Funded by the Horizon 2020 research and innovation programme
of the European Union (GA 769638)

Project Acronym:	**INTEND**
Project Title:	INtentify future Transport rEsearch NeeDs
Project Number:	769638
Topic:	**MG-8-7-2017**
Type of Action:	**Coordination and support action**

D2.2 Report on key transport concepts of the future

(Version 1, 30/04/2018)

Deliverable:	D 2.2 Report on key transport concepts of the future
Work Package:	WP2 : Define the landscape: mapping the future prospects of transport
Due Date:	M5
Submission Date:	30/04/2018
Start Date of Project:	01/10/2017
Duration of Project:	12 Months
Organisation Responsible of Deliverable:	Centre for Research and Technology Hellas (CERTH)
Version:	1
Status:	Final
Author name(s):	Alkiviadis Tromaras, Aggelos Aggelakakis, Efthymis Papadopoulos
Reviewer(s):	All partners
Nature:	☒ R – Report ☐ P – Prototype ☐ D – Demonstrator ☐ O - Other
Dissemination level:	☒ PU - Public ☐CO - Confidential, only for members of the consortium (including the Commission) ☐ RE - Restricted to a group specified by the consortium (including the Commission Services)

Document history			
Version	**Date**	**Modified by**	**Comments**
0.1	30/04/2018	Alkiviadis Tromaras, Aggelos Aggelakakis, Efthymis Papadopoulos, Afroditi Anagnostopoulou, Maria Boile	Draft
0.2	05/06/2018	Alkiviadis Tromaras, Aggelos Aggelakakis, Efthymis Papadopoulos, Afroditi Anagnostopoulou, Maria Boile, Thomas Trachsel, Vladislav Maras	Draft
1	14/06/2018	Alkiviadis Tromaras, Aggelos Aggelakakis, Efthymis Papadopoulos, Afroditi Anagnostopoulou, Maria Boile	Final

Contents

List of figures

List of tables

List of abbreviations

AEB	Autonomous Emergency Braking
AI	Artificial Intelligence
ANP	Analytic Network Process
AV	Autonomous Vehicle
B2B	Business-to-Business
BEV	Battery Electric Vehicle

BRT	Bus Rapid Transit
C-ITS ITS	Cooperative Intelligent Transport Systems
CST	Cargo Sous Terrain
DRT	Demand-Responsive Transport
EC	European Commission
ETCS	European Train Control System
EU	European Union
EV	Electric Vehicle
eREV	Range Extended Electric Vehicle
eVTOL	Electric Vertical Take-Off and Landing
FaaS	Freight as a Service
FCEV	Fuel Cell Electric Vehicle
FP7	7th Framework Programme for Research and Technological Development
FSS	Freight Shuttle System
GoA	Grade of Automation
H2020	Horizon 2020 EU Research and Innovation Program
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
ICT	Information and Communications Technology
INTEND	INtentify future Transport rEsearch NeeDs
ITS	Intelligent Transport System
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
LaaS	Logistics as a Service
MaaS	Mobility as a Service
N&V	Noise and Vibration
OEM	Original Equipment Manufacturers
PATS	Personal Airborne Transportation Systems
PRT	Personal Rapid Transit
SESAR JU	Single European Sky ATM Research Joint Undertaking
SORA	Specific Operations Risk Assessment
SSH	Socio-economic Sciences and Humanities
SSS	Short Sea Shipping
STTP	Strategic Transport Technology Plan
TaaS	Transport as a Service
UAV	Unmanned Aerial Vehicle
VTOL	Vertical Take-Off and Landing
WP	Work Package

Executive summary

Deliverable's D 2.2 main objective is to identify the major transport concepts and developments of the future in the literature, within a time horizon of 2020-2035 and beyond. The overall aim is to effectively identify the key transport concepts of the future through a variety of reports and research projects that have already carried out this work. Deliverable D 2.2 aggregates all the information gathered by the aforementioned literature under one roof, thus compiles the findings of past projects and more recent work that has been published within the last few years.

The approach taken involved a literature review for the purpose of identifying a distinct definition of the term "transport concept", followed by an extended literature review-based methodology and search on the aforementioned term for the capturing of the key future transport concepts applicable to passenger and freight transportation sectors. The former review resulted in a literature gap of a precise definition of the term "transport concept", thus a definition for this term was developed. For the purposes of D 2.2, "transport concept" has been defined as a concept or idea that presents how mobility takes place between two places, referring to movement of passengers or freight. It may describe the vehicle and the way that transportation or mobility takes place. Some examples of such transport concepts are given below:

- *Automation – autonomous vehicles (AVs)*: This concept suggests that mobility will be automated, including any type of autonomous vehicle/vessel
- *Electrification – electric vehicles (EVs)*: Although EVs refer to a technology that is already available, this concept suggests a shift from conventional fuels towards electricity, including any type of electrified vehicle/vessel
- *Seamless transport chains – multimodality, intermodality*: This concept entails the complete connectivity between cities and regions and the enhancement of multimodality and intermodality of network systems. Being applicable to both freight and passenger transport, it includes the ideas of seamless logistics, seamless national and international travel for passengers, seamless urban transport chains as a result of MaaS, etc.
- *Small vehicles developed fit-for-urban-purpose*: This concept suggests that in the future, the cars used in urban areas will be smaller in size. The concept includes ideas regarding downsizing ICEs, new vehicle designs between e-bikes and e-cars and foldable city cars.
- *Urban cross-modal logistics*: This concept refers to the utilization of all transport modes available in the city logistics processes, including electric vans, (electric) bikes or tricycles (smaller and more flexible means of road freight transport).
- *Crowd delivery*: This concept is related to the involvement of private individuals traveling on a particular route, in urban deliveries.

For the implementation of the current Deliverable, particular emphasis was placed on EU FP7 and H2020 funded research projects, namely MOBILITY4EU, FUTRE, RACE2050, OPTIMISM, METRIC and IKNOW. Additionally, future transport-related websites, technology-oriented websites and several forward-looking reports also provided input and further supported the attempted identification of the major future transport concepts of the future.

The various transport concepts captured by the literature review, pertained either to one particular transport mode (road, aviation, rail, maritime) or to different combinations of the aforementioned modes. Similarly, certain transport concepts were sector specific i.e. passenger or freight, while others could be applied to both. The identified transport concepts were not categorised by transport mode. On the contrary, they were grouped according to the transport sector that they were/could be applicable to (passenger or/and freight transport). The identified concepts with a potential application to both passenger and freight transportation sectors, were included to both of the aforementioned categories.

After a thorough review of the pertinent literature available, matrices listing future transport concepts over sources were prepared. The overall aim was to determine concepts that are researched, discussed or proposed in the majority of the literature sources, thus to indicate a certain level of consensus to those that are more likely to shape the future transport landscape. A cut-off criterion for reaching a consensus was defined, for the purpose of identifying the dominant concepts of the future on the basis of high frequency of occurrence in the literature reviewed. The seven top-cited concepts for each passenger and freight transport, were agreed to form the dominant transport concepts of the future. The results from this task are given below.

Brief main results

Based on the aforementioned methodology steps, the seven top-cited concepts for passenger transport were identified and considered to be the dominant ones. The table below presents the dominant identified passenger transport-applicable concepts of the future, in a more synoptic way. The concepts are ranked according to their frequency of occurrence in the reviewed literature.

Dominant passenger transport-applicable concepts of the future

Passenger transport brief synopsis of transport concepts
Automation – passenger transport
Shared mobility, on-demand mobility, MaaS
Electrification – passenger transport
Seamless transport chains – multimodality, intermodality
Personal air transportation, “flying cars”, “flying taxis”
Smart use of travel time
High-speed rail
Superfast ground and underground transportation (hyperloops)

The same principles were also applied for freight transport. The table below presents the dominant identified freight transport-applicable concepts of the future, in a more synoptic way. The concepts are ranked according to their frequency of occurrence in the reviewed literature.

Dominant freight transport-applicable concepts of the future

Freight transport brief synopsis of transport concepts
Shared mobility, on-demand mobility, MaaS, FaaS, LaaS
Seamless transport chains – multimodality, intermodality
Automation – freight transport
Electrification – freight transport
Delivery drones
Superfast ground and underground transportation (cargo tubes, underground freight pipelines)
Freight consolidation hubs, freight distribution centres

It is worth noting that some of the future transport concepts identified in the literature appeared to be non-recurring, since they have not been researched or discussed by several research projects and forward-looking reports. To that end, the dominant transport concepts are far fewer than the total number of the identified transport concepts.

The dominant identified transport concepts of the future applicable to passenger and freight transport, were further analysed in terms of which transport mode they are applicable to, how likely they are to be implemented as well as when they are likely to become mainstream (Section 4). Moreover, they were explained in further detail, in the last section of the current Deliverable (Section 5).

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, waterborne) as well as infrastructure and transport systems which will be treated horizontally. The INTEND project will also review past forward looking projects and relevant recent studies in order to present future mobility concepts. Megatrends that will be affecting the future transport system will be identified using literature review. To ensure validity of the results, the Analytical Network Process (ANP) will be used to weight the megatrends, the influence of technological development trends as well as the one of political imperatives and derive reliable outcomes on the most predominant trends. 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:

- Define the transport research landscape
- Define the Megatrends and their impact on research needs
- 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 also develop an online platform, the INTEND Synopsis Tool that will constitute a dynamic knowledge base repository on the major developments in the transport sector. This will provide a visualisation of main outcomes resulting from the already described ANP. The basis for the platform will be Transport Synopsis Tool which is already 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 focus of D 2.2 is to identify the key transport concepts of the future, which consist of visions of what transportation will look like within a time horizon of 2020-2035 and beyond. The identification of the major future transport concepts will enable a “sketching” of the way that mobility for people and goods is going to take place in the near or distant future. The dominant transport concepts of the future will be analysed in terms of which transport mode they are applicable to and the timeline for their implementation. Moreover, a further analysis will be provided, in order for these future concepts to be explained in more detail.

The attempted identification of the key transport concepts of the future, will be based on a thorough review of the pertinent literature dealing with mobility concepts of tomorrow. The overall goal is to extract a list of the dominant future transport concepts for both passenger and freight transportation systems, on the basis of the frequency by which they appear to be researched, discussed or proposed in the relevant literature sources.

1.1 Deliverable D 2.2 in the frame of INTEND work structure

Deliverable D 2.2 aims at providing an overview of the major transport concepts of the future. The current Deliverable is based on “Task 2.2- Identification of key transport concepts of the future”, with the overall aim to effectively identify transport concepts of the future through a variety of and forward-looking reports research projects that have already carried out this work. D 2.2 will initially present and catalogue all the transport concepts that haven been identified throughout the literature review. The latter has been divided into two sections: 1) EC related projects and 2) forward-looking reports and studies. The second step of the analysis is to present the dominant transport concepts based on the number of citations. Finally, the dominant transport concepts will be categorised depending on the transport sector (passenger/freight) and mode (road, aviation, rail, waterborne) that they are applicable to; including an analysis of the timeline of implementation.

Figure 1 depicts the structure of INTEND WPs, while the specific role and purpose of Deliverable D 2.2 is highlighted in the red circle.

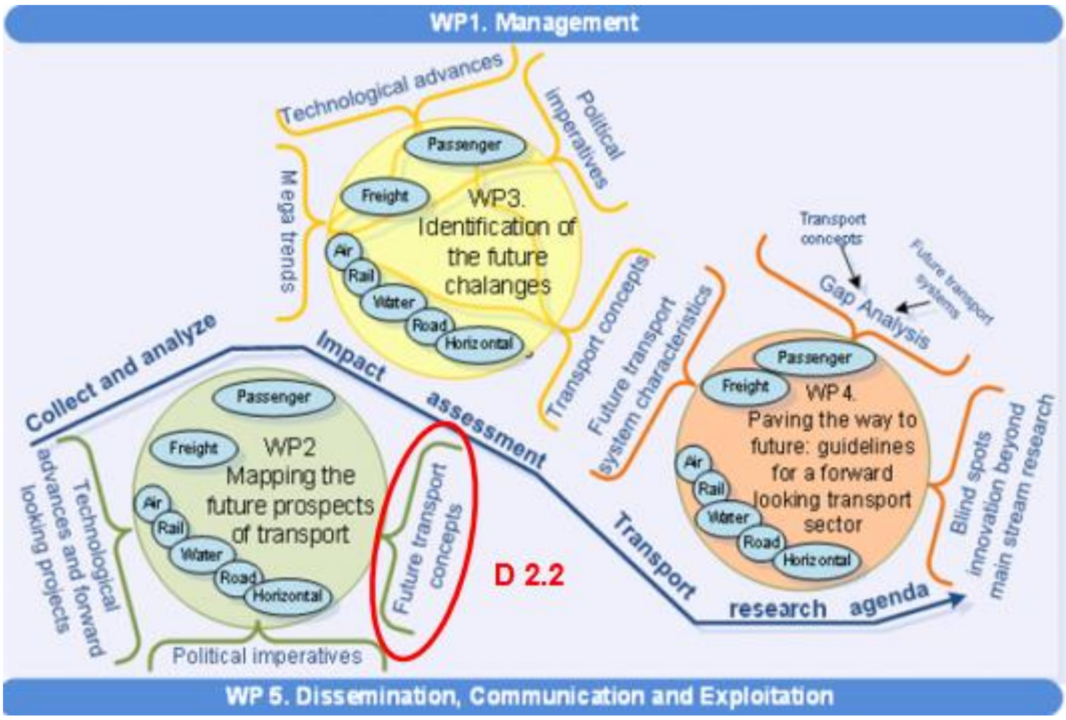


Figure 1. Overall structure of the WPs and role D 2.2

This approach will involve a literature review of completed and ongoing forward-looking research projects in order to extract the specific transport concepts that each project had researched, discussed or proposed from 2010 and onwards, including relevant pertinent literature, such as future transport roadmaps, future transport-related and technology-oriented websites and other forward-looking reports. D 2.2 looked predominantly into EU FP7 and H2020 funded research projects, namely MOBILITY4EU (CERTH), FUTRE (CERTH), RACE2050 (ZHAW, TUB), OPTIMISM (CUE) and METRIC (CUE). The aforementioned research projects have already carried out analysis of past reports or projects that cover future mobility concepts to a certain extend. Moreover, IKNOW project (University of Manchester) was also taken into account, being one of the six Blue Sky foresight research projects funded by the EU FP7, under the socio-economic sciences and humanities theme

(SSH). This approach is suitable for the time horizon of 2020-2035 that INTEND is mainly focusing on, because the transport concepts that have been researched between 2010 and the present time, are likely to be implemented by 2035. Nevertheless, D 2.2. was not confined to the aforementioned time frame and expanded into the available literature that has set a broader time horizon, covering literature that could refer up to 2050.

Additionally, future transport-related websites, technology-oriented websites and several forward-looking reports also provided input and further supported the attempted identification of the major transport concepts of the future. Some of the transport concepts identified by the aforementioned literature were largely based on private and industry initiatives, covering up a potential gap concerning the different vision that industry-based research, product development, academic research and transport stakeholders usually follow.

Deliverable D 2.2 aims to deliver a list of the dominant transport concepts of the future, enabling a “sketching” of the way in which people and goods are likely to be transferred in the future. D 2.2 will provide feedback to “WP 3- Identification of future challenges”. More specifically, the results of D 2.2 are to be used in D 3.2 “Megatrends validation and impact assessment” as input for an Analytical Network Process (ANP) which will cluster the future technologies (D 2.1), megatrends (D 3.1) and political imperatives (D 2.3) together in an effort to evaluate and prioritise all of the aforementioned information for the successful implementation of the key transport concepts of the future (D 2.2). The results of D 2.2. will be used as part of the second survey of D 3.2 where future technologies, megatrends and political imperatives will be prioritised for a successful implementation of the identified key transport concepts of the future. Additionally, Deliverable D 2.2 will provide input to “WP 4- Paving the way to future: guidelines for a forward-looking transport sector”. Recognizing the key transport concepts of the future and providing the theoretical background, D 2.2 will provide input to “D 4.1- Sketch of the future transport systems”, the main objective of which is to develop a sketch of the future transport system pointing out the differences to the recent system and providing a basis to identify future research needs. Thereby, the focus will lie on differential aspects such as the changing role of mobility, new mobility paradigms, technological innovation or new mobility solutions on a conceptual basis. In this context, the transport concepts elaborated in D2.2 form an essential basis by pointing out which concepts (known today) could very likely revolutionise or at least have an essential impact on passenger and freight transportation in the future. The results of D 2.2 are also to be used in “D 4.2- Gap Analysis”, which will define streams of needed future researches in the fields of transport technologies, mobility concepts and research systems, etc., required to achieve the political goals (imperatives) that are to be associated with shared and long-term vision about the future of transport. The Gap analysis will be based on the results of D 2.2, and comparison of the outcomes of D 3.2 “Report on Megatrends validation and impact assessment” and D 4.1 “ Sketch of the future transport system”.

1.2 Task 2.2: Identification of key transport concepts of the future

The principal purpose of Task T 2.2 is the identification of the major transport concepts of the future. An extended literature review was initially conducted for the purpose of identifying a distinct definition of the terms “transport concept” and “mobility concept”, followed by a literature review-based methodology and search on the aforementioned terms for the capturing of the key transport concepts of the future applicable to passenger and freight transportation sectors. The former review resulted in a literature gap of a precise definition of

the terms “transport concept” and “mobility concept”, thus a definition for these terms was developed for the purposes of the current D 2.2.

For the implementation of D 2.2, particular emphasis was placed on FP7 and H2020 funded forward-looking research projects, namely MOBILITY4EU, FUTRE, RACE2050, OPTIMISM, METRIC and IKNOW. The aforementioned research projects have already studied the future mobility concepts to a certain extent, having researched various relevant past reports and projects. In addition, future transport-related and technology-oriented websites as well as several forward-looking reports were further used to expand the catchment area of the applied methodology, by covering private and industry initiatives.

Concerning the data collection methodology, the overall aim was to create a systematic data collection method that would enable the identification of the dominant transport concepts of the future that could be applied to passenger and freight transportation sectors, within a time horizon of 2020-2035 and beyond. Figure 2 presents the main methodology steps that were followed in the implementation of D 2.2.

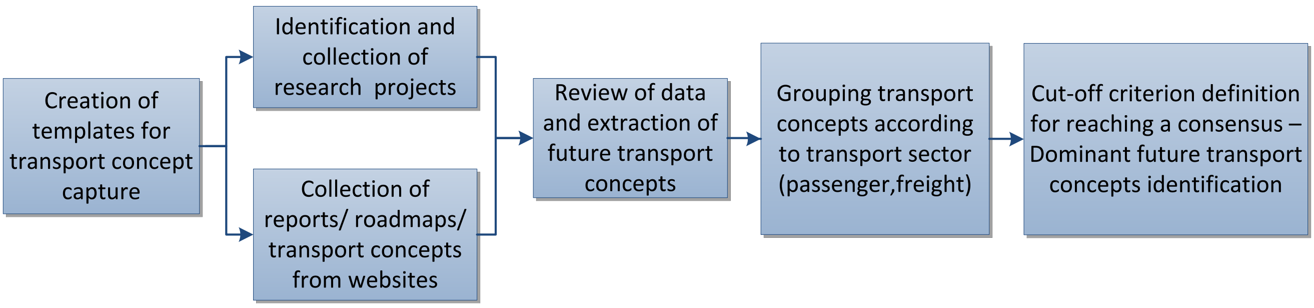


Figure 2. Methodology steps followed in D 2.2

The first step was to create a spreadsheet on MS Excel that was used for filling all the information captured by the research projects, forward-looking reports, future transport-related and technology-oriented websites. Having completed a thorough review of both research projects and pertinent literature, a matrix was prepared that contained the transport concepts including their respective reference sources. The matrix was used for the purpose of recognizing the most dominant transport concepts of the future that appeared to have been researched, discussed or proposed by the majority of the literature sources.

It needs to be noted that some of the identified transport concepts appeared to be non-recurring, since they have not been cited frequently. As a result, the dominant transport concepts are far fewer than the total number of the identified transport concepts. This was due to the fact that some of these concepts came from individual private and industry initiatives, or by the fact that the term “transport concept” itself seems to be quite abstract. As it has already been mentioned, the identified transport concepts have been grouped depending on the transport sector that they were/could be applied to (passenger or/and freight). Certain mobility concepts were sector-specific, while others were applicable to both passenger and freight transportation sectors. The latter were included in both aforementioned groups.

The dominant future transport concepts identified by the literature review, were explained in further detail and analysed in terms of which transport mode they are applicable to, as well as their timeline of implementation.

2 Transport concepts

The term “transport concept” also referred to as “mobility concept” has already been introduced. A literature review was carried out to identify a possible definition. Although, definition was identified, the term is not unknown when referring to innovative technologies that present how people or goods are transported. Therefore, a definition of the term “transport concept” is provided below in order for the reader to have a better understanding.

For the purposes of D 2.2, “transport concept” has been defined as a concept or idea that presents how mobility takes place between two places, referring to movement of passengers or freight. It may describe the vehicle and the way that transportation or mobility takes place. Some examples of such transport concepts are given below:

- *Automation – autonomous vehicles (AVs)*: This concept suggests that mobility will be automated, including any type of autonomous vehicle/vessel
- *Hyperloop*: This concept refers to mobility using underground high-speed rail
- *Mobility as a Service (MaaS)*: MaaS is already a well know concept focusing on shifting from ownership of personal vehicles towards services that offer mobility as a product, such as ride-sharing, car-sharing, ride-hailing
- *Mega-aircrafts*: This concept shows that extremely large aircrafts will be used to transport people from A to B rather than using smaller planes
- *Electrification – electric vehicles (EVs)*: Although EVs refer to a technology that is already available, this concept suggests a shift from conventional fuels towards electricity, including any type of electrified vehicle/vessel
- *Deliver drones*: This concept suggests that drones/unmanned air vehicles (UAVs) will become an indivisible part of the supply chain, supporting urban and rural deliveries

Table 1 presents the long-list of the transport concepts of the future researched, discussed or proposed in the literature review. The future transport concepts have been grouped into wider categories and brief descriptions are provided below.

Table 1. Total number of future transport concepts captured by the literature

Transport Concept – Code Name	***Transport Concept – Context, Brief Description***
Slow Travel / Slow Logistics	Reduced importance of time regarding both passenger and freight transport; “Slow Travel” and “Slow Logistics” movements, as a counter-reaction to the environmental pressure and the stress of modern life
Superfast Ground and Underground Transportation	Hyperloops, Cargo Tubes, Underground Freight Pipelines (e.g. “CargoCaps”)
Personal Rapid Transit (PRT)	Small automated pods or buses operating on designated rails (network of specially built guideways) or on streets, for either scheduled or individual destinations
Magnetic Mobility, Magnetic Levitation	Magnets as an alternative and efficient method for transportation; magnetic levitation technology for rail (maglevs), shopping carts / magnetic shoes sliding on / along magnetic tracks
Personal Air Transportation, "Flying Cars", Flying Taxis"	Urban air mobility; small personal aerial vehicles manually piloted, remotely piloted or fully autonomous; “Passenger Drones”, “Flying Cars”, “Flying Taxis”
Seamless Transport Chains – Multimodality, Intermodality	Seamless transport chains for both passenger and freight transport; seamless national and international travel for passengers; seamless logistics; seamless multimodal freight transport services; integration of all transport modes – multimodality, intermodality; seamless transport chains as a result of MaaS
Automation	Autonomous – driverless vehicles operating with no need for any human intervention; autonomous cars; autonomous trucks, platooning technology for heavy duty vehicles, autonomous networks of long-haul trucks; autonomous passenger aircrafts; automated trains for passenger and freight transport; autonomous ferries and vessels for passenger and freight transport, automation – platooning of vessels / ferries
Noiseless Transport	Noiseless aviation – advanced low-noise aircrafts; reduction of noise and vibration in trains; comfort and noiseless shipping – low vibration/waves vessels
Mega Aircrafts	Bigger aircrafts for passenger and freight transportation
Delivery Drones	Urban airspace utilization for goods deliveries; delivery drones as a part of the supply chain
Electrification	Electromobility; electric bicycles; electric cars, battery electric vehicles – BEVs, fuel cell electric vehicles – FCEVs, hybrid electric vehicles – HEVs, plug - in hybrids, full hybrids; electric trucks; electric – hydrogen-powered trains; electric aircrafts; hybrid and electrified ferries and vessels; charging infrastructure for EVs

Transport Concept – Code Name	***Transport Concept – Context, Brief Description***
Vertical Transportation - Intra-Building Mobility	Vertical Life, intra-building mobility, vertical transportation, spider-vehicles
Small Vehicles Developed Fit-For-Urban-Purpose	Smaller vehicles, vehicle designs between e-bikes and e-cars, foldable city cars, downsize ICEs
Expandable Cars	Increasingly cheap cars thanks to 3D-printing technology; expandable cars; recycling of cars
Smart Use of Travel Time	Use of travel time made available because of vehicle automation; travel time as a usable timeslot for a wide range of activities
Shared Mobility, On-Demand Mobility, Mobility as a Service (MaaS)	Shared ownership models, on-demand mobility; proliferation of car/ride/ fleet-sharing and ride-hailing; novel sharing concepts; Mobility as a Service – MaaS, Freight as a Service – FaaS, Logistics as a Service – LaaS
Private Car Ownership, Luxury Vehicles	Private car ownership remains the norm, continuing appreciation of status symbolism; luxury vehicles/cars
Seamless Security Checks, Innovative Check - In Processes	Integrated security approach "No Borders"; seamless security checks at airports, innovative check - in processes
Capsules Transported by Carrier Aircraft	Capsule concept; capsules containing people, freight or fuel transported by carrier aircrafts; “AIRLINER 2.0” designed by EPFL’s Transportation Centre (Swiss Federal Institute of Technology, TRACE)
Blue Modal Shift	Bringing transport to waterways; SSS (Short Sea Shipping) promotion
Floating Delivery hubs	Offshore platforms built on concrete floor or on novel floating platforms; maritime hubs that can be used as container storage and /or as transshipment terminals; fuel and travelling time savings
Bus Rapid Transit Corridors – BRT	BRT systems running on dedicated lanes; combining the capacity and speed of light rail with the flexibility, lower cost and simplicity of bus systems.
Co-Modality	Connecting transport of people and goods; using the space of regular services for public transport at non-peak-hours or the space of duty vehicles, to transport goods; mixed passenger and freight means of transport

Transport Concept – Code Name	***Transport Concept – Context, Brief Description***
Freight Consolidation Hubs, Freight Distribution Centres	(Peri)-urban freight consolidation hubs; freight hubs located close to urban agglomerations, for goods consolidation between long distance hauls and short-distance inner-city transport; Freight distribution centres (freight villages); multimodal settlements that provide access to different modes of transport as well as several inter-modal infrastructure facilities, for transport-oriented companies, logistics service providers, etc.
Urban Cross-Modal Logistics	Urban cross-modal logistics utilizing all transport modes; deliveries with small electric vans, (electric) bikes or tricycles; small and flexible means for road freight transport
Personal Mobility Devices	Personal mobility devices, such as Segway, electric skateboards, etc.; reduced usage of traditional forms of mobility for short distances
High-Speed Rail	High-speed train technologies; high-speed rail for passenger transport
“Pragmatic Cars" and "Fun Cars"	"Pragmatic cars" for just travelling fast; "Fun cars" designed and used for leisure purposes
Urban Cable Cars	Cable car systems as an alternative means of urban transport, after minimal adaptations
Parcels into the Receivers' Car Trunk	Urban deliveries – parcels into the receivers' car trunk (Belgian start-up company Cardrops)
Delivery Boxes	Urban deliveries – delivery boxes (“Packstationen”, DHL, Germany)
Crowd Delivery	Urban deliveries – crowd delivery; involvement of private individuals traveling on a particular route, in urban deliveries (“My Ways" pilot project, DHL, Stockholm)
Quite Night Urban Deliveries	Urban deliveries done at night, when the traffic is limited
Freight Shuttle Systems	Freight shuttle systems for high-volume freight containers; unmanned shuttles propelled by electric, linear induction motors, able to carry cargo on elevated, dedicated tracks (e.g. Freight Shuttle System – FSS initiated at Texas A&M Transportation Institute)
Smart, Dynamic and Interactive Highways	Safer and more sustainable roads; interactive lights; smart energy sources; adaptable to different conditions road signs; photo-luminescent road markings; temperature sensitive warning signs on the road; solar roadways containing heating elements, inductive charging capabilities for electric vehicles, etc.

