# SHared automation Operating models for Worldwide adoption

# SHOW

**Grant Agreement Number: 875530**

## D16.1: Market Analysis

This report is part of a project that has received funding by the European Union's Horizon 2020 research and innovation programme under Grant Agreement number 875530

## Legal Disclaimer

# Executive Summary

D16.1 provides the most recent market developments within the connected and automated transport sector and discusses the challenges for future mobility services, the importance of data in the transport sector and the position of the SHOW project within the market.

SHOW is a truly Pan-European effort, bringing together all key stakeholder across 13 EU states, with the vision to support the deployment of shared connected and electrified automation in urban transport chains through demonstration of real-life scenarios to promote seamless and safe sustainable mobility

Transport and mobility should fully contribute to achieving the emission reduction target of 55% by 2030. The sector is at the heart of the transitions and crises to which the European Union must respond. Environmentally, the transport sector accounts for 30% of GHG emissions in Europe.

Following recent innovations, the transport sector relies increasingly on the exchange of large amounts of personal and non-personal data between multiple actors. These innovations include the development of vehicles' automated functions, connected vehicles and infrastructure, smart cities and digital mobility platforms. These solutions have led to an increase in data generation with transport operators typically generating data and technology companies processing and using these data.

Data and digitalisation provide new opportunities throughout logistics and mobility systems, and for EU citizens and businesses. Moreover, efforts to digitalise the transport sector will also contribute to achieving the EU Green Deal objectives. Nevertheless, we are acutely aware of the challenges to be overcome to unlock the potential of the data economy.

D16.1 goes into detail for different connected and automated mobility services (Public transport, car sharing, demand responsive transportation, logistics as a service and mobility as a service), taking a look for the state of art as well as market growths and trends.

As a second part, D16.1 reports on a detailed competitor analysis covering pilot sites, the automotive sector for connected, cooperative automated vehicles and projects.

When it comes to the competition of demos sites there have been plenty of tests, trials, and pilots/demos especially between 2015 and 2020. The analysis made showed that there are more than 140 identified sites, either preparing or carrying out demos and pilots in CCAV. Many of these sites have had planning and piloting in several projects and initiatives and, thus, the number of pilots and demos is remarkable. Within the automotive sector three main fields of competition exist and drive the market segments: The competition of OEMs on cooperation with big IT companies, the competition within the public transport field, as well as the competition with newly developed mobility services which are just entering the market.

In the end, competition within each mobility service is high, but all shared, cooperative mobility services combined are competing with the private car usage, especially when this is not placed in the philosophy of MaaS. The fields need to cooperate, to build local mobility ecosystems and build up upon the different advantaged to make mobility in the urban, sub-urban and even rural areas more time-efficient, comfortable, cheaper, safer and sustainable.

# Document Control Sheet

| | |
|---|---|
| **Start date of project:** | 01 January 2020 |
| **Duration:** | 48 months |
| **SHOW Del. ID & Title:** | D16.1: Market analysis |
| **Dissemination level:** | PU |
| **Relevant Activities:** | A16.1: Market Analysis |
| **Work package:** | WP16: Exploitation and economic impact assessment |
| **Lead authors:** | Holcombe, Simon (EUMO), Quaranta, Romina (T-SYSTEMS), Robinson, Mark (EUMO), Willenbrock, Ralf (T-SYSTEMS) |
| **Other authors involve** | Albert Serra, Nacho Sarrio Mercade (BAX), Matina Loukea (CERTH/HIT), Sevket Oguz Kagan Capkin (CTLUP), Pekka Eloranta, Laura Riihentupa (SITOWISE), Mihai Chirca, Antoine Perello (TRANSDEV), Klaus Grabert (T-Systems), Andras KÖRIZS (Wiener Linien) |
| **Internal Reviewers:** | Jörg Worschech (IESTA)<br>Maria Gkemou (CERTH/HIT) |
| **External Reviewers:** | N/A |
| **Actual submission date:** | 20/01/2021 |
| **Status:** | SUBMITTED |
| **File Name:** | SHOW_D16.1_Market-Analysis_SUBMITTED |

# Document Revision History

| Version | Date | Reason | Editor |
|---|---|---|---|
| 0.1 | 12/09/2020 | Initial creation | R. Quaranta (T-SYSTEMS), Simon Holcombe (EUMO) |
| 0.2 | 20/11/2020 | Input to all chapters available | All listed authors |
| 0.3 | 20/11/2020 | Version sent for internal review. | R.Quaranta, J.Worschech (T-SYSTEMS) |
| 1.0 | 01/12/2020 | Version sent for peer review. | R.Quaranta (T-SYSTEMS) |
| 2.0 | 20/01/2021 | Peer reviewed version sent for submission. | R.Quaranta (T-SYSTEMS) |
| 2.1 | 20/01/2021 | Finalisation for submission by Project Coordinator | Henriette Cornet (UITP) |

# Table of Contents

# List of Tables

# List of Figures

# Abbreviation List

| Abbreviation | Definition |
|---|---|
| ADAS | Advanced Driver Assistance Systems |
| AV | Automated Vehicle |
| CCAV | Connected and Cooperative Automated Vehicles |
| CNG | Compressed natural gas |
| CS | Here: Car Sharing |
| DRT | Demand Responsive Transport |
| EPoSS | European Platform on Smart Systems Integration |
| ERTRAC | European Road Transport Research Advisory Council |
| GDP | Gross Domestic Product |
| GHG | Green House Gas |
| KPI | Key Performance Indicator |
| LaaS | Logistics as a Service |
| MaaS | Mobility as a Service |
| OECD | Organisation for Economic Co-Operation and Development |
| OEM | Original Equipment Manufacturer |
| PSO | Parts Service Organization (But in this document: Public Transport Service Organizations) |
| PT | Public Transport |
| PTA | Public Transport Authority |
| PTO | Public Transport Operator |
| SAE | Society of Automotive Engineers |
| SPACE | Shared Personalised Automated vEhicles (UITP Project) |
| UITP | Union Internationale des Transports Publics |

# 1 Introduction

## 1.1 Purpose and structure of the document

In the future, automated and connected vehicles promise to radically transform our transport and mobility patterns. Limiting the impact of human error and basing their decision on frequently updated information, automated, connected and cooperative vehicles are expected to turn transport systems safer, cleaner and more efficient.

**Deliverable 16.1** aims to produce a detailed market analysis looking at every key market segment covered within SHOW:

- Public Transportation
- Demand Responsive Transportation
- Car Sharing
- Logistics as a Service
- Mobility as a Service

The market study gives a detailed analysis about the state of art non-automated as well as automated solutions.

Furthermore, a detailed competitor analysis will be conducted across specific criteria (indicatively: robustness, readiness, inclusiveness and integrability to the PT, anticipated impact on cities life and business models viability). The competitor analysis is structured across three different elements:

- Other demo sites beyond SHOW
- Vehicle manufacturers
- Other projects beyond SHOW

The positioning of SHOW in the CCAV market will be conducted. Based on the results of the market and competitor analysis, a detailed SWOT analysis will be conducted to be re-iterated after the end of the project. The basis for this is the initial positioning of SHOW, reflected in section 1.3.2 of the SHOW Grant Agreement (GA) and the preliminary SWOT analysis in section 2.1.5 of the SHOW GA. [1]

## 1.2 Intended Audience

The deliverable will address the relevant SHOW project partners within Consortium regarding the CAAV market covering development, evaluation, implementation and exploitation aspects during the whole duration.

This document is also written to support all those who are envisioning to use public transport as a game changer for future mobility services.

## 1.3 Interrelations

Internal:

- WP2: Business models: WP2, and in specific the since September 2020 available deliverable D2.1, assessed the first state of art of the different SHOW Use Cases and is the basis for building the business models which will continuously be reiterated within WP16.
- WP9 - A9.1 – Evaluation framework: the main relation lies in the business KPIs as input for the project evaluation and further work within WP16.

- WP15: Dissemination, Training and Multiplication: WP16 work is closely related to the activities of WP15, especially in the sense of engaging stakeholders and multiplying the results within forums and at events.

External: External stakeholders and other research institutes working on all kind of mobility solutions. Apart from being recipients of this work they will be providing relevant additional input to the existing market insights from the SHOW project perspective and ecosystem with the vision to be multipliers of the results (together with WP15 – dissemination).

## 1.4 Introduction to the CCAV Market

In the future, automated and connected vehicles promise to radically transform our transport and mobility patterns. Limiting the impacts of human error and basing their decision on frequently updated information, automated, connected and cooperative vehicles are expected to make out transport system safer, cleaner and more efficient.

At present, vehicles are increasingly connected to the internet and are equipped with more and more electro-mechanical systems and driving assistance functions which take partial control of the vehicle. As a result, policies and legislation that relate to digital technology, cybersecurity and data usage are becoming increasingly necessary in the automotive sector.

However, there remain issues of customer acceptance, especially when the time and cost of adapting to a new way if driving, safety concerns and significantly increased prices of technologies are considered. In addition, many citizens enjoy driving and find completely automated driving with no steering wheel difficult to imagine.

The key findings of the survey “Special Eurobarometer 496 – Expectations and concerns of connected and automated driving” conducted by Kantar Belgium at the request of the European Commission are as follows: [2]

Among the most frequently chosen answers, respondents think that automated vehicles will reduce the need for professional drivers and take over their jobs, but that they will also reduce accidents and travel stress. This argument is also often brought up by the demo site partners themselves, as reducing the professional and also security drivers from the car, would already make business models profitable. [3]

National public authorities are expected to be important actors in the deployment of such vehicles, followed by private companies, the EU and international organisations.

In socio-demographic terms, there are some interesting patterns that emerged during the research. To varying degrees, men are almost universally more likely to say they would feel comfortable using or being around automated vehicles than women, are more aware of them and are more inclined to try or buy such vehicles.

Some of the most consistent patterns emerge when age, education and occupation are considered. In general, the younger, more educated respondents have a more positive outlook towards automated vehicles. In addition, those in higher status occupations, such as managers and self-employed, and students tend to have a more positive view on automated vehicles than those in other occupational groups.

Overall, the results suggest respondents are not yet ready to fully adopt connected and automated vehicles. If connected and automated vehicles are set to play an important role to achieve the European policy objectives in the transport field, efforts will be needed to raise awareness of the options and their implications, and to engage citizens and build their trust with respect to this innovative type of technology.

# 2 Methodological Approach

The main objective of D16.1 is the conduct of a market analysis, consisting of three key elements, namely market research, competitor analysis and SWOT analysis. The methodology that was used for each part is described in the following chapters.

## 2.1 Market research

First of all, the market that is to be researched has to be defined. To be able to give an overview of which applications for Connected and Cooperated Autonomous Mobility (CCAM) are considered within the SHOW project, the positioning of SHOW within the CCAM market is stated.

Chapter 3 defines the market to be studied as “Connected and Cooperative Automated Public Transportation Services”. Before a thorough research of each market segment is done, the market research gives an overview of the challenges that apply for all future mobility services and points out the importance and handling of data within the transport sector. This overall analysis is done with the help of international position papers and reports, as well as the experts’ views within the Consortium.

The following key mobility segments have been identified within SHOW:

- Public Transportation,
- Demand Responsive Transportation,
- Car Sharing,
- Logistics as a Service, and
- Mobility as a Service

The following factors are analysed and stated for every market segment:

- State of the Art,
- Competitive landscape, roles and mobility drivers,
- Current and future cost structure, new revenues,
- Market growths, outlook and trends,
- Connected and Cooperative Automated Vehicles.

Different partners of the SHOW consortium have worked together to conduct a market research for their individual market segment with the help of own insights and general literature research based on their field of expertise.

## 2.2 Competitor analysis

The WP16 members developed the SHOW competitor analysis for three different parts of the project. The competitor analysis handles the competition of SHOW demonstrations with **other national and international pilots**, the competition of **SHOW and other similar research projects** in the field of shared automated transport and the competition between different categories of vehicle manufacturers, focusing on manufacturers for automated public transport (PT) shuttles.

The basis of the competitor analysis is a living excel document developed by the WP16 partners. The document is in the form of three spreadsheet and expected to be updated throughout the whole project duration and used by other WPs as input for their analyses. The spreadsheet consists of three sheets: “demo sites”, “projects” and “OEMs” mirroring the above mentioned three elements of the competitor analysis.

The factors on which the analysis is conducted, is based on the KPIs proposed from SHOW work package 9, other factors that were important to point out the similarities and differences of the different actors, based on the WP16 development.

The analysis was done with the expertise and participation of all Consortium members, as well as desktop research. The following table lists the complete factor list, which is evaluated for the competitor analysis.

