SMART MAINTENANCE AND THE RAIL TRAVELLER EXPERIENCE

Deliverable 3.1 - Factors affecting train use

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REPORT CONTRIBUTORS

Name	Company	Details of Contribution
Carlo Vaghi	FIT	EU literature review and task leader
Anja Seyfert	FIT	EU literature review
Daniel Johnson	UNIVLEEDS	Academic literature review
Katherine Pangbourne	UNIVLEEDS	Academic literature review
Cristina Hernandez	UITP	EU literature review

EXECUTIVE SUMMARY

The objective of this report is to review demographic and societal factors affecting transport use at each step of a journey, by modes of transport interconnected with, or used as an alternative to the train. The interaction between societal factors and trends of mobility in relation to train use will be identified, starting from the identification of societal and demographic factors that affect mobility trends, for example technology, labour, personalization, access, economy, safety, security, and so on.

The report provides a clear view of and conclusions about factors influencing passengers' choices and connected behaviours which emerged from the literature survey. Trends and factors are explained and grouped and will feed into definitions of user profiles (personas) in task T3.2 and the survey (task T3.3). In order to reach these goals, the review will examine which societal trends influence the main aspects of a journey, and how they do so, with a particular emphasis on those within the control of train operators. These will be used to compose the Experience Map in task T3.2.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION: SCOPE OF DOCUMENT

This report aims to review demographic and societal factors affecting transport use at each step of a journey, by modes of transport interconnected with, or used as an alternative to the train. The interaction between societal factors and mobility trends in relation to train use is identified, starting with the identification of societal and demographic factors affecting mobility trends and laid out in roadmaps and ongoing and previous research.

The outcome of this task provides a clear overview of, and conclusions about factors influencing passengers' choices and connected behaviours, based on our literature survey. Trends and factors are explained and grouped to feed definitions of user profiles (personas) that will be used in subsequent SMaRTE activities. Ways by which rail used is affected by factors identified in this review will also inform our survey, task T3.3, and task T3.4. The review will indicate which of the surveyed societal trends influence the main aspects of the journey, and how they do so. This will feed into the Experience Map, task T3.2.

The document is structured as follows. Section 2 sets out a preliminary list of macro trends and social factors identified as relevant, and describes how they are operationalised for SMaRTE by means of a review matrix for cognate projects. Section 3 analyses macro trends and societal factors, by reviewing a number of EU-funded projects focusing on the topic. Section 4 describes the survey methodology and findings of the parallel review journey aspects, made by a thorough review of academic and expert literature. Our conclusions are made in Section 5 of the report. Appendices 1 and 2 provide a brief overview of the EU-projects and academic literature which we surveyed.

2. SOCIETAL FACTORS AND MACRO TRENDS: A PRELIMINARY SELECTION

We made an initial identification of macro trends to assist in grouping societal factors relevant to SMaRTE, those which relate to the relevant aspects of a journey which is likely to be affected by these trends in the short to medium term. Our preliminary list of macro trends is as follows:

1. Societal need for decarbonisation;
2. Demographic evolution and lifestyle changes;
3. Climate change;
4. Autonomous driving systems evolution;
5. ICT and IoT development; and
6. Sharing economy.

The first three macro trends are widely analysed in literature (including EU-funded projects) and comprise the main external societal factors likely to affect demand for mobility, the need to travel and ways in which potential users approach travel and transport in the next decades.

Trends four to six, primarily affect the supply of transport and integrated mobility services. Autonomous driving and ICT/IoT development represent the two main aspects of technological evolution impacting the transport sector. Although the sharing economy should be considered a horizontal societal trend not connected to a specific technological evolution, it has already led to a diffusion of innovative mobility services and business models in the market.

This preliminary clustering is intended to facilitate the analysis of relevant findings from our survey of EU-funded projects. The projects most relevant to this deliverable include a survey of the societal trends most relevant to the future of transport. Some projects are entirely focused on macro trends and societal factors and include a ranking exercise (e.g. MOBILITY4EU). However, the purpose of SMaRTE activity is not to replicate these surveys, but to identify trends and aspects identified in our literature survey and assign them to the journey aspect(s) most affected. The outcome of the investigation will include a selection of macro trends, that will be discussed with stakeholders at workshops organised as part of SMaRTE work package 3

Chapter 3 of this report summarises the main findings of each surveyed project, in the context of each of the six macro trends.

The ultimate goal of the survey is to match societal factors to journey aspects identified in the SMaRTE Description of Work, and shown in Figure 1 below.

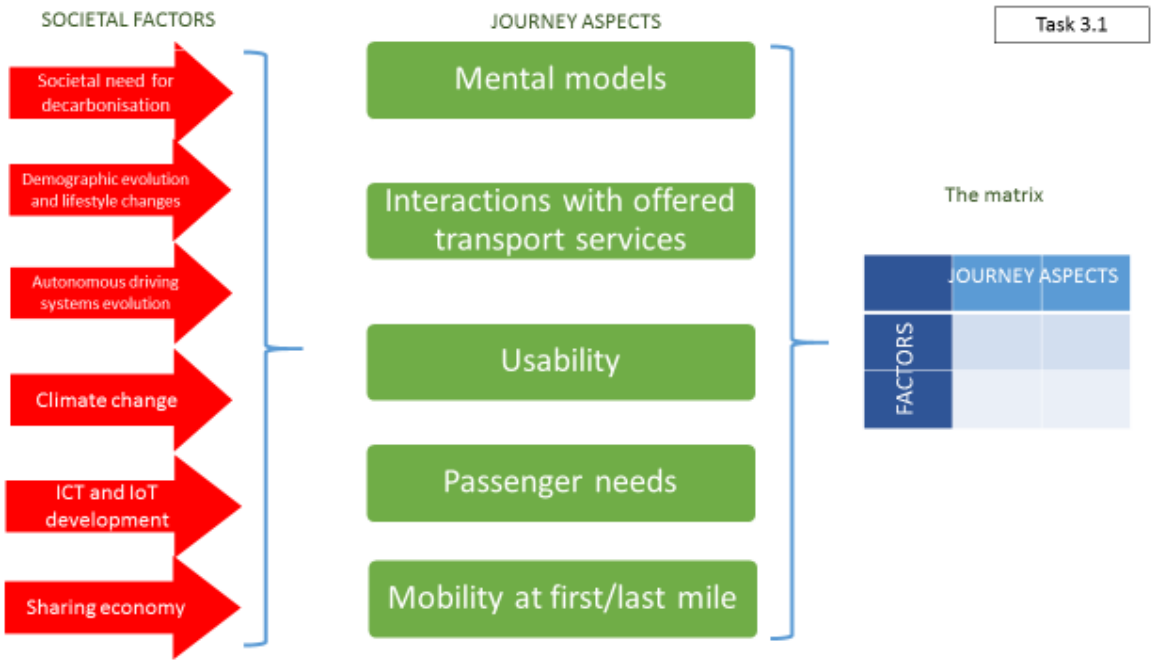

Figure 1 – Methodological scheme of the survey

The survey of relevant journey aspects has been performed by a thorough review of academic literature, as described in Chapter 4.

We developed the “matrix” to support our analysis of each factor, and to examine the possible identification of any sub-factors and to identify the journey aspects are influenced by societal and demographic factors, and the extent to which these factors play a part.

Journey aspects which will form elements of the Experience Map in Task 3.2 have been identified:

- Mental models
- Possible interactions and touch points with offered transport services
- Usability
- Passenger needs from travel experience
- Mobility at first/last mile.

However, the survey of journey aspects has gone deeper, clustering aspects according to the stage of a journey to which they relate, (before during or after a journey).

The final outcome of the survey in Chapter 5 is the development of a narrative version of the matrix from Figure 1 describing which of these trends are associated with which of the journey aspects, and how they interact.

The following glossary includes explanatory notes on the terms used in the definition of journey aspects. The same terms will be used in developing the Experience Map and identifying “personas” in other SMaRTE activities.

Term / Concept	Definition	Notes / Examples	Sources
Experience map	A strategic tool to understand and visually represent individuals’ interactions with a product, service, or ecosystem. At its centre there is the experience, meant as a complex universe of actions, responses, emotions, difficulties and an individual who wants to satisfy a need.	Key elements: - Phases of behaviour - Actions and steps taken - Jobs to be done, goals, or needs Thoughts and questions - Emotions and state of mind - Pain points - Touchpoints - Physical artifacts and devices - Opportunities	Kalbach, J. (2016).
Mental model	A simple *affinity diagram* of behaviours made from ethnographic data gathered from audience representatives.	1. Affinity diagrams, in the simplest interpretation, show groups of related things. […] A mental model for a particular topic is, in essence, an affinity diagram of user behaviours. 2. The perception people have of themselves, others, the environment, and the things with which they interact. 3. Alternative, popular definition: A person's thought process about how something works in the real world.	Young, I. (2008)

