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D3.2 Benchmarking ITS innovation diffusion and ITS production processes EU vs. US

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Reviewer(s):	Iván Zaldívar Santamaría (ATOS), Xavier Leal (ORT)
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1.0	30/01/2018	ORT	Final version

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Abbreviations

C-ITS	Cooperative Intelligent Transport Systems
CAMP	Crash Avoidance Metrics Partnership
CAR	Center for Automotive Research
CAV	Connected and Autonomous Vehicle
CEF	Connecting Europe Facility
EC	European Commission
EDPS	European Data Protection Supervisory
EU	European Union
FF	Free-Floating Model
FHWA	Federal Highway Administration
GA	Grant Agreement
GDPR	General Data Protection Regulation
H2020	Horizon 2020 Program of the European Commission
HOV	High Occupancy Vehicle
ITS	Intelligent Transport Systems
ITSPAC	ITS Program Advisory Committee
IVHS	Intelligent Vehicle Highway System
JPO	Joint Program Office
JRC	Joint Research Centre
MaaS	Mobility as a Service
P2P	Peer to Peer Model
POC	Proof of Concept
RDS-TMC	Radio Data System Traffic Message Channel
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SCS	Stationary Car Sharing
TEN-T	Trans-European Transport Network
US	United States
US DoT	United States Department of Transportation
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
WP	Work Package

Abstract

The Deliverable provides a benchmark analysis of ITS innovation diffusion in the EU and US. It also supports a categorisation of success determinants and explores future opportunities and threats. Three key areas of ITS innovation have been analyzed, in order to benchmark EU and US innovation diffusion patterns: 1) sharing mobility, 2) Mobility as a Service (MaaS), and 3) connected and autonomous vehicles (CAV's). Conclusions in the EU and US contexts stress the importance of the support from local authorities (sharing mobility), the need to overcome the critical mass barrier by making massive use of tracking technologies (MaaS) and the further challenges posed by the need for better regulatory actions (CAV's).

0. Executive summary

According to the Description of Action, the Deliverable must include “the formalization of the benchmarking process on (to be selected) ITS innovation solutions […] compare innovation diffusion processes of ITS and C-ITS solutions in the European Union and the United States, and will support a categorization of the success determinants while exploring future opportunities and threats”.

At this purpose, the **Section 2** provides a brief history of ITS deployment in EU and US, comparing current ITS deployment strategies.

The EU “bottom-up” strategy relies on the need to avoid a fragmented internal market, basically due to the different national ITS markets and players, raising the need to define and support common priorities, in order to let ITS services be deployed quickly throughout the EU by Member States and local authorities, vehicle manufacturers, road operators and the ITS industry.

On the other hand, the US “top-down” ITS strategy is based on the network of multiple federal agencies, local transportation organizations, academia, industry, trade groups, other state and local public organizations which can ensure the implementation of a top-down strategy based on the definition of priorities in advancing research, development of programmes and their adoption/monitoring.

Section 3 describes the methodology developed to produce this Deliverable. The framework methodology implies the analysis of emerging trends affecting mobility and selection of ITS areas of innovation (section 4), the identification of innovation diffusion determinants and formulation of recommendations (section 5). The Lewin’s force field analysis model has been used (Lewin K., 1951) to visually represent success and failure determinants of innovation diffusion.

Section 4 contains a description of emerging trends affecting mobility to ground a justification for selecting the areas of ITS innovation to submit to the benchmark analysis. Some of the areas of ITS innovations have been assessed, being affected, to a differing extent, by socio-economic trends and pushing forces introduced above, namely: **sharing mobility**, **Mobility as a Service (MaaS)**, and **connected and autonomous vehicles (CAV’s).**

Concerning sharing mobility, despite robust evidence on the market status of ride-sharing innovations in the EU and US could not be found, however the critical aspect to consider to boost diffusion can be found in overcoming the critical mass barrier by making massive use of tracking technologies and networks; additional success elements of innovation diffusion are increasing interoperability and opening data sharing among platforms, incentivizing multimodal transport integration, extending pre-tax benefits, establishing a community of trusted users and developing supporting policy measures (such as building HOV lanes and lowering HOV toll prices).

MaaS is at its initial stages of diffusion in Europe, whereas in the United States organisational and institutional challenges have even prevented deployment. Forces driving innovation diffusion could be: user’s willingness to move from a car-borne transport, wide range of transport modes available and majority of operators offering electronic payment, opening data and allowing third parties to sell their services, stakeholder cooperation, user incentives, innovative procurement and MaaS support as part of policy strategies; on the other hand, restraining forces identified are: challenges to make users using one single app, strong competitions among market players, development of data formats and quality checks not yet fully addressed, lack of provision of government subsidies and tax reduction benefits if MaaS is not supported by local governments, financial pressures on public transport operators if profits are sought from the sale of monthly subscriptions and ticket sales.

Innovation diffusion has been analysed for CAV's making use of evidence relating to a number of determining factors such as user acceptance and willingness to pay, data protection and cyber-security, ethics and liability, and policy and regulatory issues. According to the evidence presented, data privacy is not considered a critical barrier to innovation diffusion since nowadays large proportions of customers already share significant amounts of personal data with their smartphone software manufacturer. Ethics and liability are still currently being debated in the technical literature, however it is considered that CAV will results in a shift from personal to product liability, which will impact the insurance market significantly. Further challenges are also posed by the need for regulatory actions, such as enforcing that all new vehicles are equipped with C-ITS capabilities, defining open technology standards and developing comprehensive national frameworks.

1. Introduction

1.1 NEWBITS project

NEWBITS (New Business Models for Intelligent Transport Systems) is a Coordinated and Support Action project funded under the EC Programme Horizon 2020.

NEWBITS aims at providing further understanding of the changing conditions and dynamics that affect and influence the deployment of ITS innovations. This improved understanding must contribute to minimizing the failures inherent to ITS innovation diffusion, evolve present business models, and identify effective (policy) incentives to accelerate ITS deployment.

Although the significant added value that ITS applications can provide to the European transport system has been constantly highlighted in the past years, their deployment is considered to be slow and fragmented (C-ITS Platform, 2016; Ricardo, 2016). Robust and innovative business models that would support a truly responsive approach to accelerating commoditisation and price-competition in the market for ITS services are often missing, inter alia due to the public oriented nature of ITS users (Agelidou et al., 2015). Confidence of the core stakeholders on the (long-term) profitability of their investments in ITS services and technologies is necessary and requires sound and convincing business cases.

In consideration of this global context, the project has set the following specific objectives:

1. Applying a business ecosystem's concept for ITS and C-ITS, introducing a higher conceptual level than that of individual organizations.
2. Improve the understanding of ITS and C-ITS enablers and barriers, implementing a holistic intelligence process
3. Effectively implement a network based business modelling method for C-ITS
4. Validation of new business models, translation and capitalization of results.

NEWBITS project is articulated in three phases that correspond to certain Work Packages and activities; the two first project phases will be devoted to Data gathering and analysis (Phase1) and Network Business modelling (Phase 2), with WP6 running in parallel and acting as a key element of the NEWBITS network oriented approach. Both phases will feed the third phase (Phase 3), the implementation of which requires the execution of the biggest part of the work effort of the tasks of the previous phases.

1.2 Deliverable 3.2 objectives and structure

According to the Description of Action, the Deliverable must include "the formalization of the benchmarking process on (to be selected) ITS innovation solutions […] compare innovation diffusion processes of ITS and C-ITS solutions in the European Union and the United States, and will support a categorization of the success determinants while exploring future opportunities and threats".

To fulfil these aims, a common accepted definition of innovation diffusion appears of preliminary utmost importance which will serve as a solid reference throughout this deliverable:

Innovation diffusion can be defined as: "*the process by which an innovation is communicated through certain channels over time among the members of a social system. Diffusion is a special type of communication concerned with the spread of messages that are perceived as new ideas. […] Diffusion has a special character because of the newness of the idea in the message content"* (Rogers E.M., 2003).

The remainder of this Deliverable is structured as follows.

Section 2 provides a brief history of ITS deployment in EU and US, identifies main actors and policy programs and compares current ITS deployment strategies.

Section 3 describes the methodology developed to produce this Deliverable; it is hereby anticipated that, whilst an extensive desk-top based research of EU and US deployment initiatives was undertaken by D3.2 team, the amount and quality of both qualitative and quantitative data to ground sound conclusions on the innovation diffusion of certain ITS innovations were retained not sufficient for the purposes of D3.2; therefore, efforts were rather put into analyzing diffusion processes for certain areas of (market-deployed) ITS innovations.

Section 4 contains a description of emerging trends affecting mobility to ground a justification for selecting the areas of ITS innovation to submit to the benchmark analysis.

In **Section 5**, the results of the benchmark analysis for the selected innovation areas are presented; key recommendations to improve innovation diffusion have also been formulated.

Section 6 summarizes the findings of the work developed in this Deliverable.

2. Overview of ITS innovation deployment strategies

This Section presents a synthetic overview on the different approaches and strategies adopted in the EU and US regarding deployment and diffusion of ITS innovation products and processes.

First of all, a brief history of the ITS in EU and US is provided in order to serve as basis for the analysis performed in further sections and afterwards, the current strategies for both regions are depicted based on two key overarching documents, namely the European Strategy on C-ITS and the American ITS Action Plan 2015-2019, which are considered to be key strategic planning documents guiding ITS innovation deployment and adoption in the EU and US.

2.1 Brief history of the ITS in the EU and US

The following lines provide a brief history about the EU and US transport and ITS strategies in the recent past and how these have evolved during the last decades.

2.1.1 EU ITS history

Transport policy has been a very important topic to achieving the economic objectives of the European Community since the Treaty of Rome (Wikipedia, 2018a) in 1957. In the late 1980s the EC began to invest in ITS for roads in recognition to the potential of technological developments to revolutionise the automotive sector and its interaction with road infrastructure. The Maastricht Treaty (Wikipedia, 2018b) in 1992 was an important milestone introducing the concept of Trans-European Transport Network (TEN-T). This strengthened the basis for Member States to act together to provide key links in the European transport infrastructure, on which the European single market depends. The Euro-regional projects funded from the TEN-T budget made significant advances in harmonised data exchange between European road authorities and in the use of language independent traffic messages over the Radio Data System Traffic Message Channel (RDS-TMC). The community first White Paper on a common transport policy, also in 1992, made the completion of the internal EU market in the free movement of people and goods a priority. In 2001 a second White Paper, European transport policy for 2010 was created with key objectives of improving safety combat congestion and develop inter-modality. The Euro-Regional projects merged in 2007 into a single DG-MOVE project EASYWAY (European Commission, 2007).

In 2008, the European Commission began by consulting stakeholders on the needs for EU action on ITS in the roads sector. Member States and industry were invited to submit their points of view and the Commission services then drafted a ITS action Plan and proposals for a Directive to give it legal force. After an extended period of debate the ITS Directive (European Commission, 2010) entered into force on the 26 of August of 2010. 2011 onwards, the European Council and the European Parliament have given the European Commission seven years to complete the agreed actions and reporting the progress of the ITS deployment in their countries every three years. Also, in year 2011, the European initiative eCall (Wikipedia, 2018c), presented initially in 2001 and postponed was pushed again by the European Commission, being adopted in 2013 and scheduled to be completed in 2015. The eCall initiative will be mandatory in new cars sold within the EU from April 2018.

2.1.2 US ITS history

The American car culture began to form during the early 20th century. The first three-coloured traffic signal was developed in 1914 and the first parking meter was installed in 1935. In the 1920s alone, the number of passenger cars registered in the US nearly tripled, from 8 million to 23 million (Kaszynski, 1980). The number of registered vehicles grew to 49 million in 1960 (Rose, Mark H. & Raymond A. Mohl, 1995) and to 75 million in 1970. On the 15th of October of 1966, an act of Congress established the United States Department of Transport (USDOT). Seat belts, padded dashboards, standard bumper heights, and dual braking systems became mandatory for new cars in 1967. During this early period, the roots of ITS can be seen in research initiatives and deployments undertaken by states and regions, academic institutions and the automotive industry (ITS GOV, 2017).

During the 1970s, the US Government sponsored an in-vehicle navigation and route guidance system (ERGS) which can be considered as the initial state of a larger research and development effort in ITS (TRANSNAV, 2017).

But it wasn't until 1980s that the Americans started to reconsider their relationship with transport, when safety and environmental concerns became the increasing focus of transport policy. During this decade, technology became cheaper and smarter; Government agencies saw new possibilities for information, sensing, communication and control technologies to solve their problems. Equally important, the transport industry recognised new highway infrastructure-based technologies as a competitive business opportunity that would add value to their products and industry leaders interested in these new technologies organised a series of increasingly formal meetings, which ultimately evolved into the group Mobility 2000 (group essential in determining a conceptual definition for the Intelligent Vehicle Highway System or IVHS and promoting the creation of what today is called ITS America). During this decade, there was no formal national program (only some modest programs of university research funded by the USDOT and some other small-scale projects about freeway management where the Federal Highway Administration (FHWA) collaborated with several universities) but much of the work done at this stage set the stage for the current and future state of ITS and enabled the development and implementation of advanced technologies across transport areas in subsequent decades.

Federal activity regarding ITS began with the Inter-modal Surface Transportation Efficiency Act (ISTEA) of 1991, which established a federal program to research, develop and operationally test intelligent transport systems and to promote their implementation (ITIF, 2010). Year 1991 was also the date for the foundation of IVHS America (again, the organisation known today as ITS America). This organization petitioned the Federal Communications Commission to set aside the frequency for dedicated short-range communications (which now is the foundation for connected vehicle technology, 511) and played a key role in the national traveller information system (Wikipedia, 2018d). In 1994, the USDOT officially sanctioned the term "ITS" as a replacement of IVHS and established a Joint Program Office (JPO), located within the FHWA. Ford and General Motors formed CAMP (Crash Avoidance Metrics Partnership) to accelerate the implementation of crash avoidance countermeasures to improve traffic safety. Much of today's intelligent vehicle research has been a direct result of this partnership.

The 2000s was a decade marked by the biggest growth in communication technologies. Mobile users in the US were 338 per 1,000 people in 2000 and this number rose to 946 in

2010. Additionally, the number and the speed of Wi-Fi networks also grew immensely and cloud technology became more prevalent. Between early 2000 and 2005 the 511 was created and evolved until the creation and growth of smartphones and information apps inhibited its relevance. In 2005, the USDOT created the Research and Innovative Technology Administration (RITA) to advance transport science, technology and analysis. In this year, the USDOT initiated a program to develop and test a 5.9 GHz-based VII proof of concept (POC) and in 2008 and 2009 POC was used to investigate the technical feasibility of V2V and V2I applications.

In the present days, communication and information technologies have evolved at a rapid rate and in the US ITS applications are considered in two contexts: automated purposes and connected vehicle. The USDOT has prioritized connectivity as an important input to for the implementation of automated vehicles. In addition, commercial applications such as Waze or Uber are influencing ITS market regarding shared mobility.

2.2 ITS main actors, funding and policy programs in EU vs US

2.2.1 ITS main actors: EU

In Europe, the European Commission plays an important role as catalyst of the activities carried out by the various actors involved in the design and provision of ITS applications and services, e.g. industry, infrastructure managers and policymakers.

With particular reference to the provision of C-ITS services, the framework for stakeholders' involvement relies on setting-up of Platforms, i.e. dedicated groups of actors, belonging to different areas, which can share common needs, problems and barriers to the uptake of C-ITS applications, with the aim to develop recommendations and shared visions.

Two recently established Platforms are of interest in the identification of ITS main actors:

- the C-ITS Platform
- the C-Road Platform

The C-ITS Platform was established by the European Commission in November 2014, to identify barriers and propose solutions for C-ITS deployment in Europe. The first phase of the C-ITS platform resulted in an expert report (C-ITS, 2016), unanimously endorsed by the platform participants in January 2016. The expert report was complemented by a Cost Benefit Analysis (C-ITS, 2016b) and a public consultation (DG MOVE, 2016) which together laid the groundwork for the European Commission communications on the matter. Meanwhile, the C-ITS platform started its second phase in July 2016, delivering its final report on September 2017 (C-ITS Platform, 2017).

The C-ITS Platform, which gathers public and private stakeholders, represents all of the key stakeholders along the value chain including:

- public authorities,
- vehicle manufacturers,
- suppliers,
- service providers,

- telecom companies.

More specifically, the C-ITS Platform has provided an operational instrument for a dialogue, exchange of technical knowledge and cooperation, among the European Commission, public stakeholders from Member States, local/regional authorities and private stakeholders (such as vehicle manufacturers, service providers and road operators).