**Table 1 - Factors for the competitor analysis**

| **Spreadsheet .xlsx** | **Identified factors for analysis** |
|---|---|
| Competition of SHOW demonstrations with other demo sites | • Country<br>• Type of service<br>• Vehicles<br>• SAE level<br>• Status<br>• Remote monitor (yes/no)<br>• Environment (fenced, urban, peri-urban)<br>• Integration with existing public transport<br>• Users in focus<br>• Accessibility<br>• Anticipated impact on the city life<br>• Further plans<br>• Comments<br>• Links& Contact |
| Competition of vehicle manufacturers for public transportation shuttles | • OEM name<br>• Vehicle name<br>• Type of vehicle<br>• Country<br>• Commercially available (yes/no)<br>• Amount sold/ being used<br>• SAE level<br>• Robustness of the service<br>• Readiness<br>• Remote monitoring<br>• Remote control<br>• Operational in harsh weather (yes/no)<br>• Accessibility<br>• Business model viability<br>• Further plans<br>• Comments<br>• Links& Contact |
| Competition between SHOW and other research projects | • Acronym& name<br>• Partners involved<br>• Main results<br>• SAE level<br>• Robustness of the service<br>• Readiness<br>• Integration with existing public transport<br>• Users in focus<br>• Anticipated impact on the city life<br>• Business model viability<br>• Exploitation plans and future steps<br>• Comments |

| Spreadsheet .xlsx | Identified factors for analysis |
|---|---|
| | • Links & contact |

## 2.3 SWOT analysis

SWOT analysis is a strategic planning technique, identifying core strengths, weaknesses, opportunities, and threats which lead to fact-based analysis, fresh perspectives and new ideas regarding a specific topic. Before the start of SHOW, during proposal phase, a preliminary SWOT had been conducted and is stated in the GA represented by the GA section 2.1.5. The task of the evaluation activities is to regularly revisit this SWOT assessment and update it with the insights that have been made up until this point.

SWOT assumes that strengths and weaknesses are frequently internal, while opportunities and threats are more commonly external. The name is an acronym for the four parameters the technique examines:

- **S**trengths: characteristics of the business or project that give it an advantage over others.
- **W**eaknesses: characteristics that place the business or project at a disadvantage relative to others.
- **O**pportunities: elements in the environment that the business or project could exploit to its advantage.
- **T**hreats: elements in the environment that could cause trouble for the business or project.

D16.1 has taken the initial SWOT analysis as a basis and has attempted a first update based on the work carried out by the SHOW consortium in M1-M12 regarding the use cases, business models and market expectations/impact.

# 3 Market Research

## 3.1 Positioning of the SHOW project

Connected and automated transport plays a key role in European strategies for clean, efficient, and safe (“vision zero”) transport and towards the development of the Digital Single Market. All Automated Driving-related Roadmaps and position papers, such as those of ERTRAC and EPoSS point out that electrified and automated mobility in cities is one of the most challenging milestones to be achieved during the next decade.

SHOW is a truly Pan-European effort, bringing together all key stakeholder across 13 EU states, with the vision to support the **deployment of shared connected and electrified automation in urban transport chains through demonstration of real-life scenarios** to promote **seamless and safe sustainable mobility.** Moreover, SHOW is of strategic significance for all involved actors, providing the opportunity to:

- **European OEMs of automated vehicles to:**
  - **gain industrial competitive advantage and global leadership** through the realisation of novel and innovative **reference Pilots and Use Cases** across Europe and benefit from a wealth of real operation data, to verify and optimise their vehicles and sub-systems.
  - **test enhanced functionalities** (in terms of higher sped, operating in complex environment, interfacing non-automated traffic participants, embedding AI into their vehicle controls) and further benefit from the enhanced public acceptance of their vehicles.
- **Mobility services and PT operators to get data and hands on experience form real operation under a protected environment** (supported at sites by research performers, industries, and SMEs), in order to result in **viable for them business models, as well as informed choices for future AV procurement schemes.**
- **SMEs to gain a favourable ecosystem and added value services** in future automated and shared mobility fleets, supported by an open and interoperable system Architecture, enabling dashboard and marketplace technical environment and several big data analytics and AI algorithms. The collected big data pool will constitute a valuable asset for SMEs to base upon the training of their own algorithms and set-up their future services.

Moreover, SHOW focuses on **strengthening the international cooperation in the CCAV area**, through sharing use cases, data, and experiences, with relevant major twinning initiatives (indicatively in US, South Korea, Australia, China).

Mobility services at SHOW sites are currently at TRL9 (but without automation) and at TRL 6-7 with a small number of automated vehicles, aiming at reaching a TRL8 or 9 within the project, but with automated fleets. The vehicles used are mainly from OEMs (of TRL9 but with enhanced functionalities), thus of lower TRL for the integrated – new vehicle functionalities), with very few being still at prototype level (TRL6). The TRL of all tested vehicles at each site - initial and final – is denoted at sections 1.3.5 and 1.3.6 of GA. Furthermore, the key technological components of SHOW; namely the Dashboard, the Control tower concept, the Marketplace suite, the Big Data analytics, and AI algorithms, etc. to-date at TRL6-7, will be at TRL7 at the end of the pre-demo and TRL8 during the real-life Pilots. Still, all those TRLs need to be proved in practise and revisited after SHOW filtering towards the end of the project.

## 3.2 Challenges for future mobility services

Transport and mobility should fully contribute to achieving the emission reduction target of 55% by 2030 [4]. The sector is at the heart of the transitions and crises to which the European Union must respond. Environmentally, the transport sector accounts for 30% of GHG emissions in Europe. Mobility also means freedom of movement, which is one foundation of the European project but also a major lever to meet the challenges of equity and social inclusion. On the other hand, worker mobility is at the heart of our continent's economic dynamism and must be a clear concern of the European Union. The social and economic cost of urban congestion in Europe is estimated at 270 billion euros per year [5].

**Climate change** is one of the biggest challenges of our generation, as it constitutes a fundamental threat to our way of life and to the survival of future generations; we are most likely the last generation that is able to stop the irreversible global warming before it reaches a point beyond containment.

This is very relevant for the transport sector, where $CO_2$ emissions have continued to grow over the past decade despite earlier efforts to curb emissions, especially due to vehicle use that causes roughly half of these emissions. This experience shows that technological change and moderate modal shift ambitions are not enough to transform the sector. [6]

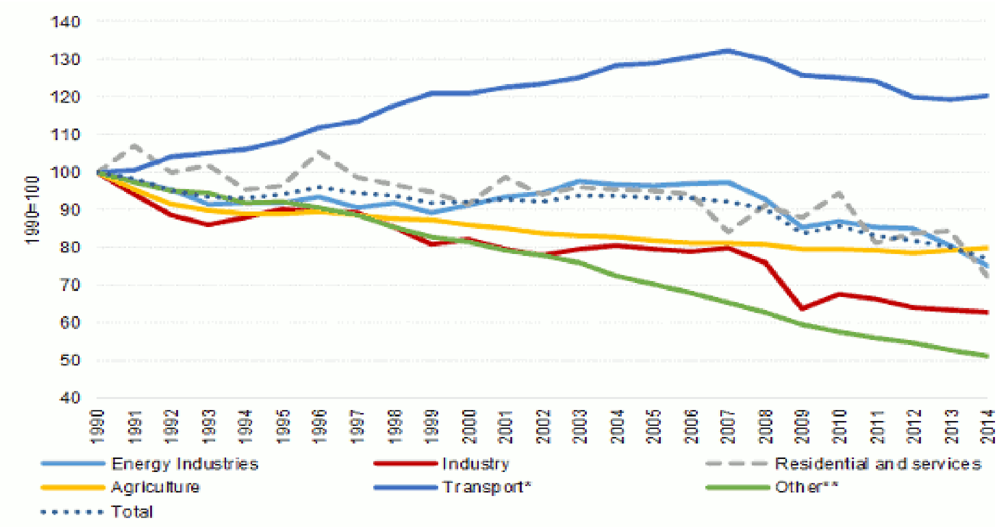



Image source: EEA, European Environment Agency, Transport emission

**Figure 1 - Greenhouse gas emissions from transport by mode.**

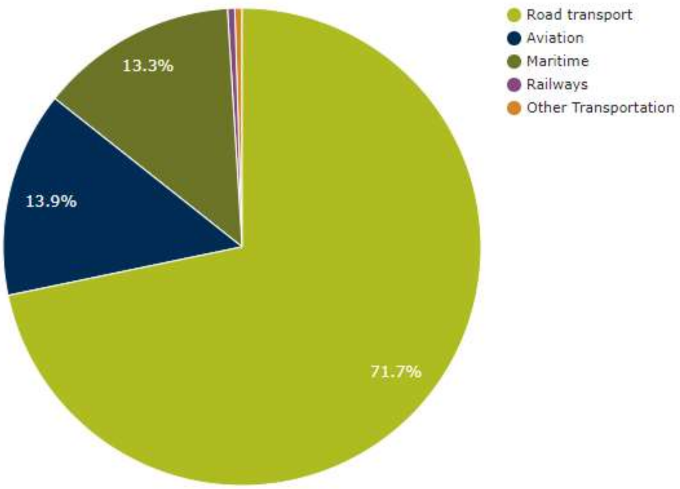



**Figure 2 - Share of transport greenhouse gas emissions [Source: EEA, European Environment Agency, Transport emission].**

This time, we should be bolder and consider all three aspects of the "avoid – shift – improve" approach.

According to the World Health Organization (WHO), **air pollution** is a big concern in many cities and has been recognised as the biggest environmental health risk in Europe. Each year in the **EU**, it causes about 400000 premature deaths and hundreds of billions of euro in health-related external costs.

Traditional fuel sources and the overall dense traffic both contribute to this problem. Congestion has been growing, both in the urban context and on the highways, costing the European economy approximately €100 billion per year.

If much of the scarce urban space is occupied by cars and other motorised vehicles, which also contribute to air pollution, this diminishes the quality of life of those living in cities. Things will get worse over time as cities grow (hence increasing the demand for transport) and when the effects of climate change are felt in cities. Working towards more quality of (urban) life, which includes a greener, more sustainable, and fair distribution of urban space and significantly improving air quality, should be one of the central topics for the mobility strategy.

The **COVID-19 pandemic** has shaken up our daily lives. For weeks and months, physical meetings and leisure activities have been reduced to a minimum. Public transport was heavily impacted – losing up to 90 percent of its ridership and farebox revenues – and will continue for a long while to feel the effect of citizens' fear of using mass transport.

In Europe, farebox revenue losses in urban and local public transport amount to €40 billion until the end of 2020. Political and financial support from the EU towards public transport is vital to reduce these losses and ensure that public transport is at the core of sustainable recovery in Europe. It is key to avoid a post-crisis modal shift towards private cars. Our sector therefore needs new concepts that will allow people to use public transport again in complete safety, as well as concepts preparing the sector for future pandemics and similarly disruptive events.

**Unsecure financing of mobility services** may put future investments at risk. Tight public budgets aggravated by the current economic crisis, reduced income from fuel taxes due to the expected shift to alternative fuels, uncertain income from other taxes, and the hesitation of authorities to establish local road tolling systems and to earmark income for public transport, all together contribute to a situation of unsecure financing beyond the next decade. However, long-term financial planning and commitment to public transport is vital for the sector.

**Digitalisation** is both an opportunity and a challenge for the transport sector. Many customers are or want to be constantly connected, while others are not. New players enter the mobility market with IT-based offers, challenging established transport companies; some of them are enriching citizens' mobility options with new sustainable travel tools that can be complementary to and integrated with mass transit systems. Data sharing and open data policies affect business models and can distort competition between several types of service providers, unless a fair level playing field is assured.

In Europe and elsewhere in the world, the **social division** is growing – a situation that has become even more severe during the COVID-19 crisis. The level of income affects the variety of mobility choices and the level of certainty about reaching one's destination. To strengthen social cohesion, it is important to offer affordable, shared, and reliable mobility choices to all citizens. Public services play a key role for this.

Another societal trend to be mindful of is **demographic change**, with the share of elderly people in the population growing over the next decade. Likewise, in order to achieve a fully inclusive society, all private and public transport services should be accessible for **persons with disabilities and with reduced mobility** to the extent possible.

**Mobility in rural areas** is currently a problem, as the public transport network is not very dense, there are often only few links to larger cities, and citizens living in these areas rely quite heavily on their private car. In order to provide equal opportunities and access to mobility services, the rural areas and suburbs require special attention.