3 Review of selected literature

The main objective of D 2.2 is to identify the key transport concepts of the future that can be applied to passenger and freight transportation sectors. The approach taken is based on a literature review of futurology research projects and forward-looking reports that have covered topics relevant to the future transport concepts, with a time horizon up to 2050. The analysis of literature was performed in parallel for passenger and freight transport, since the majority of the literature sources dealt with transport concepts and ideas applicable to both sectors.

The list below presents the research projects and forward-looking reports that were reviewed for the implementation of D 2.2:

- MOBILITY4EU (2016a). Context Map
- MOBILITY4EU (2016b). Opportunity Map
- MOBILITY4EU (2016c). Vision for 2030 Map
- Keseru et al. (2016). MOBILITY4EU, D3.1
- Aggelakakis et al. (2014). FUTRE, e-book
- Papanikolaou et al. (2014). FUTRE, D3.2
- Reichenbach et al. (2014). FUTRE, D4.3
- Hauptman et al. (2014). RACE2050, D6.2
- Delle Site et al. (2013). OPTIMISM, D3.3
- Kompil et al. (2013). OPTIMISM, D3.4
- Delle Site et al. (2012). OPTIMISM, D5.1
- Christodoulou et al. (2014). METRIC, D5.2
- IKNOW (2011);
- Manyika et al. (2013);
- Briggs and Sundaram (2016);
- Winterhoff et al. (2009);
- KPMG (2017);
- D'Incà and Mentz (2016);
- Cornet et al. (2012);
- Arbib et al. (2017);
- Corwin et al. (2015);
- Corwin et al. (2016);
- Goodall et al. (2017);
- UKi Media & Events (2018);
- Goulding and Butler (2018);
- Goulding and Morrell (2014a);
- Goulding and Morrell (2014b);
- Morrell (2017);
- Goulding and Morrell (2014);
- Dohna and Morrell (2016);
- Otto (2017);
- Lineberger et al. (2018);
- Sümmermann et al. (2017);
- Leech et al. (2015);
- Schmidt et al. (2018);
- Foulser (2017);
- OECD/ITF (2017);
- Rohr et al. (2016);
- Future Transport 2056 (2018);
- Young (2018);
- Harnish (2018);

- Sanguina et al. (2018);

Research projects and reports examined as well as the future transport concepts captured by each of the aforementioned literature sources, are presented in detail in the following sections. The transport concepts presented below have been grouped into wider categories, expressed by umbrella terms (bold text). The phrases in parentheses explain each transport concept more closely, exactly in the same way that literature sources have done.

3.1 Review of selected EC projects

As previously stated, for the attempted identification of the future transport concepts, particular emphasis was placed on EU FP7 and H2020 funded forward looking research projects.

MOBILITY4EU project (H2020, 2016-2018), is an ongoing project that aims at delivering a vision for the European transport system in 2030 and an action plan including a roadmap to implement that vision. The work towards that vision and action plan is based on the identification and assessment of societal challenges that will influence future transport demand and supply and the compilation of a portfolio of promising cross-modal technical and organisational transport solutions. In its Opportunity Map (MOBILITY4EU, 2016b), available on MOBILITY4EU official website, a portfolio of 93 promising and innovative transport solutions across all modes is presented, in response to the identified user needs. These transport solutions have been composed by project participants in collaboration with European experts from all fields in transport of passengers and freight. The portfolio includes solutions in concept or research state as well as recently implemented solutions that require further support for advancing technologies or products and for wider deployment.

Apart from its Opportunity Map, transport concepts and ideas were also identified in its Context Map (MOBILITY4EU,2016a), in its Vision for 2030 Map (MOBILITY4EU, 2016c) as well as in its "Deliverable D 3.1- Report on MAMCA scenario descriptions" (Keseru et al., 2016), which summarizes the development process and presents the scenarios built for the future of mobility in Europe. The future transport concepts identified in MOBILITY4EU project, are briefly the following:

- **superfast ground and underground transportation** (hyperloop development)
- **personal rapid transit – PRT** (autonomous, electric-driven pods operate on designated rails or on streets for either scheduled or individual destinations; to serve individual needs commercial personal rapid transit systems are promoted in urban areas by private investors).
- **personal air transportation – "flying cars", "flying taxis"** (airlines and aircraft manufacturers develop the first small on-demand aviation services, in order to provide more flexibility to customers with tight schedules).
- **seamless transport chains – multimodality, intermodality** (intermodal mega-hubs to support intermodality for passengers; intermodal mega-hubs integrating new mobility services; development of a city-wide multimodal service offer; seamless integration of the mobility services to minimize transfer time and maximize passengers' utility).
- **automation** (autonomous cars; automated and connected vehicles operating without the direct input of the driver; autonomous vehicles to improve safety and efficiency; vehicle platooning – "road train"; autonomous trucks; automated trains; remote

control of trains in an automated system of driverless trains in both passenger and freight transportation sectors; autonomous vessels; freight and passenger ships form an optimal application field for automation).

- **noiseless transport** (noiseless aviation; advanced low-noise aircrafts to improve the environmental footprint regarding noise emissions; reduction of noise and vibration (N&V) in trains; noiseless trains to increase capacity and competitiveness and to limit down the disturbance of nearby residents; comfort and noiseless shipping; low vibration/waves vessels).
- **mega aircrafts** (bigger aircrafts for passenger and freight transportation).
- **delivery drones** (drones – small unmanned air vehicles supporting urban deliveries)
- **electrification** (electric vehicles – EVs; electric cars; future generation electric vehicles; urban electric buses for public use; electric trucks for freight transport; charging infrastructure for electric vehicles; charging electric vehicles while driving; on-road charging of trucks with trolley wires or other forms of constant electrical connection; all-electric aircrafts operating with a novel fuel solution based on electricity; hybrid and electrified ferries and vessels in ports – improvements needed in order to enable longer electrified routes and higher loads).
- **small vehicles developed fit-for-urban-purpose** (smaller and lighter weight vehicles for a lower energy consumption; smaller and lighter weight electric vehicles become more affordable thanks to smaller batteries needed; small and light weight vehicles for both passenger transportation and urban deliveries).
- **smart use of travel time** (making use of the travel time freed by not driving, because of the development of the autonomous vehicles).
- **shared mobility, on-demand mobility, MaaS** (sharing of cars and bikes instead of buying them may in future develop beyond cars and bikes; moving from ownership models to using services is becoming more and more common in the transportation sector; ride-hailing, car/bike/ride-sharing services for people and goods; novel bike-sharing concepts; freight sharing services; MaaS entails that transport is consumed as a service, in contrast to personally owing the means for certain travel modes; Maas is provided through a unified platform, integrating all options of travel modes; Logistics as a Service enables individuals to choose their own logistics service provider instead of being delivered by the logistics service provider of their retailer).
- **integrated security approach, seamless security checks at airports** (integrated approach of security checks for travelling without any borders – sharing of personal traveller information, integration of national and international databases; seamless security checks at airports to enable seamless passenger processes – pre-selection and adapted security checks according to passenger security status based on big data analytics).
- **flexible timetables for rail** (flexible timetables following passenger and freight needs; respective connections that meet passengers' needs, based on the collection of real-time information about the preferred time of travel; consolidation of freight loads of different operators to increase productivity and efficiency of logistics processes).
- **blue modal shift** (bringing transport to inland waterways to provide an attractive alternative for passenger and freight transportation; short sea shipping (SSS) promotion to effectively contribute to modal shift).
- **floating delivery hubs** (offshore platforms built on concrete floor or on a novel floating platform; used as container storage and as transhipment terminals; savings

regarding fuel and travelling time, since there is no need for big vessels to come into ports; faster distribution of goods between several routes – reduced delivery time).

- **bus rapid transit – BRT** (bus rapid transit systems run on dedicated lanes; bus rapid transit to combine capacity and speed of light rail with flexibility and lower cost of bus systems).
- **co-modality** (connecting transport of people and goods; transport goods in vehicles being on their way in any case; utilization of the free space of regular services for public transport at non-peak hours (e.g. at night); utilization of the free space of duty vehicles (e.g. clean vehicles).
- **(peri)-urban freight consolidation hubs** (freight hubs/centres located close to urban agglomerations; places for the consolidation of goods between long-distance hauls and inner-city transport; utilization of efficient and green transport modes).
- **urban cross-modal logistics** (urban logistics utilizing all transport modes; urban deliveries with the most efficient mode possible depending on the route and cargo profile; use of small electric vans, electric bikes or tricycles for the last and first mile deliveries in order to lower emissions).
- **personal mobility devices** (easy and fast modes of transport complementary to walking and cycling; personal mobility devices, such as Segway and electric skateboard; reduction of the usage of traditional forms of transport for short distances).
- **high-speed rail** (high-speed rail for passenger transport; faster and more energy efficient high-speed trains; high-speed rail as an attractive alternative to air transportation).

FUTRE project (FP7, 2012-2014), aimed at highlighting which future challenges and demand drivers could have a considerable impact on the global demand patterns in the passenger and freight transport and how this might had affected the competitiveness of related industries and service providers. In doing so, the project aimed at bridging the gap between the manifold studies on the future of the European transport system and its subsections on the one hand, and the issue of competitiveness that needed to be supported by targeted research strategies, on the other hand. FUTRE project investigated the challenges for the European transport sector in the long term and developed strategic options for European transport research policy. FUTRE project, in “Deliverable D 3.2- Long-term future analysis on transport demand market and drivers” (Papanikolaou et al., 2014), carried out an analysis on factors of change for future transport demand and developed possible scenarios for its evolution in the passenger and freight markets. More specifically, chapters 4 and 5 analysed the key issues that were related for shaping demand and transport of passengers and freight across the four developed scenarios, thus generating the main trends and challenges based on each scenario characteristics. A number of future transport concepts referring to both passenger and freight sectors were lying between the future trends and challenges that derived from the aforementioned process.

Moreover, FUTRE “Deliverable D 4.3- Long-term impacts of the supply side on the competitiveness of the European transport industry” (Reichenbach et al., 2014), identified and further discussed several transport innovations already researched in various past research projects, namely GHG-TransPoRD, Market-up, REACT, EU Transport GHG: Routes to 2050, TOSCA, U-STIR, TRANSvisions, FREIGHTVISION and INNOSUTRA. In order to limit down the identified longlist of innovations, an internal workshop was organised

with a purpose of clustering them into innovation fields. Some of the innovation fields and subfields that came out of the aforementioned process, were considered to form future transport concepts and were captured for the purposes of INTEND. Additionally, some transport concepts of the future were identified in FUTRE e-book (Aggelakakis et al., 2014), available on FUTRE's official website. In summary, the future transport concepts researched, discussed or proposed by FUTRE project, are presented below:

- **superfast ground and underground transportation** (innovative new types of transport infrastructure – hyperloop, cargo-tube; underground freight transportation pipelines – "CargoCaps" in dense urban centres, as an alternative to the conventional transport systems).
- **personal rapid transit – PRT** (PRT is a new type of semi-public transport which offers on-demand services for individuals or small groups; PRT – small automated vehicles operating on a network of specially built guideways; advantages of individual mobility (flexibility and privacy) are combined with those of public transport (efficiency, cost); PRT utilizing electric and fully automated vehicles).
- **personal air transportation – "flying cars", "flying taxis"** (developing small aircrafts designed to be used as a kind of air taxis; personal air vehicles do not require large-scale ground infrastructure; personal air vehicles seem a promising solution to congestion problems, making use of the unexploited third dimension; required operational infrastructure and socio-economic viability issues regarding aerial transport systems).
- **seamless transport chains – multimodality, intermodality** (seamless transport chains; seamless multimodality; clever future transport chains with smooth connections between different modes of transport; innovative transhipment technologies for seamless intermodal freight transport).
- **automation** (full autonomous driving is expected to be mainstream in the next 20 to 30 years, changing our perception and understanding of transportation; automation of road transport; autonomous control; autonomous cars; autonomous trucks; autonomous vessels).
- **electrification** (electromobility in all transport modes – electric bicycles, electric cars, electric trucks, electric aircrafts, electrified vessels; electrification of road transport; battery electric vehicles – BEVs; hybrid technology allowing pure electric drive for a certain distance; fuel cell electric vehicles – FCEVs; electrification with renewable energy; charging infrastructure needed for the diffusion of electric vehicles; inductive, contactless charging infrastructure for electric vehicles).
- **small vehicles developed fit-for-urban-purpose** (high demand for vehicle designs between e-bikes and e-cars, e.g. Renault Twizy; foldable city cars (MIT Media Lab vision) that can be folded for the minimum possible usage of public space when not in use; downsizing of the entire vehicle; downsizing of the conventional internal combustion engines – ICEs; efficient zero-emission cars designed for "urban cars; smaller parking areas needed because of the desired downsizing of vehicles).
- **smart use of travel time** (driverless cars – people enjoy having free time while travelling; travel time as a usable timeslot for either leisure or work-related activities).
- **shared mobility, on-demand mobility, MaaS** (lower ownership concepts; switch from "ownership" to "sharing"; innovative sharing services for car/bike/fleet-sharing, car leasing, etc.; high demand for car leasing; leasing of second hand cars becomes

a market; reduction of transport cost through freight sharing services integrated platforms).

- **blue modal shift** (modal shift towards sea and inland waterways transport, due to climate change).
- **co-modality** (mixed passenger and freight means of transport for rail, sea and air; simultaneous transport of passengers and small freight volumes, while utilizing the same resources).
- **freight distribution centres – freight villages** (multimodal settlements that provide access to different modes of transport for transport-oriented companies, logistics service providers and production enterprises; inter-modal infrastructure facilities provision e.g. roll-on/ roll of facilities, warehouses, etc.; optimization of deliveries through coordination and consolidation).
- **urban cross-modal logistics** (urban deliveries utilizing different transport modes; smaller and more flexible means for road freight transport; shift of light weight good deliveries to cargo bikes).
- **personal mobility devices** (public transport perfectly complementing personal mobility devices).
- **high-speed rail** (high-speed trains may play an important role in the future; high-speed rail as an attractive alternative to air transport; dense network of high-speed trains).
- **"pragmatic cars" and "fun cars"** (new demand patterns for cars; "pragmatic cars" exclusively for travelling fast; "fun cars" designed and used for leisure purposes).
- **urban cable cars** (cable car systems well known from alpine ski resorts and mountainous tourist regions; potential usage as alternative means of urban transport with minimal adaptations; a few existing urban applications, e.g. Roosevelt Island Tramway, New York; potential improvement of public transport and local accessibility).
- **urban deliveries – parcels into the receivers' car trunk** (Belgian start-up company "Cardrops" initiative; service that enables deliverers to place parcels into the receivers' trunk of their car, regardless where the car is located by the time of delivery; capturing of the GPS coordinates of the car when it has not moved for 15 minutes and enabling trusted delivery partners to open the car electronically).
- **urban deliveries – delivery boxes, "Packstationen"** ("DHL" company initiative in Germany; fully automated and self-contained kiosks for dispensing and mailing parcels and envelopes; several delivery boxes – customers choose their preferred pick-up point; personalised identification number for tracking the delivery and open the box where the shipment is kept).
- **urban deliveries – crowd delivery** (involvement of private individuals in urban deliveries; "My Ways" pilot project – "DHL" company initiative in Stockholm; involvement of city residents into the last-mile delivery of online-ordered products; specifically developed app to connect individuals who seek for flexible deliveries and those who offer to transport parcels along their daily routes; small financial compensation for people who offer to deliver parcels; recipients can choose the time and location of the delivery and determine the delivery fee;

RACE2050 project (FP7, 2012-2015), aimed at novel scenarios for 2030 and 2050 about alternative futures of the European transportation industries. The project intended to identify key success factors for a sustainable growth of the European transport industry and for

policies that could preserve or increase its sustainable strength in a long perspective up to 2050. Having a critical point of view, the project aggregated all the available foresight intelligence in order to compare and assess various visions and especially different policies proposed to reach these goals. In its “Deliverable D 6.2- Wild cards and weak signals in the transportation field” (Hauptman et al., 2014), RACE2050 project collected and recorded a wide range of so-called wild cards, weak signals and disruptive technologies related to the transportation field, scanning the pertinent literature. After completing several interviews with subject matter experts and brainstorming sessions with the participation of members of the project team and external experts, D 6.2 ended up with fourteen wild cards describing disruptive future events or developments that may occur in the near or distant future and may challenge the “conventional wisdom”. These wild cards thought to provide important input to the forthcoming scenarios development process. Some of the aforementioned wild cards were considered to be future transport concepts, thus were captured for the purposes of the current Deliverable.

It is worth mentioning that except for the concepts that stemmed from RACE2050 wild cards, a few concepts were identified in the interviews with experts as well as in the brainstorming sessions presented in D 6.2. Despite the fact that these concepts were not included in the project final selection of the fourteen wild cards, it was considered appropriate to be captured, because they might had researched, discussed or proposed in other research projects or forward-looking reports. In short, the transport concepts of the future captured by RACE2050 project, are the following:

- **slow travel / slow logistics** (reduced importance of time regarding both passenger and freight transport; “slow travel” and “slow logistics” movements become mainstream as a counter-reaction to the environmental pressure and the stress of modern life; “slow movement” may include a shift from air to sea and train).
- **superfast ground and underground transportation** (an innovative super-fast method of transport will replace aircrafts and move passengers across countries rapidly, efficiently and cheaply; a super-fast revolutionary ground transportation – hyperloop or similar – will be developed and used).
- **magnetic mobility** (magnets will be considered as an alternative and efficient method for transportation; magnetic trains – magnetic levitation (maglevs); shopping carts sliding on magnetic tracks; magnetic shoes for sliding along tracks).
- **personal air transportation – “flying cars”, “flying taxis”** (small personal flying vehicles; “flying cars” – autonomous vehicles capable of flight will be developed for congested areas; “flying taxis” will travel between skyscrapers carrying 4-6 passengers, taking off and landing vertically and possibly parking on roofs; vertical take-off and landing (VTOL) personal air vehicles).
- **automation** (autonomous ground vehicles widely used; autonomous cars; assimilation of autonomous vehicles into public use; ban of human-driven cars in specific areas).
- **delivery drones** (delivery drones become indivisible part of the supply chain; rapid decrease of the delivery cost of light products to relatively short distances).
- **electrification** (all-electric road transportation based on renewable energy; electric cars; electric trucks; all roads wirelessly propel vehicles or charge their batteries using solar panels, wind turbines, etc.; electricity-propelled aircrafts).

- **vertical transportation, intra-building mobility, spider-vehicles** (growing urbanization leads to vertical and horizontal transportation in and between buildings; more vertical systems will be needed to move people between floors; vertical technologies for rapid ascent/descent will be developed for buildings; “spider vehicles” able to climb on the outside of buildings and park on walls and roofs).
- **small vehicles developed fit-for-urban-purpose** (small and light personal vehicles widely used, carrying one or two person and resembling 4-wheel motorcycles; smaller and more efficient vehicles).
- **expandable vehicles – expandable cars** (technologies for recycling vehicles will be developed; 3D- printing technology will be widely used to print cars; vehicles will become remarkably cheap and will be considered expandable; people will dispose of cars after some use, instead of repairing them).
- **smart use of travel time** (changing value of travel time; speed of travel might become less important than quality; enabling working “on the move”; transportation may become a leisure activity).
- **shared mobility, on-demand mobility, MaaS** (shared mobility concepts; autonomous and shared vehicles).

OPTIMISM project (FP7, 2011-2013), mainly focused on the development of strategies, methodologies and recommendations for optimizing passenger transport systems based on the impact of co-modality and ICT solutions. A sub-objective of OPTIMISM project was to define future changes in the passenger’s travel system that would result in more sustainable ways of travelling. The main objective of OPTIMISM WP3 was to develop scenarios in order to model the impact of the implementation of co-modality ICT-based strategies on passenger transport systems. The OPTIMISM project scenarios were defined as a function of two variables: energy prices and support of sustainable transport policies. For the development of the project scenarios, an identification of a set of strategies was required, specifically aimed at co-modality and integration of passenger transport systems. These strategies were accompanied with both ICT-based and non-ICT measures. All the aforementioned strategies and policy measures, which were presented in the OPTIMISM “Deliverable D 3.3- Delphi expert report on the future scenarios of transport and mobility” (Delle Site et al., 2013), were considered to be a future transport concepts source.

The aforementioned strategies as well as the proposed measures for each strategy, were described in more detail in OPTIMISM “Deliverable D 5.1- Definition of strategies for integrating and optimizing transport systems” (Delle Site et al., 2012). The expected impacts of the proposed policy measures especially aimed at supporting co-modality and integration in passenger transport, were further discussed in OPTIMISM “Deliverable D 3.4- Modelling future mobility – scenario simulation at macro level” (Kompil et al., 2013). The future transport concepts researched, discussed or proposed by OPTIMISM project, are briefly the following:

- **personal rapid transit – PRT** (innovative systems regarding public collective means of transport, such as personal rapid transit – PRT).
- **seamless transport chains – multimodality, intermodality** (seamless international / national travel for passengers; optimization of international / national travelling by improving the planning processes and the integration between national legs of international trips / trip legs at the local and regional level; improvements needed regarding interchange points and their access).

- **automation** (autonomous vehicles to support co-modality; autonomous cars; step-by-step development of autonomous vehicles).
- **electrification** (increasing importance of electricity in transport (e-mobility); higher willingness of consumers to purchase electric vehicles; possible and desired shift of the vehicle fleet from conventionally fuelled-vehicles to electric vehicles; electric cars; electric and plug-in hybrid vehicles; electric trucks; battery costs, power density and charging speed for electric vehicles).
- **shared mobility, on-demand mobility, MaaS** (new mobility paradigm based on public means of transport both individual and collective; new forms of collective, shared mobility based on efficient combination of all modes; vehicle rental schemes; car-sharing and bike-sharing services to reduce passenger car usage and ownership; demand responsive transport schemes; mobility as a service – MaaS; integrated travel information on different transport modes, available in a single platform; supporting travellers to make informed decisions about the combination of transport modes most convenient to use).
- **innovative check-in processes** (flight check-in in railway stations; flight check-in on board of trains; increase travel comfort by saving travellers' time and efforts).