Among the private actors involved in the Platform, there are also repair and maintenance operators, insurance sector members, associations of users and road infrastructure managers, all involved to cooperate on technical, legal, organisational, administrative and governing aspects.

Actors also included 120 experts, in the academic and research fields, who met on a regular basis in monthly working groups meetings and four plenary meetings of the C-ITS platform were organised in November 2014, May 2015, October 2015 and January 2016.

The objective of the C-ITS platform was to involve the actors of the C-ITS value chain, in order to identify and agree on how to ensure interoperability of C-ITS across borders and along the whole value chain, as well as to identify the most likely and suitable deployment scenario(s). These include the first vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) services to be deployed across the EU and their most beneficial geographical environments (long distance corridors, secondary roads and the urban environment).

The scope of the C-ITS platform was focussed on the main technical (frequencies, hybrid communications, (cyber-)security and access to in-vehicle data) and legal issues (such as liability, data protection and privacy). It also covered standardisation, cost benefit analysis, business models, public acceptance, road safety and other implementation topics, and international cooperation.

These topics were analysed and discussed in 10 working groups of the C-ITS platform. Those working groups were all chaired by DG MOVE representatives in cooperation and with active participation of other Commission services, such as JRC (Joint Research Centre), and various European Commission Directorates: DG GROW, DG RTD, DG CNECT, DG JUST or institutions such as the European Data Protection Supervisory (EDPS). A 11th working group on roadmap for the deployment of C-ITS has been put on-hold and is expected to build on the achievements of other working groups in order to accompany the implementation phase of the recommendations and make the appropriate link with automation.

Concerning the C-Road Platform, this is a joint initiative of European Member States and road operators for testing and implementing C-ITS services in light of cross-border harmonisation and interoperability. It was launched in 2016, bringing together authorities and road operators covering eleven Member States (Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, Netherlands, Slovenia, UK) to harmonise the deployment activities of cooperative intelligent transport systems (C-ITS) across Europe.

The C-Road Platform has stressed the role of the European Member States as important actors in the delivering of ITS services. The C-Road European Member States are indeed represented as Core Members, with their own C-ITS pilot deployments, either in place or in preparation.

Additionally, Associated Members are linked to the C-Roads Platform (Ireland, Switzerland and Australia), liaising with the different groups within the Platform and committing themselves to use C-Roads specifications in their pilot implementations.

The service harmonisation is one of the core topics in the C-Roads Platform. On car side and on infrastructure side, all conditions need to be harmonised. For this reason, one of the first topics was the agreement on a commonly used C-Roads infrastructure communication profile, starting with ITS-G5 and followed by hybrid communication.

2.2.2 ITS main actors: US

In the US, one of the key actor is the ITS Joint Program Office (ITS JPO), within the Office of the Assistance Secretary for Research and Technology (OST-R), which is in charge for executing Subtitle C- Intelligent Transportation System Research of Public Law 109-59 Safe Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, enacted August 10, 2005.

The ITS Joint Programme, which is part of the US Department of Transport, has the role of conduct research, development, and education activities to facilitate the adoption of information and communication technology to enable society to move more safely and efficiently.

More specifically, the program research analyses how information and communications technologies can improve surface transportation safety and mobility and contribute to America's economic growth. Technology transfer is also a key element of the ITS program. Research findings and evaluations of ITS projects and programmes are published online; a National ITS Architecture and Standards program ensures that States and jurisdictions have the framework they need to deploy interoperable ITS systems; and training on the latest ITS applications is developed and delivered by the program.

The actors involved in the ITS program, through procurement opportunities, include metropolitan areas and a variety of state and local transportation management agencies. The ITS program director leads the ITS Joint Program Office (JPO), which is comprised of program managers and coordinators of the USDOT's multimodal ITS initiatives. In addition, individual staff members manage technology transfer functions, such as National ITS Architecture development and maintenance, Standards development, professional capacity building and program assessment.

All in all, the list of actors involved in the ITS development are the following:

- Federal agencies (e.g., the Federal Highway Administration, Federal Transit Administration, National Highway Traffic Safety Administration, Federal Motor Carrier Safety Administration, Federal Railroad Administration)
- Policy makers and the national, state, and local levels (State DOTs, Regional planning organizations and metropolitan planning organizations, Local transportation agencies (county, city, or municipality levels)
- Specialty agencies (e.g., police departments, sheriff offices, emergency responders, fire marshals, transit operators, port/airport authorities)

- Private sector (e.g., auto manufacturers and suppliers, railroads, dray carriers, roadside technology vendors, wireless technology vendors, software developers, data providers)
- Academia (universities and research centres)
- Professional associations and organizations (e.g., Transportation Research Board; American Association of State Highway and Transportation Officials; Institute of Transportation Engineers; International Bridge, Tunnel and Turnpike Association; Institute of Electrical and Electronics Engineers; American Society of Civil Engineers; Intelligent Transportation Society of America; CV Trade Association; American Public Transportation Association; Association for Unmanned Vehicle Systems International; Society of Automotive Engineers; Specialty Equipment
- Market Association; CTIA – The Wireless Association; and AAR – Association of American Railroads)
- Advocacy and focus groups (e.g., the Crash Avoidance Metrics Partnership)
- International partnerships (such as the current ITS partnerships with the European Commission, Canada, Japan, Korea, and Mexico) are key to bringing ITS experiences from around the world to capture best practices and lessons learned and standardize practices toward more efficient use of ITS.

Table 1 summarises the type of actor and their role in the EU and US ITS services.

Type of actor	EU		US	
	Actor	Main role	Actor	Main role
Institutional	European Commission and Member States	Funding for research and innovation. Guidance for standardisation. security and certificate policy. Awareness campaigns on ITS benefits Interoperability and cross-border projects.	Federal departments of transport	Funding for technology transfer, implementation, operations, maintenance, research, testing. ITS testing and developing new ideas, networking and cooperation agreement
Private	Associations operators, industry	Collaboration and cooperation with institutions	Operators, industry	Partnerships with Institutional bodies

Table 1: Main actors in EU and US

2.2.3 ITS funding: EU

The EU makes funding available for cooperative, connected and automated vehicles through Framework research programmes and deployment projects.

From a historical point of view, for more than 15 years research and deployment projects have proved the feasibility of C-ITS services. Under Horizon 2020, research into Intelligent Transport Systems has shifted focus to the integration of transport modes and the links with automation. A dedicated call for project proposals on automated road transport was launched in 2016. In the context of the Strategic Transport Research and Innovation Agenda, the European Commission is developing a roadmap on connected and automated transport to steer and coordinate future R&I activities in Europe. This work is complemented by large-scale deployment projects to develop cooperative systems on the Trans-European Transport network in 13 countries,19 making use of EU funding programmes such as the Connecting Europe Facility (CEF).

The CEF funding indeed supports trans-European infrastructure and new technologies. CEF has already provided over €100 millions of funding for ITS through the first call for proposals, triggering investments of more than €400 million for the deployment of ITS and C-ITS services in Europe. Additional CEF funding of about €170 million has been available for new projects under the 2015 call, as well as via future calls (INEA, 2016).

All in all, CEF the budget for transport is about €22.4 billion EU co-funding, corresponding to over 130 Million EUR alone since 2014 through CEF and H2020 ITS main actors on the topic of cooperative, connected and automated vehicles 2014-2020.

2.2.4 ITS funding: US

In US, information on funding concerning ITS projects and deployments can be elicit from the U.S. Department of Transportation budget highlights (US DoT, 2017). For example, in 2017 $200 million for pilot deployments on safe and climate-smart autonomous vehicles to create better, faster, cleaner urban and corridor transportation networks and more than $60 million in research on advanced and emerging technologies and alternate fuel vehicles have been established.

However, the resources reported in such reports sometimes concern funding in related ITS topics, like cybersecurity, safety and data integrity and the identification of resources allocated specifically to ITS services may be subjected to a high degree of uncertainty.

On the other hand, straightforward information on funding to ITS programmes can be found in the ITS Program Advisory Committee (ITSPAC) reports to Congress. The series of communication allow to identify funding information on specific ITS programmes.

On 2016, the last report available, it is stated that: “there is a broad consensus that funding challenges are occurring at a time when the transportation system needs more investment. Many mobility, safety, environmental concerns, and public investment in ITS continue to compete directly with critical core maintenance and capacity needs. It is clear that greater public and private investment in ITS strategies will be necessary to realize the potential benefits”.

The report to Congress informs that a minimum of $100 million annually are allocated for awarding deployment grants, “over and above dedicated research funding”.

2.3 Current ITS deployment strategies

The overview on EU and US strategies to develop ITS services can be carried out through the comparison of two key documents:

- The European Commission Communication issued on the 30.11.2016, illustrating the European strategy for the development and take-up for C-ITS services (European Commission, 2016)
- The ITS JPO’s 2015-2019 ITS Strategic Plan, presenting a wide array of technical, policy, institutional, and organizational concepts to further develop ITS services in the US.

The former document represents an important milestone to the definition of the EU strategy for the coordinated deployment of C-ITS in Europe. The strategy outlined in the Communication aims to avoid a fragmented internal market in the field of C-ITS and create synergies between different initiatives. It also addresses the most critical issues, including cyber-security and data protection (both particularly important for public acceptance) and interoperability and recommends action at different levels to meet the 2019 and future targets.

The latter document, with reference to the US context, addresses the following aspects of a more general ITS strategy:

- identifies a vision “Transform the Way Society Moves,” and the ITS JPO’s associated mission of advancing research that cuts across all surface modes;
- outlines technology lifecycle stages and strategic themes articulating outcomes and performance goals that define six program categories;
- describes “Realizing Connected Vehicle Implementation” and “Advancing Automation” as the primary technological drivers of current and future ITS work across many sectors;
- presents enterprise data, interoperability, ITS deployment support, and emerging ITS capabilities as additional program categories that are supplemental and interdependent activities critical to achieving the program’s vision.

Furthermore, the US strategic plan further identifies research questions aligned to program categories in each stage of the technology lifecycle, in addition to cross-cutting organizational and operational disciplines that relate to the program categories.

Comparing the two strategies, the following table summarises the key differences and similarities between the EU and US strategy, denoting for the sake of simplicity the EU strategy as a “bottom-up” vs a US “top-down” approach.

The EU “bottom-up” strategy relies on the need to avoid a fragmented internal market, basically due to the different national ITS markets and players, raising the need to define and support common priorities, in order to let ITS services be deployed quickly throughout the EU by Member States and local authorities, vehicle manufacturers, road operators and the ITS industry.

On the other hand, the US “top-down” ITS strategy is based on the network of multiple federal agencies, local transportation organizations, academia, industry, trade groups, other state and local public organizations which can ensure the implementation of a top-down strategy based on the definition of priorities in advancing research, development of programmes and their adoption/monitoring.

Table 2 shows differences and similarities between the two strategies.

<table>
<tr><th>Strategies</th><th>Differences between EU and US</th><th>Similarities</th></tr>
<tr><td>EU “bottom-up” strategy</td><td>Need to define a framework of common minimum requirements for the deployment of C-ITS services, validated by all relevant stakeholders.</td><td rowspan="2">Focus on stakeholders’ involvement in the definition of the ITS strategy.

Communication and education, including training, are considered as important factors contributing to deployment acceleration. The purpose of a strong communication and education plans is to facilitate awareness, understanding, acceptance, adoption, and deployment of ITS technologies across all stakeholder groups.</td></tr>
<tr><td>US “top-down” strategy</td><td>Organizational disciplines (performance management, technology tracking), which enable the ITS JPO to react to current and emerging trends, address findings from stakeholder engagements, and stay ahead of a changing environment. They establish a structure and framework that provide guidance for decision making and actions, and at the same time are shaped by the actions taken.</td></tr>
</table>

Table 2: ITS development strategies in EU and US

3. Methodological framework

The methodology of this Deliverable firstly envisages focussing on key emerging trends and pushing forces affecting the mobility sector with the aim of justifying the selection of the ITS innovations being the object of the benchmark analysis of ITS innovation diffusion in EU and the US; subsequently, innovation diffusion factors relating to the selected ITS innovations are considered in detail and an evidence-based justification of their success or failure to penetrate the relative market is given.

To gather the data required to perform a comparison of innovation diffusion processes, Newbits D3.2 team undertook an extensive desktop-based research on relevant ITS case studies (i.e. ITS deployment initiatives) in the EU and US, which were researched from within the ITS market segments previously identified in WP2 (NEWBITS project, 2017); for information, the list of all deployment initiatives considered for the EU and US markets are included within **Appendix 1**.

Since the availability of both quantitative and qualitative data relating to the market penetration status of those ITS case studies was limited, a purely analytical benchmark methodology could not be applied; by means of a contingency plan, it was decided to assess innovation diffusion processes for certain ITS innovation areas, rather focussing on local deployment initiatives.

As a preliminary step of the comparative analysis, Section 4 includes a grounded justification for selecting those areas of innovation and provides an overview of their main characteristics.

In Section 5, with explicit reference to the selected innovation areas, technological, organisational, policy-related, financial, and regulatory factors are considered to identify key innovation diffusion determinants; furthermore, relevant recommendations boosting ITS innovation diffusion on the EU and US markets have also been formulated.

To visually represent success and failure determinants of innovation diffusion, the Lewin's force field analysis model has been used (Lewin, 1951); this is a conventional change management model widely used to understand change processes and inform decision making in organisations, specifically in planning and implementing change management programmes. Within the framework of this deliverable, such model has only been used for the purpose of representing factors enabling and restraining innovation diffusion graphically.

Lewin (1951) bases the force field analysis theory on the assumption that two sets of forces work together to keep a certain equilibrium, which either facilitate or prevent change; such equilibrium is kept with a balance of the following forces:

- **Driving forces** which influence a specific situation and work to support a pre-set objective (typical examples are changing markets, new technologies, competition, public acceptance, incentives, legislation); and
- **Restraining forces** which would prevent from achieving a defined goal or objective, by limiting the pushing effects of driving forces.

As a result, if an organisation or a social system want to achieve change, it will need to disrupt or unbalance such equilibrium by deploying specifying change management processes.

The application of the Lewin's force field analysis model to ITS innovation diffusion, as being the proposed change object of the method, has resulted in a graphical representation of forces that driving and restraining innovation diffusion; moreover, such representation has also informed the formulation of ad-hoc recommendations to achieve wider innovation diffusion.

The schematic representation of the framework methodology is shown in **¡Error! No se encuentra el origen de la referencia.**.

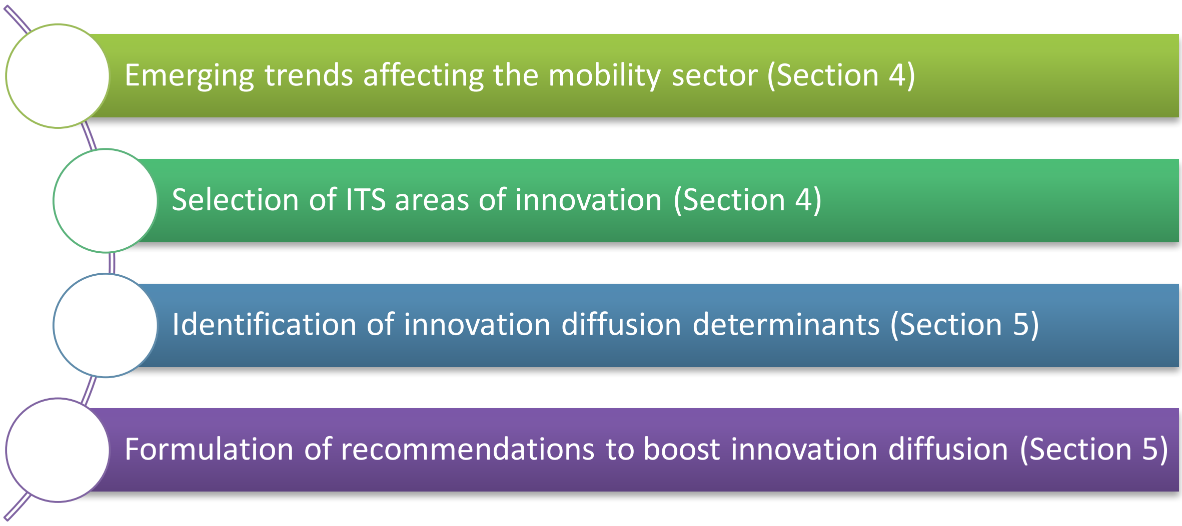

Figure 1 Schematization of framework methodology.

Source: TTS.

4. ITS innovation areas

The aim of this Section is to firstly give a concise summary of emerging trends and innovation-pushing forces in the mobility sector to provide a grounded justification for selecting the ITS innovation areas being the object of the comparative innovation diffusion analysis; subsequently, a brief overview of the main characteristics of ITS innovation areas studied has been provided.