Despite lots of initiatives to attract new and qualified employees, the public transport sector experiences a **shortage of staff**. Considering that the public transport sector is forecast to grow and cater for more passengers in the future, the need for new employees in the companies will continue to grow as well – and if not met, will slow down the shift to sustainable public transport.

Similarly, **automation** is an opportunity as much as it is a challenge for future mobility systems. Urban rail automation is well advanced and highly successful. **Autonomous road vehicles present huge opportunities when integrated into an effective local public transport network.**

The risk is that, if the private use of fully autonomous (electric) cars becomes prevalent, cities will face an increase of traffic and congestion, as the cost of circulating in the streets will be close to zero. It will be important for local authorities to anticipate this and to encourage shared mobility, limit single car occupancy, and to consider road tolls in order to put a price on traffic. [7]

## 3.3 Public Transport

### 3.3.1 State of the art

#### 3.3.1.1 Why do we need public transportation?

The role of public transport is to provide people with mobility and access to employment, education, retail, health, and recreational facilities, as well as community facilities.

But the public transport is in continuous change, the urban mobility landscape is evolving fast and novel solutions are being offered to citizens all over the world: From e-scooters, to bike- car- and ridesharing to the rise of (e-)cycling and ride-hailing. The number of mobility services are growing rapidly, and especially in larger cities. Is this the mobility revolution everyone is talking about? Or are these niche services publicised by the media and huge capital investments? And how should public authorities and local public transport companies act in response?

But before responding to all these questions, we propose to review the whole landscape of the mobility. As shown in the chart below, urban passenger transport modes can be classified according to their accessibility (public vs. private) or their use (collective vs. individual). We once limited the definition of public transport to mass transit, combining public access and collective use, but it is only one element of that definition, which now embraces every collective or shared mobility solutions. In other words, public transport should include all collective and shared modes.


**Figure 3 - Redefining Public Transport [Source: Transdev].**

In this landscape the autonomous mobility can be in different “boxes.” We might have:

- Private access & Individual use: individual automated car;
- Public access & individual use: robo-taxi;
- Public access & collective use:
    - Mass public transport: automated metro, automated bus, automated BRT, automated train;
    - Automated Demand Responsive Transport;
    - Robo-taxi;

The research and the industry stakeholders focus on the vision of automated vehicles going everywhere and after the first years of research a solution is to be found. The philosophy is that the ADAS systems became increasingly complex and the vehicle reach progressively a more complete SAE level until reaching the level 4/5. In the above figure, this is called the “Horizontal Path”.

What completely changed in the last years is the philosophy that the vehicle should be directly level 4 SAE but in a delimited area (the “vertical path”). Considering this approach, new services can be developed using robo-taxi or automated shuttles or automated buses.

**Public transport offers the quickest development path to full autonomy because it can start operating in a limited area**.

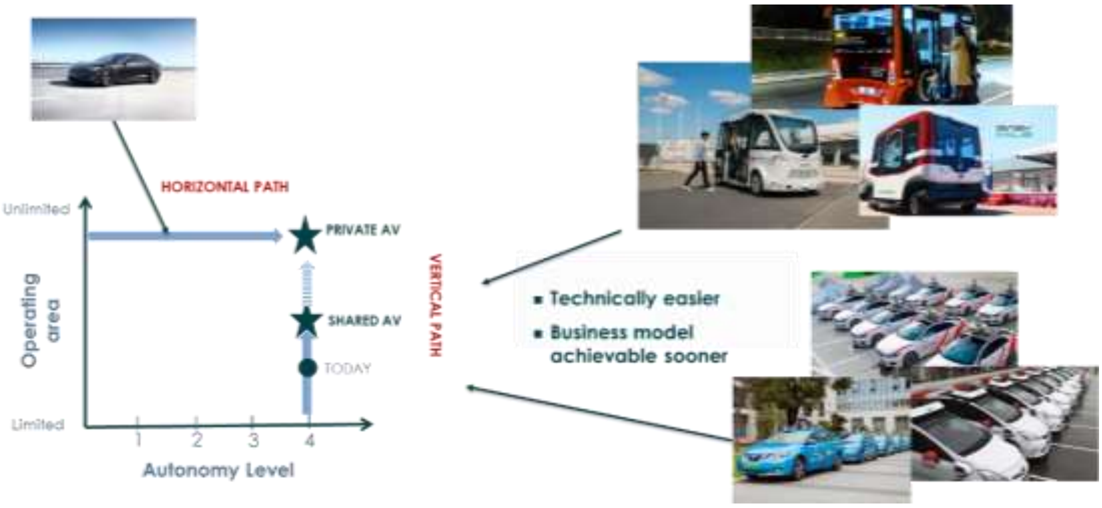



**Figure 4 - Different approaches for the development of automated driving vehicles [Source: Transdev].**

Recent studies by MIT (New York), ITF (Lisbon) and the VDV (Stuttgart) have shown that it would be possible to take every citizen to their destination with at least 80% fewer cars! Removing four out of every five cars would have a significant positive impact on cities and it affects not only the environment, traffic efficiency, and parking but also frees up a lot of urban space. In many cities, on-street parking accounts for a vast amount of land, which could be freed for other uses.

Fewer cars would also lower the cost of building and maintaining roads and generate less noise whilst having a smaller environmental impact. Driving patterns of vehicles could be algorithmically optimised, but most importantly: self-driving vehicles would also provide much safer roads as today 1.2 million worldwide a year die in automobile-related deaths and 90% of the accidents are due to human error.

But this will only happen if AVs are introduced in fleets of driverless shared automated vehicles of varied sizes reinforcing an efficient high-capacity public transport network supporting walking and cycling. Indeed, the above-mentioned studies clearly state that these results are only obtained if automated vehicles are shared and they complement an efficient high-capacity public transport system. Public transport is and remains the only solution able to fulfil the lion’s share of trips by using a minimum amount of space in dense urban environments and enabling people to travel in a time-efficient manner [8].

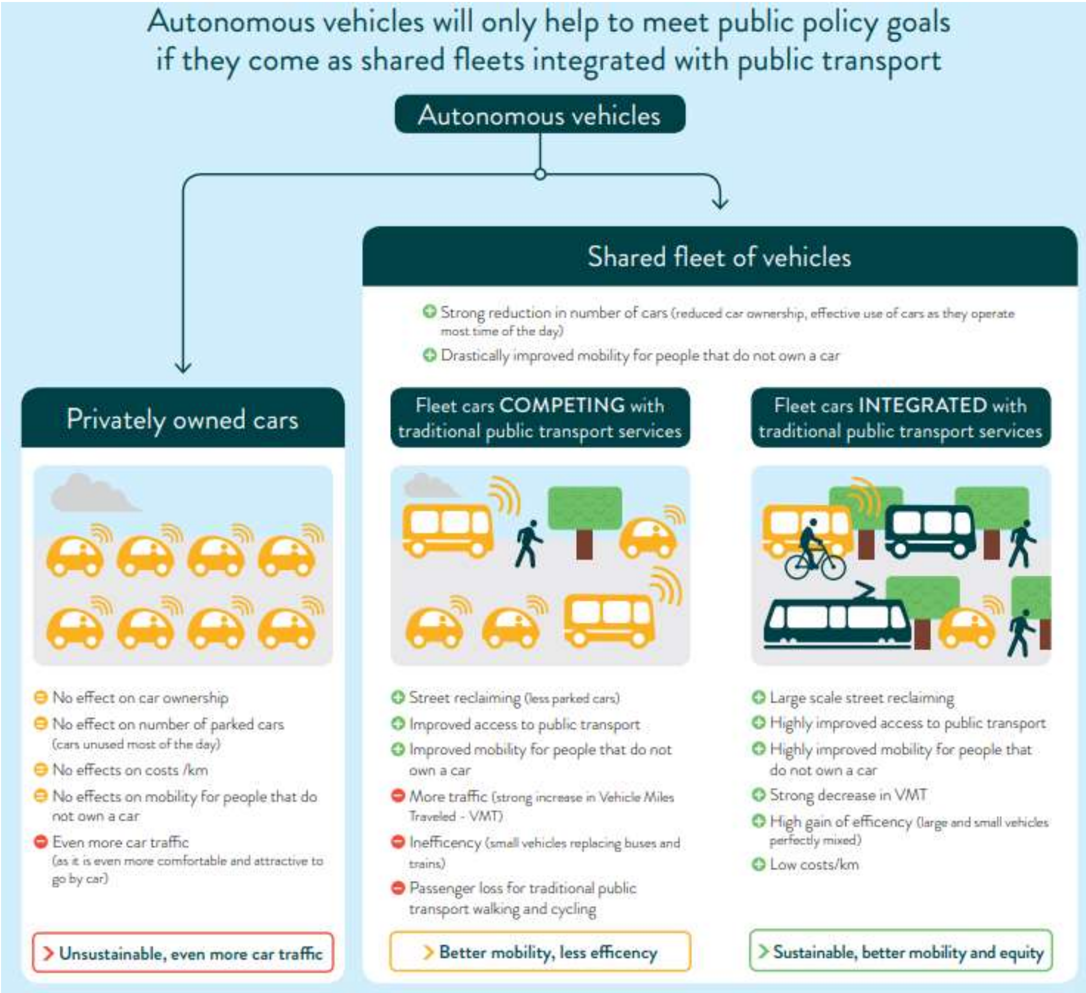



**Figure 5 - The importance of shared Automated vehicle fleets in public transport, by ERTRAC [Source: UITP, Autonomous Vehicles: A potential game changer for urban mobility. Brussels: International Association of Public Transport].**

### 3.3.1.2 The role of public transportation in the overall mobility landscape

In 2030, a little less than ten years from now, about 60% of the world population will live in cities. With this increasingly rapid urbanisation process, metropolitan areas will have to rely on their best assets to address the threats and seize opportunities.

With the increase of urban population inevitably comes an increase of mobility demand. Large public transport infrastructures are, more than ever, needed everywhere in the world and we are witnessing a global movement towards the construction of mass public transport systems. From the Grand Paris Express to Moscow metro extension, from London Cross Rail to the six metro lines of Riyadh being built simultaneously, from the AUD 30 Billion investment in Melbourne public transport system to the 100 metro lines built in China during the last ten years, major projects are developed on all continents.


**Figure 6 - Public Transport in Europe [Source: UITP, Climate Action Manifesto].**

A large public transport infrastructure is essential; it is the only sustainable and efficient way to move large numbers of citizens. It is and will remain the backbone around which sustainable mobility solutions will thrive.


**Figure 7 - Public Transportation for a sustainable future [Source: UITP, Climate Action Manifesto].**

However, delivery timelines are an important challenge, and the stakeholders are compelled to find ways to shorten these, like the economic and social growth of our cities, and the empowerment of the people that live in them depends on it.

Large public transport projects are not the only answer to demand for more efficient mobility solutions. Digitalisation has accelerated the trends towards a sharing economy, which is bound to play an essential role in the future of urban transport. Car/Bike/Scooter-sharing, Ride-hailing, demand-responsive transport, and other flexible and shared modes are increasing their presence in our urban landscape. Their usage will only grow, slowly replacing individual vehicles.

For the first time in over a century, car ownership is no longer a synonym of freedom for urban dwellers. On the contrary, individual cars are becoming an economic and social burden in cities. Digitalisation and the sharing economy have changed the paradigm: from transport to service, from supply-led to on-demand transport, from ready-made to tailor-made. We have a diversity of transport options available, which allows to build mobility packages according to the needs of passengers, making mobility options more diverse and cheaper … **Mobility becomes a service**!

This is made possible by the development of innovative solutions introduced by new actors coming from different sectors: IT, media, automotive industry, banking etc. They generate mobility products with an added value that everyone wants to harness.

On the other hand, many of those who were once considered as "conventional" operators have left their local playing field to provide services in cities on other continents. They are also diversifying their services through targeted partnerships with start-ups and new mobility players. It is the strength emerging from this collaboration that will bring the much-needed shift from car-oriented cities to sustainable mobility-oriented cities – to the benefits of the populations and urban environments. [9]

#### 3.3.1.3 Framework for the public passenger services in the EU

**Public Service Organisations**, or PSOs, gave their name to Regulation (EC) No 1370/2007 of the European Parliament and of the Council of 23 October 2007 on public passenger transport services by rail and by road. This Regulation is at the core of how all public transport services are organised across the EU Member States, Norway and Switzerland.

Here we look at the historical context of the market's organisation in Europe, the resulting adoption of the PSO Regulation, the diversity of situations that have flourished in Europe and finally the latest revision of the Regulation and its consequences for the railway market.

To understand the organisation of the public transport market one must start with the players. At its core, the organisation of public transport requires two players: the organising authority (public transport authority – PTA) and the operator (public transport operator – PTO).