Term / Concept	Definition	Notes / Examples	Sources
		4. People form mental models through experience, training, and instruction. The mental model of an interactive system is formed largely by interpreting its perceived actions and its visible structure. Expectations resulting from the use of other or similar systems are also of importance. 5. If a user's mental model of an interactive system is incomplete or contradictory, then the user cannot easily use the interactive system.	
Persona	A hypothetical archetype of actual user.	1. A persona is a description of a user and what he or she intends to do when using an interactive system. 2. Personas are not real; rather they are imaginary but realistic examples of the real users they represent based on empirically determined data (e.g. observations, interviews). 3. Personas typically have a name, age, some background, goals and aspirations. A persona description should include information about the persona's knowledge about and interest in the subject matter of the interactive system. 4. Personas are defined by individuals' goals.	Cooper, A. (2004)
Touchpoint	A touchpoint is a point of interaction involving a specific human need in a specific time and place.	1. Identifying the touchpoints means consider every level at which the relationship between individuals and an organization takes place. 2. Typically, touchpoints include a range of elements, such as: - TV ads, print ads, brochures - Marketing emails, newsletters - Website, apps, software program - Phone calls, service hotline, online chat - Service counter, checkout register, consulting - Physical, shipping materials - Bills, invoices, payment systems 3. There are three primary types of touchpoints: - Static: don't allow users to interact with them (e.g.: email newsletter, ads) - Interactive: (e.g. website, apps) - Human: involve human-to-human interaction (e.g.: sales representative, support agent)	Risdon, C. (2013) Kalbach, J. (2016)
Usability	Extent to which a system, product or service can be used by specified users to	Usability, when interpreted from the perspective of the users' personal goals, can include the kind of perceptual and emotional aspects typically	ISO 9241-11:1998

Term / Concept	Definition	Notes / Examples	Sources
	achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.	associated with user experience. Usability criteria can be used to assess aspects of user experience	
User experience	Person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service.	1. User experience includes all the users' emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviours and accomplishments that occur before, during and after use. 2. User experience is a consequence of brand image, presentation, functionality, system performance, interactive behaviour and assistive capabilities of the interactive system, the user's internal and physical state resulting from prior experiences, attitudes, skills and personality, and the context of use.	ISO 9241-210:2010

Table 1 Glossary of terms used in the definition of journey aspects

3. MACRO TRENDS – THE SURVEY

The identification of macro trends and societal factors affecting the travel experience and the use of rail is based on a review of relevant EU-funded projects. Among the wider literature of research projects and related deliverable reports, the following list of projects relevant for the analysis has been identified:

Name of the project	Relevant Deliverables	Project scope
3iBS (FP7)	11.2, 11.3[1]	To promote and exploit key findings from research on bus systems, exploit and implement key solutions, and promote the dissemination and exchange of knowledge on a global scale.
EBSF (FP7)	Final[2]	To increase the attractiveness and raise the image of bus systems in urban and suburban areas, by means of developing new technologies on vehicles and infrastructures in combination with operational best practices in the whole bus system together with infrastructural requirements and mobility concepts.
GOF4R (S2R IP4)	2.1[3]	To fill in a specific role within the Shift2Rail Innovation Programme related to Passenger Services (IP4) by identifying and removing obstacles which could prevent the successful deployment of a fundamental technology (the Interoperability Framework), developed in other projects, needed to realise innovative services for a more attractive multimodal European transportation system.
MIND SETS (H2020)	2.1, 2.2, 3.2, 3.3[4]	To support mobility policy, the mobility service sector and supply industry to tailor their innovations and investments to better meet and stimulate further sustainable mobility demand to enrich the lifestyles, experiences and well-being of all Europeans in the future
MOBILITY4EU (H2020)	2.1, 2.3, 3.1[5]	The project is working on delivering a vision for the European transport system in 2030 and an action plan including a roadmap to implement that vision. The entire process from studying trends and options for solutions, developing a vision and finally the action plan is organized within a structured participatory approach that aims to engage a broad stakeholder community into the consultation processes
SKILLFUL (H2020)	WP1[6]	To critically review the existing, emerging and future knowledge and skills requirements of transport workers, with emphasis on competences required by important game changers and paradigm shifters (such as electrification and greening of transport, automation, MaaS, etc.); To structure the key specifications and components of the curricula and training courses that will be needed to meet these competence requirements optimally, with emphasis on multidisciplinary education and training programmes.

Table 2 List of relevant EU-funded projects surveyed

This selection was made following several criteria:

1) A preliminary list of 11 EU-funded projects (H2020, S2R, FP7, etc.) considered relevant to our purpose was made, based on partners' knowledge, existing and previous project partnerships, and from the list of projects in SMaRTE description of work;

[1] Karlsson et al. (2014), (2014b)
[2] EBSF (2014)
[3] Colzani P. et al. (2018)
[4] Pickup et al. (2015), Unal et al. (2015), Konings et al. (2015), Franckx and Mayeres (2015), MCRIT et al. (2016), Franckx and Mayeres (2015b).
[5] L'Hostis, A. et al. (2016), Deep Blue (2016), Keseru et al. (2016)
[6] Bekiaris (2017)

2) Some projects were dropped from the list (e.g. DETRA, NODES, ATTRACkTIVE) as their conclusions did not fall within the scope of the survey;
3) Some projects (COACTIVE; IMOVE) were removed from the list as their relevant deliverables were not available when the literature survey was made.

It is worth mentioning that some S2R IP4 projects (e.g. ATTRACkTIVE), whilst not relevant to the survey of macro trends, are relevant to SMaRTE project in general terms, and we continue to cooperate.

The following sub-sections describe the outcome of each project in the shortlist (Table 2), specifically the project deliverables we identified as dealing with macro trends and societal factors. A summary description of these deliverables is provided in Appendix 1.

Each sub-section includes the relevant outcome of each project per each macro trend identified in Section 2. Our survey demonstrates that while some projects cover all macro trends and provide useful insights for the identification of societal factors, other projects appear relevant to some trends only. The present review reports also insights on the “needs of the passenger of the future” when surveyed by the projects.

SOCIETAL NEED FOR DECARBONISATION

MINDSETS

Of the projects included in our survey, this project is one of two with the most detailed analysis of trends relating to the need for decarbonisation. MIND-SETS recognised the following trends:

- **Reduction in car-use** is perceived as having a positive impact on the environment;
- Policies aimed at reductions in car use are more acceptable to people with strong biospheric values, and less to people who value their finances, status or pleasure;
- There is a need for awareness of **carbon footprints**, provided by public authorities;
- Adopting pro-environmental travel modes might rely on activating normative goals rather than goals that favour self-interest (posstible strategies: reducing the conflicts or strengthening normative goals);
- The need for decarbonisation will lead to **more active mobility** (walking, cycling, etc.).

MOBILITY4EU

A thorough survey of aspects connected to the societal need for decarbonisation is provided in MOBILITY4EU, with the following key statements on macro trends and their impact on transport and mobility:

- Transport dependence on fossil fuels is expected to be replaced by **electrification and sustainable biofuels** by 2050;
- However, the transport sector will continue to be a major source of global and local emissions: a vision of a decarbonised transport sector by 2050 is ambitious (40% chance in the best case scenario);
- **Efficient drivetrains, greener materials and alternative technologies** will play an increasingly important role;
- Road infrastructure will have to accommodate new vehicle and fuel technologies;

- Shift of transport modes away from individual car use towards **greener modes of travel**;
- New mobility concepts with **new kinds of vehicles** (e.g. E-Bikes or (small) E-Cars);
- Increased awareness of environmental concerns is engaging society in more sustainable patterns of behaviour (see “lifestyle changes”).

DEMOGRAPHIC EVOLUTION AND LIFESTYLE CHANGES

3iBS

The project, which focused on research and solutions for the bus of the future, provides some insights into impact as a consequence of lifestyle changes. The creation of an **accessible, complete travel chain for users** is considered necessary in order to attract new users to public transport.

Users require an increasing degree of **accessibility,** to provide all passengers (including those who are permanently and temporarily physically-challenged, sensory-impaired, or with intellectual disabilities) with safe, secure, comfortable, non-discriminatory, reliable and affordable travel conditions.

The **design** and location of bus stops is recognised as a crucial element in the drive to improve the quality and accessibility of bus services, as well as the need for **larger facilities** (hubs, terminals). Safety and accessibility aspects must be taken into account from design to evaluation. Improved design of stops/shelters is required, providing protection against all weathers, lighting and seating, and improved audio and visual information.

EBSF

EBSF is a key project in setting the scene for buses of the future. It stresses the need for new services, with new concepts for bus stations, based on the needs of all the stakeholders. EBSF recommends stations and stops better connected to the road infrastructure, and identifies a need for higher intermodality between bus and other modes of transport, including rail.

Passengers of the future will increasingly **need carefully designed, high-quality services** which invite passengers to select their desired space, with access to grab bars and columns as legibility tools. There will be dedicated and adaptable spaces for specific users (disabled passengers, passengers with prams, etc) offering a layout that combines several arrangements to offer a choice to passengers.

GOF4R

This S2R IP4 project used a wide range of interviews and focus groups to make a detailed analysis testing user and operator reactions to the “Travel Companion” (TC) developed in IT2RAIL (and being further developed throughout S2R IP4 projects.

GOF4R conclusions as reported in GOF4R D2.1, are useful in summarising the needs of passengers in the (near) future, when given the opportunity to use an ICT tool to organise their multimodal travels. The project concluded:

1. Usefulness of the TC: Today, organising complex, multimodal, European-wide trips is time consuming and requires a lot of effort. Travellers must adjust to a variety of interfaces and tools. The TC could make the planning and buying process a lot easier;
2. Better protection of passenger rights: In case of disruption, the TC should offer full assistance, providing information on travel alternatives if the original plan is no longer feasible, and also on passenger rights and reimbursement procedures;
3. Accurate and reliable information: Consumers need to feel confident that they receive an overview of the best travel solutions, taking into account preferences and needs. Reliability (of data and information) and transparency (storage and processing of personal data) are two important aspects which determine whether a traveller uses the TC. Crowdsourcing can be a good tool to complement information from 'official' sources.