4.1 Selection of ITS innovation areas

Mobility can be seen as a demand driven by other needs (either personal ones or influenced by societies) and understanding the critical trends and drivers dominating it, it appears to be of paramount importance to achieve sustainable and integrated mobility planning; inherently, four megatrends are impacting mobility in several cities and megacities across the globe (CIVITAS, 2016):

1. **Accessibility-over-ownership consumption culture**: in many industrialised and highly-developed countries, a new generation has emerged who are willing to use and share products or services, rather than owning or purchasing it; this concept has also been reflected in transport, where the high cost of vehicle ownership has led people to access on-demand services (such as car-sharing, bike-sharing, carpooling services and any other on-demand services) to fulfil their mobility needs in place of using their own cars;
2. **Scarcity of resources**: this trend can be expanded on a bi-dimensional scale; scarcer and more expensive raw materials are pushing prices for energy, efficient mobility services and new technologies upwards; and the lack of physical spaces and financial resources are limiting investments in new infrastructures;
3. **Digitalisation and connectivity**: the increasing innovation in ICT and its penetration in everyone's life has developed a "work anywhere, anytime" mind-set; in the transport sector, on the one side this has implied that young generations are always connected to social media and less interested in driving; on the other side, the sharing economy generation, thanks to the pervasive presence and massive use of innovation technologies, have direct and easy access to shared ownership goods;
4. **Demographic trends**: the urbanisation phenomenon of city suburbs and the demographic increase affecting many cities around the globe are forcing policy makers to seek out for intelligent mobility solutions; on the other hand, the increase of single-person households is generating a demand for individual mobility solutions to be tailored to (very) specific user needs.

For the purposes of this deliverable, D3.2 team decided to assess some of the areas of ITS innovations which diffusion may be facilitated, to a differing extent, by the trends and pushing forces introduced above, namely: **sharing mobility**, **Mobility as a Service (MaaS)**, and **connected and autonomous vehicles (CAV's)**; indeed, whilst sharing forms of mobility have mainly taken advantage from the first two trends (i.e. the spread of an accessibility-over-ownership consumption culture and the scarcity of resources), MaaS and CAV's are instead currently gaining momentum thanks to the recent ICT advancements, increased user needs/desires for connectivity and reduced user's interests in owning or driving a vehicle.

Furthermore, an important aspect considered to validate the selection of such innovation areas is that they share certain common characteristics: a) have a strong social and economic impact on every day mobility needs; b) they can be easily customized to meet specific user demands; and c) they require a minimum level of population density, modest percentages of public transport users and limited use of active travel modes (i.e. walking and cycling modes) to scale up.

4.2 Brief overview of selected ITS innovation areas

This Section provides a scan through the most relevant characteristics of the range of ITS innovations being the object of this Deliverable.

4.2.1 Sharing mobility

As established earlier, the emergence of attitudes towards sharing a product or consuming a service in replacement of ownership and purchases has both a social and economic dimension, since it provides users with increased convenience and improved access to certain products and services.

Within the mobility sector, sharing forms of mobility, such as car-sharing, bike-sharing and on-demand services, have the direct beneficial effects of reducing car ownership and usage, therefore contributing to reduce traffic congestion within cities; the use of these types of mobility services are being pushed by the belief that cars are an underused and under-optimized asset, by the large city space required to accommodate parking demands and the low levels of vehicle occupancy during commuting trips.

The ITS innovation areas of sharing mobility that are assessed in this report are car-sharing, ride-sharing, ride-sourcing and bike-sharing.

4.2.1.1 Car-sharing

The following definitions can be extrapolated from the technical literature for car-sharing:

- “Car-sharing is generally defined as short-term vehicle access among a group of members who share a vehicle fleet that is maintained, managed, and insured by a third-party organization. It is typically provided through self-service vehicle access on a 24-hour basis for short-term trips.” (Shaheen et al., 2015a)
- Car-sharing Is the behaviour of sequential short-term car access in exchange for monetary payment (Le Vine et al., 2014).

Despite the differences, the two definitions both imply the possibility for the members of a car-sharing scheme to access vehicles short-term without any intermediate action required by third-party organisations.

Free-floating and stationary car sharing are two different car sharing models that cater for specific needs; **free-floating or one-way car sharing (FFCS or OWCS)** provides for wider flexibility since vehicles can be dropped off at the end of a certain trip anywhere within a certain area, thus resulting in more flexibility for the user. They can be used for short one-way trips (mainly for shopping and leisure journey purposes) within city centres and therefore can compete with conventional taxi and new mobility providers, such as Uber and mytaxi. Since FFCS generally operates mainly within city centres, a strong cooperation with local authorities is required in order to achieve flexible parking policies and avoid any parking constraints, which would strongly limit the scope of business operations; this is the case of car2go in London which had to stop operations as it was unable to secure parking permits in all London boroughs (Deloitte, 2015a).

On the contrary, **stationary car sharing (SCS)** provides for round trips with the start and end points being the same, thus resulting in a lower flexibility for the users. However, despite this, they represent a valid alternative to replace rental cars and individual ownership; moreover, station car sharing schemes are available in small to medium size cities and rural regions and the availability of a wide range of brands and models allows meeting diversified user needs. A crucial aspect is that stationary providers are locally based and are generally backed up by public funding or third-part investors (Deloitte, 2015a).

A third car sharing model which has been gaining momentum over the last few years is the **Peer-to-Peer model (P2P)**, whereby private individuals rent their own car though an online platform in exchange for a fee; while this provides an alternative for making longer distance trips in comparison to stationary car sharing, it also competes with short-term car rentals and carpooling. Generally, the platform handles the transaction between the vehicle owner and the user community, offer insurance and also equip the car with technological device to ease vehicle access. Given the nature of P2P, users have a wide selection of vehicle brands and sizes and can only make round trips returning the vehicle to the pick-up point. The P2P market is relatively dynamic and new players, as well as financial investors, are emerging rapidly (Deloitte, 2015a).

4.2.1.2 Ride-sharing

Ride-sharing is a type of sharing mobility consisting in to adding new passengers to an existing trip; this also allows filling empty seats in somebody else's vehicles, which translates in a reduction of single-occupancy vehicles trips on the transport network. Usually, drivers sharing a destination with their riders accept riding requests in exchange for a fee from riders to compensate their time and mileage. It should also be emphasised that, with the latest advancements in mobile technology, ride-sharing can be easily planned/organised through smartphone technology and that the likelihood as a rider to find drivers headed towards a common destination has increased significantly in recent years.

Ride-sharing can materialise in the following forms (CIVITAS, 2016):

- **Carpooling:** this is a ride-sharing form typically used for commuting travel, which is generally arranged between parties; riding is normally undertaken using own vehicles in order to minimise fuel and vehicle operating costs for both parties;
- **Vanpooling:** similar to carpooling, this sharing mobility alternative is undertaken using slightly bigger vehicles in order to connect homogenous groups of commuters to/from their workplace; most frequently, vehicles are provided by employers and transport is run and managed by collective transport operators; and

- **Real-time or dynamic ride-sharing**: though an on-line telematics platform, generally accessed via a mobile application, drivers and passengers are matched based on their common destinations, before the trip starts; passengers can also be added to the trip while the trip is taking place and are expected to pay a share of the cost of the trip.

From the review of the deployment initiatives researched in the EU and US, it was evident that in several cases carpooling and vanpooling users generally have access to a wide range of benefits introduced by local authorities such as discount on parking permits, exclusive use of shared parking spaces, use of dedicated carpool or vanpool high-occupancy vehicle (HOV) lanes on the transport network, and reduced tolls.

4.2.1.3 Ride-sourcing

The concept of on-demand ride services, such as Uber and Lyft, has increased significantly over the past years giving rise to an uncertain regulatory and policy climate.

Ride-sourcing can be defined as a service which connects, through a mobile platform, a rider's request with private drivers who use their personal vehicles for undertaking the trips; the connection is based on Geographic Information Systems (GIS) and Global Positioning Systems (GPS) technologies as well as on Internet-enabled devices (typically smartphones) which allow people to organize ride-sourcing in real time (CIVITAS, 2016).

Several business models have been deployed/are being deployed and can be clustered in the following categories (Shaheen et al., 2015b):

- **Ride-sourcing services**: these are services that, using smartphone applications, are able to connect community drivers with passengers; while there are many other terms to indicate such services, typical examples include taxis, Lyft, Sidecar, uberX, as well as other more specialised services such as Lift Hero (i.e. a ride-sourcing option using certified medical personnel to safely transport elderly passengers);
- **Ride-splitting**: whilst these services allow splitting costs between drivers and passengers sharing a similar route, they also allow for dynamic changing of routes as passengers are picked up in real time. To provide an example, Lyft Line in the San Francisco Bay Area encourages passengers to congregate at selected intersections in exchange for discounted fares as a means of consolidating business operations and making the service more efficient.
- **E-hailing**: in response to a global wave of disruptions in the mobility sector, the taxi industry has also been modernising by providing phone applications to reserve a taxi ride. Typical examples of such services are Hailo, iTaxi, Arro, Curb and Freewheel.

4.2.1.4 Bike-sharing

Shaheen et al. (2015c) define bike-sharing as systems which "allow users to access bicycles on an as-needed basis from a network of stations, which are typically concentrated in urban areas. Bike-sharing stations are usually unattended and accessible at all hours, granting an on-demand mobility option. In these systems, the operators are typically responsible for bicycle maintenance, storage, and parking costs."

Bike-sharing was firstly established in Amsterdam in 1965, when a system using white painted bikes was made available for citizens; since then, bike-sharing business models have evolved significantly and bike-sharing schemes are now spread worldwide; notably, nowadays there are currently around 1000 bike-sharing schemes available worldwide, whilst as of 2014, according to Marsden et al. (2015), 414 bike-share schemes operate in Europe and only less than 50 in North America.

Such existing bike-share schemes can be grouped in (CIVITAS, 2016):

- **Dock-based systems** whereby users pick up from and return bikes to IT-enabled docks or stations located throughout a service area;
- **Dock-less or GPS-based systems** whereby the bikes are equipped with GPS devices and quite often with locks in order for them to be parked in any publicly available cycling rack in a predetermined service area;
- **Low-cost, tech-light systems:** users often sign up online and then receive a text or email with a code to open the bike's lock or access a lock box with a key; and
- **Peer-to-peer bike sharing systems** which allow users to rent or borrow bikes hourly or daily from individuals or bike rental shops.

4.2.2 Mobility as a Service

Two broad categories of travel planning services can be identified (Shaheen et al., 2015b):

- **Single-mode travel planning services** which are designed for a specific mode of transport including both public transport and routing assistance information; an ever-growing number of apps acquire real-time information on delays of bus services, road network traffic congestion and incident data to generate optimal routes for travellers based on cost, environmental impact and time indicators.
- **Multi-modal travel aggregators**: these platforms perform route planning involving different transport modes (i.e. public transport, taxi services, car-sharing, ride-sharing, on-demand ride services, cycling, walking and private vehicles) and provide ancillary services. Depending on the app considered, these platforms also give real-time information to users regarding time, costs, fuel consumption, calories burned; whilst some apps allow cyclists to add additional criteria for their route choice, such as safety or the topography of the route, other features may include the possibility to book and pay directly for third-party services.

Whilst there is no single authoritative and comprehensive classification of travel planning services, as in a crowded marketplace these are emerging and evolving continuously, a natural evolution from travel planning services provided by single transport operators towards holistic mobility integrator solutions has been depicted in Figure 2.

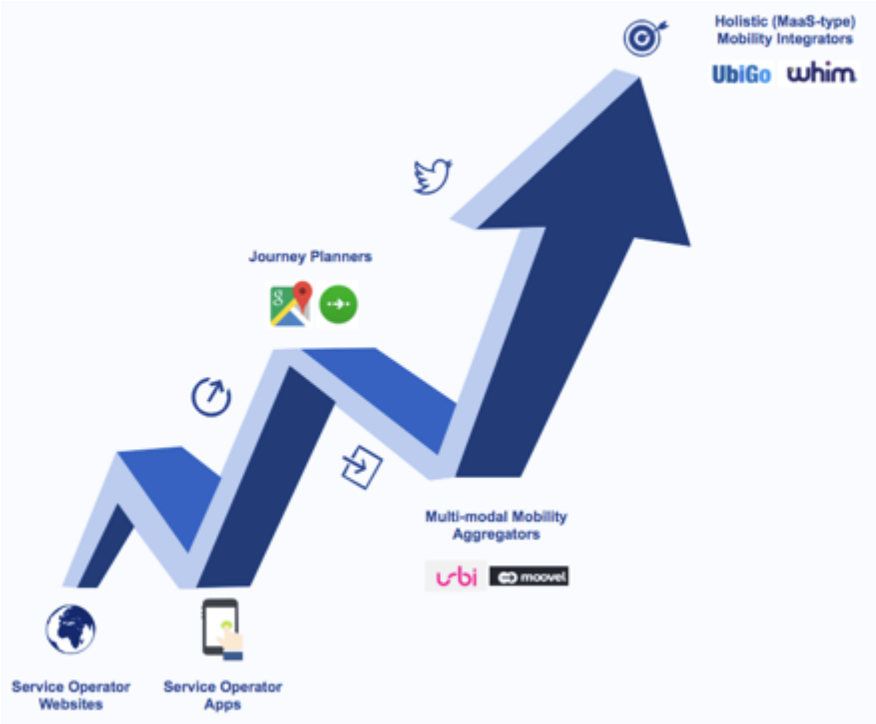

Figure 2 Evolution of travel planning services.

Source: TTS.

A natural progress of multi-modal aggregators is represented by MaaS, which can be defined as (Kamargianni et al., 2015):

"The term "Mobility as a Service" stands for buying mobility services based on consumers' needs instead of buying the means of transport. Via "Mobility as a Service" systems consumers can buy mobility services that are provided by the same or different operators by using just one platform and a single payment. The platform provides an intermodal journey planner (providing combinations of different transport modes: car-sharing, car rental, underground, rail, bus, bike--sharing, taxi), a booking system, a single payment method (single payment for all transport modes), and real-time information. MaaS users can use the Service either as Pay--As-You-Go or they can purchase mobility packages based on their or their family's needs".

It is evident that the MaaS ecosystem is made up of many actors, i.e. customers, mobility management players, telecommunication companies, payment processors, public and private transport providers, MaaS provider, data providers and local authorities with responsibilities in city planning and transport planning, who strive together for a holistic, integrated mobility ecosystem.

The intrinsic innovation standing out of MaaS is the combination of multiple actors into a single business ecosystem and the aggregation of their varied services into a single digital platform; therefore, a critical element of success for MaaS to succeed is to develop a route bringing different actors to work together, which should be elaborated in consideration of the diversified and somewhat contraposing stakeholder objectives; more specifically, synergies building such ecosystem should be fostered at various levels (Transport Systems Catapult, 2016):

- ***Infrastructure***: integration of different levels of physical infrastructure must thoroughly be designed to enable an easy transfer among different transport services; this is the area where transport planners should prepare strategies for linking up various modes (i.e. bus and subway interchanges, cycle racks and car-sharing spaces at stations);
- ***Data provider***: the data provider manages data exchange between multiple service providers; considering that individual service providers would not be willing to share their customer and service data, having a third-party actor facilitating this task eliminates a critical barrier;
- ***Transport operators***: given that currently each transport operator has its own app, or provide any other user interface platform (with its own interface and payment mechanisms), and customer bases, cooperation amongst operators and integration of their transport services are strongly required to develop a MaaS ecosystem;
- ***Mobility or MaaS operator***: this is the innovative actor within MaaS, a third-party aggregator of all private and public services which, link up the services, share the data with transport and data providers, arrange bookings and facilitate payment via a single platform.

According to Karmagianni et al. (2015), the level of cooperation required within a MaaS environment should be analysed on a case-by-case basis, however, they differentiate six levels of cooperation, contextualised using numerous MaaS examples across the globe:

1. Cooperation only in terms of providing discounts for ***combined subscriptions***;
2. ***Ticketing integration***: when one smart card can be used to access all the modes taking part in the service;
3. ***Payment integration***: when one single invoice is issued for all of the customers' mobility needs;
4. ***ICT integration***: when there is a single application or online interface that can be used to access information about the modes;
5. ***Institutional integration***: when multiple modes included in the service are owned and operated by one company; and
6. ***Integration with tailored mobility packages***: when customers can pre-pay for specific amounts (in time or distance) of each service tailored towards their needs.