METRIC project (FP7, 2013-2015) primarily intended to map the regional transport innovation capacity and to identify the competitive advantage of regions. The project delivered guidelines for the preparation of regional innovation roadmaps - strategy plans, based on the identified strengths of each region. Furthermore, METRIC project further explored regional innovation potential and produced recommendations to support weak regions. In its "Deliverable D 5.2- Development of innovation roadmaps" (Christodoulou et al., 2014), several transport innovation roadmaps were presented. These roadmaps were structured around ten transport innovation (technological) fields that had been identified in the EC – Strategic Transport Technology Plan (STTP). The aforementioned transport innovation roadmaps aimed to assist regions in the identification of specific areas of interest and to lead their first steps.

Although not quite specific but generalized (e.g. "clean, efficient, safe and smart road vehicles") the transport innovation roadmaps presented in D 5.2, included some future transport concepts that were identified and captured for the purposes of the current Deliverable. In summary, the future transport and mobility concepts identified in METRIC project, are presented below:

- **personal air transportation – "flying cars", "flying taxis"** (innovation will enable air transport systems to accommodate manned and unmanned air vehicles, seamlessly and securely).
- **seamless transport chains – multimodality, intermodality** (seamless transport chains; enhancing the interoperability and inter-modality of network systems; integrating information and communication systems to provide seamless services; establishing multimodal centres to ensure the smooth interaction between modes for both passenger and freight transportation; seamless logistics – smooth combination of different modes and minimization of delays / interruptions).
- **automation** (new vehicle concepts – autonomous vehicles; autonomous cars; autonomous trucks for freight transport; autonomous aircrafts – next generation of aircrafts thanks to automation and high technology).

- **noiseless transport** (noiseless aviation; quiet air vehicles; new technologies to reduce noise emissions in the air transportation; noise reduction of air traffic operations; noiseless trains; reduction of noise and vibration in trains; solutions to mitigate noise and vibration at the level of both rail infrastructure and rolling stock).
- **electrification** (electromobility in the automotive sector; electric cars; electric trucks; electricity- and hydrogen- powered vehicles; further developments required to improve performance and economic efficiency of electric vehicles; focus on charging / refuelling infrastructure, wireless charging and reduction of charging time for the further diffusion of electric vehicles).
- **integrated security approach, seamless security checks at airports** (innovation will allow seamless and highly secure security checks at airports).
- **blue modal shift** (shift to waterborne transport, in line with transport White Paper goals; blue modal shift to improve performance of logistics chains and increase use of greener modes of transport).
- **freight distribution centres – freight villages** (creating appropriate logistics centres and terminals; freight distribution centres).
- **urban cross-modal logistics** (urban deliveries using different transport modes; small electric vehicles for urban freight transport and distribution).
- **high-speed rail** (a complete European high-speed rail network is needed; a high-speed rail network accompanied with a dense railway network to cover the needs of the majority of medium-distance passengers).
- **quite night urban deliveries** (urban deliveries done at night, when the traffic is limited).

IKNOW project (FP7, 2008-2011) aimed at creating and interconnecting knowledge on topics and developments likely to occur and reshape or radically alter the future of science, technology and innovation in Europe and the world. Within the context of IKNOW project, several wild cards and weak signals were identified and further analyzed in terms of how they affect the European and global science, technology and innovation policy. Although the project was not particularly transport related, some of its identified wild cards and weak signals touched the transportation sector, forming potential transport concepts of the future. These transport related wild cards and weak signals that were considered to comprise future mobility concepts, were presented in the IKNOW project official website (IKNOW, 2011), as well as in RACE2050 project D6.2 (Hauptman et al., 2014). The future transport and mobility concepts identified in the IKNOW project and captured for the purposes of the current Deliverable, are briefly the following:

- **slow travel / slow logistics** (importance of time is strongly decreasing; shift from “just in time” concept to “slow logistics” movement to reduce environmental costs caused by transportation; ordered goods remain in the storage until a certain amount of goods can be loaded onto a single truck; the “slow travel” movement becomes mainstream as a counter-reaction to environmental pressure and the stress of modern life).
- **personal air transportation – “flying cars”, “flying taxis”** (pilotless personal airplanes “flying cars” based on unnamed aerial vehicle – UAV technologies; appropriate computerized air traffic control; safe personal air transportation systems widely used, as an attractive alternative to today’s private cars).

- **seamless transport chains – multimodality, intermodality** (integrated multimodal supply chains to enable seamless just-in-time deliveries without stop-overs across the world; reduced costs, higher quality, most satisfied customers).
- **automation** (automated guidance systems for vehicles revolutionise traffic; people agree to less driving pleasure; autonomous cars; autonomous vehicles to reduce accidents, fatalities and traffic congestion; smart use of the freed daily commute time; autonomous passenger aircrafts operating completely via autopilot, not having a pilot on board).
- **noiseless transport** (noiseless aviation; new technologies such as smart high lift and flow control systems to enable noiseless aviation; rise of air traffic thanks to deregulations regarding night flights; vast increase of CO_2 emissions).
- **electrification** (wide use of electric cars; electric cars become widespread as new generation of batteries emerges to markets; development of fuel-cell electric vehicles – FCEVs as a better alternative to biofuels and electric cars; electric aircrafts).
- **shared mobility, on-demand mobility, MaaS** (growing demand for mobility services; more and more people prefer to rent, rather than own, mobility devices or to use public transport; shared mobility schemes as a result of the growing awareness regarding environmental problems caused by transportation).

Table 2 presents all the future transport concepts that have been identified by EC projects. The matrix shown in Table 2 lists future transport concepts over sources, aiming to determine concepts that are processed in the majority of the EC projects reviewed thus to indicate a certain level of consensus to those that are more likely to shape the future transport landscape.

Table 2. Future transport concepts from EC projects

Future Transport Concepts	***EC PROJECTS (FP7, H2020)***						
	RACE 2050	***MOBILITY4EU***	***FUTRE***	***METRIC***	***OPTIMISM***	***IKNOW***	***Total Number of Citations***
Slow Travel / Slow Logistics	**+**	**-**	**-**	**-**	**-**	**+**	**2**
Superfast Ground and Underground Transportation (Hyperloops, Underground Freight Pipelines)	**+**	**+**	**+**	**-**	**-**	**-**	**3**
Personal Rapid Transit (PRT)	**-**	**+**	**+**	**-**	**+**	**-**	**3**
Magnetic Mobility, Magnetic Levitation	**+**	**-**	**-**	**-**	**-**	**-**	**1**
Personal Air Transportation, "Flying Cars", Flying Taxis"	**+**	**+**	**+**	**+**	**-**	**+**	**5**
Seamless Transport Chains - Multimodality, Intermodality	**-**	**+**	**+**	**+**	**+**	**+**	**5**
Automation (autonomous cars, trucks, trains, aircrafts, vessels)	**+**	**+**	**+**	**+**	**+**	**+**	**6**[1]
Noiseless Transport	**-**	**+**	**-**	**+**	**-**	**+**	**3**
Mega Aircrafts	**-**	**+**	**-**	**-**	**-**	**-**	**1**
Delivery Drones	**+**	**+**	**-**	**-**	**-**	**-**	**2**

[1] Autonomous Cars, 6 citations (all projects), Autonomous Trucks, 3 citations (MOBILITY4EU, FUTRE, METRIC), Autonomous Aircrafts, 2 citations (METRIC, IKNOW), Automated Trains, 1 citation (MOBILITY4EU), Autonomous Ferries and Vessels, 2 citations (MOBILITY4EU, FUTRE).

Future Transport Concepts	*EC PROJECTS (FP7, H2020)*						
	RACE 2050	*MOBILITY4EU*	*FUTRE*	*METRIC*	*OPTIMISM*	*IKNOW*	*Total Number of Citations*
Electrification (electric cars, trucks, aircrafts, vessels)	+	+	+	+	+	+	**6**[2]
Vertical Transportation - Intra-Building Mobility	+	-	-	-	-	-	**1**
Small Vehicles Developed Fit-For-Urban-Purpose	+	+	+	-	-	-	**3**
Expandable Cars	+	-	-	-	-	-	**1**
Smart Use of Travel Time	+	+	+	-	-	-	**3**
Shared Mobility, On-Demand Mobility, MaaS	+	+	+	-	+	+	**5**
Seamless Security Checks, Innovative Check - In Processes	-	+	-	+	+	-	**3**
Blue Modal Shift	-	+	+	+	-	-	**3**
Floating Delivery Hubs	-	+	-	-	-	-	**1**
Bus Rapid Transit Corridors - BRT	-	+	-	-	-	-	**1**
Co-Modality	-	+	+	-	-	-	**2**
Freight Consolidation Hubs, Freight Distribution Centres	-	+	+	+	-	-	**3**
Urban Cross-Modal Logistics	-	+	+	+	-	-	**3**

[2] Electric Cars, 6 citations (all projects), Electric Trucks, 5 citations (RACE2050, MOBILITY4EU, FUTRE, METRIC, OPTIMISM), Electric Aircrafts, 4 citations (RACE2050, MOBILITY4EU, FUTRE, IKNOW), Hybrid and Electrified Ferries and Vessels, 2citations (MOBILITY4EU, FUTRE).

Future Transport Concepts	***EC PROJECTS (FP7, H2020)***						
	RACE 2050	***MOBILITY4EU***	***FUTRE***	***METRIC***	***OPTIMISM***	***IKNOW***	***Total Number of Citations***
Personal Mobility Devices	**-**	**+**	**+**	**-**	**-**	**-**	**2**
High-Speed Rail	**-**	**+**	**+**	**+**	**-**	**-**	**3**
"Pragmatic Cars" and "Fun Cars"	**-**	**-**	**+**	**-**	**-**	**-**	**1**
Urban Cable Cars	**-**	**-**	**+**	**-**	**-**	**-**	**1**
Parcels into the Receivers' Car Trunk	**-**	**-**	**+**	**-**	**-**	**-**	**1**
Delivery Boxes	**-**	**-**	**+**	**-**	**-**	**-**	**1**
Crowd Delivery	**-**	**-**	**+**	**-**	**-**	**-**	**1**
Quite Night Urban Deliveries	**-**	**-**	**-**	**+**	**-**	**-**	**1**

3.2 Review of selected forward-looking reports

Manyika et al. (2013) researched and assessed the potential implications of several rapidly growing technology areas on industry, economy and society. Twelve disruptive technologies were identified that could have the potential to radically reshape life, business and global economy by 2025. The disruptive technologies identified were further analyzed in terms of their potential reach and scope and their potential economic impact and disruption, providing useful insights to business leaders, policy makers and society in general. Among others**, autonomous and near-autonomous vehicles** were considered to form one of the twelve identified rapidly advancing technologies with a significant potential to drive economic impact and disruption by 2025. Under this umbrella term, three different future transport concepts were identified and captured for the purposes of the current Deliverable: **automation**, including **autonomous cars, trucks**, **aircrafts** and **boats**, **smart use of travel time** as a result of driverless cars and trucks, as well as **delivery drones**.

The report mentioned that **autonomous cars and trucks** are expected to revolutionize ground transportation – regulations and wide public acceptance permitting – affecting car users, industries related to cars and trucks, technology-related industries and intermodal logistics systems. Benefits resulting from autonomous cars and trucks widespread use, such as enhanced safety, reduced congestion, increased productivity in the trucking industry and lower fuel consumption and emissions, could have a huge economic impact. Moreover, autonomous and driverless cars and trucks will enable "drivers" to make **use of the time freed**, working, relaxing or socializing during their commute. Such a fact may emerge new business models and opportunities for industries willing to provide in-transit experience. Last but not least, the report recognized the potential widespread use of low-cost commercially available **drones** that could be used for different applications including **deliveries**.

Briggs and Sundaram (2016) aimed at identifying the increasing role of information and communications technology – ICT in enabling mobility services and sustainability. The overall aim was to present the potential extend of future mobility challenges and examine ways to address these challenges based on new approaches and new mobility business models. According to the analysis, ICT solutions have a great potential to address future mobility challenges and enable new mobility business models that will change the usage of vehicles and networks. Several transport concepts were identified in the aforementioned analysis, including **seamless transport chains – multimodality – intermodality**, **automation**, **electrification**, **small vehicles developed fit-for-urban-purpose** and **shared mobility**, **on-demand mobility**, **Maas**.

- **seamless transport chains – multimodality, intermodality** (public and private transport linkage to seamlessly deliver multi-modal mobility offers; shift from single-mode transportation to multi-modality).
- **automation** (highly and fully autonomous vehicles; autonomous cars; autonomous vehicles for car ownership and emissions reduction and for safety improvement; several technologies supporting automation, such as autonomous emergency braking – AEB, high-definition mapping and artificial intelligence – AI, become mainstream by 2025).

  electrification (hybrid and electric vehicles for road transport emissions reduction; hybrid, plug-in hybrid, range extended electric vehicles – eREVs and full-battery

electric vehicles – BEVs already available; technology improvements and supportive policies needed for a widespread diffusion of electric vehicles).

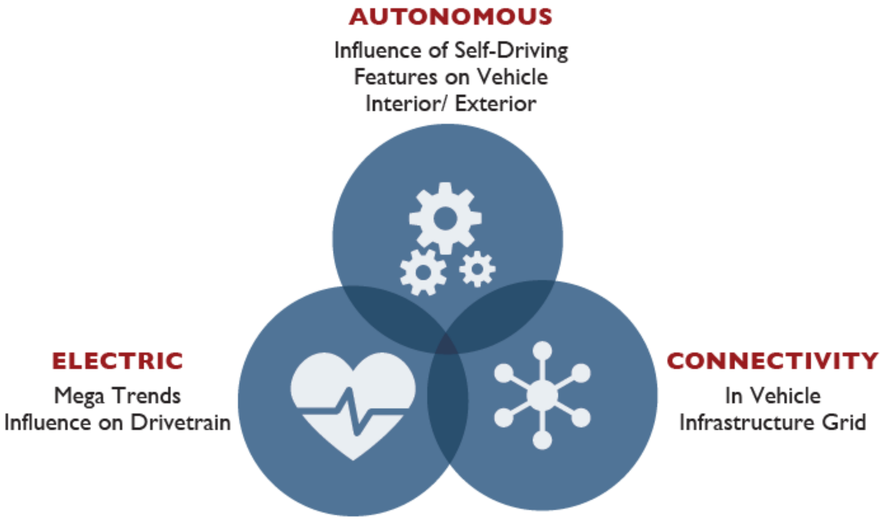


Figure 3. Convergence towards Electric, Connected and Autonomous Vehicles

Source: Briggs and Sundaram (2016)

- **small vehicles developed fit-for-urban-purpose** (smaller, lighter and more sustainable vehicles).
- **shared mobility, on-demand mobility, MaaS** (rise of alternative mobility services, such as car-sharing, bike-sharing, ride-sharing, car-pooling and ride-on-demand / ride hailing services; shift from private cars to shared mobility offers; reduction in private car ownership; integrated MaaS; shift from limited alternatives to an integrated multi-modal set of mobility options; MaaS to enable customers to make informed mode choices; more convenience, time and cost savings for MaaS users; agreements between several public- and private-sector bodies needed for MaaS implementation).

Figure 4. The evolving user-centric approach to MaaS

Source: Briggs and Sundaram (2016)

After having taken into consideration the deep crisis that automotive industry has undergone, Winterhoff et al. (2009) analysed the emerging long-term trends with a view to predict the different types of mobility customers of the future. Based on these new mobility requirements, four different business models were presented, aiming to provide automotive industries with useful insights regarding their future development and resilience. The study delivered an agenda including core elements to guide automotive industries on developing their future strategy plans. The transport concepts that were identified and captured by the aforementioned study, are the following:

- **electrification** (electric cars; electric cars widely used especially in megacities).
- **small vehicles developed fit-for-urban-purpose** (shift from big, luxurious vehicles to smaller and more efficient vehicles; downsizing cars/vehicles).
- **smart use of travel time** (in-transit experience fulfilling customers' needs; car experience as an extension of office and living room, in-transit experience making use of multimedia networking).
- **shared mobility, on-demand mobility, MaaS** (shared mobility schemes; car-pooling; car-sharing; short-term rental car offers; usage is increasingly more important than ownership; increasing demand for mobility services that combine mobility, media integration and connectivity).
- **private car ownership – luxury vehicles** (size, luxury and engine performance remain important purchase criteria for specific and smaller customer groups).

KPMG (2017), in its Global Automotive Executive Survey, assessed the status quo and the future prospects of the global automotive industry. A big number of automakers, suppliers, dealers, rental companies, financial and mobility services providers, ICT-related companies and customers participated in the survey, enabling the latter to result in interesting and insightful findings. All these different opinions of the aforementioned senior executives and customers, enabled KPMG to identify the key trends in the automotive industry until 2025. Among the identified key future trends, several future transport concepts were captured, which are briefly presented below:

- **automation** (autonomous and self-driving cars; autonomous driving will revolutionize current car usage and radically alter customers' purchasing criteria; autonomous cars will redefine vehicles' utility and enable new service- and data-driven business models; autonomous vehicles for road safety improvement; zero-error ability as a major element in automation concept).
- **electrification** (electrification proved to be the major key trend in the automotive industry until 2025; an e-mobility share up to 30% of the worldwide automotive production is estimated by 2023; battery electric vehicles – BEVs; fuel cell electric vehicles – FCEVs; hybrid electric vehicles – HEVs; plug-in hybrids; full-hybrids; BEVs are believed to be the first key trend; dense charging network, long-distance infrastructure of super-chargers, workplace and home chargers needed for a widespread diffusion of BEVs; FCEVs are partially considered as a bigger breakthrough, largely because of their strong attachment to the existing infrastructure; FCEVs technology still far from market maturity).
- **small vehicles developed fit-for-urban-purpose** (downsizing the internal combustion engines – ICEs were evaluated as the 10th key trend, being no longer a major key trend in the automotive industry).

- **smart use of travel time** (effective use of the freed – thanks to driverless vehicles – travel time, as a major purchasing criterion; vehicle independent products and services).
- **shared mobility, on-demand mobility, MaaS** (shared economy mobility concepts; shift towards less car ownership; fewer personally owned vehicles produced and sold; shift towards MaaS when cost and discomfort become higher than utility of personally owned vehicles; MaaS for more efficient utilization of resources – less cars on the roads but more personal miles travelled).

Figure 5. Key trends in the automotive industry until 2025

Source: KPMG (2017)

D'Incà and Mentz (2016) recognized that current mobility business models are to be challenged by future disruptions expected to emerge in the transportation sector. In their research, they attempted to outline the future transport landscape, to highlight the challenges that transportation sector will face over the next decades and to recommend the adaptations that will be required. In doing so, they consulted several executives and experts operating in the transportation industry. Future mobility concepts analyzed in this report, are **hyperloop**, **automation** (**autonomous cars, trucks, buses and trains**) and **shared, on-demand mobility**, **MaaS**:

- **superfast ground and underground transportation** (hyperloops for passenger transportation, e.g. 1200 km/h hyperloop).

- **automation** (autonomous vehicles – AVs; autonomous – self-driving cars; autonomous trucks; development of fully autonomous and shared vehicle fleets; shared autonomous cars replace personally owned cars; automation for improved safety, capacity and power-train efficiency; autonomous buses; automated trains).
- **shared mobility, on-demand mobility, MaaS** (expansion of sharing economy; increase of shared car usage; shared autonomous cars replace private cars – reduction of private cars; shared mobility becomes mainstream; significant increase of car- and ride- sharing; mobility on-demand; sharing and end-to-end mode integration thanks to MaaS; car- and ride- sharing options better integrated with other transport options).

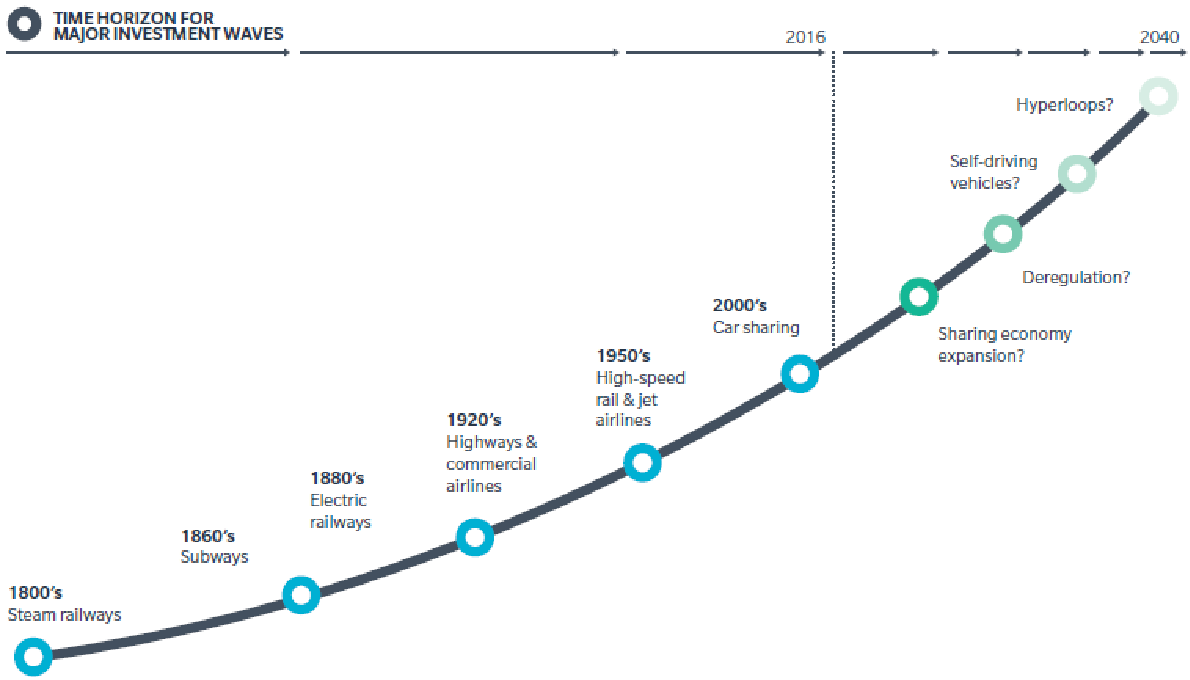


Figure 6. The changing pace of innovation

Source: Source: D'Incà and Mentz (2016)

Taking into account the emerging paradigm shifts in the automotive industry, driven by CO_2 regulations, shared mobility schemes and increased awareness of environmental problems cause by the transport sector, Cornet et al. (2012) studied the trends that will reshape the automotive sector. After having identified consumer behaviour patterns, the study described demands which will form key opportunities for the development of the automotive industries in the coming decades. The study, identified the following transport concepts of the future:

- **electrification** (electrification of the powertrain of cars; reduction of CO_2 emissions thanks to younger and more electrified shared car fleets; electric shared vehicles fueled with renewable energy sources).
- **smart use of travel time** (be accessible on the way; connectivity and media integration while driving; use of travel time for car-based media consumption; car-based media consumption as an economic opportunity for automotive industries – monetizing driving time).
- **shared mobility, on-demand mobility, MaaS** (increase of car-sharing; car-sharing as a replacement to private car ownership; car-sharing is partially seen as an addition

to and not a replacement of private cars; car-sharing using fleets of shared cars with a large share of electric vehicles).

- **private car ownership – luxury vehicles** (despite general reduction in car ownership, young people are still willing to own private cars; some people will continue to own cars and see them as status symbols).

RethinkX is an independent project aiming at understanding the dynamics of disruption across major market sectors, including transportation. Within this framework, Arbib et al. (2017) analyzed and forecasted the potential implications of Transport as a Service- TaaS disruption on individual car ownership, automobile industry and oil value chain. The report used Seba Technology Disruption FrameworkTM to make its forecasts about the speed and scale of the TaaS-driven disruption. The transport concepts identified in this report and captured for the purposes of the current Deliverable, are presented below:

- **automation** (autonomous vehicles; fully autonomous vehicles – automation level 5 – with no need for human intervention; self-driving cars; widespread regulatory approval of autonomous vehicles; big share of passenger miles travelled served by shared autonomous electric vehicles).
- **electrification** (electrification of drivetrains; electric vehicles will disrupt internal combustion engine – ICE vehicle sales; electric cars and trucks; supercharging infrastructure needed; shared autonomous electric vehicles).
- **smart use of travel time** (TaaS will free up time otherwise spent driving; smart use of travel time – working, studying, sleeping, etc.; TaaS providers could offer additional services, such as entertainment – movies, work services – “offices on wheels”, food and beverages – “coffee on wheels”; revenues for TaaS providers generated by entertainment and product sales, on-board advertising, data monetization).
- **shared mobility, on-demand mobility, MaaS**, **TaaS** (widespread use of shared vehicles; reduction of individual vehicle ownership – especially ICEs; shift from individual car ownership to on-demand mobility and per usage charge; TaaS as a new model for passengers to access transportation on-demand; TaaS to provide higher level of service than current ownership models; TaaS as a cheaper alternative to privately owned cars; TaaS utilizing autonomous electric vehicles owned by fleet operators; rapid and widespread adoption of TaaS concept; integrated – all modes included mobility options).
- **private car ownership – luxury vehicles** (although highly reduced, individual car ownership and use of ICEs or EVs could continue, at the side of TaaS use).