MINDSETS

As concerns lifestyle changes and their impact on mobility, MIND-SETS recognised the following trends:

- After rising almost continuously since the end of WWII, the motorisation rate in western European countries has declined since the 2000s.
- The **decentralisation connected to co-working hubs** will have a generally positive impact on environment.
- Mobility freedom must be fulfilled.
- **Travel choices are not only affected by instrumental criteria (e.g., travel time, monetary costs, safety) but also by attitudes and social motives**. Mobility choices are based on Objective Elements, Perceptual Filters, Value Sets and Beliefs.
- Psychological factors affect mobility: hedonic, gain and normative goals.
- Time and cost are seen as the ultimate guidelines for mobility (and residential, job and job search, school placement) decisions. **Use of time 'in mobility'** is becoming increasingly important.
- The importance of **'slow' traffic**: the society of tomorrow is not determined by speed but by better transportation modes and bikes and other soft modes will gain prevalence
- The **need for social inclusion in mobility** is increasing and will be assisted by smart transport technology. Automation and cost reduction will help mobility for the elderly, and disabled people (temporary or permanent). New technologies or services should be tested and validated for the elderly (growing market in the ageing society) or other vulnerable users.

In line with these trends, the following side-impacts are also foreseeable in the provision of transport services:

- Increasing **need for on-demand and multimodal mobility services**
- Demand-responsive transport, resource-aware journey planning involving taxis, shared bicycles, parking spaces etc.
- Enhancing **service personalisation, customisation of services and profiling**, and user empowerment.

MINDSETS D2.1 concludes as follows:

> *The role of mobility in society is changing. It is redefining the abilities of individuals to move about in time and space to satisfy their activity needs, thereby influencing the chances and opportunities that are available to those individuals. Travel time is no longer 'wasted time'. The private car is no longer the only channel through which to project your personality. Mobility should be seen as a basic need provided to all individuals sufficiently and should serve the purpose of social inclusion and cohesion in the society, and should contribute to quality of life of individuals by having a positive impact on psychological and physical well-being. Vulnerable citizens such as people who are living under the poverty line or who are restricted in their mobility, such as elderly, handicapped or single mothers, should be taken into account in designing new mobility products and services. New mobility services and policies aim at improving mobility inclusion by improving accessibility. Mobility is a key asset in helping the fulfilment of three basic needs that are found to enhance psychological well-being: autonomy, competence and relatedness.*

MOBILITY4EU

A thorough survey of aspects connected to the demographic and lifestyle changes is provided in MOBILITY4EU, with the following main statements on macro trends:

- **Telework and part-time work** are two major current trends that are likely to grow further in the future. Restructuring of working arrangements (working time, part-time work, teleworking, self-employment at flexible times) have an impact on travel demand (trip generation, temporal and spatial distribution of trips). Teleworking may induce long distance trips and trigger urban sprawl;
- Development of user-centred mobility services where the user has more information;
- The boundaries between private life and work will progressively disappear;
- **Travel time** will be increasingly used for **multitasking** (working) to add useful minutes to an otherwise very crowded daily schedule. Therefore the Value of Time spent in travel will change its value and significance;
- People turn towards **healthier and active life**. Public focus on health and wellness is shifting mobility choices towards more active modes such as walking and cycling in denser urban areas. However, the number of car drivers is likely to grow, and less active mobility is expected throughout the general public;
- **Reducing travel demand** and provide accessibility to work and services within local self-sustaining neighbourhoods. People prefer to spend their free time and holidays in close proximity to their homes;
- Cities embrace **car-free neighbourhoods** to improve liveability;
- Growing cities lead to a more intense mobility;
- Terrorism is a growing concern in our societies and for governments, and infrastructure. In general terms, this may increase the **security/accessibility tension**: provide more security in transport by introducing controls/barriers that reduce accessibility;
- Ageing society requires new accessibility solutions as do people with disabilities;
- Safety will remain a key issue for infrastructure (road, rail);
- Reduced need for travel planning, information constantly and immediately available;

- **Customer-centric** products and services will be increasingly demanded, based on information about the individual passengers and their needs.

In line with these trends, the following side-impacts are also foreseeable in the provision of transport services:

- Passengers need more interoperability of transport means, the more users are able to benefit from them wherever they are;
- Higher level of integration of mobility services steered by publicly managed transport partnership;
- The efficiency and profitability of private actors in transport will be enhanced by the provision of interconnected transport services;
- Cooperation between private and public actors to reduce carbon emissions and increase efficiency will be enhanced;
- Spatially expanding cities and the urban sprawl lead to the **need to extend public transport in lower density**;
- Cities and regions are competing implementing innovative transport solutions.

SKILLFUL

The project aimed to define future transport sector professional and job profiles. It identified the following trends relating to lifestyle changes:

- New urban planning paradigms, leading to less transport for commuting;
- Life-long training integration,

They are assumed to generate the following impacts on mobility services:

- Digitalisation of users;
- Personalisation of services;
- Transport on demand schemes that adapt flexibly to the kind and number of objects to be transported;
- Different modes of transport coexist on the mobility network, as well as several types of vehicles and services for motorised transport.

CLIMATE CHANGE

MINDSETS

The trends connected to societal needs for decarbonisation mentioned above, are also connected to a rise in the climate change awareness. This will lead to more binding policies towards sustainable mobility:

- Biospheric values lead to the adoption of more environmentally friendly modes of transport and **acceptance of transport services or policies fostering green mobility**;
- Cities will become more sustainable, **low carbon technologies** and shared services will make them look like villages, becoming healthy and revalued places;
- Increasing importance of policies for e-mobility and charging by renewable energy sources. E-mobility will meet daily needs.

- E-mobility will improve in the next two decades with an increased range of cheaper batteries

MOBILITY4EU

Climate change aspects and trends are considered by MOBILITY4EU in connection with the societal need for decarbonisation, as environmental issues and especially climate change are gaining importance within society. Air pollution is increasingly perceived as critical, as its impact on health in urban centres becomes more evident.

Policies targeting the environmental impacts of transport will be increasingly introduced and accepted on global, European and national level, and in reaction to higher degrees of awareness. This will lead to stricter regulation of carbon emissions, both for freight and passenger transport. Long-distance travel will become more expensive due to the carbon taxation introduced all across Europe. Aviation's environmental footprint will be monitored and a carbon tax built into ticket prices all across Europe.

Carbon emissions will be subject to tight regulations and stronger price mechanisms. Vehicles will have to adapt to regulations, and road infrastructure will accommodate new vehicles and fuels.

SKILLFUL

According to SKILLFUL, climate change is leading to:

- Electrification in all transportation modes and alternative fuel technologies;
- An improved circular economy and recycling , including batteries;
- Extension of energy aggregators business to the transport sector; vehicles/ infrastructures connected to the grid (V2G).

AUTONOMOUS DRIVING SYSTEMS EVOLUTION

MINDSETS

The project conducted a thorough review of trends connected to, and the impact of the evolution of autonomous driving systems. It concluded that by 2020 the following will emerge:

- Automation is not policy but market-driven;
- Autonomous driving will have a positive impact on environment, safety and congestion;
- It will support the creation of new industries, although acceptance by people at risk of losing their job is a very critical issue;
- Due to the reduced opportunity cost of the time spent in traffic, people will tolerate long travel times, and especially **longer commuting trips**;
- Longer commutes might lead to **further urban sprawl**, and to buildings with a larger environmental footprint;
- People will be reluctant to own fully automated cars. This may increase the ratio of shared vs. owned vehicles;
- Automation in public transport, challenge is becoming overall mobility operators;
- The rise of automated vehicles will **reduce the opportunity cost of time spent in car travel**, and this will further undermine the competitive position of some transit services;

- Transit will probably concentrate increasingly on mass transportation between hubs. **Shared Automated Vehicles (SAVs)** will provide first- and last-mile connectivity to public transit and fill service gaps in the transportation-network;
- Automated vehicles will provide **mobility services to people currently unable to drive**.

MOBILITY4EU

The project considers the introduction of autonomous vehicles as likely limited to long distance travel. Automated driving should make it possible for car drivers to spend their travel time undertaking other useful activities.

Safety will be crucial with the gradual introduction of automated vehicles in cities. **Road safety** is expected to improve as automated vehicles should reduce accidents resulting from human error. However, the difficulty resides in **mixing automated vehicles with non-automated vehicles**, pedestrians, cyclists and other road users in urban traffic.

Liability remains an important barrier, and could gradually shift from drivers to OEMs.

SKILLFUL

Besides the general trend towards autonomous and unmanned transport systems, SKILLFUL identifies the likely increase in drones and robots for logistic operations.

ICT AND IOT DEVELOPMENT

3iBS

The project included an interesting survey on the needs of passengers and transport operators connected to the smooth development of ICT in transport and Intelligent Transport Systems. **Standards for interoperability** are essential for allowing innovations to complement existing products and services and integrate existing systems. ICT is crucial for coordination between modes and operators, relationships and interdependencies between ticketing, infrastructure, passenger information, safety and security and public transport usage, flexible and standardised access to information.

Information about all public transportation must be integrated and harmonised, since information accompanies travellers through the whole journey.

A lack of common standardisation may prevent innovations from becoming “shared best practice”. An important function is the usability and accessibility expert who can act as the link between users and developers.

EBSF

The project focuses on the role of ICT in transforming buses into “intelligent systems” able to providing a broad range of information to passengers, drivers, operators, and a smart use of on-board energy. Real time information enabled by ICT will include the transmission to passenger of

the state of the art of the operators and identifies the gap areas according to the user needs and requirements.