4.2.3 Connected and autonomous vehicles

CAV's incorporate a range of different technologies which facilitate the safe, efficient movement of people and goods; increased connectivity allows vehicles to communicate with their surrounding environment, providing valuable information about road, traffic and weather conditions. Car manufacturers continue to explore ever-increasing levels of automation for personal vehicles.

The Society of Automotive Engineers (SAE), the automotive standardisation body, has come up with a taxonomy and classification system for autonomous vehicles, with levels 0 – 5, with 0 and 5 being 'no automation' and 'full automation' respectively (Figure 3); the four key stages of technology on the autonomy roadmap are often referred to as feet off (SAE level 1 in figure below), hands off (SAE level 2), eyes off (SAE level 3), brain off (SAE levels 4 and L5).

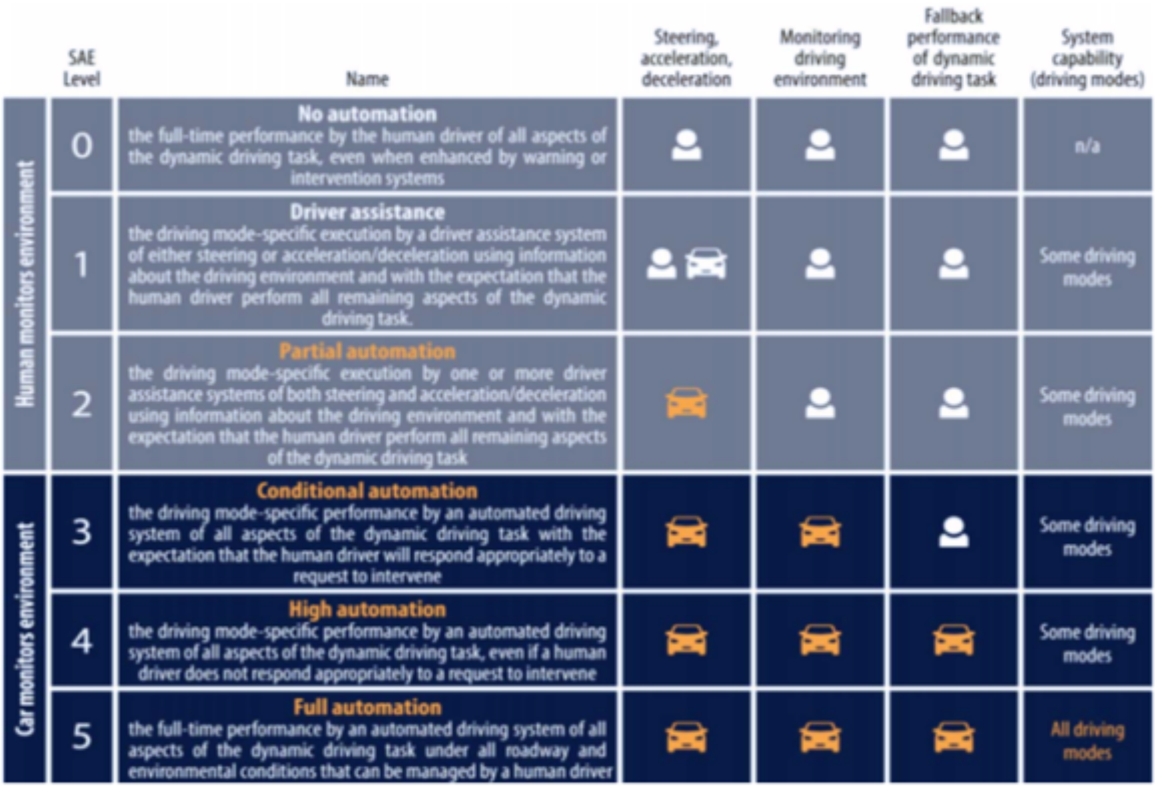

Figure 3 Levels of Automation.

Source: Automated and Autonomous Driving, OECD/ITF, 2015 (adapted from SAE Standard J3016, SAE International 2014)

In order to better distinguish between connected, automated, and autonomous vehicles, the technical literature gives the following definitions (McKinsey&Company, 2015):

- *"“**Connected car**” describes a car equipped with communication technology that allows for the direct flow of data to and from the car, without the need for a mobile device. Besides the known communication and information services from the mobile world, a connected car can communicate directly with “the cloud” to offer services such as connected navigation, including dynamic routing based on traffic, weather, or road conditions, or an automatic parking spot finder that offers directions to available parking spots. A connected car will be able to exchange information in real time with its immediate surroundings, including other vehicles (vehicle-to-vehicle; V2V) and/or infrastructural elements (vehicle-to-infrastructure; V2I). This is also an enabler for data-enhanced driving functionalities such as automatic vehicle speed adjustment in accordance with traffic flow and speed limits, or collision avoidance.*
- *“**Cars with automated functions**” offer selected functionalities where the car operates independently. These functionalities are designed to make the experience of owning and driving a car more convenient, more efficient, and safer. Possible applications could be an autopilot on highways, temporary platooning of multiple cars similar to a cycling peloton, and self-parking on private property (garage, carport). This does not necessarily relieve the driver of his/her responsibility to be in control of the vehicle at all times: he/she remains “in the loop” and in ultimate control. A car with*

automated functions does not have to be cloud-connected, as it can rely only on its sensors and actuators for selected automated functionalities as well (e.g., automated parallel parking or self-parking on private property). Nevertheless, these functionalities can be enhanced by connectivity (e.g., to adapt to the driver's routine and pull the car out every morning at 7:00 a.m. or even adapt to the meeting schedule on the driver's calendar).

- *The "**car with autonomous functions**" drives completely independently (steers, accelerates, brakes) on all roads in all circumstances. This functionality allows the car to complete tasks even without the "driver" being in the car (e.g., driving to the gas station or to a remote parking spot). Such a car relieves the driver of his/her responsibility to be in control of the vehicle and shifts the liability to the manufacturer or developer (driver is "out of the loop"). A car with autonomous functions anticipates and acts independently based on gathered internal and external information (e.g., from other vehicles (V2V), or from infrastructural elements (V2I), or directly from the cloud). This allows the car to supplement its sensory information with real- time updates about other vehicles' behaviour, traffic control, parking spots, toll gates, etc."*

5. Results of benchmark analysis

This Section analyses strengths and weaknesses of the selected ITS innovation areas in the context of the geographical and demographical characteristics of the EU and US; the benchmark analysis of ITS innovation diffusion in the EU and US has been performed through an evidence-based review of a range of indicators including finance, policy and regulations; success and failure determinants of innovation diffusion have been identified and subsequently represented through the force field analysis model described in Section 3; lastly, key recommendations accelerating innovation diffusion are formulated.

5.1 Sharing mobility

5.1.1 Car-sharing

A synthetic overview of major car-sharing players along with the high-level service model characteristics they provide is shown in Figure 4.

Figure 4 Characteristics of major car-sharing operator service models.

Source: TTS re-elaboration from Bloomberg New Energy Finance, 2016.

Interestingly, flexible car-sharing is less common than stationary car-sharing in the United States, which is contrary to what happens in Europe; however, it should be noted that one way car-sharing can attract far more members than round-trip car-sharing, although as a counterpart one-way sharing models have higher investment and operating costs, given the several hundred vehicles that are required to start up a service efficiently (Auto Rental News, 2015).

According to Shaheen et al. (2016), as of October 2014 the global B2C "car-sharing was operating in 33 Countries, five continents, and an estimated 1,531 cities with approximately

4.8 million members sharing over 104,000 vehicles. Europe, the largest car-sharing region measured by membership, accounts for 46% of worldwide membership and 56% of global fleets deployed. The world's second largest car-sharing market, North America, accounts for 34% of worldwide members and 23% of vehicle fleets".

An interesting comparison on the general market development status in Europe and the US was presented in Shaheen et al. (2016), which findings can be summarised as below:

- In Europe, in 2014 there were 2,206,884 car-sharing members (revealing a growth rate of 79% with respect to 2012), 57,947 vehicles (resulting in a growth rate of 68% in comparison to 2012) and an average member-to-vehicle ratio of 38.1; and
- In the US, in 2014 there were 1,625,652 car-sharing members (revealing a growth rate of 34% with respect to 2012), 24,210 vehicles (resulting in a growth rate of 24% in comparison to 2012) and a member-vehicle ratio of 67.1.

Notably, in North America the car-sharing market development has been following three major phases: initial market entry and experimentation (between 1994 and mid-2002), growth and market diversification (between mid-2002 and late-2007) and commercial mainstreaming (between late-2007 and today. Generally, the reasons for such a low car-share use in the US can firstly be found in the lack appropriate complementary infrastructures (mainly walking and cycling modes) and the longer commuting distance to work (but also all other journey purposes), which clearly represent important deterrents for car-sharing (Centre for Automotive Research, 2016).

Based on the current market potential, travel behaviour trends and historical growth trends mentioned above, it has been predicted that car-sharing programs in North America will reach around 3,8 million users and 50,800 vehicles by 2021 revealing a steady growth, which will decrease over time, i.e. from 23% in 2016 to 6% in terms of membership growth, due to market saturation. Conversely, in Europe by 2021 it is expected a prediction of up to around 10 million members and 242,600 vehicles, resulting in a growth slowdown from 35% in 2016 to 10% in 2021 (CAR, 2016) (Figure 5).

As a sign of the general car-sharing market saturation, commercial operators are putting in place consolidation and multi-nationalisation processes, which are generating a natural transition from a variety of not-for-profit organisations and a few established local businesses to an industry dominated by for-profit operators and large market players. This phenomenon clearly varies between countries, and an exception to this in Europe is Germany that will keep its role of market leader, i.e. in Germany a membership growth from 0,26 million users in 2012 to 3,1 million users by 2020 is indeed expected; however, despite this growth, experts do not expect vehicle ownership to decrease significantly since Germans are emotionally connected to their own vehicles and value cars from well-known brands (Deloitte, 2015).

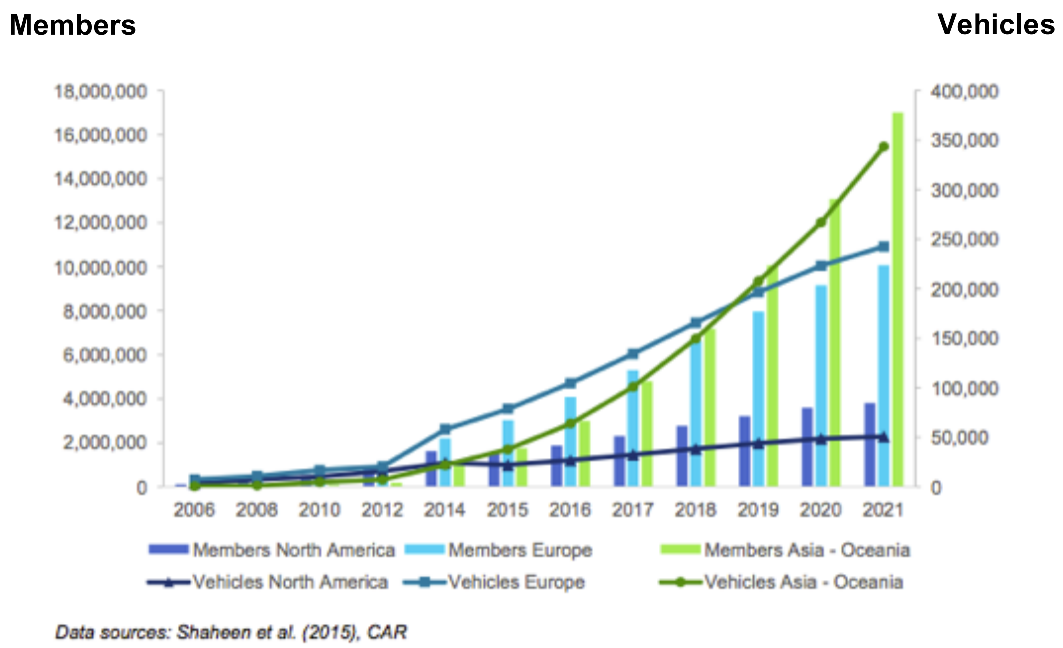

Figure 5 2006-2014 car-sharing historic growth and 2015-2021 projections in three regional markets. Source: Centre for Automotive Research, 2016.

From a practical point of view, car-sharing operators require public parking spaces within cities, which can be denied by local authorities if car sharing is not considered a viable opportunity, or its benefits are not entirely acknowledged; on the other hand, local governments could also support car-sharing by promoting investments in complementary modes, such as walking and cycling or by incentivising other shared forms of mobility; therefore, cooperation with local governments appears to be critical. Other typical factors that would hinder the next-stage innovation diffusion of car-sharing are associated with the high implementation and maintenance costs (related to the purchase of vehicle fleet and insurance costs), the lack of service flexibility to adapt to changing population density/composition and different network traffic scenarios, and high value put by customers in brand recognition (Center For Automotive Research (CAR), 2016).

Driving and restraining forces of car-sharing diffusion have been visually represented using the force field representation model in Figure 6.

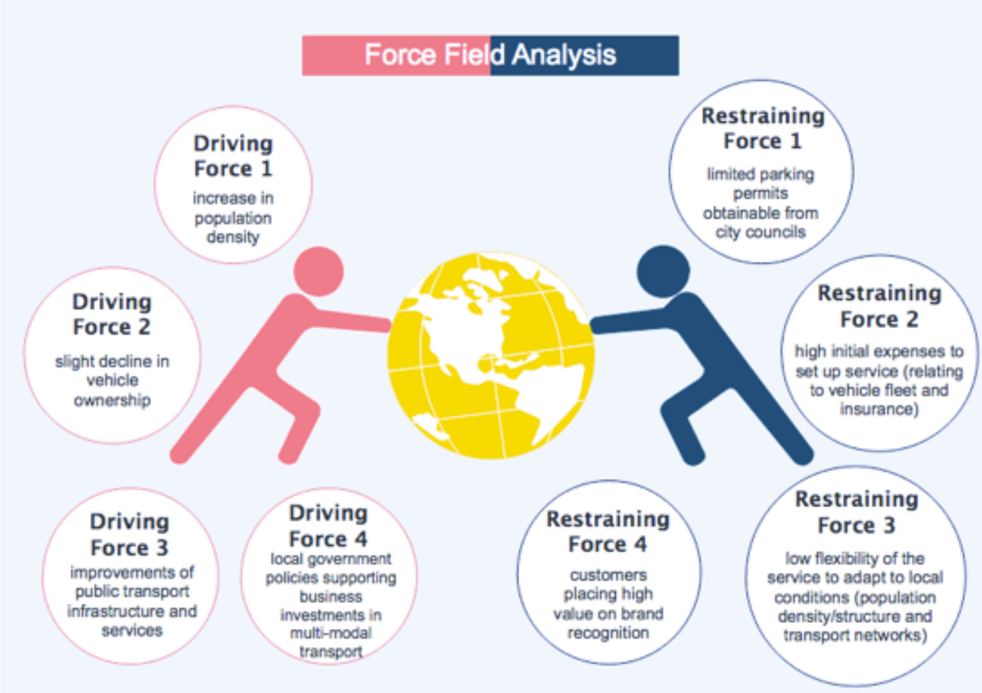

Figure 6 Output of force field analysis for car-sharing.

Source: TTS.

Drawing on the insights provided by Deloitte (2015b), A number of key recommendations have been formulated to accelerate innovation diffusion of car-sharing, based on restraining forces and threats described above.

Barrier	Suggested action to overcome barrier
Financial viability	Local funds from city governments and transport authorities could facilitate market expansion strategies.
Lack of awareness	While addressing multi-modal transport strategies, local governments and transport authorities should develop awareness raising programs to promote car-sharing as one of the available alternatives to replace private car trips.
Lack of parking spaces	Local authorities should release parking spaces at a discounted cost or for free; the lost revenue would be offset by annual fees paid by providers or by public funds saved from not investing public money in road infrastructure measures to achieve congestion reduction.
Lack of policy support	As part of their planning application processes, local authorities should require that private developers provide car spaces specifically allocated to car-sharers to allow staff and visitors to travel more sustainably to/from development sites (i.e. residential estates, business parks, health and leisure centres, etc.); local authorities should also support employers financially to establish fleet-sharing agreements with private operators.

Table 3 Suggested recommendations to achieve wider innovation diffusion of car-sharing

5.1.2 Ride-sharing

Reliable statics enabling a comparison on the current market status of ride-sharing between EU and US are hardly available.