In a Deloitte University Press publication, Corwin et al. (2015) studied the future development of transportation, researching how the emerging technologies and social trends will shape a new business ecosystem as well as the potential implications on the transportation industry. Having reported the driving forces that are expected to play a significant role in the future development of transportation, the report envisioned four co-existing mobility futures that derived from the intersection of two major trends (vehicle control – driver versus autonomous and vehicle ownership – private versus shared). The report concluded with several recommendations, aiming to guide the next steps of the automotive industries. The report discussed several mobility concepts that are expected to form the future transport landscape:

- **seamless transport chains – multimodality, intermodality** (seamless multimodal transportation as the new norm; greater system interoperability to enable

multimodality; traveling using multiple and connected modes of transport; single fixed price charged).

- **automation** (emergence of autonomous – driverless vehicles; autonomous cars will soon become a commercial reality; a new era utilizing fully autonomous and shared cars accessible on demand; rapid decrease of road traffic accidents thanks to autonomous cars; autonomous trucks for freight transport).
- **electrification** (electric cars; maturing powertrain technologies – electric vehicles, battery electric vehicles, fuel-cell electric vehicles; electrification for lower emission levels).
- **smart use of travel time** (greater time available thanks to autonomous vehicles and shared mobility patterns; multimedia consumption and multitasking options while travelling; advertising, subscription and data monetization as potential revenue sources for companies).
- **shared mobility, on-demand mobility, MaaS, TaaS** (shared mobility challenges current private ownership model; shift from private car ownership to shared, on-demand mobility; mobility consumption based on pay-per-use; a world of car-sharing – continuing growth of shared vehicles usage; growing appreciation of the conveniences created by car- and ride-sharing; expansion of shared vehicle services, shared on-demand autonomous vehicles; using smartphone apps for transport; integration of sharing schemes with all other modes of transport).
- **private car ownership – luxury vehicles** (personally owned human-driven vehicles – private ownership remains the norm; personally owned autonomous vehicles – widespread acceptance of autonomous vehicles, yet continuing private ownership).

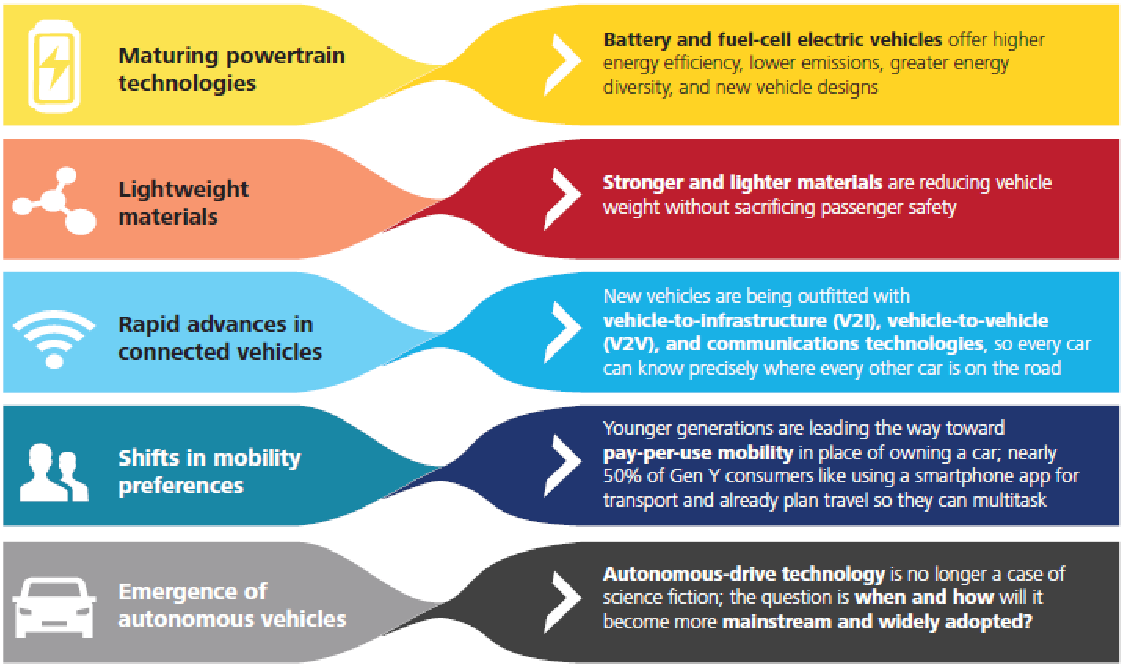


Figure 7. Converging forces transforming the future evolution of automotive transportation and mobility

Source: Corwin et al. (2015)

Taking into account the rapid pace of change, Corwin et al. (2016) conducted a research that was the follow-up to previously mentioned one, aiming at outlining the future evolution of

mobility. Gathering opinions of several corporate executives, technologists, government leaders and academics, the paper attempted to foster collective thinking about the future challenges and potential developments of the automotive transportation and mobility in general. The transport concepts researched, discussed or proposed in this study, are briefly described below:

- **personal rapid transit – PRT** (autonomous and shared pods for the last leg of urban trips).
- **seamless transport chains – multimodality, intermodality** (emergence of seamless intermodal transport choices; seamless mobility as a result of shared, on-demand and autonomous-drive model of the future).
- **automation** (shift from driver-driven vehicles towards a future system based on – but not exclusively composed of – autonomous vehicles; fast introduction of fully autonomous vehicles as a part of shared fleets or for private ownership; autonomous cars; autonomous commercial trucks; automation for buses, trains and other forms of transport).
- **electrification** (an extended range of affordable electric vehicles to markets in the coming years; electric cars and trucks; electric and fuel-cell electric vehicles; advanced electrical vehicle architecture and components; battery recharging infrastructure needed).
- **small vehicles developed fit-for-urban-purpose** (smaller in size vehicles, small pods).
- **smart use of travel time** (in-transit experience enhanced by shared autonomous vehicles providers; different options offered, such as entertainment, relaxing, business applications, meals, etc.; economic opportunities for companies – in-vehicle experience enablers).
- **shared mobility, on-demand mobility, MaaS** (a move away from personally owned vehicles towards shared mobility schemes; rise of car- and ride-sharing platforms; expansion of shared vehicle services, MaaS).
- **private car ownership – luxury vehicles** (car fleets based on – but not exclusively composed of – shared vehicles; drivers prefer owning vehicles, while seeking automation for its conveniences).

After having recognized that **mobility as a service – MaaS** constitutes the next big revolution in mobility, Goodall et al. (2017) examined the current scope, described its major elements and the role of different players in its implementation and outlined the future evolution of MaaS concept. According to the article, MaaS concept derived from two key trends: the growing desire of people for more liveable cities and the increasingly widespread use of shared mobility options and journey planning apps. The next logical step would be to integrate all these options under one roof (in a single digital platform), a vision that basically describes the MaaS concept. Such a fact would enable end-to-end trip planning across all modes of transport, while offering flexible and smart payment/ticketing schemes and personalized mobility offers based on user preferences.

The article also recognized the various core elements for a successful implementation of MaaS concept, namely seamless and fast internet connection for smartphones, dynamic information updates regarding travel options as well as integrated, smart and cashless payment options. Apart from the above-mentioned elements, another crucial factor was recognized to be the cooperation between several different players, such as public and

private mobility providers, mobility management players, telecommunication industries, local authorities, etc. Being complementary to MaaS concept, other future transport concepts captured by the article include **seamless transport chains** (seamless intermodal travel, as a result of the rise of MaaS) and **automation** (MaaS offerings utilizing autonomous cars and buses).

UKi Media & Events (2018) prepared a publication in order to showcase the proceedings and frame the Future of Transportation conference, scheduled to take place on June 19-20, 2018 in Cologne, Germany. The review titled "The Future of Transportation 2018" looks at all possible future transportation concepts, some of which stemmed from industry initiatives. The wide range of future transport concepts and mobility solutions presented, enables the reader to visualize how transportation will look like in the future. The review presented and discussed several future transport concepts. These are:

- **superfast ground and underground transportation** (hyperloop is characterized as the revolutionary "fifth mode of transport"; hyperloop is quickly gaining credibility and support; increasing competition for the introduction of hyperloop as a viable transportation option; hyperloop development to alleviate the future transportation challenges; hyperloop as an attractive alternative to air transportation;
- **personal rapid transit – PRT** (autonomous and small pods for the last leg of urban trips; autonomous small pods for travelling inside stations – e.g. rail stations or airports and between stations and city centres; autonomous, shared and small pods/buses for more flexible routes and timings; several PRT systems already running – Finland, Germany, UK; novel pod-related concepts – modular, fully-electric, zero-emissions passenger pods/capsules able to use road, fly and be carried by other transport modes such as trains and hyperloops (POP.UP, Italdesign and Airbus).
- **personal air transportation – "flying cars", "flying taxis"** (airborne autonomous low-speed aircrafts are likely to play an important role in urban and inter-urban travel; Personal Airborne Transportation Systems – PATS and autonomous passenger aerial vehicles will quickly be affordable for everyone; trials already running across the world; increasing interest coming from aviation and automotive manufacturers as well as technology related companies; further developments required in terms of testing and design in order for passenger drones to form safe and reliable transport modes; designing "vertiports" to accompany the Electric Vertical Take-Off and Landing vehicles – eVTOL revolution; several personal airborne transportation systems in progress: CityAirbus, Vahana, EHang184, Volocopter 2X, Uber Elevate).
- **seamless transport chains – multimodality, intermodality** (seamless travel experience thanks to mobility as a service – MaaS concept development).
- **automation** (autonomous vehicles will transform the way people move; road safety improvement, congestion reduction and aging population transportation form benefits coming from autonomous vehicles; autonomous cars; off- and on-street testing already running across the world; 90% of the vehicles sold by 2040 are predicted to be highly or fully autonomous (Level 4 and 5); the majority of autonomous vehicles are expected to be electric; public acceptance, safe interaction of different road users, legal issues – regulations, cyberattacks, privacy and safety form key topic areas for autonomous vehicles; infrastructure able to be understood by both autonomous and non-autonomous vehicles needed; autonomous trucks; automation of high-speed trains).

- **noiseless transport** (noiseless freight trains; quiet transportation by rail to reduce road freight traffic).
- **delivery drones** (future drone deliveries directly to customer window; drones will revolutionize the delivery of goods; safe integration into the aviation system needed; new concepts required to ensure safety).
- **electrification** (electric vehicles – EVs will have a huge impact on the movement of people and goods; EVs as a key enabler for emissions reduction; electric cars; electric trucks; more affordable EVs over the coming years; several forecasts regarding the rise of EVs sales; widespread adoption of EVs and replacement of conventional internal combustion engines – ICEs; future transportation networks able to charge vehicles while traveling; charging infrastructure network needed – a fast-charging network across Europe is planned by the automotive Original Equipment Manufacturers – OEMs; sharing schemes utilizing electric vehicles).
- **smart use of travel time** (because of the non-involvement in the driving process, people are able to spent that time working, sleeping, studying, surfing the web, etc.).
- **shared mobility, on-demand mobility, MaaS** (growing use of sharing schemes – car-, ride- and bike-sharing; novel bike-sharing schemes – dockless bike hire; several leading OEMs targeting the ridesharing market; reduction of private car ownership thanks to shared mobility; sharing schemes challenged by traditional taxi service companies and local governments; MaaS will completely change the way people and goods are going to be transferred in the future; MaaS concept entails an offering of a single digital service that integrates the entire transport network and enables end-to-end journey planning; MaaS as an attractive alternative to private car ownership; MaaS concept requires integration and regulation of different forms of transport and various providers; public and private entities collaboration depicts the main concern around MaaS concept implementation).
- **capsules transported by carrier aircraft** (a concept that stems from “AIRLINER 2.0”, designed by EPFL’s – Swiss Federal Institute of Technology – Transportation Centre – TRACE; capsules containing people, freight or fuel transported by carrier aircraft; flying wing able to carry capsules for different purposes; capsules resemble the main body of an aircraft, being able to be used as train carriages as well).
- **urban cross-modal logistics** (multimodal solutions to improve last-mile efficiency of urban logistics; smaller and cleaner vehicles for urban deliveries).
- **high-speed rail** (long-distance passenger traffic with high-speed trains; high-speed rail as a competitive alternative to air transportation; innovative cheaper alternatives to high-speed rail and hyperloop: “AeroCity” concept proposed by Delft University – similar to an autonomous bus that makes use of aerospace technologies to reduce friction and enable high speed, without the need for high-tech tracks or tubes).
- **urban deliveries – crowd delivery** (private individuals who travel on particular routes are involved in urban deliveries of goods and packages; individuals take part in the delivery service, earning extra money; increasing trend of crowd delivery; crowd delivery for emissions and congestion reduction; crowd delivery as an early stage of a more flexible transportation system).

In an ARUP Foresight publication, Goulding and Butler (2018) considered the major factors driving significant challenges for the future transportation systems and discussed transport-related solutions and opportunities that could help cities deal with these emerging challenges. The report was the outcome of a series of relevant discussions between several

participants, held by London Transport Museum, in collaboration with Arup, Gowling WLG and Thales UK. The transport concepts of the future captured by the report, include:

- **superfast ground and underground transportation** (hyperloop enabled by rapid technological change).
- **personal rapid transit – PRT** (autonomous pods for public transport; increased efficiency and reduced congestion thanks to autonomous pods).
- **personal air transportation** (autonomous passenger drones).
- **seamless transport chains – multimodality, intermodality** (seamless urban travel for passengers; multi-modal transport in a seamless journey).
- **automation** (autonomous and fully autonomous vehicles; shared mobility utilizing autonomous vehicles; technological advances, safety, public acceptance, legal issues and cost reduction as determinant factors for the adoption of autonomous vehicles; autonomous cars; autonomous trucks; automated trains; small autonomous vehicles for urban deliveries).
- **delivery drones** (drones used for different functions, including package deliveries).
- **electrification** (electric cars and trucks; investment to encourage wide use of electric vehicles; charging points for electric vehicles; electrified trains – hydrogen-powered trains for passengers – hydrail).
- **shared mobility, on-demand mobility, MaaS** (rise of sharing schemes such as car-, ride- and bike-sharing; shared mobility using fleets of autonomous vehicles; shared and demand-responsive transport – DRT; integration of various public and private forms of transport to provide planning, booking and payments through a single digital platform/application).
- **co-modality** (opportunities to combine passenger and freight services).
- **urban freight consolidation centres** (consolidation centres for efficiency increase and traffic/emissions reduction in cities).
- **high speed rail** (high speed trains for better regional and inter-regional transport connectivity).
- **quite night urban deliveries** (shift to night-time deliveries, driven by vehicles automation concept).

In another ARUP Foresight publication, Goulding and Morrell (2014b) reflected on the driving forces shaping the future of rail and attempted to visualize how rail travel might look like in the future. The overall aim of the report was to set an inspiring vision for rail, identifying potential opportunities for its future development. Mainly focused on rail transportation, the transport concepts of the future captured by the report are briefly the following:

- **superfast ground and underground transportation** (implementation of hyperloop concept; hyperloop concept might lead to extremely fast methods of travel; underground freight pipelines for moving goods within and between urban areas (e.g. CargoCap, Germany).
- **personal rapid transit – PRT** (PRT systems are likely to find more applications in the future; driverless pods for moving from, to and inside rail stations; PRT powered by clean energy or magnetic levitation; several autonomous pod schemes under research/development).
- **magnetic mobility – magnetic levitation** (magnetic levitation for rail; magnetic levitation for PRT schemes/pods).

- **seamless transport chains – multimodality, intermodality** (seamless connections between rail and other modes of transport for more holistic travel experiences; integration of rail with other modes of transport; inter-modal transport solutions including rail).
- **automation** (automated trains for both passenger and freight transport; automated trains for running time and reliability optimization).
- **electrification** (electric trains – hydrogen fuel cell trains; by 2050 it is expected that hydrogen could be a major means of powering trains).
- **high-speed rail** (high-speed trains form a cheaper, greener and more sustainable transport solution).
- **freight shuttle systems** (automated, emissions-free, electric-powered transporters moving on elevated guideways, accompanied by high-efficiency terminals and communication, command and control systems; e.g. Freight Shuttle System – FSS initiated at Texas A&M Transportation Institute).

The report also envisioned several technologies for the future development of rail, which however were not considered to form transport concepts of the future. Some of the aforementioned ideas include flexible timetables, monitoring drones for predictive maintenance and improved security, intelligent robots to repair and maintain rail infrastructure, flexible interiors for different passenger needs, power generating floors, etc.

Morrell (2017) showcased twenty emerging technologies with a high potential to disrupt both the engineering and construction sectors. After defining and presenting these potential technologies, the report discussed their potential applications as well as their impacts on the aforementioned sectors. Moreover, a timeline was included in order to represent a probable timescale regarding the maturity level of each technology (concept, demonstration, commercialization and adoption). **Passenger drones** and **autonomous vehicles** are two of the technologies analyzed in the report, which were considered to form future transport concepts.

- **personal air transportation – “flying cars”, “flying taxis”** (passenger drones as a faster alternative to ground-based modes; autonomous aerial vehicles capable of transporting individuals or small groups of passengers; several concepts and prototypes already in development for use, especially in high-density urban areas; personal air transportation may affect building and public space design as well as transport infrastructure; readiness level: demonstration until 2025, commercialization and adoption before 2030).
- **automation** (autonomous vehicles – AVs; autonomous cars or other vehicle types capable of transporting users without any human intervention; AVs based on GPS and sensory observation; road safety and mobility access improvement as well as emissions reduction thanks to widespread use of AVs; AVs may affect road design, need for parking spaces, public transport and freight systems; readiness level: demonstration until 2025, commercialization until 2030, adoption in 2030).

Goulding and Morrell (2014a) envisioned the future of highways, in an ARUP Foresight publication that dealt with the future development of highways and transport infrastructure. The report recognized the forces that are expected to drive changes in highway design and construction (climate change, population growth, capacity constraints, new emerging technologies, changing user behavior patterns) and proposed concepts and solutions to

stimulate innovation across the sector. The transport concepts of the future drawn from the report, are briefly presented below:

- **seamless transport chains – multimodality, intermodality** (integrated transport networks, providing seamless connections to multiple modes – cars, buses, trains, non-motorised transportation; multi-modal solutions with seamless transition between different modes).
- **automation** (autonomous cars; autonomous trucks for freight transport; autonomous vehicles to increase safety and alleviate traffic congestion; autonomous vehicles to improve mobility access of the elderly and disabled people – new markets for the automotive companies; potential implications of autonomous vehicles on the infrastructure, e.g. narrower roads, reduced roadside signage, etc.).
- **delivery drones** (drone delivery systems for small deliveries aimed at remote, hard-to-reach areas; delivery drones to cater for areas with problematic road network).
- **electrification** (electric vehicles; battery electric vehicles; hydrogen fuel-cell electric vehicles; most drivetrains are expected to be electrified in the future; charging infrastructure / networks needed to support battery electric vehicles; wireless charging infrastructure embedded in the road – wireless inductive charging for electric cars and buses).
- **shared mobility, on-demand mobility, MaaS** (changing traditional models of car ownership; emerging shift towards shared mobility schemes; rise of on-demand car services, such as car- and ride-sharing; MaaS concept will probably become more widespread in the future).
- **freight consolidation centres** (freight consolidation centres to improve urban freight transport efficiency).
- **freight shuttle systems** (automated, emissions-free, electric-powered transporters moving on elevated guideways; freight shuttle systems for high-volume freight containers).
- **smart, dynamic and interactive highways** (safer and more sustainable roads, using interactive lights, smart energy sources and adaptable to different conditions road signs; photo-luminescent road markings; temperature sensitive warning signs on the road; solar roadways containing heating elements, inductive charging capabilities for electric vehicles, etc.).

In the last ARUP Foresight publication taken into account for the attempted identification of the key transport concepts of the future, Dohna and Morrell (2016) reported a set of fifty trends and issues that are expected to shape the future of transport in the UK. Among the identified trends and issues, which covered social, technological, economic, environmental as well as political areas of change, the following transport concepts of the future were extracted:

- **seamless transport chains – multimodality, intermodality** (communication between different modes of transport thanks to ITS and technologies; integrated, multi-modal transport solutions, including active modes).
- **automation** (autonomous cars; autonomous trucks; technological developments, cost reduction, public acceptance and legal issues form key factors for the timescale of adoption of autonomous vehicles).
- **delivery drones** (rapid advances in unmanned aerial vehicle – UAV technology; drones already trialled for different applications, including package deliveries).

- **electrification** (electrification of transport to reach decarbonization goals; electrification of personal and public ground transportation; electric cars, buses, bicycles, trucks and trains; further developments needed for the widespread adoption of electric vehicles – inductive charging infrastructure, costs reduction, etc.).
- **smart use of travel time** (in-vehicle use of travel time; autonomous vehicles may compete with other modes, as a result of the in-vehicle transit experience).
- **shared mobility, on-demand mobility, MaaS** (a shift from car ownership towards platform-based peer-to-peer services; emerging trend towards shared mobility; car ownership reduction).
- **freight consolidation centres** (logistics consolidation; freight consolidation centres to increase goods delivery efficiency and reduce congestion and emissions in city centres).
- **high speed rail** (regional and inter-regional connectivity improvement thanks to high-speed rail).

In an Ipsos MORI publication, Otto (2017) researched several issues concerning the disruptive concept of autonomous cars. After having interviewed several car owners from different countries across the world, the article presented interesting results regarding customer attitudes to autonomous driving, potential impacts in vehicles design, public acceptance towards autonomous cars, etc. Young consumers living in big cities appeared to form the key target group, being highly interested in purchasing an autonomous vehicle. Moreover, public acceptance towards driverless cars appeared to be higher in Asia, with the consumers in Northern Europe being more skeptical. The article also acknowledged how people are willing to spend their time while traveling with a fully autonomous vehicle as well as the automotive companies that are believed to be in the lead with autonomous car technology.

The transport concepts captured by the article, include **automation** – autonomous cars, **electrification** – electric cars, **smart use of travel time** as a result of autonomous cars and **shared mobility, on-demand mobility, MaaS**. It is worth mentioning that the article recognized automation, electrification and shared mobility as the three key trends with a high potential to reshape the automotive landscape. According to the article, these trends will possibly merge in the future, to form different single mobility concepts.

	Asia	America	Europe
Sleep / take a nap	10 min	6 min	5 min
Work, write mails and business communication	5 min	5 min	5 min
Communicate privately (directly or via phone/e-mail/messenger/video)	15 min	14 min	17 min
Relax by reading (books/online news feeds, etc.)	4 min	5 min	5 min
Relax by watching movies/videos/TV-series/playing games	8 min	6 min	5 min
Online shopping	2 min	2 min	1 min
Still pay attention to the road	16 min	22 min	22 min
		60 min	

Figure 8. Activities while driving fully automated, drivers' preferences

Source: Otto (2017)

In a Deloitte Insights publication, Lineberger et al. (2018) explored the current situation regarding **passenger drones** and **flying cars** technology, the remaining obstacles for a widespread adoption of the personal air transportation concept as well as the potential impacts on urban mobility. The study provided definitions for the different vehicle categories broadly described by the umbrella term “flying cars” (passenger drones, traditional flying cars, revolutionary vehicles) and showcased the existing relevant concepts and their development phases. Furthermore, regulations, technology maturity, infrastructure, air traffic management, safety as well as psychological barriers were identified to be the key hurdles in the further development and adoption of the concept. Finally, the study recognized business opportunities emerging from personal air transportation concept and its potential implications on other sectors. Apart from **personal air transportation** that this study mainly focused on, other future transport concepts identified include **automation** (autonomous vehicles), **electrification** (electric vehicles) and **shared mobility, on-demand mobility, MaaS** (bike-sharing, ride-sharing, shared flying cars/taxis).

