing out of employment and wages; Less manufacturing jobs; more jobs in R&D-intensive industries;	
		advances in artificial intelligence			
		less manufacturing jobs			
		more jobs in R&D-intensive industries			
	Facts	One in ten jobs in the OECD area could be automatable over the next decade.			
Society	Social agendas	influencing STI policy agendas	Increasingly influencing STI policy agendas	could lead governments to use broader notions of research impacts in their assessments;	
		impact of research on governments assessments			
	Facts				
	Science and innovation in society	highly-educated citizenship	communication habits by the following generation are: <ul style="list-style-type: none">• Silent generation: Purchase of a principal residence,• Baby boomers: Job security,• Generation X: Work-life balance,• Millennials: freedom and flexibility,• Generation Z: security and stability highly-educated citizenship increasingly interested and engaged in the debates around the direction of STI developments;	transforming societies, altering the ways in which people live, work and communicate; ubiquitous connectivity will support more flexible working arrangements, though with uncertain consequences for work-life balance; ICTs, synthetic biology, additive manufacturing, nano- and micro-satellites, and advanced energy storage – will empower individuals and social collectives (e.g. NGOs) to conduct their own research and innovation activities;	
		more flexible working arrangements			
		individuals and social collectives conduct their own research and innovation activities			
		Facts			
	Urbanisation and consumption	“smart” urban areas	urban areas will become increasingly “smart”, influencing the direction of innovation in sectors such as housing and transportation; a growing middle class and increasing consumption in emerging economies will increase demand for innovative consumer goods worldwide;	urban development in many developing countries will present health challenges, including the increasing risk of global pandemics. These challenges could have a significant influence on future research agendas.	
		growing middle class			
		increasing consumption in emerging economies			
		Facts			nearly 90% of urban expansion will take place in Asia and Africa – by 2030, it will more than double; Asia will host 64% and account for over 40% of global middle-class consumption;
	Health, inequality and well-being	Innovation and inequality	innovation may increase inequality	innovation will increase inequality as benefits predominantly accrue to innovators and possibly their customers - for all actors in society to benefit, innovations must diffuse; technologies can directly promote social inclusion and economic growth; digital technologies have opened up access to education, financial services and other knowledge-based services;	most new technologies require new sets of skills to use – this possibly contributes to unemployment and inequality, and highlights the need for skills training; new concepts such as social innovation, frugal innovation, inclusive innovation and social entrepreneurship are leading to new innovative business models and can contribute to a more inclusive approach to innovation;
innovations must diffuse					
open up access to education					
require new sets of skills to use					
new innovative business models					
Facts		income inequality increased in most OECD and BRICS countries;			
Health innovation		extension of life expectancy	extension of life expectancy and improvements in quality of life over the last century can be attributed to the success of biomedical research and innovation; pharmaceutical research is entering a new era of open science and the use of converging technologies to uncover the genetic and biochemical underpinnings of diseases;	threat of growing antimicrobial resistance; digital technologies massively increase the amounts of medical data available and enhance the power of data analysis in the service of healthcare decision-making	
		improvements in quality of life			
		biomedical research and innovation			
		converging technologies			
		enhanced the power of data analysis			
		Facts			

Table 19 Megatrends identified in European Parliament (2017)

MT	Terms and phrases		Explanations / Results / introduction	Challenges
	Level 1	Level 2		
Ageing population	ageing global population	increased life expectancy	combination of increased life expectancy and declining fertility rates leads towards ageing population; stark differences in demographic changes between developed countries and developing countries; high-income countries are experiencing population stagnation or decline; m many developing countries, particularly in sub-Saharan Africa, are experiencing “youth bulges” and expansion of working-age population;	Demographic scenarios in high-income and developing countries pose challenges for governments seeking to create policies that are economically sustainable and politically palatable. As dependency ratios shift with growing elderly populations, governments will be faced with falling saving rates, falling consumption, and growing pressure on social services.
		declining fertility rates		
		economically sustainable and politically palatable policies		
	Facts	By 2040, the median citizen of Brazil and Mexico will be almost as old as the that of the United States, and China’s will be older. South Korea, Taiwan, and Singapore have median ages similar to Germany, Italy, and Japan. More than one-third of the global over-80 population will live in China and India by 2040 and 10% will be in Latin America. By 2030, China’s working-age population will be contracting by 0.7% per year, and internal migration from rural to urban areas will not be sufficient to supply new workers for the manufacturing labour force. Russia’s total population, now around 140 million, is expected to drop to 125 million by 2030. Overall, the demographic old age ratio (people over 65 per 100 people aged 15-64) in the EU is expected to increase from 27.8 to 50.1 by 2050, meaning that there will only be two working age people for every person over the age of 65.		
Fragile globalisation	globalisation in a multipolar world	Economic leaders	there are numerous variables that will shape whether the purported anti-trade environment of 2016 lasts to 2035; in the most likely scenario, globalisation patterns will be shaped less by politics and more by structural factors; Global trade is steady as a percentage of global growth, likely due to China’s reorientation towards domestic consumption and the maturing of trade in goods;	A more services-oriented economy will have different requirements for global trade governance, but Beijing, Brussels, and Washington will remain the key decision points for global economic affairs.
		globalisation elsewhere		
		structural changes in globalisation		
	Facts	in 2015, the EU spent less than 2% of GDP on R&D (OECD members on average spent 2.4%, the United States 2.8% and Japan 3.5%); the EU venture capital market is underdeveloped relative to the United States and the EU also lags behind the United States in numbers of large high-tech companies and patents;		
Technological revolution	Industrial and technological revolution	technological advances	by 2035, technological advances will have a major impact on the social and economic foundations of society;	Technologies involving automation and machine learning have the potential to disrupt job markets, making millions of jobs obsolete. As technologies like self-driving cars begins to proliferate, governments at all levels will be faced with questions of adaptation, governance, and human development. Countries will be forced to consider how much of their core information infrastructure they will permit to be run by companies domiciled in other countries.
		artificial intelligence and automation		
		sharing economy		
		data privatisation		
	Facts	the possibility of a proliferation of self-driving car technology by 2035 is likely; in the next 20 years, researchers at the Oxford Martin School estimates that 47% of jobs in the United States will become vulnerable to computerization, and that 35% of UK jobs could be eliminated as a direct consequence of artificial intelligence;		