**The PTA organises the service**: it decides where the transport lines run, where they stop, at what times and for what price. The PTA is also called the "competent authority" and will vary depending on the institutional and administrative structure of each Member State. In some, the local competent authority will be the city, in others a regional entity or another specific intermediate administrative level.

**The PTO runs the service**. As its name suggests, the PTO operates the service on behalf of the PTA. Based on service requirements laid down by the PTA, the PTO actually runs the lines, takes care of the overall maintenance and in some cases even acquires the rolling stock. Crucially, the PTO also hires and manages the staff. The PTO's exact role will vary depending on the Member State and on the contract with the PTA.

The PTA and PTO can be the same body, or two different entities.

**Reinforcement of the legislative framework: adopting the PSO Regulation**

Essentially, Regulation 1370/2007 does three things:

- It makes public service contracts almost always compulsory and defines their minimum content;
- It defines which award procedures for public service contracts are allowed;
- It establishes specific State Aid rules applicable to the public transport sector.

In 2007, the European Commission became convinced by the necessity to revise and complement the existing European legislation pertaining to the awarding of exclusive rights and financial support in the public transport sector. The result of this belief was the publication of the EU Regulation 1370/2007.

In order to summarise it briefly, one could say that the Regulation starts from the point of view that the free-market competition is the reference situation. When this institutional framework is in place, the Regulation does not apply. However, if a transport authority wants to realise more transport services than what appears from pure 'free market' commercial possibilities, for example for realising additional 'public services obligations' that an operator would not provide based on its own commercial interest, then the Regulation's prescriptions need to be followed. In that case, if an authority wants to give exclusivity to an operator and/or pay an operator to allow him to realise those public service obligations, then two main instruments are available: contracts and general rules. Contracts can be used to give an operator a temporary exclusive right (and/or payment) to operate certain public passenger transport services. Contracts have in principle to be competitively tendered, even though several exceptions are allowed. General rules essentially create the possibility to give fare rebates to groups of users, in particular in free market circumstances, and compensate operators financially via payments that have to be available to all operators in the area that would like to make use of them.

A few summarising observations can be made about the effects produced by the implementation of the Regulation 1370/2007. The Regulation was first perceived by its ‘users’ to be complex or confusing; it is likely that its consensual character, which had led to accommodating a larger variety of options for institutional arrangements in the Regulation, was contributing to this perception. Yet, this complexity also contributed to numerous implementation issues and which confirmed the presence of a difference between structure and practice: some authorities, mostly regionals/locals, were not aware of the existence of the Regulation and lacked knowledge about its content, or lacked resources and skills to implement it. An important warning was made on the danger of suggesting best practices for adoption by others and unexpected side effects also occurred in the first place, such as the replacement of competitive tendering by direct awarding (case of Estonia and Italy). Finally—confirming earlier concerns—data availability and comparability remained very problematic.

More surprisingly, perhaps, obtaining a clear overview of the actual institutional situation across Europe remains an exceedingly challenging task, even in the context of such large studies.

**Applying the PSO Regulation: a great diversity of situations**

It could seem from the above that all aspects of the organisation of public transport are strictly governed by the PSO Regulation.

In reality, however, and in application of the subsidiarity principle, some aspects of the organisation of public transport are not at all impacted by the Regulation.

For instance,

- The Regulation does not interfere with the institutional structure of Members States: it does not decide who the competent authorities are;
- It does not impose or define any public service obligations. This means in practice that competent authorities are responsible for the definition of their priorities and therefore of the public service obligations they wish to establish;
- It does not impose social, environmental, or quality criteria: competent authorities are free to establish social, qualitative, or environmental criteria such as working conditions, access for PRMs, security conditions, etc;
- It does not interfere with the authorities’ decision on how to organise public transport services: by network, by mode of transport, by route or a mix of those. In some countries for instance, operators might obtain exclusive rights for the whole network whereas in others, contracts might be awarded by transport mode, and sometimes even line by line.

**Moreover, the PSO Regulation leaves room for local particularisms.**

Indeed, the PSO Regulation does not impose competitive tendering. As we have seen, it leaves the choice between competitive tendering and direct award to an internal operator. If some countries have chosen one or the other as the sole management mode, generally speaking, both are possible and present in a given Member State. As the UITP map of country overviews shows, this is the case in most countries, both for urban and rail transport.

There are also times when the theory doesn’t quite match up to reality. In some countries, the tendering procedure systematically leads to the incumbent operator being granted the contract as no other company answers the call. This can be due to the size of the contract or to the level of compensation if it is known to be inadequate.

Over the years, two major trends in the market have become noticeable:

The first is market consolidation which has led to the emergence of large transnational passenger transport operators that we take a look at in UITP map of International players.

The second is that large incumbent railways have positioned themselves for aggressive expansion outside their domestic markets, and this also includes full or large control over urban transport operating companies. Take Abellio for instance, fully owned by the Dutch NS, or Arriva, owned by the German DB, or even Keolis, owned at 70% by the French SNCF.

### 3.3.2 Cost structure and new revenues

#### 3.3.2.1 Funding of public transportation

Public transport operation is funded through four main channels:

- Fares;
- Taxpayer and government subsidies;
- Third-party funding;
- Renting advertisement within the vehicles.

The ratio and/or importance of each funding source varies depending on the local context, but stability and security can be found in the diversity of its funding sources. In 99% of networks, fares cover a substantial part of the operational costs. In large European cities, the coverage rate has been reported to grow up to 50%, where for instance, the cost coverage in Germany from fares grew from 43% in 2008 to 53% in 2018. However, small, and medium-sized cities tend to rely to a lesser extent on fare revenue than large cities, the loss of which can be recovered more easily from other sources. For instance, only 9.2% of the operational costs were covered by fare revenue in the French city of Dunkirk, and countries like Luxembourg or Estonia also had low coverage rates, complemented with subsidies.

Public transport is not free to organise, operate and improve. If fare revenues are removed, then the other two funding sources will have to increase. This means increasing taxes and/or developing more commercial revenues to compensate, such as renting space in stations.

In addition to operational costs, PT networks require major investments dedicated to further developing their services, in most part supported by the public sector. Increasing the share of government subsidies to compensate for the loss of fare revenue might have the effect of crowding out available funds for the development of the network. Hence, making PT less attractive for private investors.

While the balance between each funding source can be adjusted to fit the local context, the many positive externalities brought by public transport makes a compelling argument in keeping a certain level of support from society through taxes.

The following list shows positions of CAPEX and OPEX:

CAPEX:

- Cost of vehicle fleet;
- Cost of physical infrastructure;
- Cost of digital infrastructure;
- Machines and equipment;
- …

OPEX:

- Repairs, Maintenance (for vehicle and infrastructure);
- Expense for Services (offices, rent costs, heating…);
- Depreciation costs;
- Personnel costs (operation, R&D, Education…);
- Material consumption;
- Fuel consumption / Energy consumption;
- Marketing and Communication;
- Other costs (prototyping, certification...);
- Sustainability costs (Carbon Emission);
- IT-Cost;
- …

#### 3.3.2.2 Evolution of the cost structure

Technology, and in particular digitalisation, creates significant opportunities for holding costs and improving operational efficiency. This will eventually have an impact on the cost structure of PT companies.

Digitalisation enables condition-based and predictive maintenance, which provide significant cost reductions. They not only reduce maintenance costs but also increase fleet availability and operational readiness.

The electrification of PT is a confirmed trend with the progressive implementation of ambitious programmes for the deployment of electric bus fleets, in Europe. The **electrification of bus fleets has an important impact on cost structures**. Indeed, the cost of acquisition of vehicles, of energy of course, but also of the infrastructure, of maintenance and of operations, must be adapted to the type of propulsion, and differ significantly from what has been done with diesel buses. While the cost structure is changing, public transport companies are also looking for a **more stable funding model**. They are constantly exploring alternative revenue sources, including better exploiting existing assets.

It is a growing understanding that while public transport benefits a much broader range of actors than it serves directly, authorities are expecting to support schemes, making all beneficiaries of public transport pay. In this respect, Land Value Capture is still expected to be a virtuous scheme for the city, businesses, and public transport actors. We are also observing a trend towards the implementation of demand management schemes, from parking to congestion charging, with the goal, among others, to raise funding for public transport. This is not exclusive of the permanent efforts of authorities to optimise fare revenues.

With the growth of public transport and its diversification, come new opportunities to raise more revenues.

The UITP Trends Report 2019 provides an analysis of these trends to support the public transport sector to grow and lead the transition towards a more sustainable urban transport system for more liveable and competitive cities.

#### 3.3.2.3 Potential cost reduction through automation

Automated vehicles have the potential to eliminate one of the main elements that cause economies of scale in public transport: drivers' wages. The cost advantage of placing many travellers in large vehicles, such as buses or trams, will be reduced; thus, shared mobility services with smaller vehicles are expected to play a larger role in a future of highly or fully automated vehicles. [Alejandro Tirachini, Constantinos Antoniou, The economics of automated public transport: Effects on operator cost, travel time, fare, and subsidy]

Some empirical estimations of the dramatic effects of automation on reducing the costs of motorised shared mobility have been made. For example, in Zurich, automation is estimated to reduce the cost of taxi trips by 85% [12] and in Singapore, total operator costs of an electric 6-m long shuttle bus are reduced by 70% if automated, as compared to its human-driven equivalent [13]. More conservative estimations are provided by Wadud, 2017 [14] for the United Kingdom, who, after assuming that with automation a 40% of current driver costs will still be needed, estimates cost savings of 30% for the taxi industry and between 15% and 23% for the truck industry.

But all these estimations considered that the driver is replaced by a technology at 1 to 1 without considering the complexity of what we call Autonomous Transport Systems. Basically 4 big pillars are in the composition of this complex systems: the automated vehicle, the operational control tower with the supervisor (an operator), the connected infrastructure and finally the MaaS application (the connectivity with the final user). To make shared vehicles work we need to replace the driver by 4 complex systems that today are not fully developed.

Beyond operating cost savings, automation is expected to affect PT in many ways. Several automation technologies will be introduced in PT services, such as collision avoidance, lane-keeping, bus platooning, bus precision docking (i.e., having a narrow and stable gap between the vehicle and the platform at bus stops), cooperative adaptive cruise control (CACC) and automated emergency braking [15], [16]. The expected benefits of such innovations include a reduction of collisions, injuries and liability costs, improved services for people with reduced mobility and an increase in transport capacity, especially in dedicated infrastructure, such as bus lanes and segregated corridors [15]. Lutin, (2018) [16] predicts a great reduction in cost and improvement in service in the US paratransit industry, which caters for persons with reduced mobility, due to automation, even though a fully automated service for mobility-impaired passengers poses further challenges as, e.g., robotic assistance will be needed for boarding and alighting.

#### 3.3.2.4 Concept: Free fare Public Transportation (FFPT)

At a time when cities face serious environmental and societal challenges, sustainable urban mobility has never been this high up on the agenda. With the transversal role that PT plays in terms of urban quality of life, increasing and easing its access is a major challenge. Following this line of thought, the concept of **free fare public transport (FFPT)** has been gaining traction in the public discourse, as several large cities have implemented or experimented with it.

While free PT is often brought up in political discussions, its implementation has very concrete implications on the organisation of public transport. Yet, the **strengthening of public transport services and infrastructure must remain the overarching principle** throughout these discussions. It is therefore crucial to carefully consider the stated objectives which this measure is meant to achieve as well as its impacts, in order to decide whether or not it is the most right use of public funds. In doing so, one must keep in mind that **free public transport as such does not exist**, as transport service and infrastructure have to be funded one way or another. Hence the reference to free fare public transport means that public transport users do not contribute to funding the service directly through the payment of a fare.

Drawing from the experience of FFPT cities, the "UITP Policy Brief on Full free fare public transport: Objectives and alternatives" [17] provides an analysis of the various stated objectives and the extent to which FFPT is the right tool to achieve them. Finally, it offers recommendations for public transport authorities and decision makers who are contemplating full FFPT as an option for their cities.

#### 3.3.2.5 Data as a new revenue sector

As public transport becomes increasingly a data-driven sector, and while new actors offer a broader range of mobility services with uncertain business models, which interfere with current transport systems and urban infrastructure, governance models must be adapted. From the growth of ride hailing, the deployment of on-demand services and the emergence of micro-mobility, the challenge is to develop governance frameworks that take advantage of innovation, while steering developments towards truly sustainable urban transport solutions benefitting the communities.

Regulation should ensure that fair rules are set, for instance, on the use and sharing of data, and that data produced by public transport is well valued.