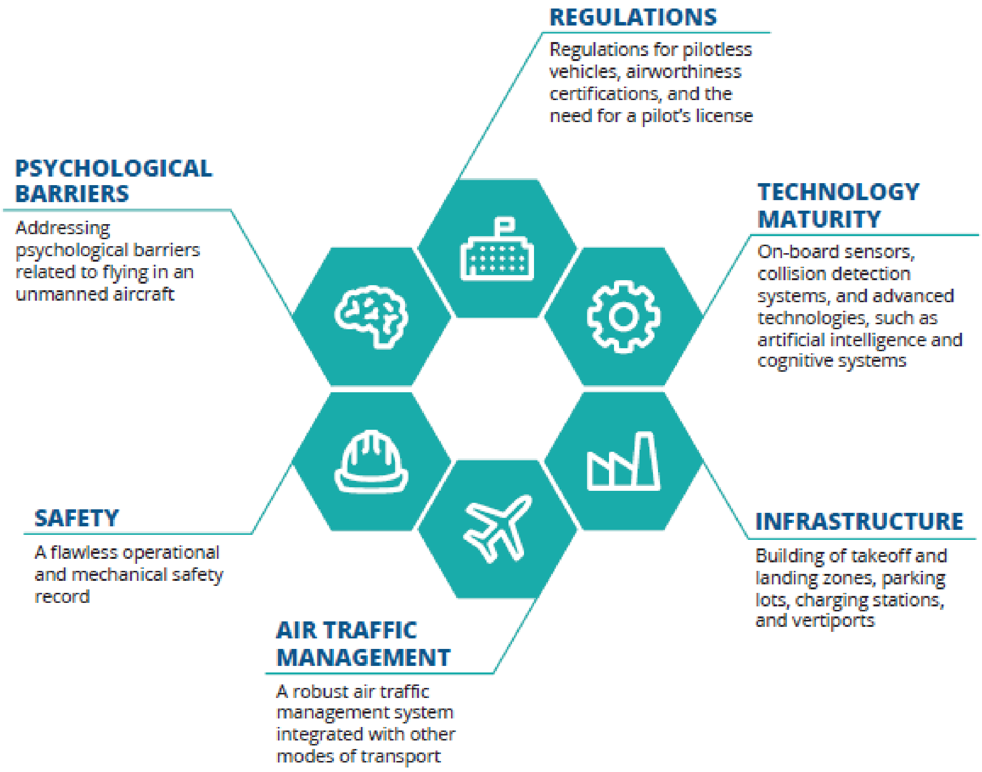


Figure 9. Considerations for commercial passenger drone development and adoption

Source: Lineberger et al. (2018)

Sümmermann et al. (2017) developed and introduced their concept for “Seamless Mobility as a Service – Seamless MaaS”, aiming to set the scene for a successful implementation of MaaS concept. After having recognized that the Seamless MaaS future of transportation will necessitate more cooperation between companies and industries and a new digital infrastructure layer, they assessed potential cooperation models and different technological solutions. In this context, they envisioned the so-called Open Mobility System – OMOS concept, a non-profit blockchain-based system aimed at creating new ways of transacting and data sharing among all players participating in Seamless MaaS. OMOS could have a number of advantages compared to a fully centralized and closed mobility system controlled

by a single party, such as openness, transparency, co-creation and fair competition encouragement, information monopolies avoidance, secure and real-time data sharing, etc. According to the report, OMOS further development is highly dependent on solving some technological issues as well as on adopting co-operation. The specific transport concepts of the future captured by the report, are:

- **seamless transport chains – multimodality, intermodality** (seamless mobility experience for customers; multi-modal journey planning; many different mobility services and transport modes available for passenger journeys).
- **automation** (autonomous cars; seamless MaaS will integrate all transport modes, including autonomous cars; automated public transport).
- **shared mobility, on-demand mobility, seamless mobility as a service – seamless MaaS** (new sharing models emerging; car-sharing; ride-hailing; more mobility options and increased availability of transport thanks to shared mobility; integration of all the existing travel options, including sharing services, end-to-end journey planning services and all modes of transport; integration of the so far highly fragmented mobility services).

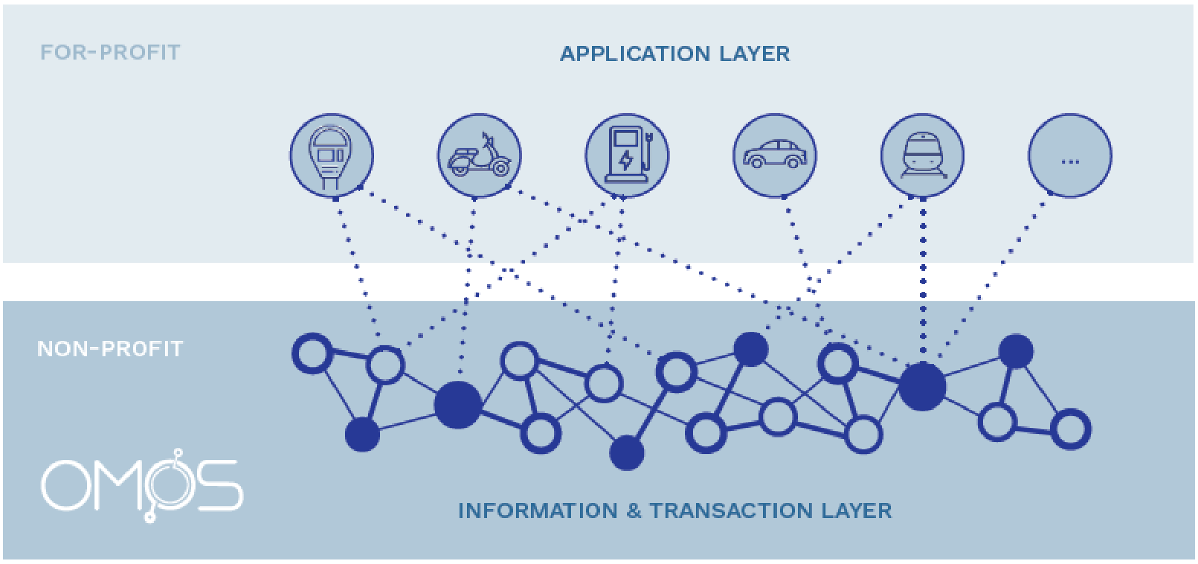


Figure 10. The OMOS ecosystem – an open and shared infrastructure serving for-profit applications

Source: Sümmermann et al. (2017)

Leech et al. (2015) evaluated the potential contribution of connected and autonomous vehicles to the UK economy. The research examined how the disruptive concept of autonomous and connected vehicles will affect the UK economy and society, expanding its industrial base, improving safety, alleviating congestion, increasing productivity and freeing up urban space. After having identified the different sectors that are expected to benefit from this emerging concept, the study forecasted its economic impact on the UK economy and recognized business opportunities as well as challenges for its future development and adoption. Leech et al. (2015) concluded that connected and autonomous vehicles could lead to huge social and economic benefits for the UK. The transport concepts of the future drawn from the report, include **automation**, **electrification** and **shared mobility, on-demand mobility, MaaS** (sharing schemes utilizing autonomous, electric-powered vehicles).

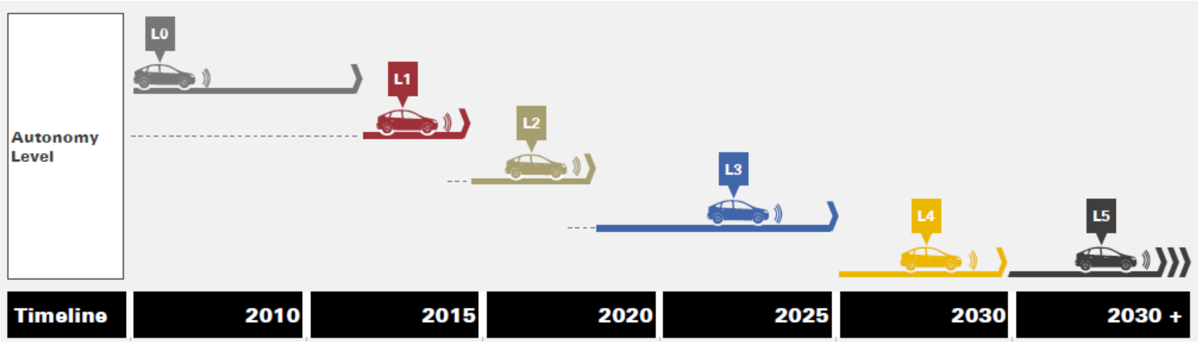


Figure 11. Connected and autonomous vehicle technology roadmap

Source: Leech et al. (2015)

Schmidt et al. (2018), in an Accenture Insights publication, provided a roadmap with the intention of guiding automotive OEMs to get the most out of the opportunities emerging from the mobility as a service – MaaS concept. The report identified the crucial challenges that need to be addressed by OEMs and presented different business model options for their future development (luxury vehicle manufacturer, business-to-business – B2B asset provider, vehicle and fleet operator, car mobility service provider, full mobility provider). The transport concepts of the future identified in the report, include **automation** as well as **shared mobility, mobility as a service – MaaS** (encouraged by autonomous vehicle development, global markets for MaaS are expected to grow in the future; shared mobility utilizing self-driving vehicles).

Foulser (2017), provided a so-called "MaaS Requirements Index" guide, with the overall aim of helping transport and local authorities to set their future MaaS strategy. Since MaaS concepts could vary significantly in their structure, the guide was developed in order for the transport and local authorities to determine the regulatory, governance, commercial and technological environment required for both achieving their objectives and optimizing user experience. The report further discussed about the regulation and modal blend appropriate for different MaaS ecosystems. The transport concepts captured by the report, include **seamless transport chains – multimodality, intermodality** (seamless multi-modal passenger travel thanks to MaaS concept), **automation** (rise of sharing services as a precursor to autonomous vehicles), **electrification** (widespread adoption of electric vehicles) and **shared mobility – on-demand mobility, MaaS** (demand-responsive services; sharing schemes, e.g. car- and bike-sharing; full integration of private and public mobility services; integration of different transport services – public and private – to provide planning, booking and payment options through a single platform).

OECD/ITF (2017) in Transport Outlook 2017, provided an overview of emerging trends and prospects for the transportation sector globally, presenting future prospects regarding transport demand up to 2050, including passenger and freight transportation as well as CO_2 emissions. The transport concepts of the future, drawn from the aforementioned literature source, are briefly presented below:

- **superfast ground and underground transportation** (hyperloop and similar superfast surface modes are still at an early stage; serious doubts about their technological and financial viability).

- **automation** (arrival of autonomous vehicles in the coming decades; autonomous cars and trucks; autonomous trucks may lead to a shift towards road freight transportation).
- **electrification** (development of electric vehicles as a necessity to meet sustainability goals; electric vehicle initiative 20 by 20 – car fleet of 20 million electrified cars globally by 2020; increasing sales of electric cars as a result of technological improvements and supportive policies; more electric car models as well as charging infrastructure required, for the further adoption of electric vehicles).
- **shared mobility, on-demand mobility, MaaS** (shift towards on-demand transport; shared mobility is likely to change mobility patterns; emerging car-sharing and carpooling schemes separate mobility and car ownership; car-sharing to increase accessibility; changing role of cars as a result of ride-sharing; digital innovation as an enabler for MaaS; well-informed, multi-modal travel choices based on MaaS).
- **high speed rail** (high-speed rail as an alternative to air transportation; high-speed rail for inter-city travel, replacing air and road transportation share; low impact of high-speed rail on aviation demand, because of the high cost of appropriate infrastructure).

Rohr et al. (2016) developed future transport scenarios for 2035, taking into account potential socio-economic changes as well as emerging technologies and innovations. The research, aimed at exploring the way in which emerging technologies may affect transport in the future and increase its efficiency. Scenarios were constructed that were further used in order to identify policies and innovation investment areas. The transport concept identified in the report, include **seamless transport chains – multimodality, intermodality** (seamless travel across modes as a result of user applications, big data and intelligent processing), **automation** (autonomous vehicles – AVs to reduce accidents frequency, increase capacity and drivers productivity, improve accessibility for the elderly, disabled people, etc.; safety, security, liability, privacy, cost and regulation issues form the major barriers for the further adoption of AVs) and **delivery drones** (small unmanned aerial vehicles – UAVs to perform automated deliveries).

Future Transport 2056 (2018) developed a strategy supported by a set of plans, in order for New South Wales, Australia to achieve a 40-year vision for its transportation system. Several transport concepts of the future were captured, that are expected to radically change the way in which people and goods will travel in the future. These are:

- **personal air transportation – “flying cars”, “flying taxis”** (expansion of the use of drones, enabling point-to-point transport for people).
- **seamless transport chains – multimodality, intermodality** (seamless multi-modal journey as a result of MaaS; seamless travel across transport modes; seamless inter-regional and cross-border travel).
- **automation** (autonomous cars, trucks, buses and trains; safer travel thanks to automation).
- **delivery drones** (widespread use of drones for routine freight delivery; use of drones for several applications, including last-mile freight deliveries; safety, noise impacts and landing infrastructure form the key issues to be addressed).
- **electrification** (electric road vehicles – cars and trucks; electric vehicles including hybrid, plug-in hybrid, all-electric, hydrogen fuel cell and solar-powered vehicles; more affordable and a wider range of electric vehicles in the future).

- **shared mobility, on-demand mobility, MaaS, FaaS** (flexible on-demand services and applications of shared mobility thanks to mobile phone technology; foster shared and demand-responsive services; enable flexible service models based on shared use; MaaS – integrated, multi-modal travel experience, choosing between a wide range of travel options; enable passengers to plan and pay for their end-to-end journey through a single interface; “freight as a service” – FaaS, as a result of technology developments in logistics).
- **personal mobility devices** (new personalised devices for short trips, such as e-bikes and motorised scooters; personal mobility devices to move people out of single occupant cars; several advantages of personal mobility devices – fast, affordable and effortless transportation).
- **smart, dynamic and interactive highways** (infrastructure that improves efficiency, reliability and safety; smart road infrastructure).

Global Railway Review Vol. 24 Issue 02, published on April 2018, discussed topics relevant to the emerging opportunities for the desired future transformation of rail transport. Several articles were taken into account for the attempted identification of the transport concepts of the future, including Young (2018), Harnish (2018), Sanguina and Dersin (2018). Largely focused on rail transportation, the future transport concepts captured by the aforementioned articles, include **superfast ground and underground transportation** (hyperloop), **seamless transport chains – multimodality, intermodality** (integrated and globally competitive passenger and freight supply chain solutions; integration of trains with other modes of transport), **automation** (fully automatic trains for passenger and freight transportation), **electrification** (electrified – hydrogen-powered trains for passenger and freight transport) and **high-speed rail** (high-speed trains as an attractive alternative to aviation and road transport; combination of different elements needed for a successful high-speed railway system – emphasis on broad networks, frequent departures and connecting services, modern train design, etc.). Particular emphasis was also placed on intelligent predictive maintenance techniques as well as on innovative ways for analysing data from sensor devices.

Table 3 presents the future transport concepts drawn from the report-based literature. The matrix given in Table 3 presents future transport concepts and their respective sources, aiming to indicate a level of convergence to those concepts that are considered to be the dominant ones for the future transportation landscape.

Table 3. Future transport concepts from report-based literature

Future Transport Concepts	***REPORTS***																										
	Manyika et al. (2013)	*Briggs and Sundaram (2016)*	*Winterhoff et al. (2009)*	*KPMG (2017)*	*D'Incà and Mentz (2016)*	*Cornet et al. (2012)*	*Arbib et al. (2017)*	*Corwin et al. (2015)*	*Corwin et al. (2016)*	*Goodall et al. (2017)*	*UKi Media & Events (2018)*	*Goulding and Butler (2018)*	*Goulding and Morrell (2014b)*	*Morrell (2017)*	*Goulding and Morrell (2014a)*	*Dohna and Morrell (2016)*	*Otto (2017)*	*Lineberger et al. (2018)*	*Sümmermann et al. (2017)*	*Leech et al. (2015)*	*Schmidt et al. (2018)*	*Foulser (2017)*	*OECD/ITF (2017)*	*Rohr et al. (2016)*	*Future Transport 2056 (2018)*	*Young (2018), Harnish (2018), Sanguina et al. (2018)*	***Total Number of Citations***
Superfast Ground and Underground Transportation (Hyperloops, Underground Freight Pipelines)	-	-	-	-	+	-	-	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	+	-	-	+	**6**
Personal Rapid Transit (PRT)	-	-	-	-	-	-	-	-	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	**4**
Magnetic Mobility, Magnetic Levitation	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	**2**
Personal Air Transportation, "Flying Cars", Flying Taxis"	-	-	-	-	-	-	-	-	-	-	+	+	-	+	-	-	-	+	-	-	-	-	-	-	+	-	**5**
Seamless Transport Chains - Multimodality, Intermodality	-	+	-	-	-	-	-	+	+	+	+	+	+	-	+	+	-	-	+	-	-	+	-	+	+	+	**14**
Autonomous Cars	+	+	-	+	+	-	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	-	**22**
Autonomous Trucks	+	-	-	-	+	-	-	+	+	-	+	+	-	+	+	+	-	-	-	-	-	-	+	-	+	-	**11**

Future Transport Concepts	REPORTS																										
	Manyika et al. (2013)	*Briggs and Sundaram (2016)*	*Winterhoff et al. (2009)*	*KPMG (2017)*	*D'Incà and Mentz (2016)*	*Cornet et al. (2012)*	*Arbib et al. (2017)*	*Corwin et al. (2015)*	*Corwin et al. (2016)*	*Goodall et al. (2017)*	*UKi Media & Events (2018)*	*Goulding and Butler (2018)*	*Goulding and Morrell (2014b)*	*Morrell (2017)*	*Goulding and Morrell (2014a)*	*Dohna and Morrell (2016)*	*Otto (2017)*	*Lineberger et al. (2018)*	*Sümmermann et al. (2017)*	*Leech et al. (2015)*	*Schmidt et al. (2018)*	*Foulser (2017)*	*OECD/ITF (2017)*	*Rohr et al. (2016)*	*Future Transport 2056 (2018)*	*Young (2018), Harnish (2018), Sanguina et al. (2018)*	**Total Number of Citations**
Autonomous Aircrafts	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Automated Trains	-	-	-	-	+	-	-	-	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	+	+	**7**
Autonomous Vessels	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**2**
Noiseless Transport	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Delivery Drones	+	-	-	-	-	-	-	-	-	-	+	+	-	-	+	+	-	-	-	-	-	-	-	+	+	-	**7**
Electric Cars	-	+	+	+	-	+	+	+	+	-	+	+	-	-	+	+	+	+	-	+	-	+	+	-	+	-	**17**
Electric Trucks	-	-	-	+	-	-	+	-	+	-	+	+	-	-	-	+	-	+	-	-	-	-	+	-	+	-	**9**
Electric Trains – Hydrogen-powered trains (hydrail)	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	**3**
Small Vehicles Developed Fit-For-Urban-Purpose	-	+	+	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**4**
Smart Use of Travel Time	+	-	+	+	-	+	+	+	+	-	+	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	**10**

Future Transport Concepts	***REPORTS***																									
	Manyika et al. (2013)	*Briggs and Sundaram (2016)*	*Winterhoff et al. (2009)*	*KPMG (2017)*	*D'Incà and Mentz (2016)*	*Cornet et al. (2012)*	*Arbib et al. (2017)*	*Corwin et al. (2015)*	*Corwin et al. (2016)*	*Goodall et al. (2017)*	*UKi Media & Events (2018)*	*Goulding and Butler (2018)*	*Goulding and Morrell (2014b)*	*Morrell (2017)*	*Goulding and Morrell (2014a)*	*Dohna and Morrell (2016)*	*Otto (2017)*	*Lineberger et al. (2018)*	*Sümmermann et al. (2017)*	*Leech et al. (2015)*	*Schmidt et al. (2018)*	*Foulser (2017)*	*OECD/ITF (2017)*	*Rohr et al. (2016)*	*Future Transport 2056 (2018)*	*Young (2018), Harnish (2018), Sanguina et al. (2018)*	***Total Number of Citations***
Shared Mobility, On-Demand Mobility, MaaS	-	+	+	+	+	+	+	+	+	+	+	+	-	-	+	+	+	+	+	+	+	+	+	-	+	-	**21**
Private Car Ownership, Luxury Vehicles	-	-	+	-	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**5**
Capsules Transported by Carrier Aircraft	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Co-Modality	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Freight Consolidation Hubs, Freight Distribution Centres	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	+	-	-	-	-	-	-	-	-	-	-	**3**
Urban Cross-Modal Logistics	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Personal Mobility Devices	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	**1**
High-Speed Rail	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	+	-	-	-	-	-	-	+	-	-	+	**6**
Crowd Delivery	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**

Future Transport Concepts	***REPORTS***																										
	Manyika et al. (2013)	*Briggs and Sundaram (2016)*	*Winterhoff et al. (2009)*	*KPMG (2017)*	*D'Incà and Mentz (2016)*	*Cornet et al. (2012)*	*Arbib et al. (2017)*	*Corwin et al. (2015)*	*Corwin et al. (2016)*	*Goodall et al. (2017)*	*UKi Media & Events (2018)*	*Goulding and Butler (2018)*	*Goulding and Morrell (2014b)*	*Morrell (2017)*	*Goulding and Morrell (2014a)*	*Dohna and Morrell (2016)*	*Otto (2017)*	*Lineberger et al. (2018)*	*Sümmermann et al. (2017)*	*Leech et al. (2015)*	*Schmidt et al. (2018)*	*Foulser (2017)*	*OECD/ITF (2017)*	*Rohr et al. (2016)*	*Future Transport 2056 (2018)*	*Young (2018), Harnish (2018), Sanguina et al. (2018)*	***Total Number of Citations***
Quite Night Urban Deliveries	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
Freight Shuttle Systems	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	**2**
Smart, Dynamic and Interactive Highways	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	**2**

3.3 Review of selected future transport-related and technology-oriented websites

As it has already mentioned, several future transport-related and technology-oriented websites were also taken into account in the attempted identification of the key future transport concepts. Some of the concepts captured by these websites were based in private and industry initiatives, demonstrating to a large extent the industry-based vision of the future transportation. Table 4 presents the transport concepts captured by the aforementioned websites, as well as the total number of citations for each future transport concept.

Table 4. Future transport concepts from website sources

Transport Concepts	***Websites***	***Total Number of Citations***
Personal Rapid Transit (PRT)	• Project "Next", http://www.next-future-mobility.com	**1**
Personal Air Transportation, "Flying Cars", Flying Taxis"	• Cece (2016) • Marr (2017) • Overly (2017) • Tucker (2018) • Kotoky (2018)	**5**
Seamless Transport Chains - Multimodality, Intermodality	• The World Bank (2017)	**1**
Automation (autonomous cars, trucks, vessels)	• Mobility of the Future – Examining future changes in the transportation sector, http://energy.mit.edu/research/mobility-future-study/ • Project "Next", http://www.next-future-mobility.com • Marr (2017) • Carey (2017) • UITP (2017)	**5**
Delivery Drones	• Marr (2017)	**1**
Electrification (electric cars and trucks)	• Mobility of the Future – Examining future changes in the transportation sector, http://energy.mit.edu/research/mobility-future-study/	**1**
Shared Mobility, On-Demand Mobility, MaaS	• Mobility of the Future – Examining future changes in the transportation sector, http://energy.mit.edu/research/mobility-future-study/ • Grosse-Ophoff et al. (2017) • UITP (2017)	**3**
Blue Modal Shift	• The World Bank (2017)	**1**

4 Reaching a consensus

The selected studies taken into account in the attempted identification of the future transport concepts, appeared to vary regarding their time perspective. Some studies had a mid-term perspective of up to 2030, while some others had a long-term perspective of up to 2050. To that extent, the transport concepts of the future captured for the purposes of the current Deliverable, suggest different ways in which people and goods are likely to be transported in the future, with a time horizon up to 2050.

Having identified the future transport concepts in the pertinent literature, the next logical step was to define the criteria that would enable the identification of the concepts that are more likely to occur. Taking into consideration both academic research-based and industry-based visions for the future of transportation, the identification of the key/dominant transport concepts of the future will be based on the frequency by which they appear to be researched, discussed or proposed in the wide variety of the literature sources reviewed.

The Delphi method is a broadly accepted technique, used for gathering data from respondents within their domain of expertise. Being an appropriate tool for achieving a convergence of opinion and consensus-building, Delphi method is widely used in various scientific fields (Hsu and Sandford, 2007). While the percentage (%) of agreements required for reaching a consensus in the Delphi method varies from study to study, several researches adopted a 70% percentage among the different sources, experts' opinions, etc., as the cut-off criterion for consensus (Suris and Akre, 2015; Kelly et al., 2016; Kleynen et al., 2014). Despite all the aforementioned information, a potential adoption of a 70% cut-off criterion for reaching a consensus regarding the dominant transport concepts of the future, would lead to only three concepts while 50% would result to five. This fact, can be partially explained by the existence of many different transport concepts discussed or researched in the pertinent literature.

To that extent, in the current Deliverable a different approach has been adopted: the dominant transport concepts of the future for both passenger and freight transportation sectors, were considered to be the seven top-cited concepts that appeared to have been researched by the literature sources reviewed. This particular number of future transport concepts was not chosen randomly. Taking into account the limitations imposed on people ability to process information, such as the span of absolute judgement and the span of immediate memory, it is broadly believed that number seven appears to be an appropriate number of options regarding one-dimensional judgements/variables. After having researched the limits on people capacity for processing information, Miller (1956) concluded that there is an upper limit on people capacity to process information on simultaneously interacting elements and this limit is seven ± 2 elements. Moreover, Saaty and Ozdemir (2003) also suggested that number seven represents a limit concerning human capacity and ability to process information.

The seven key identified transport concepts of the future for each passenger and freight transportation sector, were considered to be an appropriate set of concepts for further analysis and elaboration through the application of the ANP methodology. To a later stage, experts will select those future transport concepts that they consider becoming a reality, shaping the way in which people and goods will be transported.

A total number of 35 transport concepts of the future was captured by the literature (Table 1), with some of them being sector-specific and some others applicable to both passenger and freight transportation. In the following sections, the dominant future transport concepts are presented. The analysis includes the transport modes that each concept is applicable to and a timeline for their potential implementation, based on literature predictions and using Short (2020-2025), Medium (2025-2030) and Long term (2030-2035+) scale.

4.1 Key transport concepts of the future in passenger transportation

Based on the aforementioned principles the seven top-cited concepts for passenger transport were identified. The transport concepts presented below, are ranked according to their frequency of occurrence in the reviewed literature:

- **automation – passenger transport** (driverless vehicles, including autonomous cars, aircrafts, trains, vessels for passenger transportation).
- **shared mobility, on-demand mobility, MaaS** (shared mobility schemes, such as car-, bike- and ride-sharing, ride hailing, car-pooling, etc.; on demand mobility, demand-responsive mobility; MaaS – a single-digital service offering that integrates various public and private forms of transport and provides end-to-end journey planning, booking and payment options).
- **electrification – passenger transport** (electric-powered vehicles, including electric cars, trains, aircrafts and vessels/ferries for passenger transportation).
- **seamless transport chains – multimodality, intermodality** (seamless transport chains for passenger transport; seamless national and international travel for passengers; seamless passenger travel as a result of MaaS).
- **personal air transportation – "flying cars", "flying taxis"** (urban air mobility; passenger drones for urban passenger transport).
- **smart use of travel time** (time made available because of vehicles automation; travel time as a usable timeslot for leisure, socializing or work-related activities).
- **high-speed rail** (high-speed trains for passenger transport; high-speed rail networks as an attractive alternative to aviation).
- **superfast ground and underground transportation** (hyperloops for passenger transport; hyperloop for faster and more sustainable surface transportation).