Ride-sharing (especially long-distance ride-sharing) has grown exponentially in Europe in recent years thanks to technology advancements; catalysts were increasing systems' interoperability and data sharing functionalities among platforms and multimodal integration with other transport modes and services. In the US, ride-sharing has had a slower growth and accurate forecasts are difficult to formulate given the number, diversity and small scale of ride-sharing programmes, which in most cases are informally arranged between drivers and riders; it should also be considered that the US is not a very attractive market for operators, due to a massive presence of rural and low accessible areas and to the lack of good urban public transport infrastructure and services, which are essential for undertaking the first-and-last miles of multi-modal travels involving ride-sharing. Therefore, despite the developments in the IT sector, it is expected a much more limited growth of the ride-sharing market in the US, in comparison to market growth expectations in Europe (CAR, 2016).

A snapshot of the major ride-sharing players along with the main characteristics of the service model they provide is shown in Figure 7.

Figure 7 Characteristics of major ride-sharing operator service models.

Source: TTS re-elaboration from Bloomberg New Energy Finance, 2016.

The critical aspect in widening innovation diffusion is to overcome the critical mass barrier and this was achieved by several ride-sharing businesses operating on the market by making massive use of tracking technologies and social networks; additional elements of success are increasing interoperability and opening data sharing among platforms, incentivizing multimodal transport integration by local governments (such as extending pre-tax benefits), and additional policy-related measures such as building HOV lanes and lowering HOV toll prices (CAR, 2016).

A further success determinant is the establishment of a community of trust that would make users more comfortable in sharing a ride with other people; the sense of trust and community could be reinforced adopting peer-review mechanisms between members of the service.

A force field analysis has been undertaken to represent market-related forces driving and limiting innovation diffusion; this will inform the formulation of ad-hoc high-level recommendations to achieve wider adoption and diffusion of ride-sharing solutions (Figure 8).

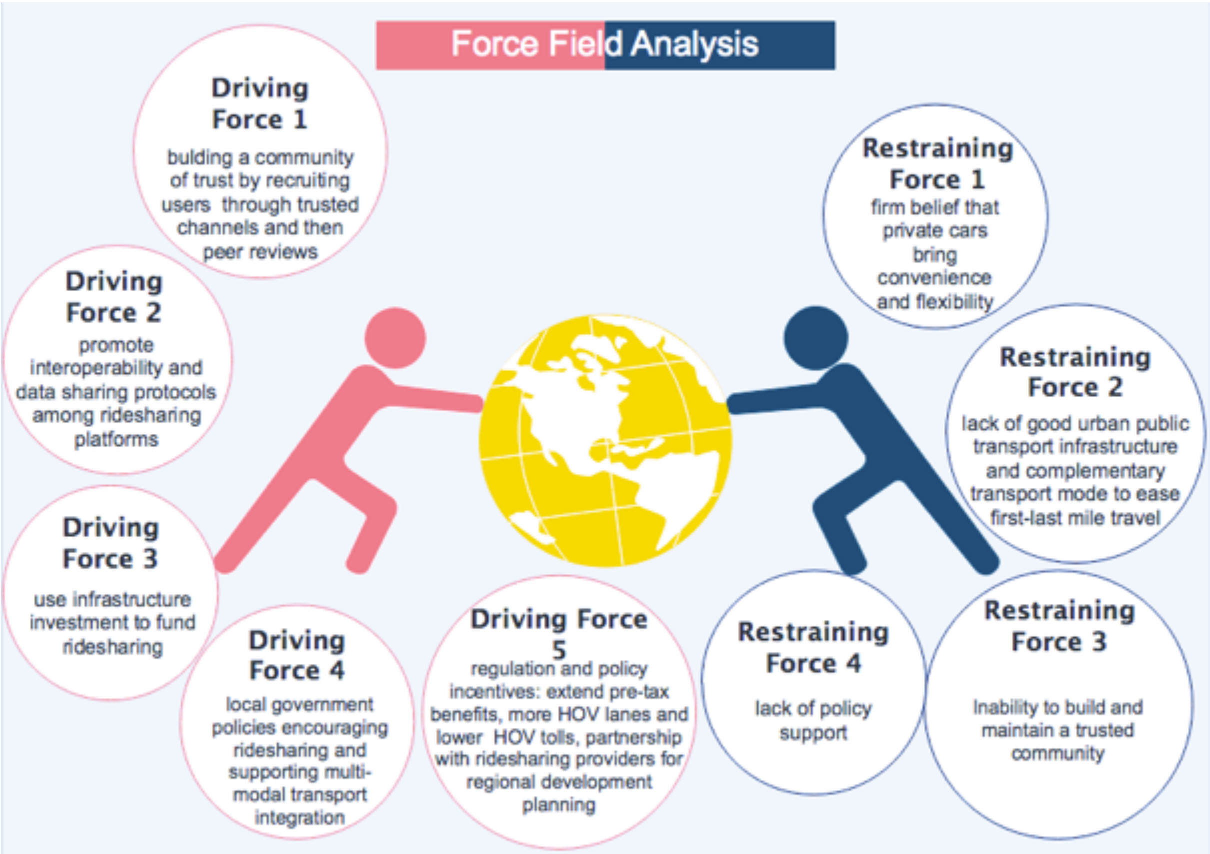

Figure 8 Output of force field analysis for ride-sharing.

Source: TTS.

Based on the insights from Deloitte (2015b), driving and restraining forces above have been translated into specific recommendations to accelerate innovation diffusion of ride-sharing solutions (Table 4).

Barrier	Recommendation to overcome barrier
Critical mass	Interoperability among ride-sharing databases and standards should be fostered to enhance open source data sharing amongst ride-sharing platforms; additional measures could also be to target young commuters and deploy a ride-sharing service along congested routes into the city.
Lack of trust	User recruitment through trusted channels (i.e. companies, universities) in an attempt to build a community of trust with people sharing same destinations.
Lack of regulatory and supporting policies	Measures like extending pre-tax benefits to ride-sharing (relating to parking, public transport passes), tax incentives for ride-sharers, HOV lanes, lower toll prices for HOV will favour ride-sharing as a valid complement to other equally sustainable forms of transport.
Lack financial support	Using infrastructure investments to fund ride-sharing platforms.
Public marketing of commercial platforms	Framework agreements between policy makers and on-demand car service providers to incentivise use of commercial platform and help achieve sustainable mobility targets set out by local governments.

Table 4 Suggested recommendations to achieve wider innovation diffusion of ride-sharing

5.1.3 Ride-sourcing

The market of on-demand ride services has been growing at a fast pace over the past years, with Uber Lyft and Sidecar, as key leading market players, creating new business models and reshaping the transport arena; the rise of such business models is also posing several concerns regarding the disruptive impact on the taxi industry, the inability to materialize congestion reduction for cities and the need for regulating a market that is rapidly reaching its saturation.

Ride-sourcing systems have expanded at a rapid pace since late 2000 globally with Uber, Lyft and Didi Chuxing leading the market; however, additional ride-sourcing companies are competing with them in congested regions of the planet. To testify the rapid expansion of this market, it notable that a large number of venture-backed start-ups have invested into ride-sourcing companies for a total of $11 billion in 2015, and total $21 billion to mid 2016 (Bloomberg New Energy Finance, 2016) (Figure 9).

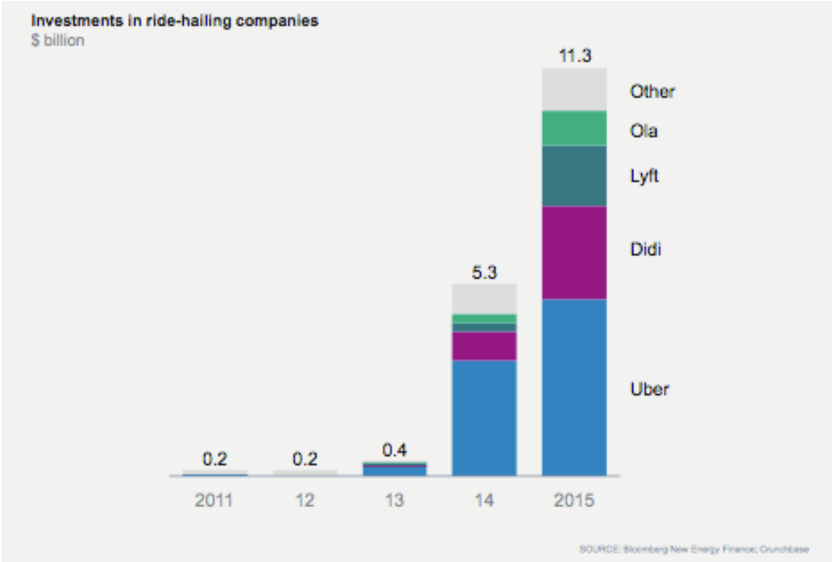

Figure 9 Investments in ride-sourcing companies.

Source: Bloomberg New Energy Finance, 2016.

A snapshot of the major ride-sourcing players along with the characteristics of the service model they provide is shown in Figure 10.

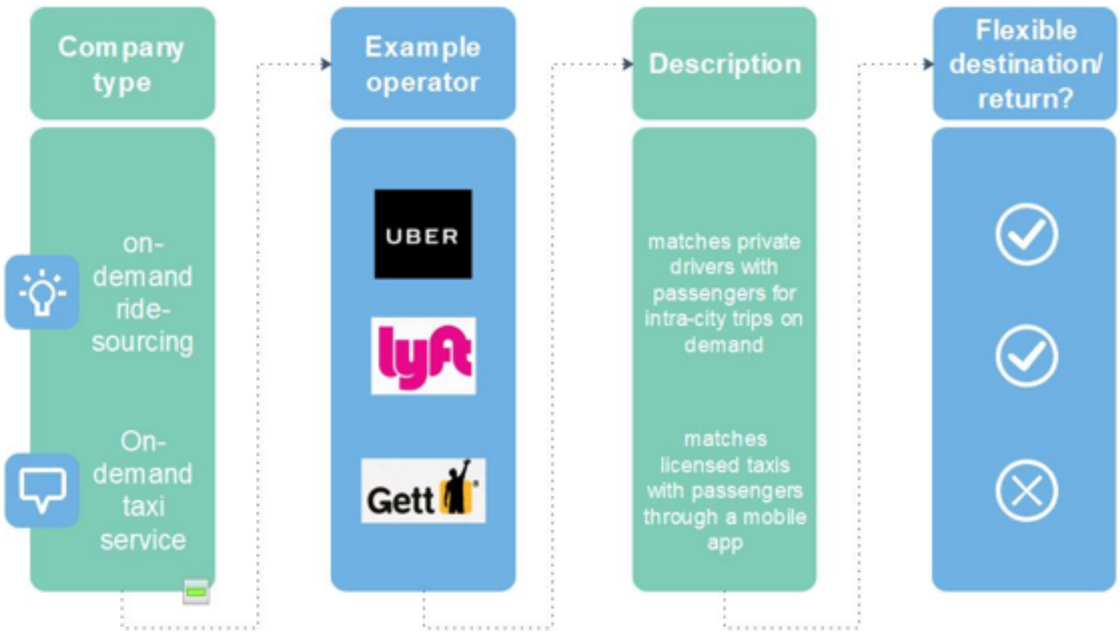

Figure 10 Characteristics of major ride-sourcing operator service models.

Source: TTS re-elaboration from Bloomberg New Energy Finance, 2016.

Ride-sourcing has experienced swift and extensive growth over the last few years; as of April 2015, Uber operated in 301 cities in 57 countries (ITS America, 2015); Rayle et al. (2016) attribute their success to the “efficiency and reliability of the matching platform and pricing mechanisms, along with the accountability of the rating system”.

Over the years, regulators across the world have been proposing legislation that would make ride-sourcing companies similar to conventional taxis; whilst this has already been accomplished for Uber (which was heralded taxi company (European Court of Justice, 2017), it is unclear whether on-demand ride services will be able to keep their fares down should such legislative and regulatory actions be implemented anytime soon. In addition to this, it has also to be considered that most ride-sourcing business models are currently challenged by exceptional costs regarding licensing fees, driver status and benefits, insurance and passenger safety (CAR, 2016).

In summary, typical success determinants for ride-sourcing services are considered to be: potentially high consumer preference towards accessing on-demand services (thanks to reduced costs in comparison to taxi services and increased convenience when compared to other transport modes), an un-regulated market, flexible and transparent pricing, rating system that develops a trusted community of users; obstacles to ride-sourcing innovation diffusion are instead identical to those presented for ride-sharing systems, given the similarities of these two types of technology, and stringent regulatory frameworks.

A force field analysis has also been undertaken for ride-sourcing to represent forces that drive and restrain innovation diffusion (Figure 11).

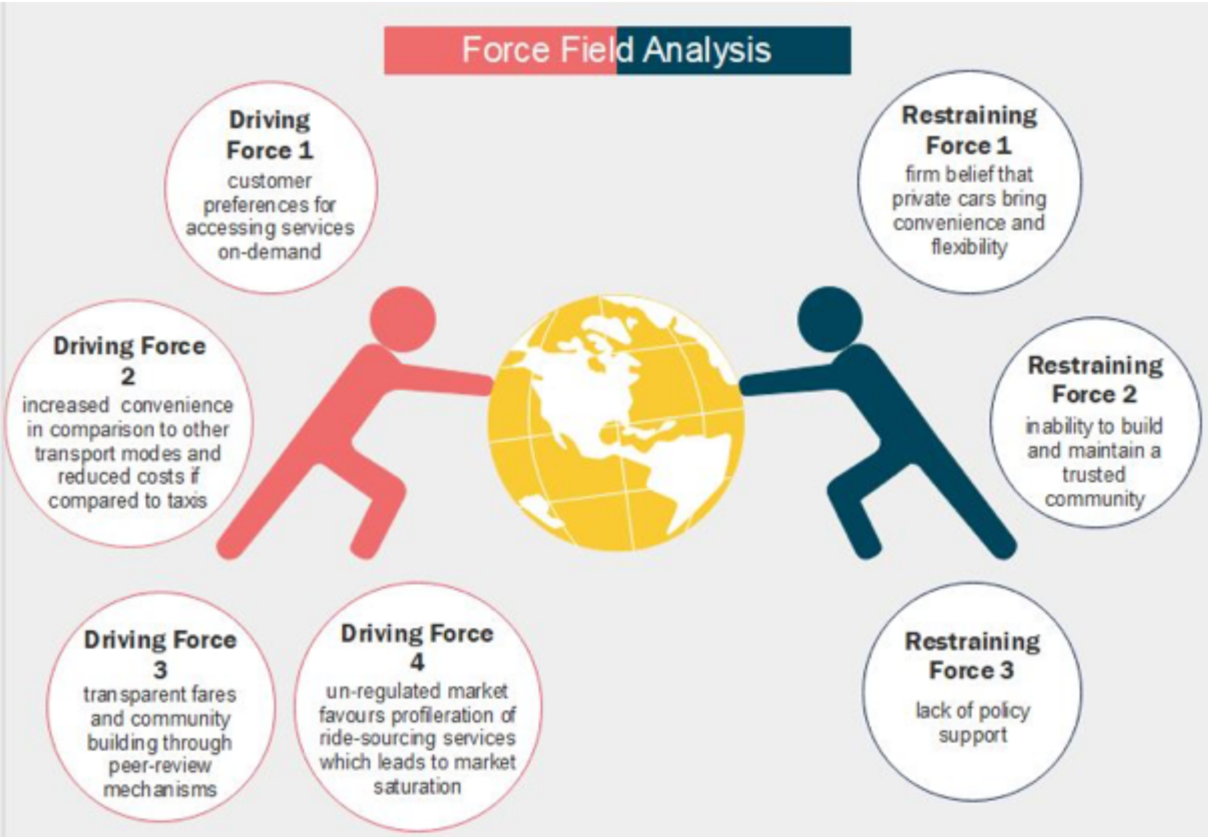

Figure 11 Output of force field analysis for ride-sharing.

Source: TTS.

Drawing on the results of the force field analysis above and insights from Deloitte (2015b), a number of key recommendations have been formulated to accelerate innovation diffusion of ride-sourcing solutions (Table 5).

Barrier	Recommendation to overcome barrier
Synergy building between local authorities and commercial providers	Interoperability among on-demand services databases and standards should be fostered to develop a synergy building effect. Local authorities should incentivise the data sharing process by enforcing taxi companies to publish taxi trip and fare data and encouraging private operators to do the same.
Lack of supporting policies	Measures such as HOV lanes and lower toll prices for HOV will favour ride-sourcing as a valid complement to other equally sustainable forms of transport.
Regulatory aspects	On-demand services should be legitimised by regulations; tax incentives for ride-sharers may also facilitate expansion strategies.

Table 5 Suggested recommendations to achieve wider innovation diffusion of ride-sourcing

5.1.4 Bike-sharing

Bike-sharing has seen an exponential growth worldwide since the beginning of 2000s, going from 13 schemes in 2004 to approximately 1000 programs in 2015 (Meddin, 2016); the countries with the largest number of bike-sharing schemes are China (237), Italy (114) and Spain (113), whereas in terms of the fleet size, Fishman estimates that at the end of 2015 the global bike-share fleet is at 1 270 000 bikes, of which 1 036 400 are available in China (Fishman, 2016).