MINDSETS

The project begins its analysis of trends with the assumption that mobility experiences start from ICT devices: mobility visions can no longer be separated into ‘physical trips’ and ‘virtual trips' on the Internet. Travel behaviour is changing through the use of ICTs in the maintenance of social networks (direct effect of ICTs), social interaction (indirect effect of ICTs), stronger relationships between social interaction and physical mobility, and increased demands for mobility. It will increasingly lead to:

- Customisation and collaboration of mobility products and services;
- New mobility technologies will provide people with more mobility freedom and informed choices;
- Threats to privacy due to the diffusion of tracking and tracing;
- Understanding the users’ values and motivations will be central, as the private sector needs market acceptance to generate up-take;
- Collaborative habits and peer-to-peer exchanges make the development process more efficient, and public administration can benefit from them;
- Real time interactions between users and services, requiring joint collaboration of all actors (users, transport operators, private companies and legislators);
- New technologies will develop as long as they satisfy specific needs currently not being satisfied by existing services or solutions;
- In some cases, new technology may generate new needs.

MOBILITY4EU

According to the project’s conclusion, the most important way in which ICT development impacts on transport, is changes in the perception of transport time, more value placed on comfort and the option to avoid driving. Smart online apps empower citizens through digital technologies to participate in planning and impact monitoring. Public and private transport services converge in Mobility as a Service (MaaS) initiated by these large mobility companies providing real-time trip planning, booking and payment services for all transport modes.

Through Internet of Things (IoT), transportation modes will communicate with each other and with the environment. Security concepts resilient against attacks will be carefully researched although there will be an inevitable increase in the risk of cyber attacks.

ICT and IoT are drivers enabling several interesting trends affecting the behaviour of passengers and their needs, as surveyed by MOBILITY4EU:

- Expectations of connectivity and real time by users;
- Passengers want more data privacy;
- Passengers will expect certainty in terms of time, so reliable and accurate real-time information will be key;
- Transport users want to enjoy the benefits of the digital and technological revolution;

- Demand for information and online services to book and pay for mobility services is high, especially from the younger generations.

The following effects on transport and mobility service provision are anticipated by MOBILITY4EU:

- National and local road charging schemes are widely introduced with electronic tolling and variable rates with a standardised pan-European payment and monitoring system;
- The idea of Smart Cities will further push the digitisation and deployment of new technologies in transport;
- Long distance travel is supported by faster and more energy efficient high-speed trains with inductive charging and a seamless integration of other modes with air transport;
- A wider deployment of automated systems in cities could also lead to a significant increase in the 24-hour availability of products and services;
- Cooperative Intelligent Transport Systems (C-ITS) are developed in public-private partnership to increase road safety and capacity. Maintenance of road and rail infrastructure is increasingly automated.

SKILLFUL

The project focuses on ICT-based society, and mobility led by new purchasing models (e-commerce) and new production methods (Industry 4.0). Trends identified as having an impact on mobility are as follows:

- Customisation of services;
- Shorter development times for services and goods, including mobility;
- Wide range digitalization and connectivity of all modes;
- Cooperative Systems and V2X interfaces, traffic big data handling methods;
- Extended use of RES in transport (well to wheel);
- Multimodal seamless service providers with service roaming agreements between them (MaaS).

SHARING ECONOMY

MINDSETS

The project focuses on sharing economy and shared mobility, identifying the following trends:

- Reduced vehicle ownership, more sharing (especially younger generations);
- Growth in car sharing and bike sharing;
- Policymakers promoting biking as improving mobility, environment, health, business, territorial attractiveness;
- Sharing and collaboration will be residual to private cars and public transport;
- The role of the public in driving the process determines the impact of shared options on traffic;
- Car ownership becoming out-dated in favour of public fleets of cars managed in car sharing schemes;
- Private, public and shared mobility systems will run in parallel;
- People who use “shared mobility” services may be very different from the ‘average’ citizens, and the behavioural changes observed amongst early adopters (such as decreased use of

private cars) may therefore not be representative for what is achievable in the general population;
- 'Shared' solutions are becoming increasingly well suited to solving the first/last mile problem in public transport, a significant barrier to the shift from private car use to public transport.
- Shared Automated Vehicles (SAVs) will provide first- and last-mile connectivity to public transit and fill service gaps in the transportation-network.
- For low income households, solving the 'last mile' problem can signify a step change in their prospect if affordable/subsidised;
- Improving the balance between public and private travel components- seamless integration of regular PT with sustainable personal mobility schemes (e.g EVsharing).

MOBILITY4EU

The project has a special focus on sharing economy as an effect of the spread of "Sustainable consumption" culture. The latter is rapidly diffusing in line with the perception that the resources required to sustain current levels of economic growth may not be available over the next decades. This may change attitude to car ownership, improve the image of public transport and cycling and hence increase demand and reduce long distance trips. New societal and technology trends will lead to the demand of new and innovative business and financing models for mobility solutions.

Sharing economy and collaborative consumption is substituting ownership models and has also made a significant impact on the transport of people and freight.

People increasingly turn to eco-friendly, local, cooperative production of food and energy, urban gardens and peer-to-peer services. Moreover, a circular economy will allow developing viable business cases for e-mobility, increasing the resale value of used vehicles.

The following impact on the provision of transport and mobility services is anticipated by MOBILITY4EU:

- Tax-incentives discourage private car ownership and support car- and ride-sharing instead;
- Sharing economy will lead to new kinds of vehicle usage (sharing or 'use rather than own');
- Local road traffic restrictions will enable local initiatives to share mobility resources;
- Car-sharing may be organised on a per-use level or through affinity groups, large employers, transit operators, neighbourhood groups, or large car-sharing businesses;
- Ride-sourcing may substitute longer public transport trips, but is more likely act as complementary to public transport, especially to provide seamless first- and last-mile solutions;
- The belief that mobility should be solely regulated by a single actor, commonly the local authority, will be gradually abandoned;
- Within MaaS, mobility companies promote their own transport solutions such as car-sharing (in cooperation with car manufacturers) and widely deployed ride-sharing;
- Public transport operators adapt flexible timetables and modular trains to provide flexibility to adapt to passenger needs and demand;
- Increased local neighbourhood planning is initiated by local citizens using social media and online co-creation platforms;
- Peer-to-peer services and initiatives gain popularity.

SKILLFUL

The project focuses on Mobility as a Service (MaaS) as an enabler of shared mobility services (carpooling, carsharing, DRT and FMS schemes, etc.), and integration of infrastructure-based and in-vehicle services.

According to SKILLFUL, the reduced lifetime of cars and other vehicles as a result of heavier use by MaaS schemes will lead to a **higher diffusion of retrofitting** (including tools and jobs connected to retrofit) and software upgrade services.

4. JOURNEY ASPECTS - ACADEMIC LITERATURE SURVEY

In this section the main journey aspects, and how they are influenced by macro trends affecting mobility, are analysed. The methodology and findings of the survey of academic literature and the evidence from strategic reports are described. The purpose is to supplement the survey of EU-funded projects with further insights and evidence of factors influencing rail travel experience.

METHODOLOGY

In order to uncover relevant academic literature, a keyword search protocol based on SMaRTE objectives was developed. The SCOPUS database was scanned, supplementing the list generated through existing knowledge of the literature, and a keyword search of Google Scholar. Each search strategy was recorded separately and prioritised using a two-step process.

The search terms and parameters are shown in Table 3 below.

Database	Search Terms	Return
SCOPUS	TITLE-ABS-KEY (rail AND "customer experience" or "attitudes") AND PUBYEAR > 1999	242
	TITLE-ABS-KEY ("customer experience" AND rail) AND PUBYEAR >2004	12
	TITLE-ABS-KEY ("customer loyalty" AND rail*) AND PUBYEAR>1999	21
Google Scholar	door-to-door rail passenger satisfaction	About 16,500 results (0.16 sec)
	Searched within for 2010-2017	About 8,120 results (0.05 sec)

Table 3 Search Parameters for the Academic Literature

For Scopus, having generated a list of candidate literature from a key-word search, the first step was to clean the list by using titles to eliminate irrelevant results. Those not about rail or rail user experience were deleted, and the remainder were judged to be Good, Neutral or Bad in terms of going forward for review. The Google Scholar search was manually sifted by title and brief description until the relevance dropped below a reasonable level. Results after the fifth page were omitted using this method.

The second stage for both Scopus and Google was to reassess those categorised as Neutral by reading the abstract. There were four separate searches that went through this process. These

were then reviewed to remove duplicates, and the Expert Knowledge list was added (again checking for duplicates).

The final list contains 50 unique items of peer-reviewed academic literature and a number of reports from relevant policy and governance sources acquired through internet searching guided by expert knowledge. These items have each been evaluated by at least one assessor using a standard template (see Appendix 2).

A narrative version of the academic literature review of key factors influencing rail passenger experience is presented in the following part of the chapter. After transferring the findings to fit the objectives of the trends/journey aspects matrix (see Table 1) and its format, the factors 'Climate Change', 'Autonomous Driving', 'Sharing Economy' had no entries. Further targeted Google searches were made (e.g. on 'Mental Models', 'Climate Change' and 'Rail Travel'; 'Climate Change' AND 'Rail travel Attitudes'; 'Sharing economy' AND 'rail travel'; 'autonomous driving' AND 'rail travel'), to select a small number of papers and reports to bolster the discussion in Chapter 5. For Climate change, most literature is about the impacts of climate change on rail infrastructure, rather than on customer experience. The most relevant results (Jaroszweski et al 2014, 2015) have been used. A second targeted search on 'climate change' AND 'Rail travel attitudes' uncovered Hess et al (2013). For automated driving we selected Cyganski et al (2015), Folsom (2011), Bagloee et al (2016), and for the sharing economy we chose Trivett et al (2013).