As it can be seen, the total number of the identified key transport concepts of the future applicable to passenger transport, is eight. This is due to the fact that the last two concepts (high-speed rail and hyperloop) had an equal number of citations. Table 5 presents the dominant future transport concepts regarding passenger transportation and their total number of citations. The transport modes that each concept is applicable to and a timeline for each concept potential implementation, are also presented. The latter is based on the predictions from the reviewed literature.

Table 5. Dominant future transport concepts for passenger transport

Passenger Transport - applicable Transport Concepts	Total Number of Citations	Road	Aviation	Rail	Waterborne	Timeline for Implementation
Automation – Passenger Transport (autonomous cars, aircrafts, trains, vessels)	**34**	+	+	+	+	Medium term
Shared Mobility, On-Demand Mobility, MaaS	**29**	+	-	-	-	Medium term
Electrification – Passenger Transport (electric cars, trains, aircrafts, vessels)	26	+	+	+	+	Medium term
Seamless Transport Chains – Multimodality, Intermodality	20	+	+	+	+	Long term
Personal Air Transportation, "Flying Cars", “Flying Taxis”	15	+	+	-	-	Medium term
Smart Use of Travel Time	13	+	-	-	-	Medium term
High-Speed Rail for Passenger Transport	9	-	-	+	-	Medium term
Superfast Ground and Underground Transportation, Hyperloops	9	-	-	+	-	Long term

4.2 Key transport concepts of the future in freight transportation

The same principles with the previous section were applied for freight transport. The transport concepts presented below, are ranked according to their frequency of occurrence in the reviewed literature:

- **shared mobility, on-demand mobility, MaaS, FaaS, LaaS** (mobility as a service – MaaS as last mile for freight transport; “freight as a service” – FaaS for more efficient goods shipping and delivery possibilities; “logistics as a service” – LaaS – to give consumers more control and flexibility over their home deliveries; LaaS to enable individuals to choose their own logistics service provider and bundle deliveries as they wish).
- **seamless transport chains – multimodality, intermodality** (seamless transport chains for freight transport; seamless logistics – smooth combination of different modes and minimization of delays/interruptions in the logistic chain; seamless multimodal freight transport services).
- **automation – freight transport** (driverless vehicles, including autonomous trucks, trains and vessels for freight transportation).
- **electrification – freight transport** (electrified vehicles, including electric trucks, trains, aircrafts and vessels for freight transportation).

- **delivery drones** (small unmanned air vehicles supporting urban deliveries; delivery drones as an indivisible part of the supply chain; delivery drones to cater for hard-to-reach areas).
- **superfast ground and underground transportation** (cargo tubes; underground freight transportation pipelines in dense urban centres, as an alternative to the conventional transport systems; underground freight pipelines for moving goods within and between urban areas).
- **freight consolidation hubs, freight distribution centres** (multimodal settlements that provide access to different modes of transport for transport-oriented companies, logistic service providers and production enterprises; inter-modal infrastructure facilities provision; optimization of deliveries, efficiency increase and traffic/emissions reduction in city centres).

Table 6 presents the dominant transport concepts of the future applicable to freight transportation, as identified on the basis of the frequency by which the appeared to be discussed or proposed in the total number of the literature sources reviewed. The transport modes that each concept is applicable to and a timeline for each concept potential implementation, are also presented.

Table 6. Dominant future transport concepts for freight transport

Freight Transport - applicable Transport Concepts	Total Number of Citations	Road	Aviation	Rail	Waterborne	Pipeline	Timeline for Implementation
Shared Mobility, On-Demand Mobility, MaaS, FaaS, LaaS	**29**	+	+	+	+	N/A	Medium term
Seamless Transport Chains – Multimodality, Intermodality	**20**	+	+	+	+	N/A	Long term
Automation – Freight Transport (autonomous trucks, trains, vessels)	18	+	+	+	+	N/A	Medium term
Electrification – Freight Transport (electric trucks, trains, aircrafts, vessels)	16	+	+	-	+	N/A	Medium term
Delivery Drones	10	-	+	-	-	N/A	Short term
Superfast Ground and Underground Transportation, Cargo Tubes, Underground Freight Pipelines	9	+	-	+	-	+	Long term
Freight Consolidation Hubs, Freight Distribution Centres	6	+	+	+	+	N/A	Medium term

5 Dominant future transport concepts – Further analysis

The following section aims to further explain the main dominant future transport concepts that were identified for both passenger and freight transport.

5.1 Automation – Passenger and Freight Transport (autonomous cars, trucks, aircrafts, trains, vessels)

Automation refers to connected and automated technologies and constitutes key technological advancements that will be influencing and shaping our future mobility and quality of life (ERTRAC, 2017). In the long-term automation will have a revolutionary impact on travel behaviour and urban development (Raponso et al., 2017). For road transport the main drivers for the advancement of automation are related to (ERTRAC, 2017):

- Increased driving safety through accident reduction by removing human error
- Increased transport system efficiency thus reducing energy consumption and emissions
- Increased passenger comfort which enables user’s freedom for other activities
- Social inclusion for elderly and impaired users
- Accessibility to restricted city centre areas

Already many car and truck automakers are working on autonomous vehicles and low levels of automation are currently being introduced into conventional vehicles using internal combustion engines. Connected automation will also play significant role in the further uptake of automation and will enable further expansion of functions of a vehicle as well as collection of big data (Voege, 2016). Future projections estimate a gradual increase of vehicle autonomy with fully autonomous vehicles expected to become available in the market by 2025-2035 (see Figure 12). In the road freight sector highway platooning and highly automated trucks on open roads will be available within the aforementioned timeline according to ERTRAC (2017) (see Figure 13).

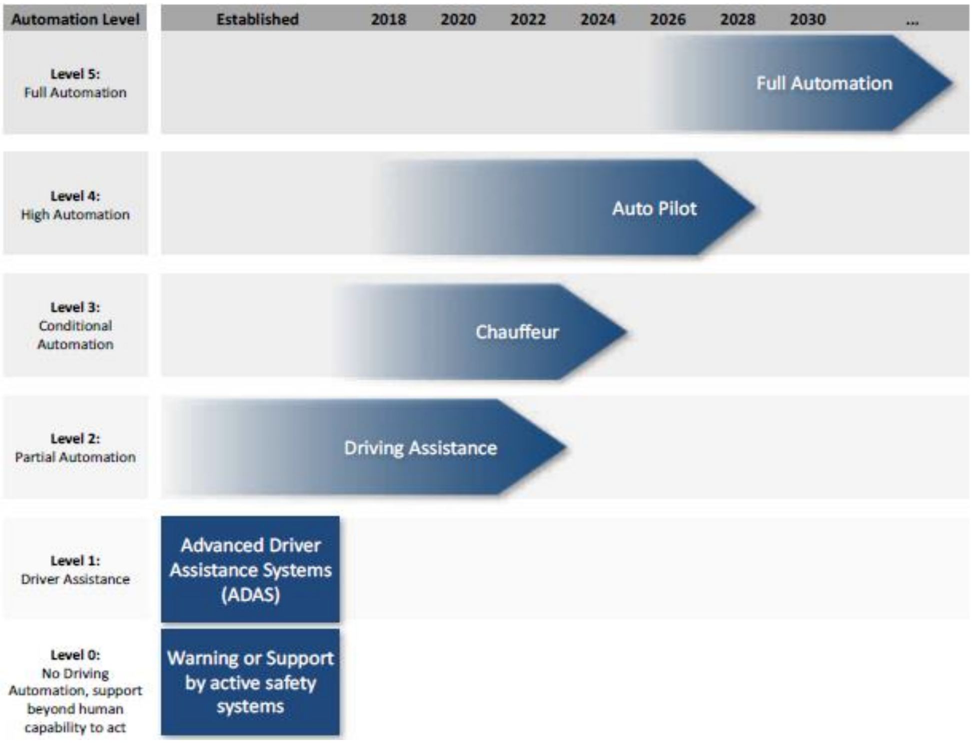


Figure 12. The vehicle automation development paths

Source: ERTRAC (2017; 12)

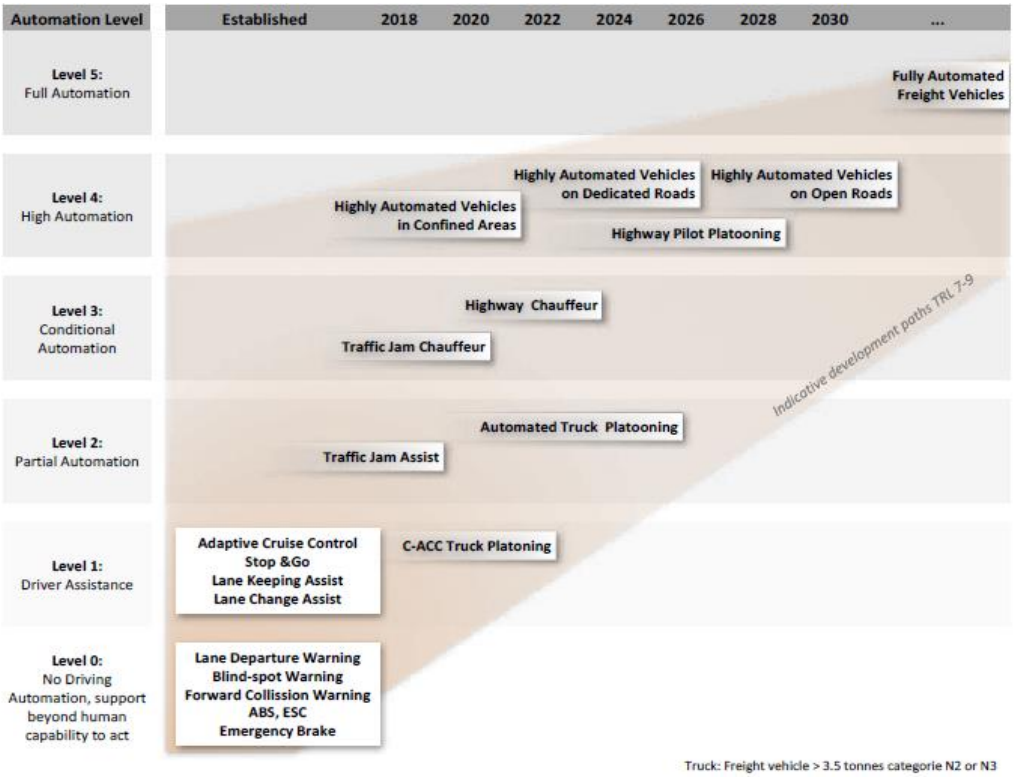


Figure 13. The Automated Driving development path for freight vehicles

Source: ERTRAC (2017; 14)

In the aviation sector automation technologies are already being introduced in conventional aviation and smarter avionics systems are being integrated in the cockpit. The prime reasons for further automation are increased safety levels, increased throughput, effectiveness and cost efficiency (Voege, 2016). Automation and connectivity might also change the operational environment for air transport with moving from urban areas to remote areas that will be connected with autonomous air services. This concept will also require the development low noise air transport systems (Voege, 2016). A reverse concept that involves the use of inner city airports that offer high intermodal connectivity with rail and public transport was developed by Bauhaus Lufthart CentAirStation design project[3]. The use of passenger drones for short distance travel and unmanned passenger aircrafts could also reduce energy efficiency.

In the rail transport sector, automation already exists in selected market segments such as metro transport, with the example of Copenhagen's metro[4] offering full autonomy (Grade of Automation-GoA) GoA4 over specific lines. However, automation is still rare in the main rail lines. The main plans for EU according to Shift2Rail are that at least 50% of the metro lines to be GoA4 which refers to unattended train operation, while demonstrators are planned for 2020-2025 that will take GoA1 (Manual operation supervised by European Train Control System -ETCS) towards GoA4 over main lines (Shift2Rail, 2015). In the freight sector, trials of fully autonomous freight trains are being carried out by the Rio Tinto mining company in Australia[5]. According to Shift2Rail (2015) the main driving forces for automation will be:

- To increase the transportation capacity on existing lines
- To reduce the operating costs and improve energy efficiency
- To contribute towards the vision of a fully automated rail freight system

In the Waterborne sector ship autonomous technology will reshape the sector with crewless vessels, while smaller vessels are already developed and in service, while larger are under development (Lloyd's register, 2017). Key driving factors for automation in this sector will be labour, operating costs and optimised commercial flexibility as a result of big data (Lloyd's register, 2017). Examples of research on autonomous vessels are the Yara Birkeland vessel by the Yara and Kongsberg companies (Paris, 2017), the Svitzer Hermod vessel by Rolls Royce (2017), as well as the research project MUNIN[6]. Some of these vessels are meant to come into service between 2020 and 2025. Automation on the other hand is well advanced in modern ships offering target detecting radars, automated warnings for crossing traffic as well as autopilots and track pilots making use of satellite positioning systems (Voege, 2016). Further automation in the waterborne sector is expected to assist in the adoption of Shipping 4.0 into deep sea, coastal and inland shipping thus in an effort to improve safety and energy efficiency either through full automation or shore-based control (Voege, 2016). Autonomous ship operations are also included within these concepts. Commercial shipping is expected to be one of the major adapters of automation and smart ship technologies with shipping segments of the market, such as dry bulk cargo having the most economic benefits (Lloyd's register, 2017).

---

[3] https://www.bauhaus-luftfahrt.net/en/topthema/centairstation-and-citybird/
[4] http://intl.m.dk/#!/about+the+metro/travel+information/copenhagen+with+kids
[5] http://www.riotinto.com/australia/pilbara/mine-of-the-future-9603.aspx
[6] http://www.unmanned-ship.org/munin/

5.2 Shared mobility, on-demand mobility, MaaS, TaaS, FaaS, LaaS

The emerging shared economy model, boosted by new communication technologies, forms nowadays an integral part of the global economy. Fueled by the shared economy model, shared mobility is rapidly gaining popularity, with several shared mobility schemes globally being introduced. Traditional models of car ownership are changing and will be replaced by platform-based shared mobility services. Shaheen and Cohen (2016) define shared mobility as "an innovative transportation strategy that enables users to have short-term access to a mode of transportation on an as-needed basis". Shared mobility encompasses several service models, including car-sharing, bike-sharing, ride-sharing (carpooling/vanpooling), ride-hailing, courier network services (flexible commercial delivery, shared trucks, electric vehicles, electric cargo bikes), public transit services, scooter sharing, shuttles, shared parking, etc. (Shared-Use Mobility Centre, 2015, Shaheen and Cohen, 2016). Freese et al. (2014) identify car-sharing, ride-sharing, bike-sharing and shared parking as the four markets with the highest growth potential.

Europe has experienced a rapid development of car-sharing, in terms of both number of cars and users. According to Schiller et al. (2017), Europe accounts for about 50% of the global car sharing market, while the total number of car-sharing users is expected to grow up to 15 million by 2020. Shared mobility, also referred to as on-demand mobility, has proven to be a dominant transport concept of the future, taking into account the frequency of occurrence in the literature reviewed. In broad terms, literature suggested a further proliferation of shared mobility paradigms in the future, accompanied by a reduction in car ownership. Positive effects of shared mobility include to name a few, efficient use of resources, environmental benefits, reduced traffic congestion, extending affordable access to transportation and reduced transportation costs.

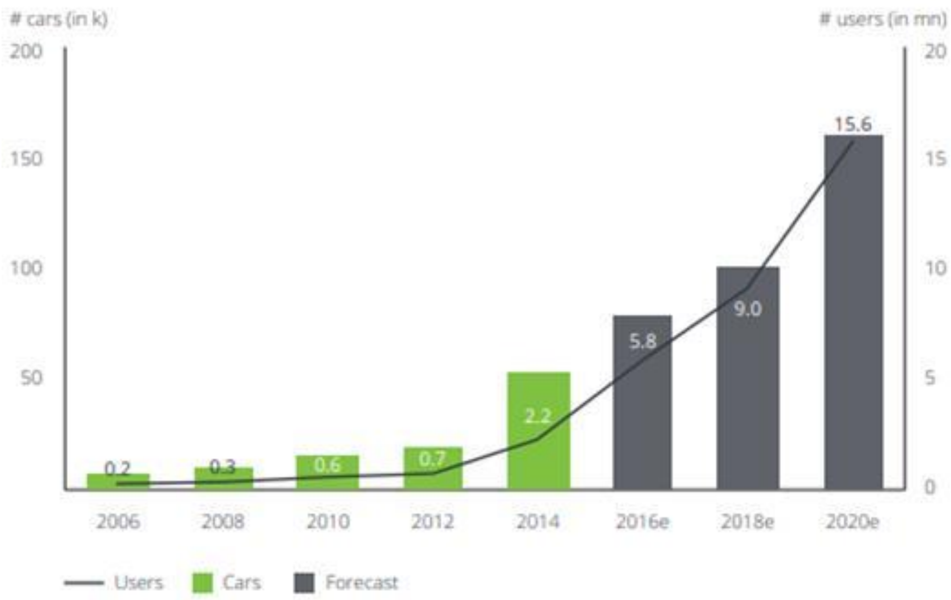


Figure 14. Car-sharing market development for Europe (2006-2020)

Source: Schiller et al. (2017)

Taking into consideration the suggested evolution and rapid rise of shared mobility schemes in the future, the next logical step would be to integrate all these options under one roof, a

vision that basically describes Mobility as a Service – MaaS concept. The latter entails an offering of a single digital service (a unified platform) that integrates all travel options including various public and private forms of transport, while enabling end-to-end journey planning, booking and payment options. Jittrapirom et al. (2017) reviewed the already given definitions of MaaS concept, all of which include some of its core characteristics: integration of transport modes/options, tariff option ("mobility package" and "pay-as-you-go"), one single digital platform offering, interactions between multiple actors, use of technologies (smartphones, mobile internet, GPS, etc.), demand orientation, registration requirement, personalization and customization of mobility offers.

MaaS appeared to be one of the key transport concepts of the future, according to its frequency of occurrence in the literature reviewed. Literature suggests that MaaS will become the new norm, changing the way people and goods will be transported in the future and enabling passengers to make well-informed choices about the combination of modes most convenient to use. Several MaaS pilots have already appeared around the world, such as Whim – Helsinki, UbiGo – Gothenburg, Qixxit – Germany, Moovel – Germany, Beeline – Singapore, SMILE – Vienna, Bridj – Boston Kansas City, Washington, Communauto/Bixi – Canada (Goodall et al., 2017). The integration and regulation of different forms of transport and various public and private sector mobility providers, as well as the technological environment required, form the main concerns around MaaS concept implementation.

Most of the literature sources reviewed for the purpose of the D 2.2, researched MaaS in the scope of passenger transportation sector. Nevertheless, MaaS is considered to be a future transport concept applicable to freight transportation sector as well. Apart from last mile logistics using MaaS, two discrete terms have been mentioned in the literature, "Freight as a Service – FaaS" and "Logistics as a Service – LaaS". Future Transport 2056 (2018) defined FaaS as "a business model whereby on-demand and ride-sharing concepts formulate different procedures for the supply of goods to customers, which is accessed through a single account and booking interface". Moreover, based on the cooperation of shippers, retailers and delivery companies, LaaS "enables individuals to choose their own logistics service provider, instead of being delivered by the logistics service provider of their online retailer" (MOBILITY4EU project, 2016-2018). Klingebiel and Wagenitz (2013) recognized that LaaS will offer a comprehensive support regarding the design, planning and operational management of supply chains.

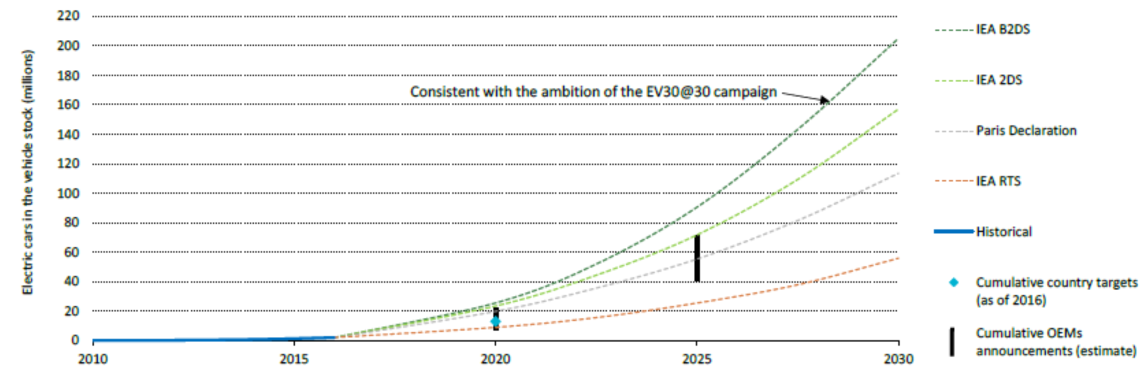
Taking into consideration all of the aforementioned information, shared mobility schemes and the next step of MaaS implementation, form a future transport concept with a high potential to disrupt the whole transport landscape.

5.3 Electrification – Passenger and Freight Transport (electric cars, trucks, aircrafts, trains, vessels)

Electrification is one of the most commonly referred technologies that will be considered across the four transport sectors as a transport concept which is in fact already being used and will continue to further penetrate each market at a different pace.

In the road sector, the global number of electric vehicles surpassed 2 million in 2016 according to OECD/IEA (2017). Passenger cars, vans and buses already in service with growing market penetration while in Scandinavian countries EVs are outperforming conventional sales (ACEA, 2018). OECD/IEA (2017) predictions shown in Figure 15 suggest

that EV car fleet could be between 9 and 20 million by 2020 and 40-70 million by 2025 based on automakers' production pledges. Other predictions by Bloomberg New Energy Finance (2017) suggest that EVs will attribute to 19% of the global light duty vehicle fleet and 43% of the annual global sales by the year 2035. The main driving force for larger market penetration will be the reduction of battery cost before 2030. In the freight sector, longer battery range remains an issue although many automakers have introduced or are further developing truck applications like Tesla (Tesla, 2018) and Cummins (Cummins, 2017). Electric trucks and vans are being used by various companies for delivery, logistics and other purposes (Margaritis et al., 2016). Moreover, Fuel Cell Electric Vehicles (FCEV) although some models are available in the passenger transport market (cars, buses), they are expected to contribute to 10% of the vehicle mix by 2030 according to IEA (2010) while Amsterdam Roundtable Foundation and McKinsey & Company (2014) suggest that market penetration for different types of powertrains will depend on what CO_2 vehicle emissions regulations will be introduced in the future. Only strict regulations will result to larger penetrations of EVs and FCEVs in the future.



Notes: The RTS incorporates technology improvements in energy efficiency and modal choices that support the achievement of policies that have been announced or are under consideration. The 2DS is consistent with a 50% probability of limiting the expected global average temperature increase to 2°C. The B2DS falls within the Paris Agreement range of ambition, corresponding to an average increase in the global temperature by 1.75°C.

Figure 15. Deployment scenarios for the stock of electric cars to 2030.