With the emergence of new business models, we are increasingly observing incumbent public transport companies now able to "disrupt" themselves and offer new mobility solutions, such as MaaS or on-demand ride-sharing services. This indicates that with the right governance framework, a convergence of actors towards the most promising services to complement mass public transport solutions can rise.

With such an active environment, transport authorities play an ever-important role, which extends beyond the usual realm of public transport governance to the regulation and management of the whole urban transport system.

### 3.3.3 Market growth, outlook and trends

We are presenting multiple statistics on PT because we consider this information necessary to understand the size and complexity of the market. Even if only 1% of this overall transport is becoming automated, this is still representing a huge market.

> In 2015, 243 billion public transport journeys were made in 39 countries around the world. This figure represents an 18% increase compared to 2000.

The following graph illustrates the total number of journeys in the countries/regions that were studied. The size of the bubble corresponding to each country/region is an indicator of total number of journeys; the value, in billions. By looking at each axis, we can identify the impact of urban population and journeys per capita on total journeys for each country/region involved.

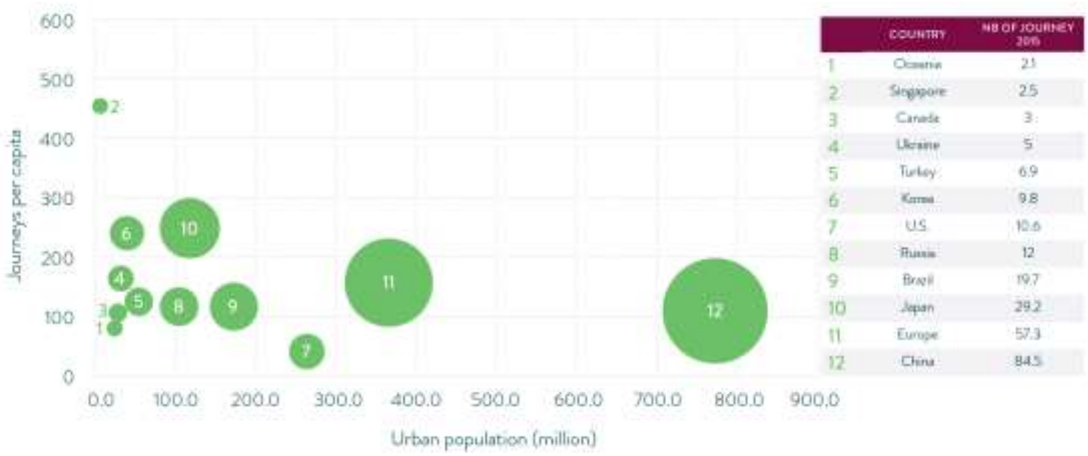



**Figure 8 - Different levels of demand per capita (2015) [Source: Transdev].**

Focusing on journeys per capita, it is evident that an average resident of the selected countries made 121 journeys in 2015 (almost one journey every three days). This figure differs in each country, ranging from 37 to a value 12 times larger.


**Figure 9 - Various levels of demand per capita (2015) [Source: Transdev].**

The following graph illustrates annual journeys per capita in large countries:

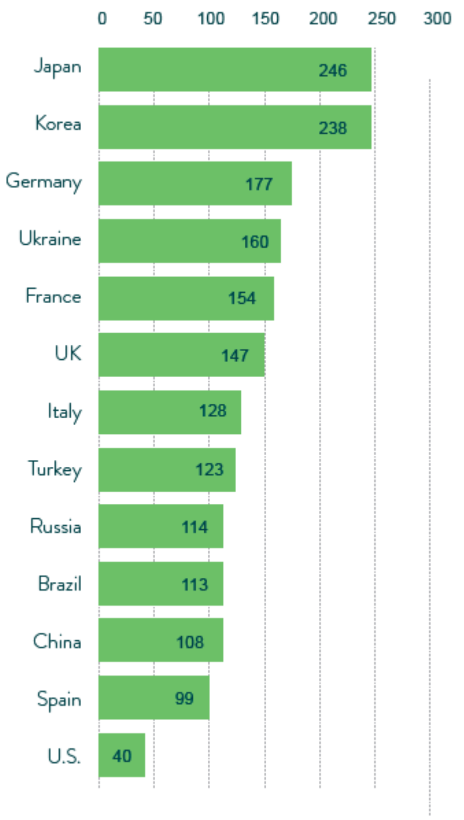



**Figure 10 - Annual journeys per capita in large countries (2015)**

For the purpose of this study, 'large countries' were considered to be any with more than 30 million urban residents. Considering a greater proportion of the urban population lives in larger countries, they have the potential of being big markets for public transport.

The following graph details the growth rates of large countries


**Figure 11 - Journey's growth rates in large countries 2000-2015**

Image sources: Transdev

### 3.3.3.1 Trends

It becomes increasingly clear that the ecosystems is at the beginning of a new mobility era based on these fundamental trends:

- **Clean vehicles:** Combustion engines will be phased out and in the future all vehicles will (have to) be clean.
- **Shared vehicles:** The shared use of vehicles will increase both in the form of car-sharing (consecutive sharing of vehicles) and ridesharing (simultaneous sharing of vehicles).

- **Automated vehicles:** In the future vehicles will be driverless and connected, which will offer many opportunities for completely new mobility services.
- **Digitalisation of mobility:** Optimisation of existing services and creation of new ones based on smart data and IT solutions that change the way people move and consume goods.

If applied in a smart way, these trends offer an absolute momentum for better and more sustainable urban mobility with public transport as the backbone. They will help the ecosystem to reclaim urban space and rebuild streetscapes to create attractive cities for people. If no action is taken, the risk is that cities and public transport companies lose control and the ability to shape future urban mobility systems.

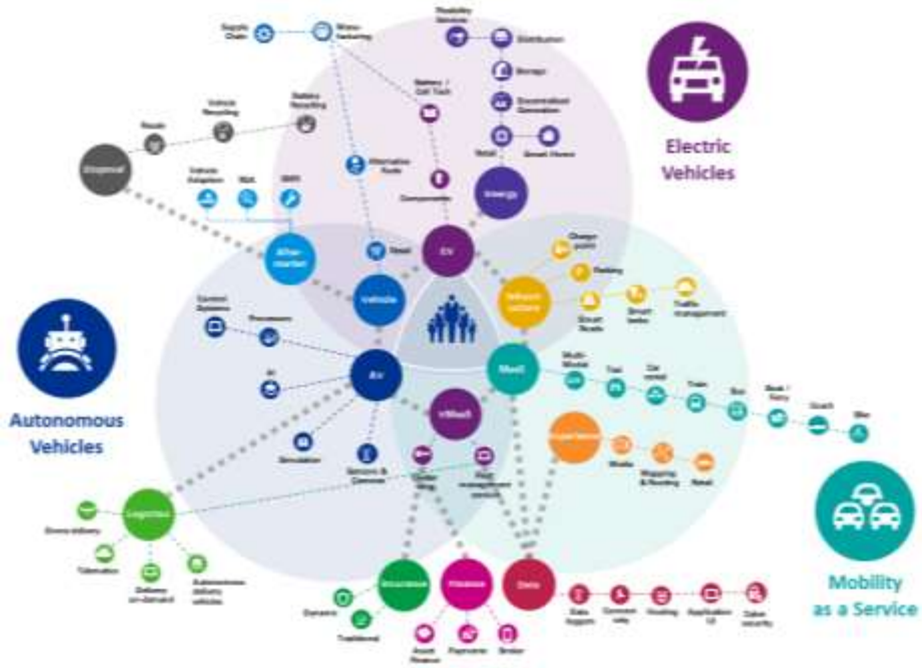



**Figure 12 - Emerging technologies are disrupting multiple sectors and value chains [Source: Transdev].**

We expect a multitude of new entrants to take a share of this new market, with unprecedented levels of partnership and collaboration in the search for novel solutions.

At the same time, sources of value will fundamentally shift both within value chains and across the ecosystem. The value derived from today's personal car is fairly equally split between upstream (raw materials to finished vehicles) and downstream (all other parts of the value chain).

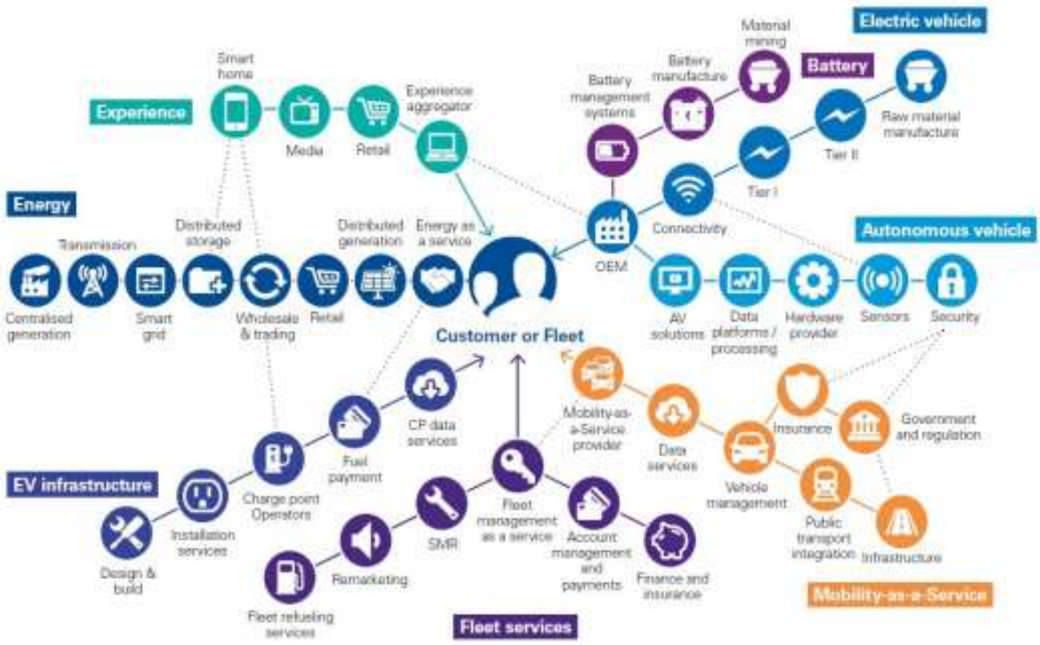



**Figure 13 - A complex system of interconnected value chains emerges [Source: Transdev].**

### 3.3.3.2 Initiatives on automated public transportation

Automated road vehicles (AVs) provide many opportunities for better urban mobility services. But how AVs can best be integrated depends on the environment of the area. The SPACE project partners have defined a list of different use cases, or scenarios, to offer guidance on how to deploy AVs in environments with different densities – ranging from an urban setting, a suburban setting, and small cities, to rural areas. When you filter for one of these environments in the list below, it will show you only the most relevant scenarios, which does not mean this AV scenario is not seen in other environments. The list is not exhaustive and given the ongoing changes and technological developments, it will be updated over time. The scenarios have been put on a timeline to underline what scenarios are already happening, which ones are under development for implementation in the near future and which ones still need some time. An important aspect to be noted is that every use case does not necessarily require a different type of vehicle and a fleet of AVs can be used for different scenarios.

For examples of automated metros in the world take a look at the UITP's Observatory of automated metros under: http://metroautomation.org [18]

Following the same approach, a dynamic map [19] was built also for the automated/autonomous vehicles and in Table 1 we are presenting some examples of initiatives on automated PT presented in the SPACE Project dynamic map.


**Figure 14 - SPACE Project - dynamic map of AV experimentations [Source: SPACE].**

**Table 2 - Example of SPACE initiatives on automated public transportation**

| Project | Objective |
|---|---|
| **Evaps, Saclay, France– Transdev & Vedecom** | This shuttle service, operated by Transdev for VEDECOM, aims to build a liaison between Massy-Palaiseau multimodal train station and the Polytechnique campus. The general aim of this pilot is to demonstrate the benefits of connected infrastructures and of the safety and efficiency of this type of service. |
| **HEAT, Hamburg, Germany – Hochbahn** | HEAT is a pilot project from HOCHBAHN (PTO) in HafenCity, the new business and residential district close to the city centre and the harbour of Hamburg. The shuttle follows a fixed circular route with 5 stops and is wheelchair accessible. It is reachable at the dedicated stations. Along its route it interacts with mixed traffic on public streets and pedestrian crossings. |
| **Ommelander Hospital, Groningen, Netherlands – Arriva** | This autonomous shuttle service provided transport from the entrance of the Ommelander Hospital in Groningen, to further public transport connections. The Northern Netherlands region offers – in all aspects – everything it takes to allow autonomous transportation to become a sustainable feature of its whole future transportation system. |
| **Boulogne-sur-Mer Autonomous Vehicle Project – RATP, IDF Mobilités, City of Paris** | Boulogne sur Mer's initiative consisted of an experiment on Quai des Paquebots along a pre-defined 300m road, near the Sea National Centre (which has about 60.000 visitors per year). RATP, IDF Mobilités and the City of Paris are collecting feedback from travellers on this pilot. This feedback will be taken into account when creating the autonomous bus line which the city is hoping on eventually putting into place. |

### 3.3.3.3 How the market will be shaped in the next 10-15 years

With each innovation, each new challenge we address, we are pushing the boundaries of the very definition of our sector. While mass public transport will remain the backbone around which sustainable mobility solutions will thrive, the multiplicity of complementary solutions is making the passenger transport market more complex. We once limited the definition of public transport to mass public transport, combining public access and collective use, but it is only one element of that definition, which now encompasses every collective or shared mobility solution. In other words, public transport should include all collective and shared modes.