MAIN FINDINGS

The structure of other literature reviews have been used to categorise the literature, with the aim of mapping out the journey elements in an approximately sequential way, and identifying the key barriers associated with these journey elements. This will inform the planning of the Experience Map later in the SMaRTE project. Findings from the literature were incorporated to evidence the importance of the steps of the journey and the level of satisfaction or performance of the rail service (which varies in the context of each piece of literature). This has enabled the identification of current gaps in provision and where improvements could be made. A special focus has been deployed on more recent literature given the ever-changing landscape of journey planning and ticketing and information sources and options, particularly driven by recent developments in web based applications.

In identifying the key factors influencing rail passenger experience, much of the literature is couched in terms of a discussion of ways to improve the rail offering so it can be more competitive with the car. In doing so, as emphasised by Brons and Rietveld (2009), the focus must be on the passenger experience rather than the objective quality of the journey and a focus on all elements of the door to door journey, rather than the rail trip itself. It is useful then to consider the constituent elements of the rail journey and for simplicity we categorise these elements using a typology from ORR (2014), splitting the journey elements into 3 categories:

1. **Planning a journey** this includes consideration of travel options, use of information and advance ticket purchase.
2. **The journey itself** – this includes activities at the station, same day ticket purchase and on-train aspects including punctuality.
3. **After the journey** – this includes engagement with train operators, registering complaints and compensation procedures.

-

Another aspect to the rail offering as compared to car is the potential for rail not to serve the required origin-destination pairs.

Planning a journey

Consideration of travel options

This element involves consideration of rail against other modes, principally car. These comparisons would probably be more important for non-frequent journeys: A survey of over 2000 recent rail passengers carried out for ORR (2014) finds that whilst a minority of leisure/business rail passengers compare rail with other modes, the proportion is lower for commuters and comparisons usually involve car.

Information

A lack of information can lead to mistrust in public transport being able to provide the door to door service akin to a private car (CBT, 2014). This study identifies the key items of information which should be easily accessible before, and during, travel as: fares information, route maps, timetables and arrival times. Travel advice and journey planning needs to be provided through all available technologies so passengers can check their journey at any stage.

CBT (2014) report that provision of information in UK is currently inconsistent: partly attributable to the various fragmented data sources from the different operators in the deregulated environment outside London. Fares information for buses remains poor. Improving this will involve partnerships between public and private sector agencies.

The internet is the rapidly emerging as the main source of information for planning purposes, a finding apparent both through quantitative and qualitative surveys conducted for ORR (2014). The study also reported National Rail Passenger Survey (NRPS) figures which found high satisfaction ratings for information and ease of ticket purchase, but lower ratings for less frequent users.

Passenger Focus (2013) carried out research on passengers' experiences with engineering works and found that communication of engineering works could be improved and there should be focus on minimal disruption in terms of timings and use of replacement bus services. Publicity should also feature long-term benefits to promote understanding and acceptance.

Research carried out by Passenger Focus (Passenger Focus, 2011) using mystery shoppers across several UK operators found some passenger groups are disadvantaged in terms of assistance online or at stations. The availability of fares information for disabled travellers was also highlighted as an issue in evidence to the UK Parliament Transport Select Committee (House of Commons 116, 2013). This was also a theme addressed in Frye et al (2015) who highlighted the

risks of exclusion to older travellers from the increased use by operators of internet and social media for updates and information coupled with the ongoing closures of ticket offices.

Service Quality and fare aspects

Clearly travellers and potential travellers prefer faster, more frequent and cheaper journeys. The implications of changes in these aspects can be more straightforwardly captured through the use of elasticities which measure the sensitivity of rail demand to observable changes in these factors. Relevant sources for elasticities are the Passenger Demand Forecasting Handbook (RDG, 2015), the Demand for Public Transport (Balcombe et al, 2004) and Paulley et al (2006).

Rail journey times are typically longer than car (Blainey et al, 2012) and this alone represents a significant barrier for mode shift. It also applies between air and rail for longer journeys (Gonzalez-Savignat, 2004). However, it is very difficult and costly to implement significant improvements.

In terms of cost, UK work by Blainey and Preston (2010) suggests that in many cases rail is actually cheaper than car but this understanding could be lost in the complex fares structures and not reflected in user perceptions. In terms of performance against cost, 42% of respondents to the UK National Rail Passenger Survey (NRPS) as reported in ORR (2014) were fairly or very satisfied with value for money.

In assessing rail against other modes the ORR study (ORR, 2014) found that the key factors for leisure/business travellers is cost, but reliability is key for commuters (followed by door to door journey time), although the survey found this the most difficult factor to compare between modes.

Advance ticket purchase

The internet is also key for ticket purchasing especially leisure/business travellers, two-thirds of whom buy tickets from a website before travel (ORR, 2014).

The journey

These elements include: activities at the station; interchanging between modes and services; purchasing tickets on the day of travel; on the train aspects including punctuality, comfort, safety and information; and managing delays and disruption.

Access, Interchange and Integration

A key consideration in the choice between modes is the wrap-around seamless nature of the journey. Clearly, car provides seamless door to door journeys, whilst almost half of UK rail passengers use auxiliary modes for station access (DfT, 2010). CBT(2014) highlight that in order to compete with car, better integration of the multi-modal aspects inherent in most public transport journeys are considered.

CBT (2014) describe a very significant perceived penalty to interchange, arising from the non-travelling time it adds to journeys, the stress and inconvenience of moving between vehicles as well as the risks arising from missed connections. Other dimensions to the penalty highlighted in Blainey et al (2012) include waiting environment, informational and safety aspects. This penalty is greater for connections between other modes and rail than for rail to rail connections. This inconvenience is reflected in higher values of time for waiting time than for in-vehicle time (RDG

2013) and a disproportional increase the 'generalised cost' of rail, making a large difference to modal choice. Improved interchange could also be a more cost-effective measure to address than trying to increase speed on one or more of the motorised legs of a journey.

CBT(2014) highlight the following associated issues in UK with interchange journeys:

- The lack of widespread use of integrated tickets or smartcards, especially on surface transport, causes a barrier to multi modal journeys.
- Interchange stations also need to have adequate facilities to ensure the relative comfort and safety of waiting passengers.
- Whilst cycling can be viable (conditional on access distances) it requires adequate storage and security is provided at the station; eg the Cycle Hub at Leeds rail station.
- Consideration of planning and land use development can ensure good connections can be designed in from the start.
- Adequate parking provision is also a major consideration for car drivers.

While there are many excellent examples of efficient door to door provision in the UK, it is inconsistent.

The CBT (2014) report that whilst London has comprehensive ticketing arrangements whereby tickets can be bought for use of all public transport modes, outside of London there is no such requirement. In the UK examples of integrated ticketing are mainly restricted to a single area or one mode of transport such as rail with only a few cross boundary multi modal options available.

Brons et al (2009) evaluate the importance of the station access element of a rail journey using a rail customer satisfaction survey featuring questions on satisfaction with access elements of the journey, including (''connections between the rail and public transport", ''the capacity of car parks" and the ''quality of guarded bicycle parking" and ''unguarded bicycle parking"). The importance of these factors is investigated using the derived importance method, based on a regression of overall satisfaction scores against satisfaction scores for different dimensions of the journey. Accessibility is ranked 3rd for infrequent travellers. They find that all four access elements are significant with the exception of satisfaction with guarded bicycle parking facilities. Connections between rail and public transport were the most important accessibility feature.

Assistance at the station for disabled passengers was also highlighted as patchy in ORR (2014). This finding was also echoed in Frye et al (2015): in their report, written in the context of the UK's changing demographics with more older and disabled people using the network, there is a growing need for services to help access at stations and step free access. This provision too is patchy with a target of 81% of stations by 2020. The report also highlights station design issues and station staff availability: essential in helping navigate the gap between train and platform.

Information at the station and en route

Innovations like e-ticketing and journey planning information on crowding or disruption are being developed and have the potential to improve the passenger experience.

Whilst there is much scope for improvement in information provision during the journey in the UK, this may be difficult given the number of players in the UK deregulated Public Transport industry with potentially differing objectives (CBT, 2014).

ORR (2014) found that older passengers are more reliant on ticket offices, and those buying from ticket offices are less informed about restrictions. Some older people found Ticket Vending Machines to be not very intuitive.

Delays

Experience of delays on the UK network was highlighted as poor in ORR (2014) with only around 40% of NRPS satisfied with how delays are managed and a third of passengers saying they received no information about delays whilst on board. It is hard to compare reliability aspects of rail with car and Blainey et al report that rail is viewed as being unpredictable or unreliable and improvements can be costly to implement.

After the journey

These elements include the formal ways in which passengers engage with or contact their train operator, such as recognising performance, registering a complaint and compensation.

ORR (2014) report that complaints have been falling steadily on the UK network, but passengers are not informed about their rights and 1/10 people eligible for compensation make a claim.

Cost effectiveness of improvements in rail provision

The work of Brons and Rietveld (2009) analyses the satisfaction levels of different dimensions of the journey and derives importance weightings based on a regression of these levels against an overall journey satisfaction score. The data for the analysis comes from a rail customer experience survey carried out in the Netherlands (as covered in Brons and Rietveld (2007)). The idea here is that effective policy should be targeting satisfaction of more important aspects of the service, set against associated costs (deemed out of scope here). The dimensions of the journey include the following: Travel comfort; travel time reliability; station organisation and information; service schedule; dynamic information; price-quality ratio; accessibility; ticket service; personal safety; personnel.