Source: OECD/IEA (2017;25)

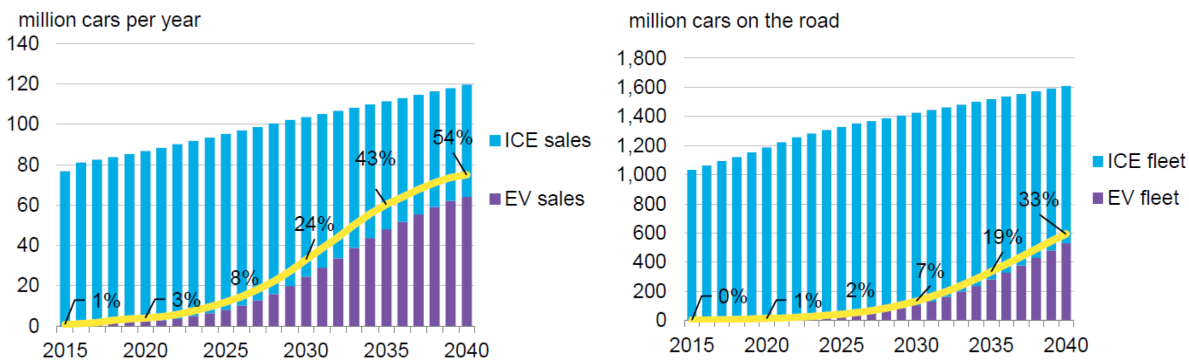


Figure 16. Annual global light duty vehicle sales (left) and global light duty vehicle fleet (right)

Source: Bloomberg New Energy Finance (2017; 2)

In the waterborne transport mode electrification is not a new concept. Auxiliary systems like pumps, compressors, cranes, heating, lighting, electronics as well as auxiliary electric propulsion (pods) is done using electric energy. Around 2,500 ships in the world are powered by electric propulsion using diesel electric, hybrid systems or battery (Meyer et al., 2016). Fully electric ships using batteries exist in small numbers (Meyer et al., 2016) while recently the first all-electric cargo ship has been launched which operates at the Pearl River in China (Leary, 2017). In addition, EU projects like E-Ferry are working on the development of a fully electric ferry, while BB GREEN[7], GFF[8], SEABUBBLE[9] have also researched small electric vessels for river transport. Hydrogen Fuel Cells are also an option that can be used either for providing power to auxiliary systems or to propel smaller vessels with also a trend for larger ones. According to Tronstad et al. (2017) around 20 projects using hydrogen fuel cells have been carried out since early 2000, while the penetration of hydrogen fuel cells in waterborne transport is most likely to be a direct effect of strict universal Sulphur regulations. Under such conditions Lloyd's Register Marine & UCL Energy Institute (2014), predict only a 9% penetration of the hydrogen as a fuel in the maritime sector by 2030 and specifically in the shipping industry

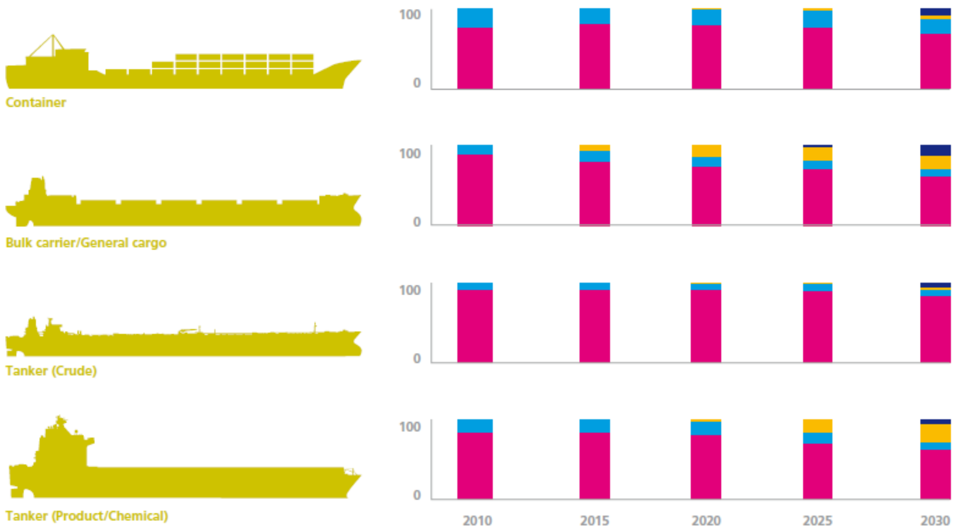


Figure 17. Fuel mix for containership, bulk carrier/general cargo, tanker (crude) and tanker (product/chemical) fleet (%)

Source: Lloyd's Register Marine and UCL Energy Institute, (2014; 36)

For aviation, electric propulsion could be a viable option in the future although, only for short range (Meyer, 2016) and it is predicted to be applicable for aircrafts with less than 100 seats (Malkin et al., 2016). Various concepts of small electric or hybrid electric aircrafts are being developed by Airbus (E-Fan and Vahana), Boeing, NASA, Rolls-Royce and Siemens, Embraer (AIRBUS, 2017; NASA, 2016; Embraer, 2018). Hydrogen fuel cells could also find application but not necessary on larger aircrafts or as the main propulsion energy. EasyJet has been carrying out trials of a hybrid hydrogen and solar fuel cell system where the electricity produced by the fuel cell will power the taxi system (Topham, 2016). Another

[7] BB GREEN: Battery powered Boats, providing Greening, Resistance reduction, Electric, Efficient and Novelty
[8] GFF: Green Fast Ferry
[9] SEABUBBLEFast-Forwarding to the Future of On-Demand Urban Water Transportation

example is a four-seater hydrogen plane named HY4[10] that has carried out flights in Germany, the Antares DLR-H2[11] and Boeing's Theator Aircraft[12].

For the rail transport sector electrification already exists to a great extent. For Europe, 60% of the main lines are already electrified and 80% of traffic is running on these lines (Meyer, 2016). Further electrification could benefit the environment although the cost of upgrading current infrastructure could be an obstacle. Retrofitting the existing aging diesel locomotives will also have benefits. Furthermore, technologies like hydrogen fuel cells have already been introduced in rail since 2002 on a mining locomotive (IEA Hydrogen, 2017) while recent examples are the Coradia iLint by Alstom (Alstom, 2017) while Siemens and Ballard Power systems are working on a new fuel cell drive system for the Siemens Mireo train platform (Railway Technology, 2018). The use of hydrogen fuel cell electric propulsion is supported by ERRAC (2016) with a timeline of implementation reaching beyond 2035 for Technology Readiness Level 6-8[13] including hydrogen production and storage.

5.4 Seamless transport chains

Seamless transport chains is another key future transport concept, applicable to both passenger and freight transportation sectors. Seamless transport entails the complete connectivity between cities and regions and the enhancement of multimodality and intermodality of network systems. This concept has been researched in, as well as out of the scope of MaaS concept, by the majority of the literature sources reviewed.

Seamless transport concept appeared to have been discussed from various perspectives in the pertinent literature reviewed. Some of them include:

- seamless logistics
- seamless national and international travel for passengers
- seamless transport chains as a result of MaaS
- establishment of multimodal centres and intermodal mega-hubs for the seamless integration of mobility services and the smooth interaction between transport modes
- integration of all transport modes – multimodality, intermodality

FUTRE project (2012-2014), defined seamless transport chains as “future clever transport chains characterized by smooth connections between different modes of transport, more frequent services, real-time information updates via smartphones and integrated ticketing and charging systems”. E.C. (2011) highlighted the importance of seamless door-to-door mobility for both passenger and freight, recognizing intermodal integration as one of the major characteristics determining transport services quality. In the same context, MOBILITY4EU project (2016-2018) suggested that an integrated and seamless transport system for people and freight must be developed, in order to reach EU goals towards sustainability and efficiency.

.

[10] http://hy4.org/
[11] http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10203/339_read-8244#/gallery/12336
[12] https://www.boeing.com/features/2015/02/corp-bsb-fuel-cell-technology-02-24-15.page
[13] LvL 6. System/subsystem model or prototype demonstration in a relevant environment; LvL 7. System prototype demonstration in an operational environment; LvL 8. Actual system completed and qualified through test and demonstration.

OECD/ITF (2012) recognized seamless transport as a crucial and ambitious strategic vision for the future of transportation and attempted to define a roadmap for its further development. The publication discussed a wide range of issues around seamless transport, such as seamless transport for trade and growth, new approaches for seamless logistics, connectivity enhancement across borders, challenges in providing seamless urban mobility, integration of transport and communication systems to provide seamless services, the role of e-ticketing, smart phones and data sharing in seamless transport provision, etc.

Some of the reviewed literature sources proposed seamless transport as a key future transport concept, in the scope of MaaS. A potential implementation of MaaS would lead to a future urban mobility ecosystem able to deliver seamless intermodal transportation. Other sources suggested seamless transport in the context of integration between specific modes of transport, e.g. integration between rail (high-speed trains) and aviation, integration of aviation with other modes in order to enable four- hour door-to-door journey by airplane, etc.

In the future, seamless multimodal transportation is expected to become a reality. Enhanced system interoperability will enable customers to travel, using a wide range of different and connected modes, on a single integrated price charged. In an IT point of view, ERRAC (2016) proposed that seamless transport travel will be enabled by 2025.

5.5 Personal air transportation – “flying cars”, “flying taxis”

Personal aerial vehicles, broadly called “flying cars” or “passenger drones” were proven to be among the key transport concepts of the future. After a long period of failed attempts, several literature sources suggest that personal air transportation is likely to become a reality.

Lineberger et al. (2018) defined the different vehicle categories broadly described by the umbrella term “flying cars”, aiming to highlight the differences in terms of their characteristics and potential uses. Passenger drones are defined as manually piloted, remotely piloted or fully autonomous quadcopters, able to move people or goods in short distances, between predetermined or on-demand origins and destinations. Flying cars are defined as vehicles able to move in both car and airplane configuration. The driver navigates the vehicle to the airport and then flies to his destination airport. These vehicles could be fully autonomous and VTOL capable. Finally, revolutionary vehicles form a combination of the aforementioned vehicle categories, being faster and capable of covering longer distances. These vehicles are characterized by full automation as well as advanced VTOL capability.

Fueled by the rapid technological advances on UAV technologies, several personal air transportation concepts are already under development and trials are taking place around the world. Some typical examples, include CityAirbus, Vahana, PopUp, Ehang 184, Volocopter 2X, Lilium and Uber Elevate (UKi Media & Events, 2018, Lineberger, 2018). Key topic areas for discussion about personal air transportation, include technology maturity, integration into the existing transport system, air traffic management, regulatory framework, appropriate infrastructure (e.g. vertiports), and safety.

Urban airspaces might be populated by passenger drones sooner than generally expected. “Flying cars” and “flying taxis” are expected to rise especially in high density urban areas, providing a faster and environmentally friendly alternative to private cars. Morrell (2017) considered that passenger drones are likely to reach the technology readiness levels of

commercialization and adoption before 2030. According to Drone Industry Insights (2017), the next 5-10 years are going to an incredible time for the roll-out of this technology.

MANUFACTURER/ Vehicle name	Development start	Current phase: CONCEPT/ DESIGN	PROTOTYPING	TESTING	PRODUCTION	Launch/ delivery
AEROMOBIL/ Flying Car	2010			■		2020
AIRBUS/PopUp	2016		■			2020
AIRBUS/Vahana	2016		■			2020
AURORA (BOEING)/ eVTOL	1989			■		2020
EHANG/184	2014			■		2018
E-VOLO/Volocopter	2012			■		2018
JOBY AVIATION/S2	2009		■			N/A
LILIUM/Lilium	2014			■		2019
MOLLER/Skycar	1983		■			2020
PAL-V	2001				■	2018
TERRAFUGIA/ Transition	2006			■		2019
VRCO/NeoXCraft	N/A		■			2020
ZEE.AERO/Zee	2010			■		N/A

Figure 18. Current development phases of passenger drones and flying cars

Source: Lineberger et al. (2018)

DRONE INDUSTRY INSIGHTS

Flying Cars, Air Taxis, Personal Drones – a snapshot

Company	AEROMOBIL	AIRBUS	AIRBUS	AURORA FLIGHT SCIENCES	EHANG	E-VOLO	JOBY AVIATION	LILIUM	MOLLER INTER-NATIONAL	PAL-V	TERRAFUGIA	ZEE.AERO
Name	Flying Car	PopUp[1]	Vahana	eVTOL	184	Volocopter V200	S2	Lilium	Skycar	Pal-V	Transition	Zee
Country												
Project started in	2010	2016	2016	1989	2014	2012	2009	2014	1983	2001	2006	2010
Funding [Mio USD]	3.2	undisclosed	undisclosed	15	52	1.2	undisclosed	11.4	undisclosed	-	5.56	100[2]
Investors	Patrick Hessel	undisclosed	undisclosed	Enlightenment Capital	GGV Capital	Crowdfunding	undisclosed	Atomico	undisclosed	-	Transcendent Holdings	Larry Page
VTOL[3]	-	✓	✓	✓	✓	✓	✓	✓	✓	-	-	✓
Battery	-	✓	✓	✓	✓	✓	✓	✓	-	-	✓	✓
Gasoline	✓	-	-	-	-	-	-	-	-	✓	✓	-
Hybrid[4]	-	-	-	-	-	-	-	-	✓	-	-	-
Prototype + Permit	✓	-	-	✓	✓	✓	-	✓	✓	✓	✓	✓
Number of rotors	1	4	8	9	8	18	12	36	4	2	1	5
Max. speed [km/h]	360	?	?	?	100	100	320	300	450	180	185	?
Max. range [km]	750	?	200	?	30	100	320	300	850	400	640	?
Seats	2	2	1	2	1	2	2	5	2	2	2	2

[1] Airbus PopUp: represents an extensive mobility concept not a sole flying platform
[2] Source: Bloomberg – "welcome to Larry Pages secret flying car factories"
[3] VTOL: Vertical Takeoff and Landing – all other platforms require a runway/airport
[4] Hybrid propulsion: electrically powered VTOL, gasoline powered horizontal flight

source: DRONEII.com April 2017

DRONEII.COM DRONE INDUSTRY INSIGHTS

Figure 19. Flying Cars, Ait Taxis, Personal Drones – a snapshot

Source: Drone Industry Insights, https://www.droneii.com/flying-cars-an-industry-snapshot

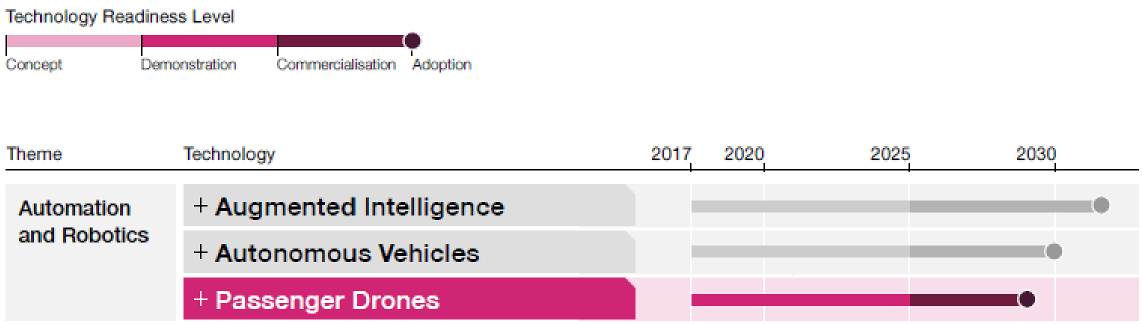


Figure 20. Technology readiness level for passenger drones – Timeline

Source: Morrell (2017)

5.6 Delivery Drones

According to the frequency of occurrence in the reviewed literature, delivery drones were proven to be among the key transport concepts of the future, regarding freight transportation. Delivery drones appeared to have been discussed through two different perspectives:

- delivery drones in urban areas, for the last-mile logistics of small, lightweight packages
- delivery drones to cater for delivery needs of rural, hard-to-reach areas

Over the coming decades, commercial drones are likely to be used for a range of applications, including deliveries. Delivery drones are likely to become an integral part of the supply chain, offering opportunities for faster delivery times for consumers, traffic congestion and emissions reduction and increased access of remote areas. Several companies, including Amazon, Google, Alibaba, the United Parcel Service, DHL and Wal-Mart have already started experimenting with such systems and the key considerations for the further development and adoption of this concept, include functionality, legislation, system integration into the existing urban infrastructure, safety, security and privacy related issues (Zickuhr et al. 2016, Gulden T. R., 2017).

Apart from urban deliveries, there have already been attempts for drone deliveries in rural – hard-to-reach areas. Aiming to cover the delivery needs for food, medicine and other necessities, the US company Matternet is designing a drone delivery network in the low-income countries with problematic road access (Goulding and Morrell, 2014a). With regard to parcel delivery drones safety, JARUS (the Joint Authorities for Rulemaking on Unmanned Systems) has recently developed a new method named “SORA” (Specific Operations Risk Assessment), in order to assess the risk of unmanned aerial vehicles – UAS operation to third parties and ensure their safe integration to the aviation system (JARUS, 2017).

Drones are expected to revolutionize the delivery of goods in the near future. In its estimations regarding the evolution of drone demand in the delivery sector, SESAR JU (2016) forecasted that 70.000 drones will deliver about 200 million lightweight parcels across Europe in 2035. According to this research, the adoption of delivery drones will occur before 2030 (see Figure 21).

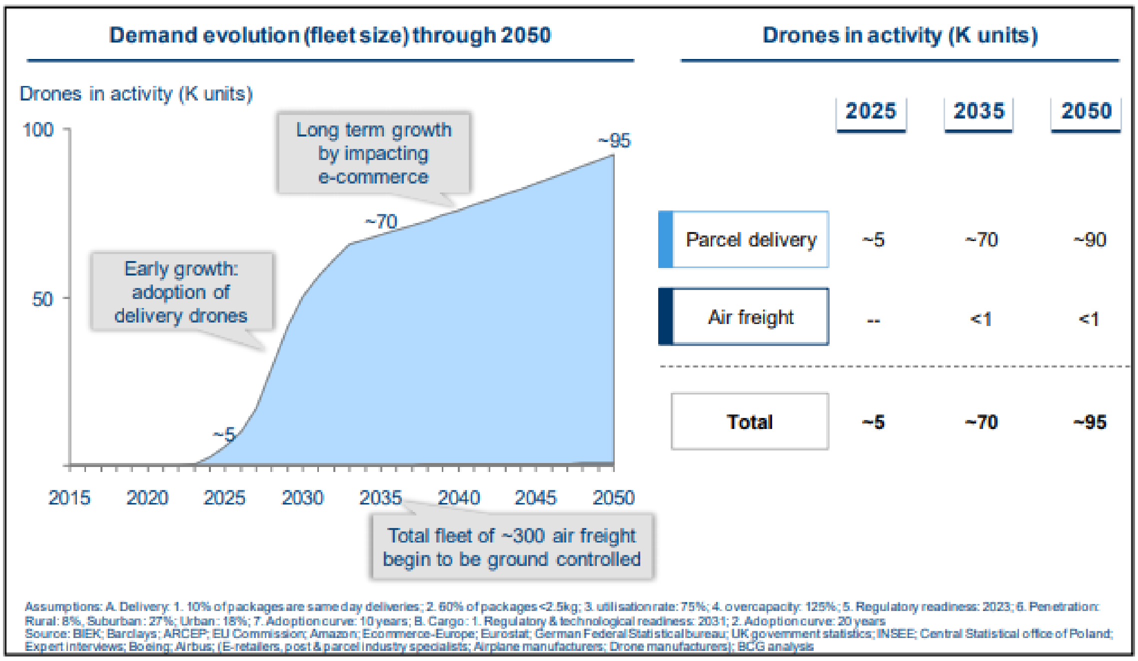


Figure 21. Summary of drone demand outlook in e-commerce and delivery

Source: SESAR JU (2016)

5.7 Smart use of travel time

Smart use of travel time, forms a transport concept of the future that is a direct consequence of the autonomous driving. Nevertheless, it was considered as an individual future concept, taking into account the wide range of potential activities while driving, as well as the tremendous opportunities for companies seeking to provide and enhance the in-transit experience.

Thanks to autonomous vehicles, travel time could be seen as a usable timeslot for a wide variety of activities. Some of the potential activities discussed in the literature reviewed, are:

- surfing the web/car-based media consumption
- working/multitasking
- studying/reading
- sleeping/relaxing
- watching movies
- online shopping

In the future, autonomous driving will enable the in-transit experience, providing significant opportunities for companies operating in different sectors, such as in-vehicle service providers, data and analytics companies, entertainment providers, social media companies, advertisers, etc. The in-vehicle services and products may be provided by the vehicle itself – automotive industries, by the MaaS providers, or by other players. Services and product sales, on-board advertising, subscription, data monetization based on media consumption, form the huge potential revenue sources for companies.

KPMG (2017) recognized that travel time will be the major purchasing criterion in the future with the emergence of autonomous cars, while Otto (2017) identified that the forthcoming change in behavior while driving will likely result in different interior designs. According to

Corwin et al. (2016), Volvo has already announced a partnership with Netflix to enable livestreaming during commute and more companies are expected to act similarly in the near future. It is broadly believed, that in-vehicle experience will probably be a defining feature of the future mobility.

5.8 High-speed rail

High-speed rail was proven to be one of the key transport concepts for the future passenger transportation. Although possibly applicable to freight transport as well, the literature suggested high-speed trains as a key future transport concept for passenger transportation sector. The perspectives by which high-speed rail have been suggested to form a part of the future transportation landscape, are briefly the following:

- high-speed rail as an attractive alternative to aviation, especially for medium and even long-distance passenger travel
- high-speed rail as a cheaper, greener and more sustainable transport alternative
- need for a complete European high-speed rail network

UIC (2018) recognized that there is not a standard definition of high-speed rail, because of the complexity of such systems and the different criteria used. High-speed rail includes a set of different elements, which constitute the whole system. Some of these individual elements include the infrastructure (new lines designed for speeds above 250km/h or upgraded pre-existing lines for speeds 200-220km/h), the rolling stock (special design train sets), the operating conditions, etc.

EC (2011) highlighted the significant role of high-speed rail in order to reach EU goals regarding a competitive and resource efficient transport systems. A complete European high-speed rail network by 2050, a stepwise tripling of the length of the existing high-speed rail network by 2030 and the development of connections between all core network airports to the rail network and preferably to high-speed rail, were some of the priorities that have been set.

High-speed rail is expected to be a key transport concept of the future and to revolutionize sustainable mobility, enabling the majority of medium-distance passengers to travel by rail and providing an efficient alternative to air and road transportation. EC (2009) forecasted that the trans-European high-speed rail network should be 22.140 km by 2020, while after the completion of the high-speed TEN-T by 2030 the network will be 30.750 km long and the traffic will be risen to 535 billion passengers per km per annum (EC, 2009, EC, 2010). Taking into account the complexity of the high-speed rail systems, Harnish (2018) identified the various elements required to be combined, for their successful operation. These include the development of broad networks than individual routes, the linkage between new high-speed lines with upgraded mixed-use feeder lines, modern trains as well as frequent departures and connecting services

5.9 Hyperloops

Hyperloops appeared to be one the key transport concepts of the future, which is likely to play a significant role in the future passenger transportation. Hyperloop, which has also been characterized as “the fifth mode” of transport, constitutes a novel superfast method of transport proposed by Elon Musk. The Hyperloop concept entails levitating small capsules traveling along a low-pressure tube. Thanks to air resistance and friction elimination, the

pods are capable of traveling long distances in times comparable to air travel (Musk, 2013, UKi Media & Events, 2018). Hyperloop forms an innovative concept with a high potential to alleviate surface congestion and radically transform the overall sustainability of surface transportation. It has been proposed as a faster and more cost-efficient transport alternative than air and high-speed rail transportation, regarding distances up to 1.500 km.

Hyperloops are quickly gaining popularity and maybe in the future people will be able to travel long distances in tubes, in a faster and more efficient way. Despite the main concerns regarding its technological and financial viability, several companies are experimenting and testing with hyperloop systems. Some typical examples include Virgin Hyperloop One, that aims to provide Dubai with the first Hyperloop system in the world by 2021 and TransPod that is focused on building a Toronto-Montreal hyperloop.

5.10 Freight consolidation hubs, Freight Distribution Centres

Freight hubs consist of areas where freight transportation players (i.e. freight forwarders, shippers, transport operators, in other cases customs), freight activities and related services are gathered together at the same location. Such services could be cargo consolidation/ deconsolidation, storage, distribution, and other value-added services (Roy, 2013). Such hubs can be located in port, airport, market, rail inland hub centric or at the outskirts of cities. The rise of e-commerce and increase in demand for goods will result in rising road congestions which will force cities and companies to improve the efficiency of freight and services (Goulding and Butler, 2018). As a result, cities and private companies will have to establish consolidation and freight distribution centres shifting the distribution of freight to inner city using smaller electric vehicles (Keseru et al., 2016) or carrying out night time deliveries using Autonomous Vehicles (Goulding and Butler, 2016). Market demand will cause port operators to extend their capacity using floating delivery hubs and automated containers terminals (Keseru et al., 2016).

Future consolidation centres will be able to bring together flow of goods for entire cities or regions while different suppliers will have to cooperate and ship together their products via single shippers in an effort to make transport cheaper, more efficient and reduce number of deliveries (Siemens, 2011). IT systems and automation will play considerable role in this endeavour.

5.11 Superfast Ground and Underground Transportation, Cargo Tubes, Underground Freight Pipelines

This concept refers to the use of pipeline transport to transport goods underground in dedicated networks that are only used for this purpose. An example is the CargoCap concept named after the same company name which is a new mode of freight transport which is expected to find applications in dense urban centres. The goods will be transported inside pods using electric propulsion and automated controls (CargoCap, 2018).

Another similar pipeline transport concept is that of Cargo sous terrain (CST) which is another innovative system for transport goods via underground infrastructure in Switzerland with an aim of implementation by 2030. The logistics system involves the use of AVs which will unload goods to hub terminals. The goods will then be transported via elevators underground and then loaded on pods capable of traveling at speeds of 30km/h. Finally, the goods will be consolidated at other hub terminals where they can be distributed by road. Hub terminals will be connected with each other (Cargo sous terrain, 2018).

6 Conclusions

The current Deliverable identifies the transport concepts of the future applicable to both passenger and freight transportation. The approach taken involved a literature review for the purpose of identifying a distinct definition of the term “transport concept”, followed by an extended literature review-based methodology and search on the aforementioned term for the capturing of the key future transport concepts applicable to passenger and freight transportation sectors. The former review resulted in a literature gap of a precise definition of the term “transport concept”, thus a definition for this term was developed for the purpose of the current Deliverable. Particular emphasis was placed on EU FP7 and H2020 funded research projects, namely MOBILITY4EU, FUTRE, RACE2050, OPTIMISM, METRIC and IKNOW. Additionally, future transport-related websites, technology-oriented websites and several forward-looking reports also provided input and further supported the attempted identification of the major future transport concepts of the future.