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Climate change	Climate change and resource competition	Growing GHG emissions	Changes in the global climate due to rising greenhouse gases will not be reversed by 2035, even if great strides are made with the implementation of political agreements to greatly reduce carbon usage in the future.	As the consequences of climate change become increasingly apparent -- and natural events such as famines and water strain become linked to climate change in popular discourse -- the world is likely to see climate-related political disputes proliferate at the national and international level. Renewable energy will proliferate and become cost-competitive around the world, but will trigger instability in countries dependent on fossil fuels, many of which are in Europe's neighbourhood.
		Resource competition		
		climate-related political disputes		
	Facts	According to the European Environment Agency, Europe is on track to hit its 2020 GHG emissions target, and to miss its 2030 target. By 2023, all countries will be expected (at a UN Framework Convention on Climate Change 'stocktake') to indicate trajectories and possible targets for GHG reduction efforts beyond 2030. By 2035, a new round of GHG emission reduction targets will be underway, more demanding than the current round.		
Shifting power relations	Changing power in the international system	country power	In many ways, the power balance in the international system in 2017 looks broadly similar to the world in 2000. Yet in some fundamental ways, the world has changed considerably. And the impact of the 2007-08 financial crisis has hit many nations' capabilities to fund military increases.	There are some broad trends that are likely to continue through 2035: the United States will remain the largest military power; China and regional leaders will see their power grow; Russia will focus on areas of asymmetric advantage to counteract its declining population; and the creation of a unified European military structure with significant expeditionary power will be one of the biggest wild cards in the international system.
		military power		
		the power balance		
	Facts	In 2035, the United States will most likely still be the world's preeminent military power. Russia's military will be highly constrained by its economy (if current trends hold, the working force population would drop from about 85 million to less than 75 million by 2035). China's military capabilities will continue to grow, a product of increased expenditures as its GDP grows and time spent incorporating modern equipment into tactical and strategic plans. The largest variable in projecting global military power in 2035 is that of the EU. At the moment, one of the largest tensions within NATO is European members spending less than the 2%-of-GDP guidelines.		
New areas of state competition		space market	When projecting long-term trends in international affairs, it is important to consider the possibility that the major conflicts of 2035 will be centred on issues that barely register in the international arena today, or are secondary matters at best. Over the next two decades, these will likely include: the space market; new weapons systems like unmanned vehicles; policing rogue states; cyberwarfare and internet governance; and the Arctic Ocean.	
		new weapons systems		
		policing rogue states		
		cyberwarfare and internet governance		
	Facts			

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Politics of the Information Age	Facts	industry disruption	Politics often evolves as a reaction to changing societal and economic trends. There is evidence -- from measures on inequality to the percentage of the economy comprised of services -- that in much of the developed world, the industrial era has transitioned to an information economy. Political reactions to these economic changes are already underway across the United States and Europe. While they are highly unlikely to completely overturn the existing political landscape by 2035, they will add new layers that will shift partisan coalitions and incentive structures.	Some of the most important aspects will be industry disruption and political competition for new or more important voting blocs such as newly upper middle class professionals, former industry workers, gig economy contractors, and the elderly.
		political competition for new or more important voting blocs		
		information economy		
Ecological threats	Facts	Natural disasters	While climate change is a gradual process that will be felt over the course of decades, it also increases the likelihood of relatively sudden disasters, from stronger hurricanes, deeper famines, or droughts.	By 2035, the world will most likely be confronted by more natural disasters, and the political system will be required to adjust to them. Northern Europe will see greater flooding. Southern Europe will experience more frequent heatwaves. The international system will need to create a more robust system to protect climate refugees and migrants, who will grow as climate change increases the power of natural disasters and rapid urbanisation means that natural disasters will affect more people.
		Risks from natural disasters		
		Climate refugees and migrants		