As of 2014, according to Marsden et al. (2015), 414 bike-share schemes operate in Europe, whilst data from the US DoT shows that in 2016 the US was operating 70 bike-sharing schemes, the majority of which implemented either by city governments or not-for-profit organisations. Despite this, according to the most recent data available, in the US only 0,6% of commuters cycle to work and the reason for this can be found in the dominant car-centric culture, the lack of good cycling infrastructure, even in urban environments, and the physical barrier of a much longer commute compared to European cities (US Census Bureau, 2014).

A synthetic review of the major ride-sharing business players along with the characteristics of the service model they provide is shown in Figure 12.

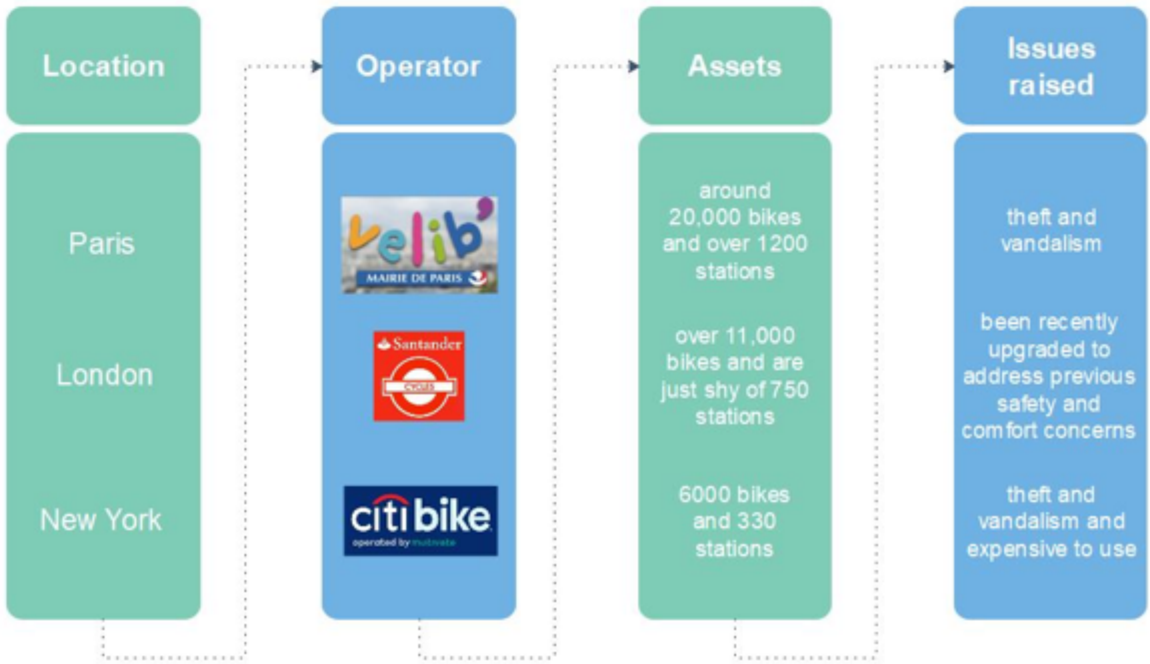

Figure 12 Characteristics of major bike-sharing operator service models.

Source: TTS.

There is little evidence available on the barriers to bike-sharing, since very little data is available for people not using bike-sharing; barriers to using and/or improving adoption of bike-sharing could be: non-users find driving too convenient; existing levels of bicycle ownership are already high; for certain destinations, a unimodal trip using own bicycles may be more convenient than a multimodal trip with public transport and shared bicycles; absence of docking stations in certain areas; safety concerns when cyclists have to drive in traffic; and if there is no immediate access to helmets at the point of departure, mandatory helmet legislation can be an important barrier (Fishman, 2016).

Typical success and failure determinants of bike-sharing schemes are shown in Figure 13, which summarises the output of a force field analysis undertaken for bike-sharing to represent forces that drive and restrain innovation diffusion.

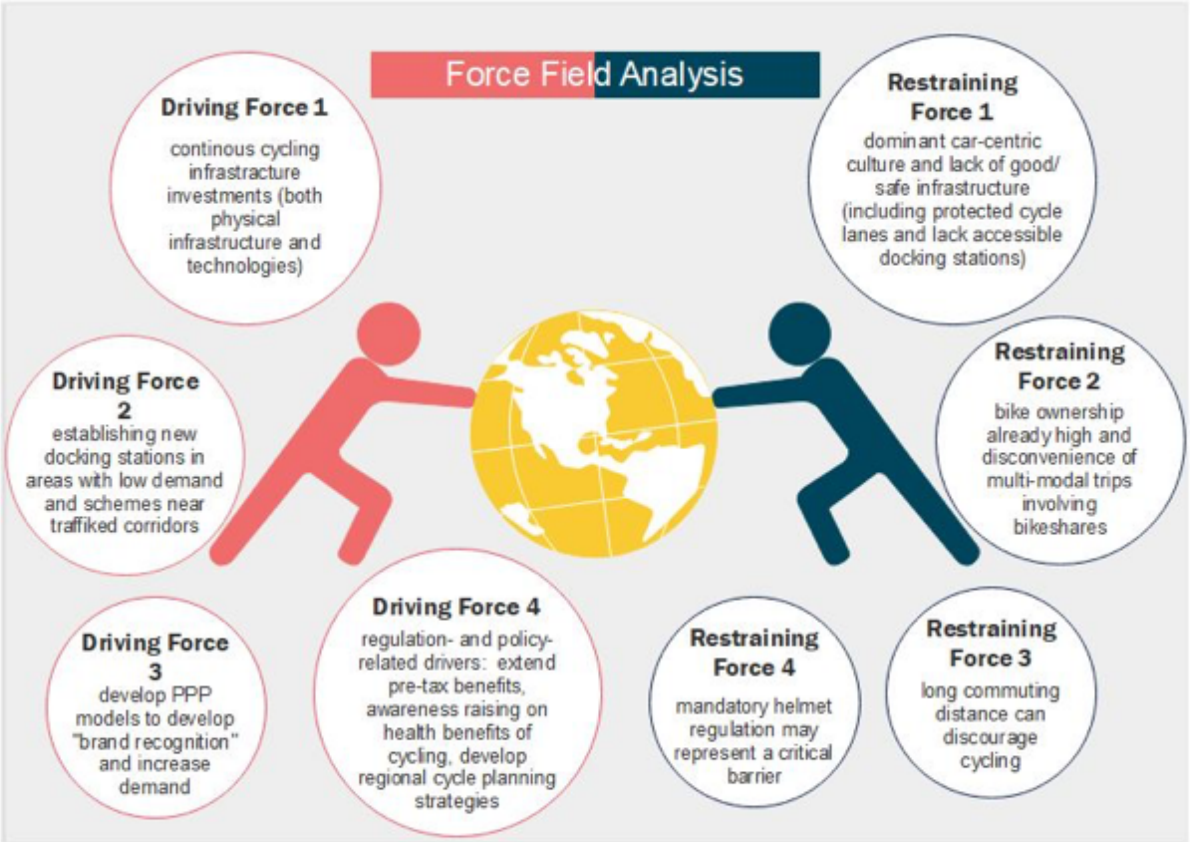

Figure 13 Output of force field analysis for bike-sharing.

Source: TTS.

Drawing on the insights provided by Deloitte (2015b), ad-hoc recommendations to accelerate innovation diffusion of bike-sharing programs have been formulated based on the analysis of the evidence described above (Table 6).

Topic area	Suggested Recommendation
Benefits awareness raising	Governments can highlight the health benefits of cycling to private individuals by establishing a direct link between bike commuting and health.
Policy support	Comprehensive cycle planning strategies should be developed by local governments as well as regional bike planning approaches aiming at connecting together the whole cycle network across different municipalities.
PPP models	Develop public-private partnerships to fund infrastructure improvements to promote diffusion of public bike-sharing services.

Topic area	Suggested Recommendation
Investment in smart cycling infrastructure	Investments in cycling infrastructure and emerging technology applications can act as catalysts of innovation diffusion; examples of this are real-time bike counters on certain routes or embedding LED lights in the pavement to alert cyclists to maintain their speed in order for them to catch up green lights at downstream intersections.
Legislation and regulatory approaches	Extending pre-tax benefits could serve as an appeal to employers. A key example of this is the Cycle to Work scheme in the UK, which while promoting healthier journeys to work and reducing environmental pollution, it allows employers to loan cycles and cyclists' safety equipment to employees as a tax-free benefit.

Table 6 Suggested recommendations to achieve wider innovation diffusion of bike-sharing

5.2 Mobility as a Service

A critical aspect to be assessed when considering MaaS innovation diffusion is the user's acceptance and willingness to pay, which could be enhanced by increasing deploying demonstrations, even with reduced scope (such as focussing exclusively on trip planning functionalities); for example, failing to implement an accurate and reliable trip planner incorporating travel information from all mobility providers within a given city and a poor user-friendly interface may result in a weak user acceptance and ultimately hinder the opportunity for MaaS to develop to the next stage of innovation adoption (MaaS Alliance, 2017).

Users, who are the focal building block of MaaS, use a number of transport services nowadays and are therefore already familiar with using new technologies to access on-demand services to satisfy their mobility needs (i.e. car-sharing, ride-sourcing and taxi apps); as such, a relevant challenge in implementing MaaS would be to make the user shift from using several apps to using a single MaaS platform to meet their demands (Voege et al., 2017); to this aim, it appears fundamental that research is conducted on the users' perspectives, acceptance and willingness to pay for MaaS services as opposed to paying for a number of mobility services individually.

In addition, making efforts to realise this shift will imply a threat for existing mobility providers (Voege et al., 2017), who operate in a business environment characterised by various market players, which compete for the same customer bases; to face this threat, collaborative synergies within MaaS should be fostered and proactive discussions involving all MaaS stakeholders should be promoted by national and local governments.

To realise a transit towards MaaS, a business ecosystem must be developed, which requires collaborative working by transport authorities, governments, transport operators and other businesses; particularly, to build a multi-actor business ecosystem, it is vital that transport and service providers share with each other access to a whole range of information in an common agreed data format (on routes, timetable, stops, prices, accessibility distances) as well as access to booking and payment interfaces; moreover, the access to travel data must also be complemented with access to in-vehicle information in a way that third-parties can establish a secure real-time connection to fleets of vehicles; this feature will give mobility operators the ability to know the status of services and vehicle at any given time and location in the transport network (MaaS Alliance, 2017).

From a technological standpoint, another essential requirement for the rapid diffusion of MaaS is an open middle-layer platform that connects the transport service providers with the MaaS operator; such platform can be managed or operated by an entity, distinct from both transport service operators and MaaS operators, who manages all data collection processes from the various service providers (including trip information, routing, and transactions) and makes such data available to MaaS operators in the form of API's (MaaS Alliance, 2017).

As an additional success determinant of innovation diffusion, regulatory uncertainties should also be addressed by defining a common set of regulations at common level to minimise the risk investments by operators and venture capitalists; complex regulatory framework different for each Country where MaaS is planned can in fact represent a threat to investing into evolving MaaS markets; furthermore, a precise set of privacy and data security rules, aiming at specifying how and for what purposes customers' data is used for, should be put in place to enhance public confidence in MaaS and relative diffusion (MaaS Alliance, 2017).

Despite a few successful MaaS solutions are currently scaling up in Europe (such as the Finnish MaaS Global's Whim solution and the Swedish counterpart UbiGo), MaaS is at its very early stages of adoption with fragmented pilots being undertaken worldwide and many more expected to come over the next few years; particularly, in the US, MaaS implementation has been limited so far due to organizational and institutional challenges, which are currently being addressed through on-going deployment initiatives.

An example of a European MaaS solution is the Whim app, which is a privately-owned (by MaaS Global company) mobility service established in 2015 in Helsinki that provides users with access to many types of transport services ranging cars to taxi, buses, trains and bike-sharing, enabling them to find the most suitable way to get to their destinations using a single integrated ticketing and payment system.

Preliminary results announced from the first **Whim** pilot (MaaS Global, 2017), run during 2016-2017 in the regions of Helsinki, Turku, Tampere and Tallinn, demonstrated that there is a high interest from users and the Whim's potential for both improving the uptake of more sustainable forms of transport and generating business opportunities for all transport service and data providers involved in the MaaS ecosystem. Furthermore, additional findings of the Finnish pilot were as follows:

- with the current costs of vehicle ownership in Finland, users' acceptance of Whim was recorded as being high and with a significant proportion of Whim users recognising the app as the best local solution to leave the private car out;

- to make a MaaS ecosystem work, contractual agreements must be procured between the MaaS operator and transport service providers, including at least public transport, taxi or taxi-like services, car-sharing and car rental services;
- as an additional basic requirement, API's (Application Programming Interfaces) would be required to set out a successful MaaS scheme in order to allow information exchange with service providers on information regarding transport services (such as timetables, routing options, vehicle locations, etc.) and details on background payment, ticketing, validation;
- *during the Finnish trial, it was also established that city financing is not needed, instead cooperation and active enabling would favour a MaaS successful scheme;*

A similar MaaS scheme is provided by **UbiGo**, which ran a six-month field operational test (FOT) undertaken with nearly 100 households in Gothenburg between November 2013 and May 2014, during which the business concept behind MaaS as a mean to lessen or eliminate the need to own a second private car was tested.

The main findings of the FOT were that UbiGo was found to be very attractive for people living in the city centres and for those owning a car and living in the city centre (of the UbiGo car owners in the city centre, 73% gave it up during the UbiGo FOT); furthermore pilot data analysis showed that, for city centre subscribers, a service such UbiGo is considered to mainly attract households in areas with (i) high availability to public transport in terms of routes and frequency and (ii) access to car-sharing within less than approximately 300 m. UbiGo was instead found less attractive for car-owning couples (of the 25% couples being single-vehicle households half of them gave up their cars) and more attractive for families with children (of car-owning families with adult children (67% of such households), 100% gave up their cars) (MAASiFiE project, 2017).

Evaluation results demonstrated that a service as UbiGo is less of an option for students and retired persons as the cost factor would play a major role for deciding against a subscription plan, which required a monthly cost of around 1200 SEK at the time of the trial (which equates to approximately 122 euros); therefore, it was concluded that UbiGo will attract users who experience the service to be an economically feasible alternative, or who consider the service as having additional benefits compared to public transport and mobility services used on their own (MAASiFiE project, 2017).

UbiGo set up limited data sharing among partners, while the business potential of the MaaS solution was retained satisfactory by all stakeholders in terms of revenues generated. However, in spite of the success obtained and the end-users being satisfied with the service, UbiGo stopped its operations after the end of the FOT due to operational difficulties in establishing a robust, successful public-private partnership among the public transport provider, the Swedish region of Gothenburg and UbiGo itself, which was presenting itself as a new private commercial service at the time of undertaking the trial (MAASiFiE project, 2017).

Compared to EU, in the US MaaS diffusion has been much more limited because of some technical, organisation and institutional challenges which have prevented the establishment of a successful MaaS ecosystem.

The following categories of challenges could be identified (NADTC, 2017):

- **Public Transport accessibility**: whilst MaaS is normally implemented in major urban areas which benefit from good geographic coverage and adequate frequency of transport services, in the US rural and small urban areas make up a large share of the territory; therefore, an overall challenge relates to the low availability of transport alternatives, funding sources and technological systems characterising such areas;
- **Challenges related to the traveller**: these include challenges to provide easy access to a suitable range of information to help travellers make informed mobility choices; to guarantee transport accessibility for older adults and disabled people; and to face the decline of taxi companies in places where low-income and disabled people rely on taxis;
- **Institutional challenges**: this category covers a variety of challenges including: a) since transport service providers have not worked together in the past, establishing a MaaS ecosystem requires a sort of internal reorganisation of their services, operations, staff and customer service activities; b) challenges relating to sharing information on services and assets with potential competitors; c) identification of a third-party subject who will act as a MaaS operator; d) access to appropriate financial instruments to cover for technology procurement, implementation and on-going operations and maintenance; and e) the lack of technology experience in organizations taking part in MaaS.
- **Operational challenges**: participation in MaaS for many public transport operators will require that they change not only the way they schedule and operate their services but also in the role of each agency in the overall transport network;
- **Technical challenges**: these are expected to be less critical than other challenges, however they include outdated or lacking infrastructure, large shares of traveller population without the ability to access MaaS services in certain areas (i.e. those without credit accounts or access to smartphones), sense of alienation and lack of technical guidance due to automation of functions for employees involved in MaaS.