Whilst station organisation and information exhibited the highest levels of satisfaction, passengers were least satisfied with the price-quality ratio, reliability and accessibility. To improve satisfaction of the overall journey, importance of the dimensions requires consideration. With this derived importance analysis, travel comfort and reliability emerge as the most important dimensions of the rail journey, with ticket service, personal safety and personnel the least important. They also carried out their analysis of importance and satisfaction for subgroups and found the following:

- *Infrequent passengers*: satisfaction levels generally higher and attach more value to travel time reliability. This group also find accessibility to be one of the most important dimensions.
- *Rail Passengers below age of 20*: elements of the non-rail parts of the journey, i.e. accessibility, organisation and information and dynamic information are more important and those related to the rail part of the journey are weighted relatively lower.
- *Passengers with Car Availability:* this group scores higher on satisfaction scores (they have 'chosen' to take rail), but no difference in importance scores.

Brons and Rietveld (2009) argue that, based on their findings, it is more feasible and cost-effective to target improvements in dynamic information and accessibility aspects rather than travel time reliability, service schedule and stations which are more expensive to improve.

Brons et al (2009) estimated a regression model of zonal rail trips (from destination stations) for Holland featuring rail service, accessibility and postcode characteristics and this also found that the previously identified access variables were significant demand determinants. This model allowed the prediction of the impact of these accessibility aspects on rail demand. For example, if frequencies of access services improved by 50%, the model predicted an increase in demand of 5%. The authors conclude that investments in these aspects of rail journeys could be more cost effective than investments in the rail services themselves, particularly in peripheral areas. It also emphasises the need for operators to consider a rail journey as a chain of journeys, not all rail based.

Blainey et al (2012) consider over 100 studies examining the barriers to mode shift to rail, including temporal, financial, physical, mental/emotional. Among the softer barriers include: Perceptions; Conscious Car Dependence; Convenience and Freedom; Lack of Control; Information Provision; Station Facilities; Cleanliness and Maintenance; Personal Security; Staff Presence; Comfort; Crowding; Other Passengers; Image of Public Transport. Complementary (external) factors included: Trip Chaining; Habit; Individuality; Age, Health and Disability; Ethnicity, Faith and Culture; Goods and Baggage; Locational Preferences; Influence of Employers; Sub-optimal Market Prices; Weather.

The findings from the papers covered in Blainey et al (2012) suggest that whilst hard factors such as cost are important, there are significant numbers of people deterred from using rail by less-tangible factors, such as perceptions, image, ticket complexity, station access and car dependence which could offer potential for relatively inexpensive improvement in modal share, ‘nudging’ people towards rail use. An important dimension to their work was that travellers are unlikely to consider barriers in isolation, making identification of significant barriers difficult.

Blainey et al (2012) conduct a qualitative assessment of the importance of these barriers and the feasibility and cost-effectiveness of addressing them (in UK context), reproduced below in Table 4 below. They find that improvements will have more success if forming part of a package of measures. Based on their assessment the authors suggest resources best targeted at improvements for small groups with potential for mode shift, e.g. staff at workplaces or shopping centre customers. Seamless journeys should also be promoted through integration of station access/egress and less uncertainty at interchanges. Publicity and PR by rail industry could also help reach out to non-users.

Importance / Cost effectiveness	High	Medium	Low
High	- Conscious car dependence (P) - Station access (P) - Habit (D) - Land use patterns (D)	- Government policy (P) - Employers' influence (P) - Cost (D) - Inaccurate perceptions (D) - Sub-optimal market prices (D)	- Ticketing complexity (S) - Image (P)
Medium	- Interchange (P) - Service frequencies (P) - Travel time (P) - Trip chaining (D)	- Crowding (P) - Network limitations (D)	- Cleanliness and maintenance (S) - Comfort (S) - Station facilities (S) - Lack of control (P) - Goods and baggage (D) - Individuality (D) -
Low	- Convenience and freedom (D)	- Journey planning requirements (S) - Age, health and disability (P) - Other passengers (P) - Personal security (P) - Reliability (D) - Structural car dependence (D)	- Staff provision (S) - Safety (P) - Ethnicity, faith and culture (D) - Locational preferences (D) - Unsuitability of trips for rail (D) - Weather (D)

Note, suffixes refer to feasibility with S- straightforward, P – possible, D- difficult

Table 4: Estimated importance, cost-effectiveness and feasibility of addressing barriers to mode shift (Source: Blainey et al, 2012)

Summary

The academic literature survey reviewed the underlying factors in the use of rail. In focusing on how to improve the rail journey for passengers there are a number of clear findings:

- There should be a focus on the full journey not just the rail aspect;
- The convenience of the rail journey should aim to match to that of a car journey;
- Whilst improvements in hard factors such as journey time and frequency changes would help, in terms of cost effectiveness, addressing informational and accessibility improvements may be more achievable;
- There is an ongoing need to try and address reliance on and attitudes towards cars;
- Certain groups are not being fully catered for in terms of accessibility and information provision such as the elderly and people with disabilities;
- One size does not fit all - different traveller groups have different requirements reflected the aspects of the journey they deem important and are satisfied with.

5. KEY OUTCOMES AND CONCLUSIONS

The ultimate goal this analysis is to assign macro trends and corresponding impacts to the journey aspects that will comprise the Experience Map in the subsequent SMaRTE activities.

The survey among EU-projects described in Section 3, and the academic literature review in Section 4 enabled the recognition of macro trends affecting travel behaviour, starting with macro trends and societal factors identified in the first instance which represent 'clusters' of trends.

Taking into account that some trends may be common to more than one cluster, Table 5 summarises the list of societal trends identified by the survey among EU-funded projects.

Cluster of trends	Surveyed macro trend
Societal need for decarbonisation	1. Car use reduction, perceived as a tool to reduce pollution 2. Information on carbon footprint 3. Active mobility (walking, cycling, etc.) and greener modes of travel 4. E-mobility and new kinds of vehicles 5. Use of alternative fuels (incl. biofuels) 6. Use of greener materials
Demographic evolution and lifestyle changes	7. Teleworking, part-time and co-working hubs increase decentralisation and urban sprawl, which leads to the need to extend public transport in lower density 8. Need for healtier and active lifestyle will lead to more active mobility (especially in denser urban areas) 9. Decline of motorization and car-free neighbourhoods 10. Use of time in-mobility (multitasking travel time) and decrease of speed as a travel choice factor 11. Ageing society leads to need for social inclusion in mobility, to ensure accessibility to disabled and elderly people 12. Need for integrated, on-demand, customised and multimodal mobility services; need to ease travel planning and booking process 13. Better protection and passenger rights 14. Security/accessibility tension in mobility
Climate change	15. Higher climate change and air pollution perception 16. Increasing importance of policies for e-mobility and charging by renewable energy sources 17. Higher diffusion and acceptance of policies to reduce and tax carbon emissions
Autonomous driving systems evolution	18. Autonomous cars diffusion, as a market-driven scenario 19. Autonomous driving lead to longer commuting trips, further urban sprawl and decrease of opportunity cost of time spent in travel. 20. Shared Automated Vehicles (SAVs) as first/last mile connectivity to public transport. 21. Automated vehicles to open up mobility services to people currently unable to drive

	22. Road safety issues as automated traffic is mixed with other mobility categories 23. Liability in automated driving could shift from drivers to OEMs 24. Drones and robots for logistic operations
ICT and IoT development	25. Diffusion of standards for interoperability 26. Higher information to passengers, more informed choice; real time interactions between users and services 27. Mobility as a Service (MaaS): multimodal seamless transport services; providers with service roaming agreements between them 28. Threaten to privacy due to the diffusion of tracking and tracing 29. IoT to enable transport modes communicate with each other and with the environment 30. New production methods (Industry 4.0); shorter development times for services and goods 31. Big data management in traffic
Sharing economy	32. Less property of vehicles, more use and sharing (especially younger generations) 33. Growth of car sharing and bike sharing 34. Crowdsourcing and ride-sourcing as complementary to public transport, especially in first-last mile transport 35. Higher diffusion of retrofitting

Table 5 Final list of macro trends and societal factors

The survey enabled the identification of 35 macro trends and societal factors: 17 are related to clusters of trends preliminarily identified as 'demand-affecting', whilst the remaining 18 are related to technological evolutions and sharing economy diffusion. Although some cause-effect relation between factors exist, the survey showed that the societal factors listed in the table are identified as 'stand-alone' in literature. However, we made an effort in our survey to show how each factor (1-35) is connected or caused, or part of a general cluster of trends (left column in the table).

The following sub-sections identify the likely impact of societal factors on each journey aspect described previously and which will form part of the Experience Map. To avoid repeating similar statements, 'usability' and 'passenger needs from travel experience' have been merged in a single category, assuming that 'usability' is a concept directly connected with the user experience.

MENTAL MODELS

According to the definition proposed in Chapter 2, a 'mental model' is 'a simple affinity diagram of behaviours made from ethnographic data gathered from audience representatives.' In other words, a mental model is a person's thought process about how something works in the real world, assuming that people form mental models through experience, training, and instruction.

In a stated preference survey of pro-environmental attitudes in a rail travel context, female respondents, older respondents, and respondents with a university degree have a stronger pro-

environmental attitude, with the opposite applying to respondents with regular car access. (Hess et al 2013).