**Figure 15 - Present picture of mobility [Source: Stock photography].**

**Figure 16 - The smart city is it full of highways [Source: concept art Transdev].**

**Figure 17 - Example of future green cities [Source: concept art Transdev].**

Trends on technological and business evolution paradoxically reinforce the importance of the human dimension in public transport: the people who public transport connects and supports. It is with a people-driven mindset that we will succeed in redefining public transport, for the benefit of all.

It seems therefore that the challenge for building the market of the future is to find the right balance between technological innovation and people involvement. The two notions cannot be opposed anymore but need to be complementary of each other. In 10 or 15 years, technology must offer to the users more freedom to choose how they want to go from one place to another.

As the market changes, stakeholders will adapt to it so will the city. In 15 years, it is likely that urban areas will be transformed to reflect accurately the new paradigm of public transportation. Obviously greener, future urban area should provide in the same place and at the same time enough room for multiple modes of transportation to coexist. One can imagine a public space on which roads, curbs and pavements are merged into one single and large space where active modes and classic modes are both present, where pedestrians, bikes, autonomous shuttles, cars, and tramway are all able to circulate safely and efficiently.

**Figure 18 - The multimodality in a city [Source: Stock photography].**

### 3.3.4 Competitive landscape, roles, and mobility drivers

The following table gives an overview about Public Transport Authorities (PTA) and Public Transport Operators (PTO) in Europe [10]. The transport authorities usually exist on a local/ regional level, for consistency we refer to the highest entities in the country, usually being ministries.

**Table 3 - Examples for PT authorities and operators in Europe**

| Country | PTA | Example for PTOs |
|---|---|---|
| Germany | EBA<br>(Federal Railway Authority) | DB Flinkster, Bahnen Monheim, Regionalverbund Aaachen |
| Austria | ÖBB (Österreichische Bundesbahnen) | Wiener Linien, Salzburg Nahverkehrsverbund, Grazer Linien |
| Italy | MIT<br>(Ministero delle Infrastrutture e dei Trasporti)<br>FSI<br>(Ferrovie dello Stato Italiane) | AMP (Agency of the Piedmont mobility)<br>Trenitalia<br>Milan-Treviglio |
| Belgium | SNCB<br>(Nationale Maatschappij der Belgische Spoorwegen) | De Lijn<br>STIB |
| Netherlands | 10 different authorities, e.g.<br>I&W (Ministerie van Infrastructuur en Waterstaat)<br>OVBGD (OV-bureau Groningen Drenthe) | Nederlandse Spoorwegen (NS), Arriva, Connexxion, Transdev, Syntus, Qbuzz |
| Sweden | Trafikverket | KEOLIS,<br>AB Stockholms Spårvägar<br>Malmö Lokaltrafik |
| Finland | Väylävirasto | HSL HRT (Helsinki) |
| France | Paris Ile-de-France | Transdev, SNCF, MobiVie, RATP, Keolis |
| Greece | Athens Metropolitan Public Transport Authority<br>Thessaloniki Transport Authority | Stasy S.A, OSY, KTEL, Organismos Sidirodromos Ellados, OASTH |
| Spain | EMTA<br>(Consorcio Regional de Transportes de Madrid)<br>MITMA<br>(Ministerio de Transportes, Movilidad y Agenda Urbana) | EMT Madrid<br>ATMV Valencia<br>ALSA<br>TITSA<br>Global |

As a representative example of the numerous modern transport services operated by a PTO is presented in the following figure.


**Figure 19 - Example of services operated by Transdev [Source: Transdev].**

These modern services exist and interact within a competitive environment within the mobility ecosystem:

- Historical competitors: Transdev, RATP, Deutsche Bahn, SNCF, Keolis, MTR...;
- Few transit authorities that increasingly operate services themselves, as their teams acquire greater transportation expertise. Who operates the services (PTO or in-house operation) varies a lot in different cities and a lot of parameters can affect the decision? For sure is that in most of the cities there is an increased range of mobility services, with even more constraints to be respected. It is well-known that the major limitation is the low budget allocated to the mobility.
- The global mobility market has been reshaped by the arrival of new players complementing existing PT services with new innovative services, in the field of micro mobility or on demand services:
  - start-ups that offer innovative services and implement new business models;
  - major groups originally positioned in other sectors: automobile manufacturers, equipment manufacturers, car rental companies and software publishers, which are increasingly active in the mobility sector.

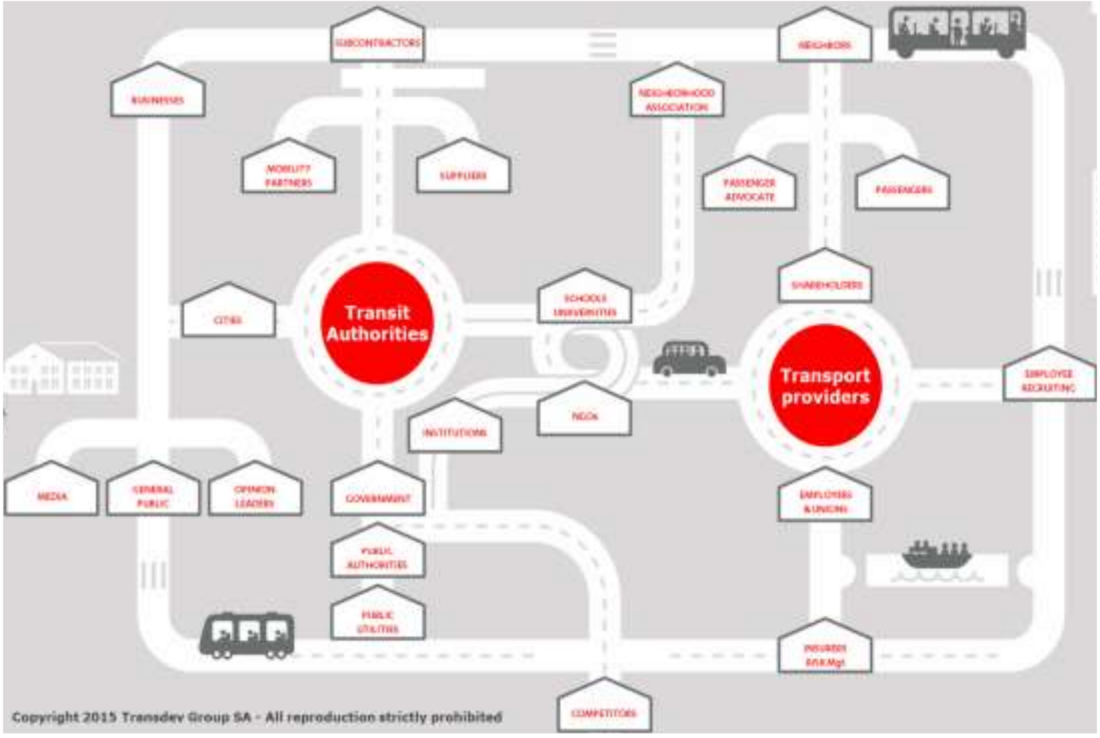



**Figure 20 - Stakeholder in the mobility ecosystem [Source: Transdev].**

One additional import factor of this ecosystem is the local, national, and international stakeholders. At national and international level, the PTOs interact with a large ecosystem: mobility authorities, municipalities, shareholders, employees and their representatives, partners and subcontractors, suppliers, insurers, passengers, residents, associations and local players in employment and education, opinion leaders and think tanks, etc.


**Figure 21 - The Mobility ecosystem [Source: Transdev].**

### 3.3.4.1 Modal distribution

This section illustrates the modal breakdown of total journeys in 2015. Insignificant inconsistencies among similar modes (in terms of name or how they serve people in different countries) were clustered as the same. For instance, what is called 'heavy rail' in the US includes suburban railway and metro; separate data are not available on any of the modes. Considering that there is another mode, commuter railway, which serves suburban areas and goes beyond areas covered by heavy rail, we clustered heavy rail as metro and commuter rail as suburban railway.

The following chart presents the modal distribution of journeys for all countries in average:

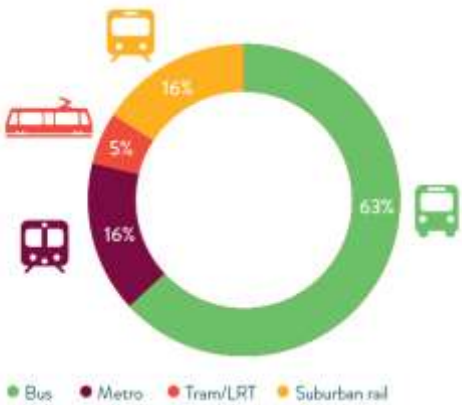



**Figure 22 - Average modal distribution of all public transport journeys (2015) [Source: Transdev].**

The chart illustrates that, on average, bus is the dominant mode of transport overall; with a 63% share, it is higher than the sum of all other modes combined. Following bus, metro and suburban rail are the most popular modes with a 16% share each. It is important to note that the distribution of journeys between modes has disparate patterns in different countries; the chart reflects the average.

To understand Mass Transit by Bus, we are presenting an extract of information from the Global Bus Survey of UITP, published in May 2019, on more than 320 bus operators in 46 countries, including 29 European countries. The data was collected on several operational indicators, most of them on the bus fleet. Each of the indicators is introduced and further explained in this report, with graphs illustrating the findings.

Since it was not possible to study all bus operators in the world, a sampling process was set up which led us to the selected operators. Further information on the sampling can be provided upon request. Complementary to this report, an extensive dataset, presented by countries and indicators is also available.

THE SPLIT OF VEHICLE TYPES

Almost 68% of bus fleet are standard buses (as regular 12-meter buses). A further 12% of them are articulated and the remainder consists of midi-buses, minibuses, double-decker, and trolleybuses.

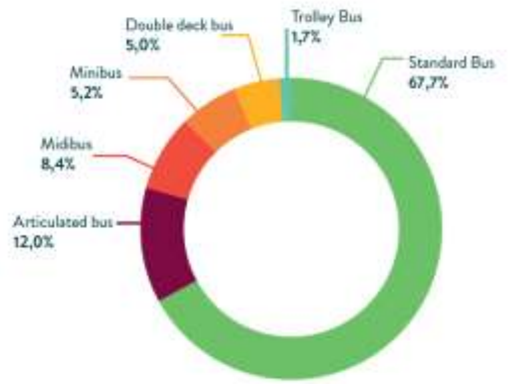
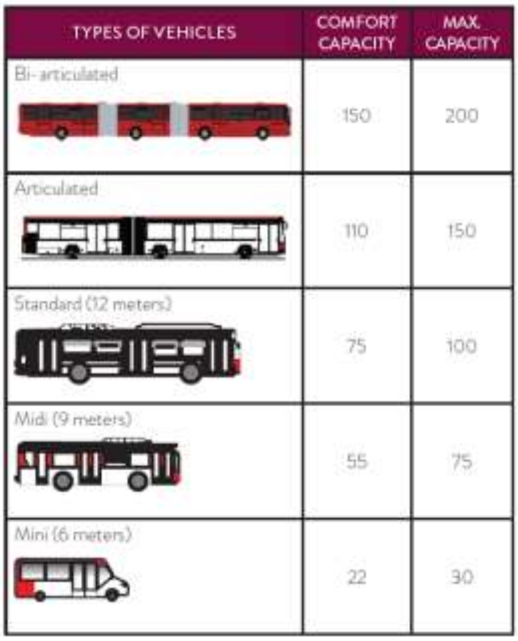



**Figure 23 - Bus fleet types**



| TYPES OF VEHICLES | COMFORT CAPACITY | MAX. CAPACITY |
|---|---|---|
| Bi-articulated | 150 | 200 |
| Articulated | 110 | 150 |
| Standard (12 meters) | 75 | 100 |
| Midi (9 meters) | 55 | 75 |
| Mini (6 meters) | 22 | 30 |

**Figure 24 - Type of buses**

A MIX OF PROPULSION SYSTEMS

Diesel is the most popular fuel by far as it represents 50% of all bus fleets. An additional 22% of the buses consume diesel combined with some additives or biodiesel. Electric buses account for almost 18% of the buses.