Forces that would drive and restrain MaaS innovation diffusion are shown in Figure 14 below.

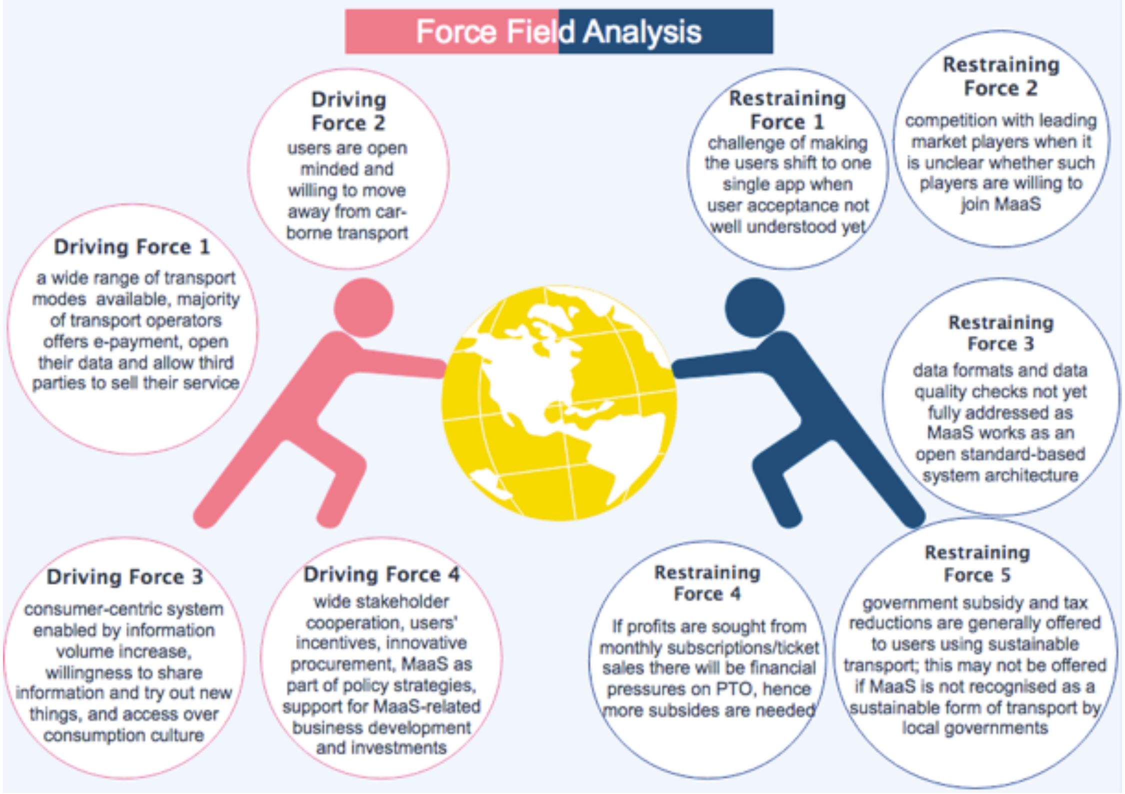

Figure 14 Output of force field analysis for MaaS.

Source: TTS.

Taking the above findings into account, some recommendations to boost innovation diffusion of MaaS across the EU and US markets have been developed (Table 7).

Barrier	Suggested action to overcome barrier
Legislation and regulation	Ensure that transparent market conditions, transport service purchase, subsidisation procedures develop to benefit MaaS operator businesses
Technical barriers	Support development of open interfaces, global interoperability and ensure necessary infrastructure for MaaS operation is in place
Financial barrier	Design instruments to finance new MaaS-related business and support international investments into MaaS solutions
User acceptance	Collect feedback and needs from users, develop awareness campaigns and provide users incentives.
Human-related	Ensure that proactive discussions and collaboration among stakeholders are always encouraged in order for a MaaS ecosystem to evolve
Lack of human expertise	Both public and private entities need to access capacity building programmes for technical and administrative staff participating in MaaS

Table 7 Suggested recommendations to achieve wider innovation diffusion of MaaS.

5.3 Connected and autonomous vehicles

The connected car market will grow significantly in the coming years; it is expected that connected cars will transform not only the way people drive, but also how vehicles are maintained and how automakers sell them. Future trends of the connected car market were analysed as part of a study called "Connected C@r 2013, undertaken jointly by Management Engineers at Strategy& and the Center of Automotive Management; through interviews with German carmakers, it was estimated that, even considering only the passenger car segment, the worldwide revenue increase coming from sales of connected cars will be 82 billion euros (i.e. from 31 billion euros in 2015 up to 113 in 2020) (Figure 15).

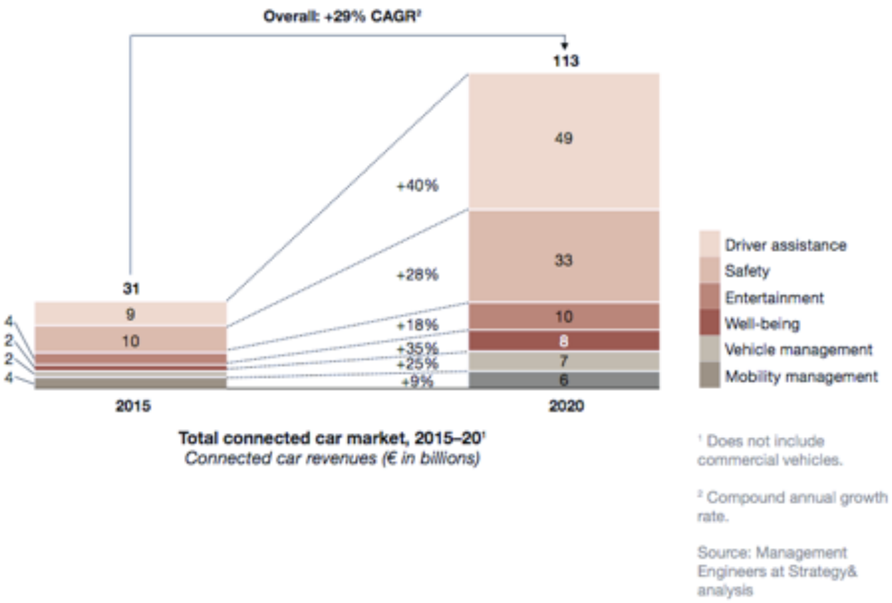

Figure 15 Total revenues in the connected car market between 2015-2020.

Source: Management Engineers at Strategy& analysis, 2013.

An Autonomous Vehicle, or 'self-driving' or driverless car, is a vehicle that is capable of sensing the environment it operates in, without direct human input. Autonomous vehicles operate using a range of technologies, including (but not exclusively) radar, GPS, computer vision and laser. They have control systems that are capable of interpreting sensory information to identify obstacles, other vehicles and signage, enabling them to navigate along (usually) pre-programmed routes. Whilst most car manufacturers are planning some level of automation of their vehicles, the major development and game-changing opportunity nowadays lies in self-driving vehicles operating in the public transport realm and the movement of goods. The economic advantages of driverless vehicles are driving investment in vehicles that can be used in transport on demand or MaaS scenarios.

Very few consumer surveys have been conducted globally to assess how consumers' behaviour might shape the future developments of autonomous driving systems. As part of a long-term study undertaken by Deloitte over the years (Deloitte, 2017) with the aim to assess consumer behaviour towards new vehicle technology, over 20,000 consumers across 17 Countries were asked about their preferences on advanced vehicle automations features; the results for US consumers, recognised globally as being one of the world's largest markets for connected vehicles application and automation, show that with respect to 2014 there has been an increased consumer's interest in adaptive safety features (from 56% to 67% of surveyed consumers), whereby the vehicle has a more proactive safety control (such as emergency braking, adaptive cruise control, and lane keeping assistance) and the driver keeps control of the driving function; similarly limited self-drive and full self-drive features have also captured a grown interest (5% and 3% increases respectively in comparison to 2014) (Deloitte, 2017) (Figure 16).

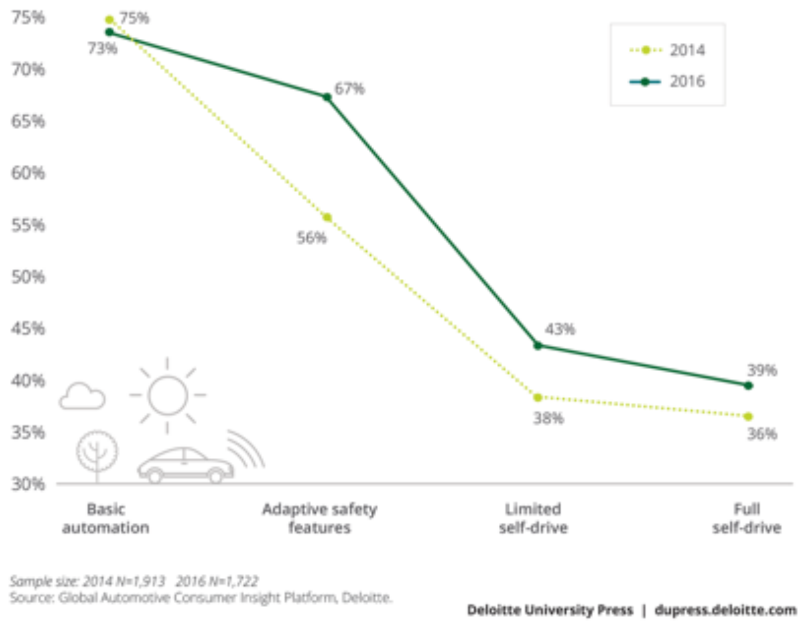

Figure 16 Percentage of US consumers interested in different levels of vehicle automation technology (2016 versus 2014).

Source: Deloitte, 2017.

This testifies that consumer interest towards increasingly vehicle drive-less capabilities is growing, but numerous challenges must be addressed which are currently tackled through several deployment initiatives currently running worldwide, with Europe and the United States playing a major lead.

A McKinsey study (McKinsey&Company, 2016) on the innovation diffusion of CAV's, which are treated as a whole thing in the remainder of this Section, predicts that, once challenges related to regulatory and legal aspects (which should comprehensively include homologation and certification, liability and ethics), safety and security and consumer acceptance are properly tackled, a high disruption scenario for full autonomy may develop, which would bring the vehicle market share of fully autonomous cars to reach 15% and nearly 90% by 2030 and 2040 respectively. In the lower level market share predicted (i.e. 15% of market uptake by 2030), it should also be considered that nearly 50% of circulating vehicles would be represented by those with conditional or better autonomy and that non-automated cars would make up the remaining 35%; this fact may pose criticism on the effective technical ability of CAV's to achieve traffic efficiency, safety and environmental benefits in presence of a road environment not solely dominated by autonomy, but formed by a mix of vehicles types characterised by differing levels of technology equipment.

The following innovation diffusion factors for CAV's are assessed in the remainder of this Section:

- User acceptance and willingness to pay;
- Data protection and cyber-security;
- Ethics and Liability; and
- Policy and regulatory issues.

- **User acceptance and willingness to pay**

In order to describe the user's level of acceptance and willingness to pay across European Countries and in the US, reference has been made to Deloitte (2017) which sought to define consumers' interest into vehicle technologies, mobility choices, willingness to pay and customer digital engagement.

As part of this study, an extensive consumer survey was undertaken in 2016 with consumers from United States (1,769 respondents), Germany (1,752 respondents), Japan (1,752 respondents), South Korea (1,759 respondents), China (1,751 respondents) and India (1,754 respondents); it was found that, despite growing interests in fully autonomous vehicles, a considerable percentage of consumers across all surveyed Countries place safety concerns in self-driving technology and this behaviour is consistent across Europe and in the United States, where surveyed consumers having safety concerns were registered at 72%-74%. Interestingly, in Europe whilst CAV's were generally retained not safe in most several European Countries (such as Belgium, France, Germany, Italy and United Kingdom, ranging from 65% to 73% of responses), CAV applications are considered to be somewhat less worrying at urban locations and considered critical from the safety point of view mainly by pre-boomers' respondents; in the US, 74% of consumers (with 77% of these being pre-boomers) consider CAVs not safe and there is no registered difference in terms of safety between urban and non-urban locations (Deloitte, 2017).

Willingness to pay for CAV will vary substantially between European Countries and US and a certain variability should be expected also within these two Continents. A significant share of consumers in the EU and US are not willing to bear the entire cost for bringing such advanced technologies to the market, even for those addressing safety issues; the amount customers are willing to pay has reduced significantly since 2014; whilst significant price drops are expected in both the US (32% reduction, from $1370 to $925) and in Europe (77% reduction, from $1590 to $360), equally in Japan where consumers tend to pay for new technologies the willingness to pay for vehicle technologies has drastically reduced in the last two years (Deloitte, 2017).

- **Data protection and cyber-security**

Interesting insights from the McKinsey Connectivity and Autonomous Driving Consumer survey undertaken worldwide in 2015 using inputs from more than 3,000 representative car customers and more than 100 executives of the automotive and automotive-related industries, have proved that consumers are well informed on data privacy matters and they are no longer reluctant to share their personal data with certain applications (McKinsey&Company, 2015).

The findings of this study can be summarised as below:

- Approximately 88% of consumers is aware that certain data (on current location, address book details and browser history for example) is openly accessible and shared with third parties and 71% of them decide to grant access to such applications;
- the top three applications that consumers around the globe would be most willing to allow access to, in return for specific services or free access to certain applications, are those related to navigation and mobility, messenger services and social media;
- notably, around 76% of respondents, under certain conditions, are willing to allow their cars to send data to third-parties to improve their product experience;
- OEM's (Original Equipment Manufacturers) are more trusted in Germany than in US or China, when it comes to data privacy.

As a result, consumer privacy represents one of the focal point to address and a topic area where the legislator will have to intervene to regulate the CAV market, for examples by establishing a precise set of rule for personal data exchange and sharing with third parties. However, as demonstrated above and despite many prejudicial expectations, data privacy is not considered to represent a critical barrier as nowadays a large proportion of customers already share significant amounts of personal data with their smartphone software manufacturer.

- **Ethics and liability**

When the CAV's become commonplace, there is likely to be a shift from personal to product liability and that will entail a rethinking for insurers and manufacturers. Indeed, it is expected that further developments in connected vehicles and their natural progression towards autonomous driving will change the insurance market drastically. Under these conditions, insurers will have to deal more with product liability insurance and need to know more about car models rather their users; there is still an open question as to where liability sits in case of accidents involving semi-autonomous cars.

From an ethics perspective, the oft-quoted 'trolley problem' which relates to the ethical dilemma of who to 'save' in an accident has been much debated (i.e. an elderly man crossing on one side or a young child crossing the road from the other side?). Many argue that this kind of ethical dilemma is largely irrelevant for self-driving vehicles. This is because humans would not necessarily be able to make the 'right' choice either, and cases where drivers face such situations are extremely rare and may be even less probable for CAV's. In summary, much of the current discussion about the ethical dilemmas of life and death decisions relating to CAV's is misplaced because it focusses on finding the 'right' decisions where no right decisions are possible, instead of realising that CAV's can get by so long as they are able to avoid making 'wrong' decisions (Hars, 2016).

- **Policy and regulatory issues**

CAV benefits sit in improving road safety, traffic efficiency reducing acoustic and environmental pollution within cities and across regions; to capitalise these benefits and support local governments to meet their sustainability agenda, a number of challenges posed by the need for regulatory actions must be overcome to foster deployment and accelerate innovation diffusion, such as enforcing that all new vehicles are equipped with C-ITS capabilities, defining open technology standards and developing comprehensive national frameworks (McKinsey&Company, 2016).

It is likely that the first fully commercial CAV operation will be in the UK or the US; this is because the UK and the US Governments have been able to develop these technologies without the restrictions in place in many other Countries, including European Countries. Unlike many other EU Countries, the UK and the US did not ratify the Vienna Convention which states that ‘a driver must be in control of their vehicle at all times’.

According to a desk-top based evidence review of CAV pilots being undertaken worldwid , it has been estimated that, as of October 2017, 55 CAV demonstration projects are currently running across the globe, most of which have started in the last 12 to 18 months, while testing activities at additional 29 cities are planned for the coming years; of the total 84 demonstration projects running (or expected to run) worldwide, 64 are running or expected to run in Europe and in the United States (Bloomberg, 2017).