In the case of passengers' behaviour and their attitude towards travel, one of the main emerging trends is the new paradigm of time spent in travel. The opportunities ICT offers to allow multitasking during travel time are going to have a dual effect: on the one hand it may further increase the demand of (rail) travel from decentralised houses to working places. As pointed out in MOBILITY4EU, teleworking may induce long distance trips and trigger urban sprawl. On the other hand, the evolution of autonomous driving – and the possibility of spending car travel time in a more productive way – may counteract the trend towards car reduction.

Blainey and Preston (2010) highlight that the complexity surrounding the understanding of fare structures can mask the fact that rail is often cheaper than car.

The survey has demonstrated that different "biospheric values" determine different mental models, especially concerning attitude towards car reduction and active mobility.

Finally, attitudes towards sharing economy may have an impact on rail use, if car sharing and ride-sharing services are organised to ensure first/last-mile connections to/from stations and terminals. Trivett et al,. (2013) found the social element of sharing/collaborative consumption is a pull factor for some segments of population.

POSSIBLE INTERACTIONS AND TOUCHPOINTS WITH OFFERED TRANSPORT SERVICES

The survey demonstrated the increasing need of supplying integrated transport services. The integration has to be achieved by means of diverse touchpoints: static (email, newsletters, ads); interactive (website, apps); and involving human-to-human interaction (e.g.: sales representative, support agent), as per the definition of 'touchpoint' proposed in Chapter 2.

The interactions between transport services are mainly influenced by ICT/IoT and spin-offs of sharing economy.

Folsom (2011) and Bagloee et al (2016) both highlight the social disruptiveness of AV vehicles in relation to disrupting car-based transport, including taxis. They do not consider the relationship of AV and rail.

Firstly, the survey (3iBS) evidenced that more integration will be possible through the diffusion of more standards for interoperability. It is of particular importance for rail technology and market, faced with need to developed further standards to ensure integration between rail and other

transport services, especially in the field of ticketing, information to customers and between operators.

As pointed out in MINDSETS, ICT development leads to more informed choice of travel among different options and real time interactions between users and services. This is a key point towards the use of rail, often perceived by mistake as the less reliable and slower travel option, especially for longer distance travels.

The wider diffusion of MaaS will guarantee the provision of multimodal seamless services, thanks to service roaming agreements between providers.
Addressing informational and accessibility improvement is of key importance. The literature review surveyed several papers [CBT (2014), Blainey et al (2012), RDG (2013)] addressing the perceived penalty to interchange. Here it is demonstrated that non-travelling time added to journeys in interchanges causes stress and inconvenience, which are intensified by factors such as bad waiting environment, lack of informational and safety aspects. This inconvenience leads to higher values of time for waiting time than for in-vehicle time, which often hampers the potential of rail. Thus focus on information, safety, and other quality aspects that may improve the travel experience at interchanges must be considered as a more cost-effective measure to address than trying to increase journey speed. In cases of planned disruption, timings and communication could be improved (Passenger Focus, 2013) through use of ICT.

IoT, to enable transport modes communicate with each other and with the environment, is going to enlarge the spectrum of touchpoints offered to potential passengers, including potential rail users. The survey (in particular, MINDSETS) also showed the possible impact of big data management and the diffusion of tracking and tracing on privacy. If data on travellers' choices and traffic are not managed ensuring the respect of sensitive data, threatens to privacy may be an obstacle to the provision of integrated transport services and modal choice touchpoints.

Sharing economy is a powerful trend towards the diffusion of interactive touchpoints for transport service integration. The use of rail will be facilitated for users as far as sharing mobility services (including crowdsourcing and ride-sourcing) will be developed as complementary to public transport, especially in first-last mile transport.

USABILITY AND TRAVEL EXPERIENCE

As defined in Chapter 2, 'usability' is the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. In the context of SMaRTE, usability relates to perceptual and emotional aspects associated with travel experience, and criteria to assess such aspects.

The macro trends survey has evidenced that the paradigm of the use of time in mobility is shifting towards the concept of "multitasking travel time" and decrease of speed as a travel choice factor. This leads to the necessity to ensure high-quality and comfortable travel services. As pointed out

in the survey among academic papers, passenger experience is a concept independent from the objective quality of the journey, since it concerns all elements of the door to door travel, rather than the trip. The need to ensure a high-quality rail service means that potential users realise that travel time could be allocated in the most effective way, including the possibility to work and connecting to the web during the trip. It would be ensured if rail and mobility operators provide the users with the necessary comfort during the trip (comfortable couches and seats, climatisation, plugs and connections, etc.) and ensure the availability of all pre and after-travel services that enhance the reliability of travel experience. In this respect, the availability of flexible ticketing and purchasing, and easy booking process, after-sale services such as easy ways for compensation and reimbursement in case of service disruptions, are becoming a must. In parallel, the travel experience is connected to the need of a continuously improved protection of passenger rights.
The academic literature review (DfT 2010) focused on the importance to achieve a usability experience at least comparable with that of car trips. Car provides seamless door to door journeys, which is still a major challenge to attract passengers to rail, to be addressed by better integration of the multi-modal aspects. The works by Blainey and Preston made for UK suggest that cost of rail travel is in many cases cheaper than car, but this is not perceived by the potential user, even nowadays threatened by the high barrier constituted by the low reliability associated by users to rail travel.

The goal to achieve ‘usability’, i.e. mobility with comfort, quality and service integration, for a wider public, is directly connected with social inclusion. The need to ensure accessibility to disabled and elderly people is generated by the macro trend towards ageing society. The literature survey evidenced that gaps for specific user categories such as elderly and disabled are evident both in terms of accessibility and information provision. This has a more general impact in terms of traveller clustering and necessity to supply each category with customised and on-demand solutions (MINDSETS), which must meet different requirements reflected in terms of which aspects of the journey they deem important and are satisfied with. However, Blainey et al. (2012) evidenced the medium-low importance and cost-effectiveness of policies addressing specific user categories and requirements.

Cyganski et al 2015) suggest that the travel-time valuation for autonomous driving is affected by current attitudes to time use during rail and public transport journeys. By logical extrapolation it is possible to see that future attitudes to rail travel might be affected by competition from AV, if passengers perceive that their needs are better met in an AV.

The review included the outcome of surveys made in GOF4R Project on the acceptance of the Travel Companion. Such survey was a comprehensive tool to assess emerging needs of potential passengers, including rail users. The opportunity to use an ICT tool to organise multimodal travels addresses surveyed passenger needs such as making the planning & buying process easier, supplying full assistance in case of disruption, information on alternatives, passenger rights and reimbursement procedures, reliability and transparency of data and information.

MOBILITY AT FIRST/LAST MILE.

The societal factors surveyed and summarised above have impact on the diffusion of first/last-mile mobility services.

As described for the previous journey aspects, the provision of transport services – whether organised by public actors, or shared, or crowd-sourced – is crucial to ensure the accessibility to rail nodes, and to promote the use of rail.

Sharing/collaborative options for first/last mile already exist, as there are many examples of car and lift sharing, as well as car-pooling. Also bike share schemes (both fixed station and dockless). As evidenced in the research by DfT (2010) and CBT (2014), the large share of users accessing stations by non-car modes (which has significant potential for integrated journey solutions users) must be supplied with facilities and devices to make interchanges between first/last-mile and long distance travel smoother. This leads to the necessity of integrated tickets or smartcards, including first/last-mile and long distance modes in a single ticket, the comfort and safety of waiting passengers, adequate storage and security for cycling users.

The use and effectiveness of first/last-mile services resides in the level of integration of such services with long distance ones, which is facilitated by the diffusion of crowdsourcing and ride-sharing platforms, MaaS and other technologies allowing the integration of transport services and the B2B data exchange between operators.

Finally, the survey (in particular MINDSETS and MOBILITY4EU), evidenced the importance of Shared Automated Vehicles (SAVs) as first/last mile connectivity to public transport, although AV generally could pose a threat to rail travel by replacing the need for first and last mile segments of the journey.

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APPENDICES

APPENDIX 1 – EU-FUNDED PROJECTS

The present Appendix reports in short the scopes of each EU-funded project deliverable surveyed for the macro trend and societal factor analysis performed and described in Chapter 3. A general description of each project's purpose is provided in Table 2.

3iBS – Deliverable 11.2[7]

The deliverable elaborates on guidelines for the identification and introduction of accessibility and safety concepts into urban bus system networks. According to the Description of Work the deliverable is to deal with the bus system infrastructure (from the passengers' and travellers' side), the information systems (incl. ticketing) and the bus interior design. More specifically the deliverable describes factors affecting and guidelines for the introduction or implementation of innovations by which an accessible and safe bus system can be further achieved.
The work has included five steps:
i. identification of the key factors that were considered to have influenced the successful implementation of innovations in case studies: Nantes and Rome. This can also be described as partners' contribution of lessons learned;
ii. compilation of available literature on drivers and barriers to innovation and implementation of innovations in general, and in transportation and public transport specifically;
iii. extraction of existing recommendations and guidelines regarding implementation of innovations in transportation and in public transport. The primary source has been earlier European projects dealing with bus system infrastructure (from the passengers' and travellers' side), the information systems (incl. ticketing) and the bus interior design, i.e. ACCESS2ALL, NICES, MEDIATE;
iv. a summary of the project partners' experiences of problems associated with the implementation of innovations in the specific areas: bus system infrastructure (from the passengers' and travellers' side), the information systems (incl. ticketing) and the bus interior design;
v. interpretation of conclusions from steps i-iv and translation into guidelines;
vi. verification of guidelines from project partners.