A remarkable finding is that China is the pioneer of operating electric buses with 57% of the buses included in this survey. Other countries with noticeable penetration of this propulsion system are Romania with 22%, and France and the United Kingdom with 18%. Concerning other alternative fuels, almost 98% of the

DISTRIBUTION OF EMISSION STANDARDS

The emission standard with the highest frequency in the sample is Euro V. 28% of the buses meet this standard and together with Euro VI buses, they make up 44% of the sample. After Euro V, Euro III and Euro VI represent the next largest shares with 23% and 17% respectively.

Austria, Lithuania, Luxembourg, Norway, Republic of Korea, and Sweden are the countries with at least 80% of buses in Republic of Korea consume CNG.

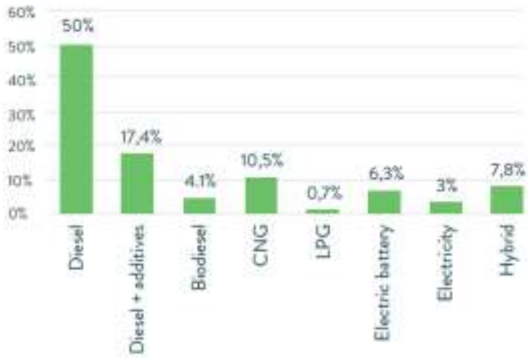



**Figure 25 - Bus propulsion systems**

their buses meeting Euro V or Euro VI standards.

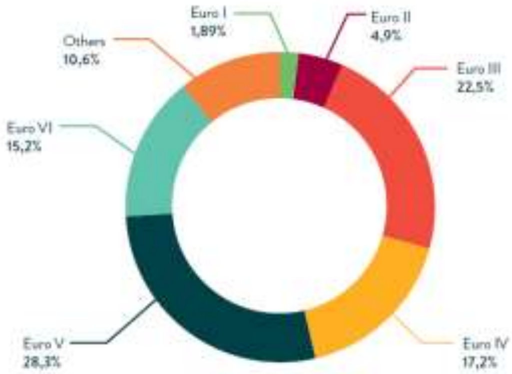



**Figure 26 - Emission standards of buses**

DRIVERS PER BUS

There is a relatively wide range of number of drivers per bus in different countries. It varies from slightly more than one up to three drivers per bus, while the average is two drivers per bus.

Some ranges for number of drivers per bus are shown and the number of countries for each range is provided.

In 63% of the cases, there are between 1.6 to 2.5 drivers for each bus.

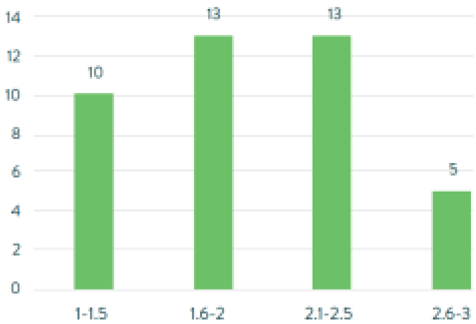



**Figure 27 - Number of countries with ranges of drivers per bus**

DRIVERS PER MILLION JOURNEYS

To look at the number of bus drivers per million journeys, four ranges have been created.

The range with the largest number of countries (17) counts between 10 and 20 drivers. This means that to transport one million passengers in those countries, between 10 and 20 drivers are required.

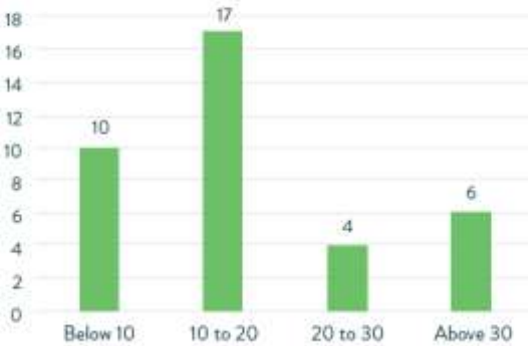



**Figure 28 - Number of countries with ranges of drivers per million journeys**

Image sources: Transdev

Another report of high importance that present is the UITP Global Taxi Benchmarking study published in 2018 [11]. As we all know, Taxi services are an individual, mostly door-to-door on-demand, offered to the public primarily at local level. By the very nature of their services, taxis are an integral element in the sustainable urban multimodal mobility chain, which relies upon efficient public transport and a range of complementary travel solutions.

Taxis are increasingly acknowledged as an extension of PT systems. The flexibility of the taxi services allowed their rapid growth and popularity on the industry globally. The last few years have been particularly challenging for the taxi industry. As a result of innovative technologies and fierce competition, major cities from across the world have seen their taxi operators reforming their services to carry on in the urban mobility scene. Regulators, similarly, required to develop new frameworks to keep up to date and adopt new players which both had opportunities and challenges associated in this new environment.

### 3.3.4.2 Daily distance driven by taxis

This indicator is calculated as the ratio between the distance driven daily while transporting passengers and the total distance driven daily. As shown on in the figures below, Delhi, Hong Kong, Kuala Lumpur, Mumbai, Singapore, and Oslo have above 60 % of daily distance driven with passengers. With 71% Mumbai is the highest and with 35% Izmir is the lowest among the cities surveyed.

Image source: Stock photo

**Figure 29 - Taxis in Budapest, Hungary**

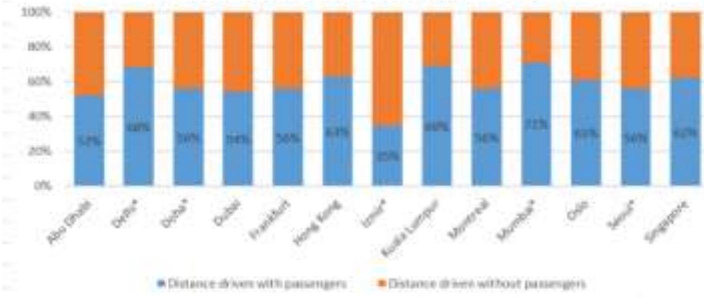



Image source: UITP

**Figure 30 - Share of daily distance driven by taxi vehicles**

### 3.3.4.3 Availability of drivers

Drivers are the integral part of the taxi system around the world. The cities like Abu Dhabi, Doha, Dubai, and Sharjah are fully dependent on expat labours for driving the taxis. Drivers to taxi vehicles ratio is used to find out adequacy of drivers. Cities like Milan, Lagos, Seoul, and Sharjah may face shortages related to drivers' availability in the future. On the other hand, cities like Casablanca, Frankfurt, Hong Kong, Sao Paulo, and Melbourne have high numbers of drivers.

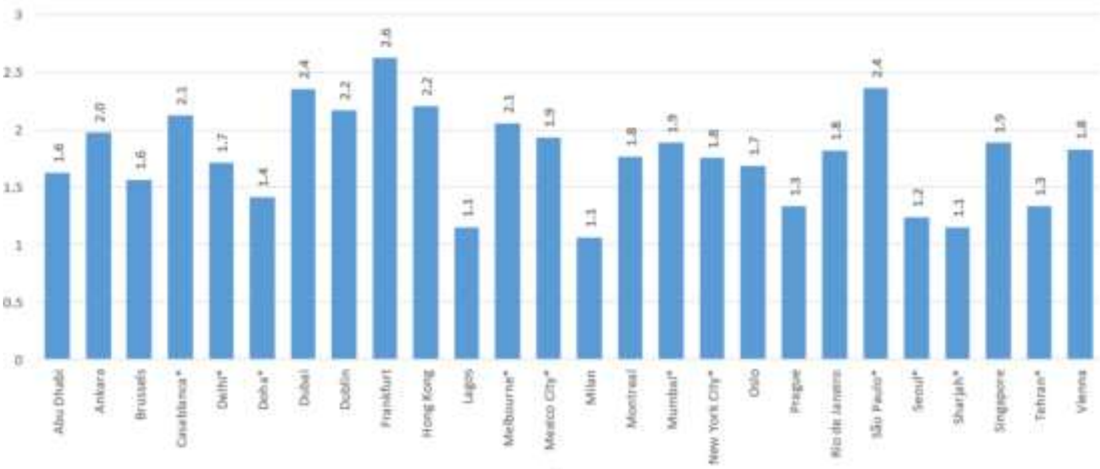



**Figure 31 - Availability of drivers per registered taxi vehicles [Source: UITP].**

### 3.3.4.4 Distance driven by day

The distance driven per taxi per day refers to the total distance driven per day, both with and without passengers. As Figure 5 reflects, a taxi in Dubai covers a distance of 570 Kms per day which is the highest among cities on the graph below. Singapore, Hong Kong, Abu Dhabi, Doha, and New York City have high mileage per day. Cities such as Kuala Lumpur (101 km), Milan (150 km), Montreal (178 km), Oslo (200 km) and Vienna (150 km) show lower mileage in comparison to other cities surveyed. Average distance among the cities surveyed is 266 km per day.

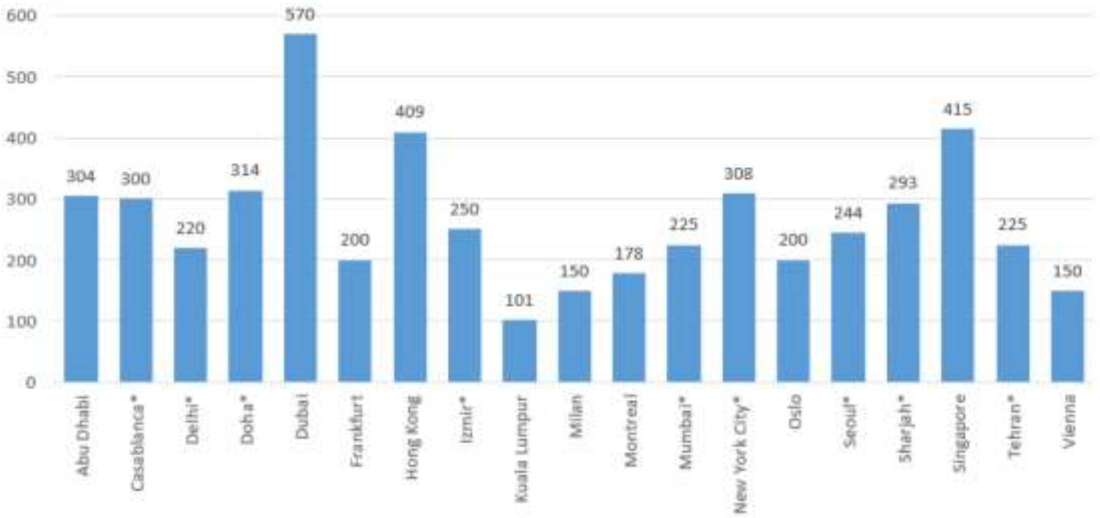



**Figure 32 - Distance driven per taxi per day [Source: UITP].**

### 3.3.4.5 Comparison: taxis on double shift

In most cities, taxis operate 24 hours a day 7 days a week, below figure shows the number of taxis that are operating in double shift (day and night) by different drivers. Dubai, Izmir, and Mexico City all of their taxi fleets are running on double shifts. In New York City, 90% of taxis are operated in double shifts and 80% in Tehran and Ankara. In developing countries, the rules related to driving hours are not strictly imposed. Consequently, the percentage of double shift is not higher, but the vehicles remain on the road for longer shift.