Within the framework of the Bloomberg Aspen Initiative on Cities and Autonomous Vehicles, an on-line survey was undertaken with cities that are playing a substantial role in CAV deployment representing local governments that are either hosting tests, developing pilots, mobilising resources, making plans and policies, or conducting monitoring and evaluation plans for CAV’s. Survey findings reveal that city understanding of CAV technology is at an early stage of development since it was found that nearly a quarter of the surveyed cities prioritised the issue only during the preceding year of the survey, nearly half responding cities have been working on CAV’s for 12-36 months and nearly one in 10 cities for more than three years (Bloomberg, 2017).

CAV use cases vary significantly across cities in EU and the US; the top three use cases that cities value most range from last mile transit solutions, to autonomous taxi and automated freight delivery systems and this is reflected in all pilots undertaken worldwide; it is particularly noteworthy that the vast majority of surveyed cities (half of the 36 cities surveyed) are investing in CAV’s to provide last-mile travel solutions such as links between rail stations and employment centres or shuttles circulating within large campuses (Bloomberg, 2017).

An assessment of barriers undertaken for a number of pilots in EU and US has resulted in similar findings for the CAV market take-up in the EU and US:

- several cities are struggling to find human and financial capital (8 pilots and 7 pilots respectively) to commit to larger scale demonstration projects;
- In many cases, it is unclear where city support is required (7 pilots), whilst in other 6 cities key barriers are represented by a poor urgency or consensus to act on CAV deployment and a lack of national/state regulation (5 pilots);
- Demonstrations take place at several locations but are generally limited in scope, since cities are partnering with OEM’s and IT players to demonstrate benefits of

CAV's at locations that isolate CAV's from the rest of the traffic environment (such as technology parks, college campuses, urban districts) and therefore are not accounting for the full complexity and heterogeneity of an urban traffic environment.

A balance of driving and restraining market-related factors is shown in Figure 17 through the force field analysis representation model.

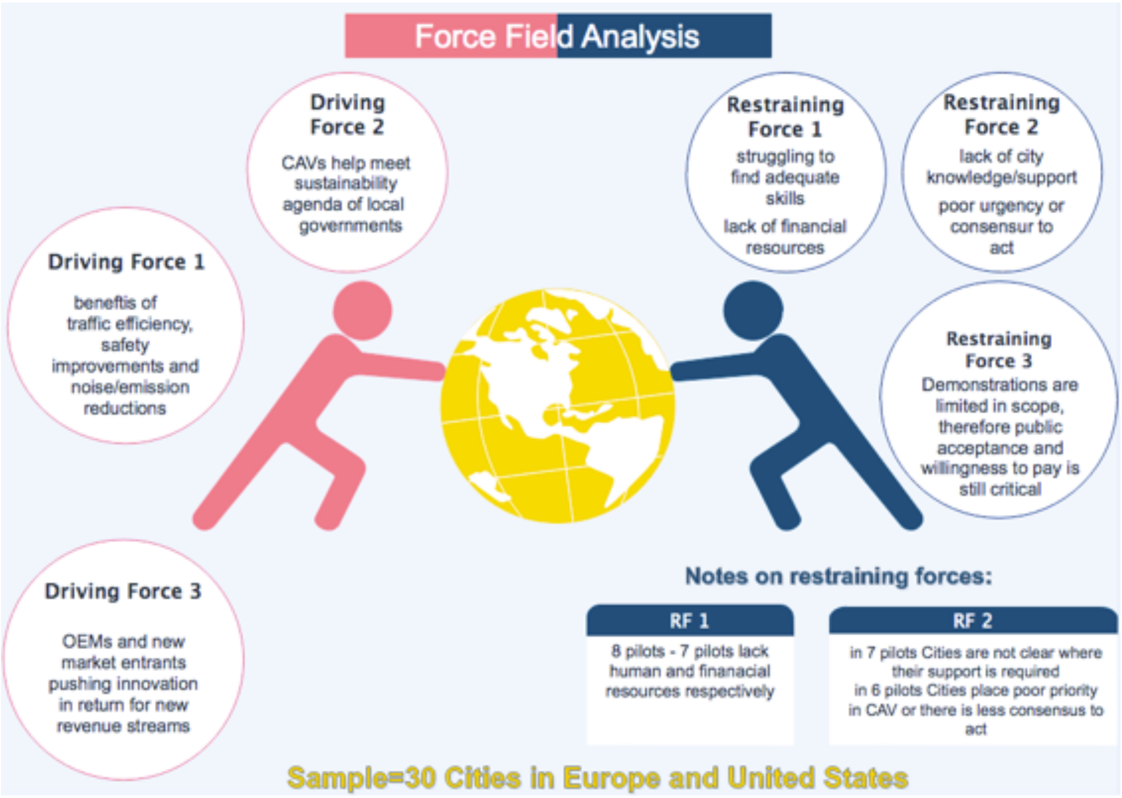

Figure 17 Output of force field analysis for CAV's.

Source: TTS.

Drawing on the findings presented above, some recommendations to boost innovation diffusion of CAV's have been formulated (Table 8).

Barrier	Suggested action to overcome barrier
User acceptance	To establish a safety track records (as part of on-going pilots) as users are more interested in advanced safety applications
Willingness to pay	Despite increasing users' interest in CAV's, there is a significantly decreased willingness to pay from both EU and US consumers, therefore costs must be improved and consensus building on CAV's developed
Data protection and cyber-security	Establishment of a precise set of rules for personal data exchange and sharing with third parties. Regulators must ensure that all testing activities for CAV's must comply with General Data Protection Regulation (GDPR);

Barrier	Suggested action to overcome barrier
	regulators must ensure that any data collected or scenarios where individuals can be identified are stringently regulated.
Technology barrier	Standardisation bodies must develop technical standards for CAV's, whilst Central Government bodies should develop national frameworks providing technological and operational conditions to develop integrated and interoperable CAV systems.
Lack of interest/priority action from policy makers	Dedicated training and awareness raising programmes on CAV benefits to inform policy makers, alongside development of guidelines for strategic city mobility planning, must be prioritised.
Regulatory issues	Regulators should mandate deployment of technologies, define open technology standards to accelerate diffusion of CAV's.
Lack of human resources	Capacity building in both the public and private domain must strongly be encouraged.
Public funding	Large scale public demonstrations of CAV applications to cover all range of operational scenarios should be funded by local governments and/or established through PPP models.

Table 8 Suggested recommendations to achieve wider innovation diffusion of CAV's.

6. Conclusions

This Section presents the main conclusions of the Deliverable, which provides a benchmark analysis of ITS innovation diffusion in the EU and US.

A brief history of ITS deployment in the EU and US as well as a description of main actors involved and policy programmes has been provided in Section 2; in the EU, main funding actors involved are the European Commission and the Member States, whereas in the US such role is covered by Federal departments of transport; in the private sector, support by associations, operators and industry actors is provided in both the EU and the US to either collaborate or establish partnerships with institutional bodies to foster ITS deployment.

Moreover, current ITS deployment strategies have been analysed and similarities and differences have also been highlighted. Notably, the EU adopts a bottom-up strategy for ITS deployment which relies on the need to avoid a fragmented market, in light of the differences among national markets and heterogeneous players within it; on the contrary, the US adopts a top-down approach which is based on a set of priories in advancing research, development of specific programmes and their adoption and monitoring, which are preliminary defined by a network of federal agencies, academia, industry, local transport organisations and so on.

In order to gather the required data to perform a benchmark analysis of ITS innovation diffusion, a large number of relevant case studies (i.e. deployment initiatives in both the EU and the US), representing ITS innovations falling under the ITS market categories previously identified within the NEWBITS project (NEWBITS, 2017), were researched by means of a desktop exercise by the NEWBITS D3.2 team; despite the large amount of information collected, the resulting evidence was retained not exhaustive to deploy an analytical benchmark method and, therefore, it was decided to focus on specific innovation areas rather than deployment initiatives.

To ground a selection of ITS innovation areas to submit to the benchmark analysis, innovation-pushing forces and megatrends affecting mobility sectors were described in Section; the selection of ITS innovation areas, sharing mobility, Mobility as a Service and connected and autonomous vehicles, has been justified by the fact that their innovation diffusion can be facilitated to a differing extent by the megatrends and pushing forces mentioned. A quick overview of the main service characteristics provided by each of those innovation areas has also been given in Section 4 of the Deliverable.

In Section 5, factors affecting ITS innovation diffusion in the EU and US have been analysed and represented through the force field model described in Section 3 (Lewin, 1951); for each area of ITS innovation considered, key recommendations accelerating innovation diffusion have also been formulated.

Within sharing mobility, car-sharing, ride-sharing, ride-sourcing and bike-sharing have been analysed.

Evidence provided shows that Europe is the largest car-sharing market measured by membership, whereas in the US the diffusion of car-sharing has been much more limited in comparison due to the lack appropriate complementary transport infrastructures and services in urban areas and the longer commuting distances. Despite this, it was predicted that the US market will have a steady growth until 2021, which will decrease over time (i.e. from 23%

in 2016 to 6% in terms of membership growth) due to market saturation; Europe will continue to keep the market leadership, although the general signs of the market saturation will be revealed by a growth slowdown up and until 2021 (i.e. from 35% in 2016 to 10% in 2021).

The major force driving innovation diffusion is the support from local authorities since, whilst operators require public parking spaces at low cost in cities in order to sustain their business operations, local authorities can also act as catalyst of innovation by investing in complementary transport infrastructure and raising awareness of car-sharing; restraining factors are high implementation and maintenance costs (related to the purchase of vehicle fleet and insurance costs), the lack of service flexibility and the high value put by customers in brand recognition.

Robust evidence on the market status of ride-sharing innovations in the EU and US could not be found, however the critical aspect to consider to boost diffusion can be found in overcoming the critical mass barrier by making massive use of tracking technologies and networks; additional elements of success are increasing interoperability and opening data sharing among platforms, incentivizing multimodal transport integration, extending pre-tax benefits, establishing a community of trusted users and developing supporting policy measures (such as building HOV lanes and lowering HOV toll prices).

Ride-sourcing has been gaining traction in recent years, giving rise to concerns regarding the impact on the taxi industry and the need for regulatory actions. The high consumer preference towards accessing on-demand services, an un-regulated market, flexible and transparent pricing, rating system represent elements for improving innovation diffusion; typical obstacles to innovation diffusion are instead identical to those considered for ride-sharing innovations.

The development of bike-sharing programmes in the US, in comparison to the EU, has been much more limited and in the majority of cases these are implemented by local authorities or not-for-profit organisations; again, the long commuting distances and the lack of complementary infrastructure may act as deterrents to cycling; whilst little evidence is available on the restraining factors, the technical literature has identified these in non-users find driving too convenient; existing levels of bicycle ownership are already high; unimodal trips using own bicycles may be more convenient; safety concerns; and mandatory helmet legislation.

MaaS is at its initial stages of diffusion in Europe, whereas in the United States organisational and institutional challenges have even prevented deployment. Based on case studies reviewed in Europe and evidence available on the challenges (mainly technical, organisational and institutional challenges) to MaaS deployment in the US, driving and restraining forces could be identified and represented graphically through the Lewin's model.

Forces driving innovation diffusion could be: user's willingness to move from a car-borne transport, wide range of transport modes available and majority of operators offering electronic payment, opening data and allowing third parties to sell their services, stakeholder cooperation, user incentives, innovative procurement and MaaS support as part of policy strategies; on the other hand, restraining forces identified are: challenges to make users using one single app, strong competitions among market players, development of data formats and quality checks not yet fully addressed, lack of provision of government subsidies and tax reduction benefits if MaaS is not supported by local governments, financial pressures on public transport operators if profits are sought from the sale of monthly subscriptions and ticket sales.

Innovation diffusion has been analysed for CAV's making use of evidence relating to a number of determining factors such as user acceptance and willingness to pay, data protection and cyber-security, ethics and liability, and policy and regulatory issues.

Despite the interests towards in-vehicle technologies, users in EU and US place both high safety concerns in CAV's and willingness to pay, even accounting national differences, has decreased significantly since 2014 (a reduction of 74% and 32% in the EU and US respectively). Data privacy is not considered a critical barrier to innovation diffusion since nowadays large proportions of customers already share significant amounts of personal data with their smartphone software manufacturer. Ethics and liability are still currently being debated in the technical literature, however it is considered that CAV will results in a shift from personal to product liability, which will impact the insurance market significantly. Further challenges are also posed by the need for regulatory actions, such as enforcing that all new vehicles are equipped with C-ITS capabilities, defining open technology standards and developing comprehensive national frameworks.

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Appendices

Appendix 1 List of ITS case studies

Table A.1.1 EU case studies

Id	Market Category	Short description of service	Deployment location	Link to initial information	Partner undertaking research
1	ATIS	Information and traffic management systems	Vitoria, Spain	Link	S2i
2	ATIS	Traffic and travel info for freight operators	Norwich, UK	Link	S2i
3	ATMS	Parking guidance system	Palma, Spain	Link	S2i
4	ATMS	Congestion monitoring and adaptive signal control system	Aalborg, Denmark	Link	S2i
5	ATMS	Mobility observatory	Funchal, Madeira	Link	S2i
6	ATMS	IT-based event-oriented traffic management system	Stuttgart	Link	S2i
7	ATPS	Mobility channel, booking and payment systems for PT	Brescia, Italy	Link	S2i
8	ATPS	Congestion charging scheme	Valletta, Malta	Link	S2i
9	APTMS	Integrated monitoring and passenger information services	Iasi, Romania	Link	S2i
10	APTMS	Fleet management system	San Sebastian, Spain	Link	S2i

11	APTMS	Mobility 2.0 services	Palma, Spain	Link	S2i
12	APTMS	Mobility Alliance	Aachen, Germany	Link (first link)	S2i
15	CVS	Connected cruise control	See fiche attached to D2.1		TTS
16	CVS	Dante	See fiche attached to D2.1		TTS
17	CVS	Freilot - TPAI		Link	TTS
18	CVS	Safecross	See fiche attached to D2.1		TTS
19	CVS	Uk Autodrive	See fiche attached to D2.1		TTS

Table A.1.2 US case studies

Id	Market Category	Short description of service	Location	Link to initial information	Partner undertaking research
1	ATIS	Parking management	St. Paul, Minnesota	Link	S2i
2	ATIS	VSL	Oakland; California	Link	S2i
3	ATIS	Smart parking management	Oakland; California	Link	S2i
4	ATIS	Traveller Information System User	Iowa	Link	S2i
5	ATIS	I-94 Smart Truck Parking information and management system	Michigan	Link	S2i
6	ATIS	SmarTrAC – traveller information system via mobile app	Various locations	Link	S2i
7	ATMS	Traffic control – signal retiming of 640 traffic signals	Oakland, Michigan	Link	S2i
8	ATMS	Traffic light synchronisation program	Boston, Texas	Link	S2i
9	ATMS	Real-time decentralized adaptive signal control system	Liberty, Pittsburgh, Pennsylvania	Link	S2i
10	ATMS	Ramp metering	Kansas City	Link	S2i
11	ATMS	Road Weather Management System - Maintenance Decision Support System	Denver, Colorado	Link	S2i

12	ATMS	Road Weather Management System - Weather Response Traffic Information System (Wx-TINFO fiche)	Michigan	Link	S2i
13	ATMS	Traffic incident management	Michigan	Link	S2i
14	APTMS	Wireless-based signal priority	Minneapolis, Minnesota	Link	S2i
15	APTMS	Real-time transit information	Tampa, Florida	Link	S2i
16	APTMS	Transit Signal Priority	Snohomish County, Washington	Link	S2i
17	APTMS	scheduling software and Automatic Vehicle Location/Mobile Data Terminals	Poinciana, Florida	Link	S2i
18	APTMS	Smart corridor project	Atlanta, Georgia	Link	S2i
19	ATPS	high- occupancy toll (HOT) lanes and priced dynamic shoulder lane (PDSL)	Minneapolis-St. Paul metropolitan area	Link	ISINNOVA
20	ATPS	Dynamic time-of-day parking meter pricing system	Los Angeles, California	Link	ISINNOVA
21	ATPS	High Occupancy Tolling	Puget Sound, Washington	Link	ISINNOVA
22	ATPS	Fee-based expressed lanes	Texas	Link	ISINNOVA
23	CVS	Pedestrian warning system (transit vehicle turning)	Portland, Oregon	Link	ISINNOVA

24	CVS	Response, Emergency Staging and Communications, Uniform Management, and Evaluation	New Orleans; Louisiana	Link	ISINNOVA
25	CVS	Integrated Dynamic Transit Operations	Columbus, Ohio	Link	ISINNOVA
26	CVS	Freight ATIS	Nationwide	Link	ISINNOVA
27	CVS	Applications for the environment (AERIS Capstone program)	Nationwide	Link	ISINNOVA
28	CVS	Tractor-trailer platooning	Uvalde, Texas	Link	ISINNOVA