After a thorough review of the pertinent literature available, matrices listing future transport concepts over sources were prepared. The overall aim was to determine concepts that are researched, discussed or proposed in the majority of the literature sources, thus to indicate a certain level of consensus to those that are more likely to shape the future transport landscape. A cut-off criterion for reaching a consensus was defined, for the purpose of identifying the dominant concepts of the future on the basis of high frequency of occurrence in the literature reviewed. The seven top-cited concepts for each passenger and freight transport, were agreed to form the dominant transport concepts of the future. These concepts were further analysed in terms of which transport mode they are applicable to, how likely they are to be implemented as well as when they are likely to become mainstream (timeline of implementation). Moreover, they were explained in further detail, in Section 5 of the current Deliverable.

Taking into consideration that these transport concepts are broadly believed to have a high potential to disrupt and radically reshape the future transport landscape, they should be further validated in order to assess their impact on defining the future transport research priorities. Their further analysis and elaboration through the application of the ANP methodology (T3.2), will result in a determination of those future transport concepts (as well as technological advances, megatrends and political imperatives) that are considered define the future transport landscape and lead the future transport research priorities.

Based on the principles defined, the following passenger transport-applicable concepts of the future were identified to be the dominant ones

- **automation – passenger transport**
- **shared mobility, on-demand mobility, MaaS**
- **electrification – passenger transport**
- **seamless transport chains – multimodality, intermodality**
- **personal air transportation – “flying cars”, “flying taxis”**
- **smart use of travel time**
- **high-speed rail**
- **superfast ground and underground transportation (hyperloops)**

By applying the same principles for freight transport, the following freight transport-applicable concepts of the future were identified to have a higher potential to define the future of the freight transportation landscape:

- **shared mobility, on-demand mobility, freight as a service – FaaS**
- **seamless transport chains – multimodality, intermodality**
- **automation – freight transport**
- **electrification – freight transport**
- **delivery drones**
- **superfast ground and underground transportation (cargo tubes, underground freight pipelines)**
- **freight consolidation hubs, freight distribution centres**

It is worth to be noted that the future transport concepts identified in the pertinent literature, form individual visions of what transportation will look like in the future. Several of the aforementioned concepts are expected to merge in the future, forming different single transport concepts. A typical example broadly discussed in the literature, is the future existence of shared mobility concepts – MaaS, utilizing fleets of autonomous and electric-powered vehicles.

7 References

ACEA, (2018), http://www.acea.be/ accessed online 9/05/2018

Aggelakakis, A., Bernardino, J., Boile, M., Christidis, P., Condeço, A., Krail, M., Papanikolaou, A., Reichenbach, M., Schippl, J., Vieira, J. (2014). *FUture prospects on TRansport evolution and innovation challenges for the competitiveness of Europe.* FUTRE e-book. Project financed by the 7th Framework Programme

AIRBUS (2017), Airbus, Rolls-Royce, and Siemens team up for electric future Partnership launches E-Fan X hybrid-electric flight demonstrator, http://www.airbus.com/newsroom/press-releases/en/2017/11/airbus--rolls-royce--and-siemens-team-up-for-electric-future-par.html assessed online 10/02/2018

Alstom (2017), *Coradia iLint regional train*, Alstom website, http://www.alstom.com/products-services/product-catalogue/rail-systems/trains/products/coradia-ilint-regional-train-/ accessed online 11/02/2018

Amsterdam Roundtable Foundation and McKinsey & Company (2014), *Evolution – Electric vehicles in Europe: gearing up for a new phase?*, https://www.mckinsey.com/~/media/McKinsey/Locations/Europe%20and%20Middle%20East/Netherlands/Our%20Insights/Electric%20vehicles%20in%20Europe%20Gearing%20up%20for%20a%20new%20phase/Electric%20vehicles%20in%20Europe%20Gearing%20up%20for%20a%20new%20phase.ashx accessed online 10/05/2018

Arbib, J., Seba, T., Kok, I., Zou, Y. S., Gordon, J., Mercer, B. (2017). *Rethinking Transportation 2020-2030: The Disruption of Transportation and the Collapse of the Internal-Combustion Vehicle and Oil Industries.* San Francisco, USA: RethinkX, https://static1.squarespace.com/static/585c3439be65942f022bbf9b/t/591a2e4be6f2e1c13df930c5/1494888038959/RethinkX+Report_051517.pdf

Bloomberg New Energy Finance, (2017), Electric Vehicle Outlook 2017, Executive Summary, https://about.bnef.com/electric-vehicle-outlook/ accessed online 10/05/2018

Briggs, M., Sundaram, K. (2016). *Environmentally Sustainable Innovation in Automotive Manufacturing and Urban Mobility - Identifying the role of technology in enabling mobility services & sustainability.* A Frost & Sullivan White Paper in Conjunction with BT, https://www.btplc.com/Purposefulbusiness/Ourapproach/Ourpolicies/cars2025report.pdf

Carey, N. (2017). *Peloton, Omnitracks partner on truck "platooning" technology*. REUTERS, https://www.reuters.com/article/us-usa-trucks-technology/peloton-omnitracs-partner-on-truck-platooning-technology-idUSKBN15V1ZL

Cargo sous terrain, (2018), http://www.cargosousterrain.ch/de/en.html accessed online 11/05/2018

CargoCap, (2018), http://www.cargocap.com/ accessed online 11/05/2018

Cece, B. (2016). Future of Urban Mobility – My kind of flyover, http://www.airbus.com/newsroom/news/en/2016/12/My-Kind-Of-Flyover.html

Christodoulou, A., Christidis, P., Condeço-Melhorado, A. (2014). *Development of Innovation Roadmaps*. METRIC Deliverable D5.2. Project financed by the 7th Framework Programme.

Cohen, A., Shaheen, S. (2016). Planning For Shared Mobility. Planning Advisory Service Report 583. American Planning Association: Chicago, Illinois

Cornet, A., Mohr, D., Weig, F., Zerlin, B., Hein, A-P. (2012). *Mobility of the Future – Opportunities for Automotive OEMs.* Munich: McKinsey & Company, https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/automotive%20and%20assembly/pdfs/mobility_of_the_future_brochure.ashx

Corwin, S., Jameson, N., Pankratz, D.M., Willigmann, P. (2016). *The Future of Mobility: What's Next? Tomorrow's Mobility Ecosystem – and How to Succeed in it.* New York, USA: Deloitte University Press, https://www2.deloitte.com/insights/us/en/focus/future-of-mobility/roadmap-for-future-of-urban-mobility.html

Corwin, S., Vitale, J., Kelly, E., Cathles, E. (2015). *The Future of Mobility: How Transportation Technology and Social Trends Are Creating a New Business Ecosystem.* New York, USA: Deloitte University Press, https://www2.deloitte.com/insights/us/en/focus/future-of-mobility/transportation-technology.html

Cummins, (2017), Cummins Unveils Next Generation of Energy-Diverse Products and Technology Solutions, Cummins Website, http://investor.cummins.com/phoenix.zhtml?c=112916&p=irol-newsArticle&ID=2297183 accessed online 10/05/2018

D'Incà, J., Mentz, C. (2016). *Mobility 2040 – Staying Ahead of Disruption*. Oliver Wyman, http://www.oliverwyman.com/our-expertise/insights/2016/nov/mobility-2040---staying-ahead-of-disruption.html

Delle Site, P., Filippi, F., Salucci, M.V. (2013). *Delphi expert report on the future scenarios of transport and mobility*. OPTIMISM Deliverable D3.3. Project financed by the 7th Framework Programme.

Delle Site, P., Filippi, F., Salucci, M.V., Zhang, Q., Brooks, R., Micharikopoulos, D., Tavlaki, E., Kompil, M., Hoppe, M., Seppänen, T., Christ, A. (2012). *Definition of Strategies for Integrating and Optimising Transport Systems*. OPTIMISM Deliverable D5.1. Project financed by the 7th Framework Programme.

Dohna, F., Morrell, M. (2016). *Future of Transport: UK – 50 trends and issues shaping the future of UK transport*. London, U.K.: Arup Foresight, http://www.driversofchange.com/projects/future-of-transport-uk/

Drone Industry Insights. (2017). Flying Cars, Air-Taxis, Passenger Drones – an industry snapshot. Drone Industry Insights, https://www.droneii.com/flying-cars-an-industry-snapshot accessed online 08/05/2018

E.C. (2010). High-Speed Europe. A Sustainable Link between Citizens. European Commission, Luxembourg: Publications Office of the European Union

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

Embraer (2018), EmbraerX unveils first eVTOL concept, https://embraer.com/global/en/news#/906344-embraerx-unveils-first-evtol-concept accessed online 10/05/2018

ERTRAC (2017), *Automated Driving Roadmap*, ERTRAC Working Group "Connectivity and Automated Driving, http://www.ertrac.org/uploads/images/ERTRAC_Automated_Driving_2017.pdf accessed online 31/01/2018

Foulser, B. (2017). *Reimagine Places: Mobility as a Service*. KPMG International Cooperative,https://home.kpmg.com/uk/en/home/insights/2017/08/reimagine-places-mobility-as-a-service.html

Freese, C., Schönberg, A. T., Horstkötter, D. (2014). Shared Mobility: How new businesses are rewriting the rules of the private transportation game. Roland Berger Strategy Consultants: München, http://www.rolandberger.de/media/pdf/Roland_Berger_TAB_Shared_Mobility_20140716.pdf

Future Transport 2056 (2018). *Future Transport Strategy 2056*. New South Wales Government, Australia, https://future.transport.nsw.gov.au/sites/default/files/media/documents/2018/Future_Transport_2056_Strategy.pdf

Goodall, W., Fishman, T., Bornstein, J., Bontrhon, B. (2017). *The Rise of Mobility as a Service – Reshaping How Urbanites Get Around.* New York, USA: Deloitte University Press (Deloitte Review 20), https://www2.deloitte.com/content/dam/Deloitte/nl/Documents/consumer-business/deloitte-nl-cb-ths-rise-of-mobility-as-a-service.pdf

Goulding, L., Butler, T. (2018). *Rethinking Urban Mobility: Three questions that will shape the future of transport in cities*. London, U.K.: Arup Foresight, http://www.driversofchange.com/projects/rethinking-urban-mobility/

Goulding, L., Morrell, M. (2014a). *Future of Highways*. London, U.K.: Arup Foresight, http://www.driversofchange.com/projects/future-of-highways/

Goulding, L., Morrell, M. (2014b). *Future of Rail 2050*. London, U.K.: Arup Foresight, http://www.driversofchange.com/projects/future-of-rail-2050/

Grosse-Ophoff, A., Hausler, S., Heineke, K., Möller, T. (2017). *How shared mobility will change the automotive industry*. Munich: McKinsey & Company, https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/how-shared-mobility-will-change-the-automotive-industry

Gulden, T. R. (2017). The Energy Implications of Drones for Package Delivery: A Geographic Information System Comparison. Santa Monica, CA: RAND Corporation, https://www.rand.org/pubs/research_reports/RR1718z1.html

Harnish, R. (2018, April). The Phased Network Approach: A market-based model for high-speed rail. Global Railway Review, 24(02), 14-18. Retrieved from https://globalrailwayreview.attach.io/r1BtlC-5G

Hauptman, A., Raban, Y., Tzezana, R. (2014). *Wilds Cards and Weak Signals in the Transport Field.* RACE *2050* Deliverable D6.2. Project financed by the 7th Framework Programme

Hsu, C.C., Sandford, B.A. (2007). The Delphi technique: making sense of consensus. Practical Assessment, Research & Evaluation. 12(10), pp. 1-8.

IEA Hydrogen (2017), *Global trends and outlook for hydrogen*, http://ieahydrogen.org/pdfs/Global-Outlook-and-Trends-for-Hydrogen_Dec2017_WEB.aspx

IKNOW (2011). Interconnecting knowledge for the early identification of issues, events and developments (e.g. wild cards and associated weak signals) shaping and shaking the future of STI in the ERA. Project financed by the 7th Framework Programme, http://community.iknowfutures.eu/mod/wiwe/all.php?type=wildcard&filter=FP7-TRANSPORT

International Association of Public Transport – UITP. (2017). *Autonomous Vehicles: Potential Game Changer for Urban Mobility*. UITP, http://www.uitp.org/news/autonomous-vehicles-urban-mobility

Jittrapirom, P., Caiati, V., Feneri, A. M., Ebrahimigharehbaghi, S., González, M. J. A., Narayan, J. (2017). Mobility as a Service: A Critical Review of Definitions, Assessments of Schemes, and Key Challenges. Urban Planning, 2(2), pp. 13.

Kelly, S. E., Moher, D., Clifford, T. J. (2016). Defining rapid reviews: a modified Delphi consensus approach. *International Journal of Technology Assessment in Health Care*. 32(4), pp. 265-275.

Keseru, I., Coosemans, T., Macharis, C., Muller, B. (2016). *Report on MAMCA Scenario Descriptions.* MOBILITY4EU Deliverable D3.1. Project financed by Horizon 2020 Programme

Kleynen, M., Braun, S.M., Bleijlevens, M.H., Lexis, M.A., Rasquin, S.M., Halfens, J., Wilson, M.R., Beurskens, A.J., Masters, R.S. (2014). Using a Delphi Technique to Seek Consensus Regarding Definitions, Descriptions and Classification of Terms Related to Implicit and Explicit Forms of Motor Learning. *PLoS ONE*. 9(6): e100227. doi:10.1371/journal.pone.0100227.

Klingebiel, K., Wagenitz, A. (2013). An Introduction to Logistics as a Service. In: Clausen, U., Hompel, M. T., Klumpp, M. (2012). Efficiency and Logistics (Lecture Notes in Logistics), Springer-Verlag Berlin, Heidelberg, pp. 209-216.

Kompil, M., Christidis, P., Lopez-Ruiz, H.G., Maerivoet, S., Purwanto, J., Salucci, M.V. (2013). *Modelling Future Mobility – Scenario Simulation at Macro Level*. OPTIMISM Deliverable D3.4. Project financed by the 7th Framework Programme.

Kotoky, A. (2018). *Uber and Bell Helicopter to Bring First Air Taxis by 2025*. Bloomberg Technology, https://www.bloomberg.com/news/articles/2018-02-06/uber-bell-helicopter-alliance-to-bring-first-air-taxis-by-2025 accessed online 07/05/2018

KPMG. (2017). *KPMG's Global Automotive Executive Survey 2017*. KPMG International Cooperative, https://home.kpmg.com/xx/en/home/insights/2017/01/global-automotive-executive-survey-2017.html

Leary K., (2017), China Has Launched the World's First All-Electric Cargo Ship, https://futurism.com/china-launched-worlds-first-all-electric-cargo-ship/ accessed online 10/05/2018

Leech, J., Whelan G., Bhaiji, M., Hawes, M., Scharring, K. (2015). *Connected Autonomous Vehicles – The UK Economic Opportunity*. KPMG International Cooperative, https://assets.kpmg.com/content/dam/kpmg/images/2015/05/connected-and-autonomous-vehicles.pdf

Lineberger, R., Hussain, A., Mehra, S., Pankratz, D.M. (2018). *Elevating the Future of Mobility – Passenger drones and flying cars*. Deloitte Insights, https://www2.deloitte.com/insights/us/en/focus/future-of-mobility/passenger-drones-flying-cars.html

Lloyd's Register Marine & UCL Energy Institute (2014), *Global Marine Fuel Trends 2030*, https://www.lr.org/en/insights/global-marine-trends-2030/global-marine-fuel-trends-2030/ accessed online 10/05/2018

Lloyd's Register, (2017),*Global Marine Technology Trends 2030 Autonomous Systems*, Lloyd's Register Group Ltd, QinetiQ and University of Southampton

Manyika, J., Chui, M., Bughin, J., Dobbs, R., Bisson, P., Marrs, A. (2013). *Disruptive Technologies: Advances that Will Transform Life, Business, and the Global Economy*. Washington, D.C., USA: McKinsey Global Institute, https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/Disruptive%20technologies/MGI_Disruptive_technologies_Full_report_May2013.ashx

Margaritis D., Anagnostopoulou, Tromaras, Boile M., (2016), Electric commercial vehicles: Practical perspectives and future research directions, *Research in Transportation Business & Management,* Vol. 18, March, pp 4–10

Marr, B. (2017). The Future Of The Transport Industry – IoT, Big Data, AI and Autonomous Vehicles, https://www.forbes.com/sites/bernardmarr/2017/11/06/the-future-of-the-transport-industry-iot-big-data-ai-and-autonomous-vehicles/#43a2c2d81137

Meyer G., Bucknall R, Breuil D.M, (2016), STRIA Roadmap "Electrification", https://trimis.ec.europa.eu/sites/default/files/roadmaps/STRIA%20Roadmap%20-%20Transport%20electrification.pdf accessed online 10/05/2018

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*. 63, pp. 81 -97

Mobility of the Future – Examining future changes in the transportation sector. MIT Energy Initiative, http://energy.mit.edu/research/mobility-future-study/ accessed online 06/05/2018

MOBILITY4EU (2016a). Action plan for the future of mobility in Europe. Context Map towards transport in 2030, https://www.mobility4eu.eu/resources/maps/ accessed online 15/04/2018

MOBILITY4EU (2016b). Opportunity Map for the future of mobility in Europe 2030, https://www.mobility4eu.eu/resources/maps/ accessed online 15/04/2018

MOBILITY4EU (2016c). Vision for 2030 Map, https://www.mobility4eu.eu/resources/maps/ accessed online 20/03/2018

Morrell, M. (2017). *Emerging Technology Timeline – 20 emergent technologies likely to disrupt our sector*. London, U.K.: Arup Foresight, http://www.driversofchange.com/projects/technology-timeline-2017/

Musk, E. (2013). Hyperloop Alpha, http://www.spacex.com/sites/spacex/files/hyperloop_alpha-20130812.pdf

NASA (2016), *NASA Electric Research Plane Gets X Number, New Name*, https://www.nasa.gov/press-release/nasa-electric-research-plane-gets-x-number-new-name assessed online 10/02/2018

OECD/ITF (2017). *ITF Transport Outlook 2017*. OECD Publishing, Paris, http://dx.doi.org/10.1787/9789282108000-en

Otto, P. (2017). *The Future of Mobility On the road to driverless cars*. Paris, France: Ipsos Views, https://www.ipsos.com/en/future-mobility-road-driverless-cars

Overly, S. (2017). *A drone carrying humans prepares to take flight in Dubai*. Washington Post Innovations Section, https://www.washingtonpost.com/news/innovations/wp/2017/02/15/a-drone-carrying-human-passengers-prepares-to-take-flight-in-dubai/?utm_term=.f639cc9f5b23 assessed online 10/04/2018

Papanikolaou A., Boile M., Reichenbach M., Schippl J. (2014). *Long-term future analysis on transport demand market and drivers.* FUTRE Deliverable D3.2. Project financed by the 7th Framework Programme

Paris C., (2017), *Norway Takes Lead in Race to Build Autonomous Cargo Ships*, The Wall Street Journal website, www.wsj.com accessed online 16/01/2018

Project "Next", http://www.next-future-mobility.com/about,https://www.fastcodesign.com/3053031/why-should-your-self-driving-car-look-like-a-car accessed online 28/03/2018

Railway Technology (2018), Siemens and Ballard to develop new generation of fuel cells for trains, Railway technology website, 27 February 2018, https://www.railway-technology.com/news/siemens-ballard-develop-new-generation-fuel-cells-trains/ accessed online 18/04/2018.

Raponso A., Ciuffo B., Makridis, M. and Thiel, C., (2017), *The r-evolution of driving: from Connected Vehicles to Coordinated Automated Road Transport (C-ART)*, Joint Research Centre (JRC), http://publications.jrc.ec.europa.eu/repository/bitstream/JRC106565/art_science_for_policy_report_1-soa_final_tobepublished_online.pdf assessed online 14/02/2018.

Reichenbach, M., Schippl, J., Puhe, M., Edelmann, M., Krail, M., Mahrscheider-Weidemann, F., Boile, M., Papanikolaou, A. (2014). *Long-term impacts of the supply side on the competitiveness of the European transport industry.* FUTRE Deliverable D4.3. Project financed by the 7th Framework Programme

Rohr, C., Ecola, L., Zmud, J., Dunkerley, F., Black, J., Baker, E. (2016). *Travel in Britain in 2035* – Future scenarios and their implications for technology innovation. RAND Europe Organization, https://www.rand.org/pubs/research_reports/RR1377.html

Rolls Royce (2017), *Rolls-Royce demonstrates world's first remotely operated commercial vessel*, www.rolls-royce.com , accessed online 16/01/2018

Roy M.A., (2013), Freight Hubs: Best Practices and Case Studies, presentation, http://www.cpcstrans.com/files/4013/8729/0156/Roy_MA_-_Exploring_Freight_Hubs_Peel_-_Panel_2_Best_Practices_2012_11_12.pdf accessed online 11/05/2018

Saaty, T.L., Ozdemir, M.S. (2003). Why the magic number seven plus or minus two. *Mathematical and Computer Modelling*, 38 (3–4), pp. 233-244.

Sanguina, C., Dersin, P. (2018, April). The Internet of Rail: How to transform data into asset management improvements. *Global Railway Review*, 24(02), 32. Retrieved from https://globalrailwayreview.attach.io/r1BtlC-5G

Schiller, T., Scheidl, J., Pottebaum, T. (2017). Car Sharing in Europe: Business Models, National Variations and Upcoming Disruptions. Monitor Deloitte, https://www2.deloitte.com/content/dam/Deloitte/de/Documents/consumer-industrial-products/CIP-Automotive-Car-Sharing-in-Europe.pdf

Schmidt, A., Reers, J., Gerhardy, A. (2018). *Mobility as a Service – Mapping a route towards future success in the new automotive ecosystem*. USA: Accenture Automotive, https://www.accenture.com/us-en/insight-mobility-automotive-ecosystem

SESAR JU. (2016). *European Drones Outlook Study. Unlocking the value for Europe*. SESAR Joint Undertaking, November 2016

Shared-Use Mobility Centre (2015). *Shared-Use Mobility: Reference Guide. Shared-Used Mobility Centre: Chicago*, Los Angeles, http://sharedusemobilitycenter.org/wp-content/uploads/2015/09/SharedUseMobility_ReferenceGuide_09.25.2015.pdf

Shift2Rail (2015), *Multi-Annual Action Plan*, http://www.shift2rail.org/wp-content/uploads/2013/07/MAAP-final_final.pdf accessed online 27/12/2017

Siemens, (2011), *Hubs of the future: An integrated mobility network for passengers and freight*, https://www.mobility.siemens.com/mobility/global/SiteCollectionDocuments/en/integrated-mobility/future-of-hubs/hubs-of-the-future-en.pdf accessed online 11/05/2018

Sümmermann, D., Öge, C.D., Smolenski, M., Fridgen, G., Rieger, A. (2017). *Open Mobility System OMOS: The Joint Journey towards Seamless Mobility*. https://www.omos.io/#whitepaper

Suris, J. C., Akre, C. (2015). Key Elements for, and Indicators of, a Successful Transition: An International Delphi Study. J. Adolesc. Health. 56(6), pp. 612-8.

Tesla (2018), Tesla Semi, https://www.tesla.com/ accessed online 10/05/2018

The World Bank. (2017). *Developing India's First Modern Inland Waterway*. The World Bank Organization, http://www.worldbank.org/en/country/india/brief/developing-india-first-modern-inland-waterway

Topham G., (2016), EasyJet plans to cut carbon emissions with hydrogen fuel-cell trial, The Guardian Website, https://www.theguardian.com/travel/2016/feb/02/easyjet-plans-cut-carbon-emissions-hydrogen-fuel-cell-trial accessed online 08/05/2018

Tucker, I. (2018). *Air taxis: we have lift – off*. The Guardian International Edition, https://www.theguardian.com/technology/2018/mar/04/air-taxis-we-have-lift-off-airbus-vahana-ehang-volocopter-uber-elevate-lilium accessed online 06/04/2018

UIC (2018). High Speed. International Union of Railways – UIC, https://uic.org/highspeed#General-definitions-of-highspeed accessed online 10/05/2018

UKi Media & Events. (2018). Mobility Solutions 2020 – 2030 and Beyond. *The International Review of Future Transportation Concepts and Technologies: The Future of Transportation Executive Briefing 2018*. UKi Media & Events, http://viewer.zmags.com/publication/5c1843a2#/5c1843a2/1

Voege T., Godziejewski B., Grand-Perret S., Rødseth Ø.J., Merat N., van Schijndel-de Nooij M., (2016), *STRIA Roadmap, Connected And Automated Transport (CAT)*, https://trimis.ec.europa.eu/sites/default/files/roadmaps/STRIA%20Roadmap%20-%20Cooperative%2C%20connected%20and%20automated%20transport.pdf

Winterhoff, M., Kahner, C., Ulrich, C., Sayler, P., Wenzel, E. (2009). *Future of Mobility 2020 - The Automotive Industry in Upheaval?* Arthur D. Little, Wiesbaden, http://dbforesight.stepi.re.kr/sub03/research/article_view/id/208/rfile/7d97ecbadb8f59b00e5264978eaf1cb9/main_category/eNortjK0UjJWsgZcMAkeAcs./page/9

Young, T.K. (2018, April). On track for the future? Global Railway Review, 24(02), 6. Retrieved from https://globalrailwayreview.attach.io/r1BtlC-5G

Zickuhr, K., Stahl, E., DuPuis, N. (2016). Cities and Drones. What Cities Need to Know About Unmanned Aerial Vehicles (UAVs). National League of Cities – NLC, Centre for City Solutions and Applied Research