3iBS – Deliverable 11.3[8]

The deliverable deals with recommendations for the implementation of solutions for meeting the mobility challenges associated with the ageing population including a list of priority actions for further research and standardisation related to accessibility and safety in public transport.
The work has included the following main activities:

[7] Karlsson et al. (2014)
[8] Karlsson et al. (2014b)

- an inventory of European projects targeting older travellers and travellers with special needs - 2004 until 2013;
- a targeted search for recommendations and roadmaps regarding accessibility to public transport, safety and security in public transport, and elderly in public transport within the same time span - 2004-2013;
- a comparison of the recommendations and roadmaps to identify common themes and differences
- an informed choice of and formulation of recommendations for future R&D.

EBSF – Final Report[9]

Through the application of the "system approach", the project aimed at designing and validating a new breakthrough generation of urban bus systems, which will stimulate European cities to ensure a higher quality of the existing services and making public transport more attractive. Such a high-level objective has been achieved through the following steps:

- Defining and validating functionalities and architecture of a bus system which answer the needs of European bus stakeholders
- Developing new technologies on vehicles and infrastructure in combination with operational best practices
- Design, developments, simulation and test of key new technologies and operational concepts in real urban scenarios
- Set-up the frame for the harmonisation and standardization of the solutions developed during the project.

Moreover, in order to mantain or improve the competitive position of European bus manufacturers and operators, the project aimed at stimulating coordinated research on bus systems to find new solutions dealing with better effectiveness of investments, operation and production costs, future possibilities for bus environmental performances and smart use of energy sources

GOF4R – Deliverable 2.1[10]

The objective of S2R IP4 project GOF4R (Governance of the interoperability framework for rail and intermodal mobility) Work Package 2 "User Demand" is twofold:
1. Analyse market actors' interests in the Interoperability Framework;
2. Analyse travellers' demand for the Travel Companion.

Deliverable D2.1 presents the outcomes of Task 2.1 which focuses on the "Analysis of the consumer demands and interest in using the TC capabilities". The needs and requirements of other market actors (operators, authorities, service providers) are addressed in a separate Deliverable D2.2 "Analysis of the demand of market actors for the IF".

Travellers do not interact directly with the Interoperability Framework or its assets. That is why in this Deliverable the focus will not be on the Interoperability Framework as such but rather on the different functionalities developed based on or thanks to the IF, which the traveller can access

[9] EBSF (2014)
[10] Colzani P. et al. (2018)

through his/her Travel Companion. This report identifies and describes conditions for a large market uptake of the Travel Companion approach by the end-users: the travellers, and is structured as follows.
As a first step, the Travel Companion has been 'deconstructed' into its consumer-oriented capabilities and interaction points.
For each interaction point, a series of assumptions have been formulated with regard to factors (incentives, needs, constraints, barriers) that could (positively or negatively) influence the consumer uptake of the TC approach. These assumptions were validated by means of interviews with relevant stakeholders.
Several workshops have been organised in Belgium, Italy, Slovakia and the Czech Republic, in order to better understand the conditions for market uptake of the Travel Companion approach and to assess potential ethnographic differences between countries and cultures.
Finally, the findings obtained during the interviews as well as the national workshops were presented and further discussed at a European-wide workshop with S2R IP4 and other experts.

MINDSETS – Deliverable 2.1[11]

The objective of the report is to provide a new perspective to understanding mobility through coordinating the intelligence from a wide range of disciplines: breaking down academic language barriers to identify common themes in thinking and approach.
This report combines with two sister reports (D2.1B) that brings together perspectives on understanding mobility from a wide range of disciplines, including economics, psychology, sociology, spatial analysis and social networking among others; and a further report, D2.1C, that develops an approach based on the analysis of the common values and mind-sets within different generations of European society.

MINDSETS – Deliverable 2.2[12]

In this report, MINDSETS takes the perspective of the practitioners, and ask the following questions:

- Are practitioners aware of the tools that are available, and do they use them? If not, why?
- Have these tools proved useful in daily practice?
- What would be needed to improve the performance and the relevance of these tools, and what does this imply in terms of future research needs?

In order to tackle these questions, a series of semi-structured phone interviews was performed, with transport planning professionals from a very wide range of backgrounds.

MINDSETS – Deliverable 3.2[13]

This MINDSETS deliverable reports the proceedings of a series of participatory activities carried out in 2015 to discuss upcoming hypotheses on these topics with experts and stakeholders across

[11] Pickup et al. (2015), Unal et al. (2015), Konings et al. (2015).
[12] Franckx and Mayeres (2015).
[13] MCRIT et al. (2016).

Europe. This process aimed at providing grounds for a new conceptual approach to mobility analysis and assessment, mobility planning and service development.
In particular, the activities that were carried out were the following ones:

- An expert workshop in Barcelona in October 2015 with around 50 participants that discussed over two days on the following topics:
  - Attitudes towards future mobility automation
  - Appraisal methodologies for better analyzing seamless mobility projects and services
  - Impacts of smart and virtual mobility: mind-sets in Big Data
  - Sustainable and inclusive mobility: role of elderly and impaired users in mobility
- A high-level consultation started discussions on these issues already in September 2015. (http://www.mcrit.com/mindsets/enq_eu.php). The around 150 respondents to the survey were mostly experts and researchers, civil servants involved in the field of transport, transport consultants and other transport stakeholders including vehicle manufacturers, service providers, infrastructure managers and groups of interest.
- A set of complementary focus groups explored population attitudes towards these concepts before the workshops in different geographical areas, mainly in the city contexts of Haifa (Israel) and Rome (Italy) and in small rural towns in the province of Barcelona (Spain).

MINDSETS – Deliverable 3.3[14]

The objectives of this document are twofold. First, take stock of future trends in the supply side (technology and business models) of mobility. More specifically, the deliverable deals with three major developments that could be real game changers: the rise of the collaborative or shared economy, the breakthrough of technologies for automated mobility, and major improvements in electric mobility. Second, the challenges these developments pose for transport planning and policy have been assessed.
After having reviewed the expected trends, what they imply for transport modelling (and thus for the planning profession) and for the management of transport demand is discussed in the report.

MOBILITY4EU – Deliverable 2.1[15]

Mobility4EU is a Coordination and Support Action of the European Commission started in January 2016 and lasting for 3 years, until 31 December 2018. The present document reports on the results of researching trends and societal drivers impacting mobility demands and transport in Europe until 2030. As compared to other comparable exercises in European researches that had a similar scope, MOBILITY4EU approach is rooted in the study of societal trends, as opposed to a more classical transport demand analysis that mostly separates trends along classical transport modes and transport markets. The report addresses the analysis of societal dynamics in a broad sense, and in a second stage identifying those trends that have an interaction with mobility and logistics. Societal trends are considered as entry points instead of transport solutions and markets. The

[14] Franckx and Mayeres (2015b).
[15] L'Hostis, A. et al. (2016).

analysis intends to cover all transport modes, all geographical scales and freight as well as passenger transport.

MOBILITY4EU – Deliverable 2.3[16]

This document presents the publishable visualization of the Context Map that resulted from the first Mobility4EU workshop on "Societal requirements and current challenges for transport". It briefly describes the first part of the story mapping process visualising the trends, societal, economic and political factors impacting mobility demand and transport system in 2030.

MOBILITY4EU – Deliverable 3.1[17]

The aim of this deliverable is to outline the process of the development of the scenarios for the future of mobility in Europe and present the narrative scenarios that were co-created with the consortium members, associated partners and external stakeholders of the Mobility4EU project. Scenario building is the first step of the multi-actor multi-criteria analysis (MAMCA), the methodology used to conduct a broad stakeholder consultation to develop a vision and action plan for mobility in Europe in 2030. Scenarios represent a range of possible developments in the future. In the Mobility4EU project the scenarios have communicative, goal-setting and decision-support functions. We applied the intuitive logics method combined with scenario co-creation workshops.

SKILLFUL – Work Package 1[18]

The outcome of WP1 was surveyed by means of the reference public documents available up to date, mainly a detailed presentation from SKILLFUL 1st Dissemination event. the objective of WP1 is defining the future trends, needs and scenarios is approached through the critical review of the existing, emerging and future knowledge and skills requirements of workers at all levels in the transportation sectorby the following activities:

- identification of the key paradigm shifters and game changersin the future transportation ecosystem.
- identification of the key enabling and supporting technologies that drive the above changes.
- identification of the emerging novel services and service bundles that will shape the future transportation sector.
- identification of the major demographic, behavioural, cultural and socioeconomic issues that will shape the future workplace in transport.
- matching of the future skill and competences requirements with the current and foresighted workforce groups in transport and identification of the leading relevant scenarios on employability enhancement in the future.

[16] Deep Blue (2016).
[17] Keseru et al. (2016).
[18] Bekiaris (2017).

APPENDIX 2 - ACADEMIC LITERATURE REVIEW – THE TEMPLATE

ID:		Title	
Author(s)			
Journal			
Volume, Page numbers			
Abstract			
Author Keywords			
Name Reviewer 1			
Name Reviewer 2			
Comments of reviewer 1 on Abstract and Keywords *Please comment on whether the author keywords are useful for further searching and on whether the abstract suggests that the full paper should be reviewed. If so what are we looking for?*			
Useful Keywords:			
Should the paper be reviewed and why:			
Comments of reviewer 1 on full document if taken forward			
Comments of reviewer 2 on full document if taken forward			