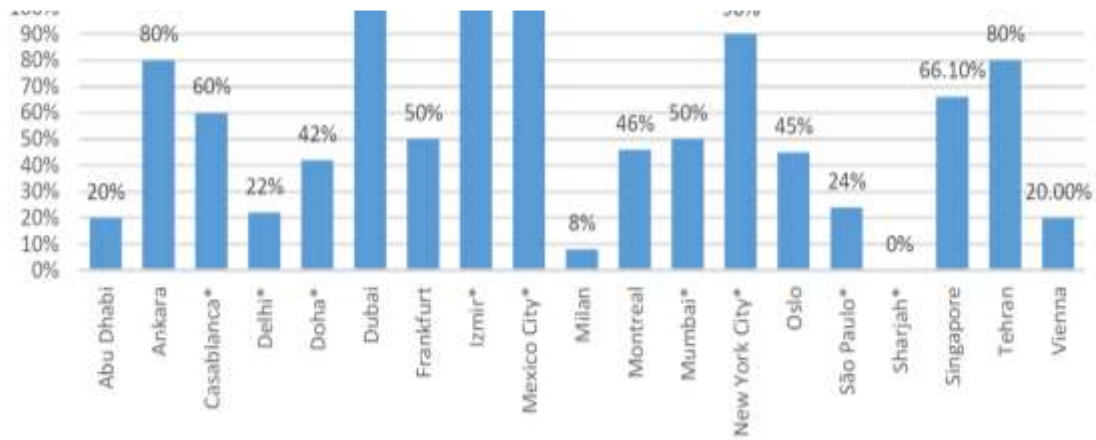



**Figure 33 - Taxi Vehicles Driven in Double Shifts [Source: UITP].**

Above graph states the average number of trips performed by the taxi in a day. New York City performing 36 trips a day. Tehran, Kuala Lumpur, and Tehran serves 5 or less trips per day on average. In United Arab Emirates the numbers for Abu Dhabi 24 and 29 for Dubai which are above the average.

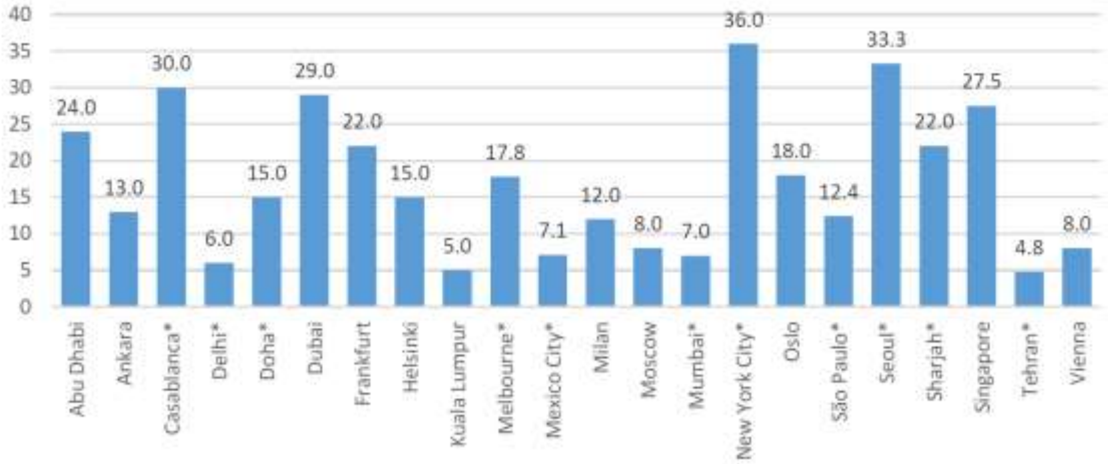



**Figure 34 - Average number of trips per car per day [Source: UITP].**

### 3.3.5 Connected and Cooperative Automated Vehicles (CCAV)

Shared, connected and cooperative automated vehicles may become a game changer for urban mobility. They can provide seamless door to door mobility of people & freight delivery services, which should lead to healthier, more accessible, greener & more sustainable cities, as long as they are integrated in an effective PT system.

Since a few years, the development of shared automated vehicle pilots is emerging around the world. Today, most of these pilots are small-scale and involve either on-demand ride services or low-speed shuttles operating in controlled environments. In order to accelerate the uptake of high quality and user-oriented mobility services, based on shared, connected and cooperative automated vehicles, there is a need for demonstrating these services in real life conditions to test the performance, safety & viability of these systems and services and to prove that they are attractive for and accepted by users. Furthermore, the potential impacts on reducing $CO_2$ emissions & pollutants, safety & overall transport system costs need to be assessed.

This is the core of SHOW's mission: to support the deployment of shared connected and electrified automation in urban transport chains through demonstration of real-life scenarios to promote seamless and safe sustainable mobility.

These demonstrations should prove that AV fleets can operate in an integrated manner with PT services, and other environmentally friendly solutions, like cyclists, e-bikes, etc. in order to be cost-efficient, reduce city traffic and finally lead to a sustainable future urban mobility. UITP relevant policy brief highlights that such a solution would enable performing all demanded trips with as much as 80% fewer cars. But to achieve this, we need communication and coordination of PT and several types of automated fleets (Demand Responsive Transport – DRT) or/and connected mobility service with automated or nonautomated fleets (Mobility as a Service - MaaS, Logistics as a Service - LaaS); which calls for aggregated services, integrated at TMC level and operated by novel business models.

### 3.3.6 Conclusion

The public transport sector is striving for excellence in delivering its mission of providing public services to all citizens. In the future, using public transport should become as easy as taking a private car today. Only then it is expected to make people shift from private car usage to public transportation.

Transdev for example, wants to be the preferred choice of citizens when it comes to their daily mobility.

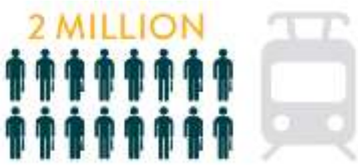
This requires a change in the way individual mobility is treated; in the future, we hope that the public transport sector will operate in a favourable regulatory environment. With the support of the Green Deal, the public transport sector is sure to achieve **net-zero greenhouse gas emissions at the latest by 2050.**

But in the context of the digitalisation of the PT and its automation, many stakeholders would like to know exactly how autonomous public transportation will evolve and which use cases are the first ones to be integrated. But even if we do not have the exact answer, we know that today the limits of the technologies are blocking the expansion of automated services. The market is ready but not the products.

But at the end of the day, automated or not, the focus should be on shared mobility and not on technology.

**In conclusion, Public Transport:**

**Table 4 - Conclusions for public transport [Source: Transdev].**

| | |
|---|---|
| **EMPOWERS ECONOMY**<br>The economic benefits of public transport are five times higher than the money invested in it. |   |
| **OFFERS SUSTAINABLE MOBILITY**<br>Doubling public transport’s market share worldwide would save around 170 million tons of oil and around 550 million of tons of CO2 equivalent. |  |
| **CREATES LOCAL JOBS**<br>Public transport companies are amongst the largest employers at the local level. They employ more than two million people in the EU and, these jobs cannot be delocalised. |   |
| **ENSURES SOCIAL COHESION**<br>Public transport brings people together. It plays a crucial role in local development, offering mobility to all and maintaining the social and urban fabric. |  |
| **CONTRIBUTES TO PUBLIC HEALTH POLICIES**<br>A shift towards active modes of transport (public transport, cycling, or walking) helps improve citizens’ health, especially in urban areas. |  |

**SAVES URBAN SPACE**

At current occupancy rates for cars, a full standard bus can take more than 40 cars off the road. A full metro set can take 600 cars off the road. In addition to traffic reduction, it frees up space otherwise used for parking in dense urban areas.

**MAKES CITIES MORE LIVEABLE**

More public transport means less congestion, less noise, better air quality and reduced pollutant emissions. It supports more efficient land use policies.

**MAKES CITIES SAFER**

Travelling by public transport is much safer than travelling by private car.

## 3.4 Demand Responsive Transportation

Demand Responsive Transport is a public or private, shared and cooperative transport service that require passengers to book their trip. The day-to-day service is determined by the mobility needs of the customers. DRT services mostly appear in areas and/or times of day with low demand for mobility (e.g., peripheral or suburban areas and/or off-peak periods). Based on the nature of pick-up and drop-off possibilities, DRT services can be classified into several subcategories, such as linear, feeder, zonal and door-to-door.

Demand Responsive Transport (DRT) is one of the fastest growing sectors of the mobility ecosystem. Consumer preferences are shifting from the existing motorized transportation towards tailor-made and flexible transport solutions. Numerous new DRT systems have started to operate all around the world from year-to-year. Due to the substantial number of innovative solutions, a general definition for DRT does not exist in literature. Several sources have been reviewed to define the broad scale of DRT services and reported in SHOW Deliverable 2.1 [20].

Demand Responsive Transit (DRT), Transport-on-Demand (ToD), bus-on-call, micro transit, on-demand-transport, dial-a-ride… all these designations cover a specific category of service among mobility services: public transport services that require the passenger to book its trip and operate the day to day serviced based on the customers mobility needs. The service doesn't operate in case there's no booking.

Demand Responsive Transport is a way to extend public mobility services in time and space and bring some public service in places and at period of the day when precisely, there is not enough public to run a regular service [21].

### 3.4.1 State of the art

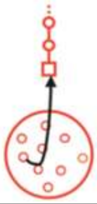
Based on the various definitions and the results of D2.1, the State of the Art on Demand Responsive Transport systems offer flexible transportation service based on customers' mobility needs both in terms of space and time. They operate only upon request; therefore, passengers have to book their trip in advance or by chance. Bookings can be made mostly via app, website, or phone. They mostly operate in areas with a lack of public transport services and/or provide a solution for people with reduced mobility. DRT systems improve quality of service and passenger experience through tailor-made services and digital tools allowing personalized services. DRT services can be provided by both public and private entities and often operates as a shared-ride service as a combination of conventional public transport and traditional taxi service [20, 22]

Many issues raised regarding DRT services since they have to be very sophisticated to fulfil the individual needs of passengers. Most of the systems operate with either physical or virtual stops. This requires an unfavourable walk between the origin and pick-up point, furthermore between the drop-off point and the destination of the trip. A comprehensive international review produced by Monash University in 2019 also noted that ODT (On-Demand-Transport) services since 2000 (as the starting point of when new technologies began to be introduced into ODT programs) have not been lowering costs, but in fact increasing costs per passenger [23]. The results from the Monash University studies showed that “simpler” routes (fixed route with deviation, rather than on-demand routing) had lower failure rates and suggested that specialist services (i.e., paratransit) and simpler service design were helpful for developing successful ODT programs.

DRT services basically perform taxi services at PT prices. As a result, they can be perceived as unfair competitors by traditional taxicab services. The same flexibility that attracts users in rural and suburban areas can be a setback for the use of the service as a feeder to public transport hubs in urban areas. Often functioning as an on-demand service, the route and schedule may be too variable for passengers who need a reliable solution to commute to the city. The challenge of predicting behavioural responses for late-running services or preventing no-shows can sometimes make it difficult to optimise routes. An effective DRT solution uses artificial intelligence to predict busy areas or times, helping to fill the routes.

Perception bias: DRT is often seen as a service geared exclusively for mobility-impaired people. Thus, it is not usually included in transportation maps and is overlooked by transportation planning apps. The following table gives an overview of DRT services and their main types [24].

**Table 5 - Overview on the types of DRT services**

| DRT type | Pictogram | Definition |
|---|---|---|
| **Addresses-to-addresses** |  | Connection between any addresses to any others in a defined zone |
| **Addresses-to-hub** |  | Feeder model<br>Connection between a hub and any address in a defined area – both ways. |
| **Virtual line** |  | Regular line only operated only after at least one demand. |
| **Stops-to-stops** |  | Zonal.<br>Connection between stops in a defined zone. |
| **Stops-to-hub** |  | Feeder model.<br>Connection between a hub and on-demand stops in a defined zone. |
| **End-of-line-to-stops** |  | Feeder model.<br>Regular line serving on-demand stops beyond terminal point |

Variations of the DRT are ensured by some services rules (Table 6 - DRT Service rules):

**Table 6 - DRT Service rules**

| | | |
|---|---|---|
| **Detour time**<br>**Time on board** |  | Maximum additional trip time as compared to direct trip.<br>Maximum time one passenger can spend on board the vehicle. |
| **Stops** |  | Number of predefined stops |
| **Pick-up or drop-off flexibility** | +/- | Maximum time variation around requested pick-up or drop-off time |
| **Booking time period** |  | Maximum/minimum time period you can book your trip |

The most comprehensive collection of DRT services is available on Wikipedia currently [25].

### 3.4.2 Competitive landscape, roles and mobility drivers

#### 3.4.2.1 Competitors

Due to the extremely high number of market players in the SHOW project it's not possible to prepare an international competitor landscape with all the market players.

Based on the information of bedarfsverkehr.at, there are more than 250 active DRT systems only in Austria. Regarding autonomous DRT, no active systems could be identified. Autonomous DRT is currently widely tested within research projects like SHOW. During the competitor analysis in Chapter 4, the deliverable analyses other projects comparable to SHOW, where also DRT is considered. Therefore, this chapter will focus on the competition between DRT and the different forms of mobility not on single providers.

One of the common goals of most of the urban mobility strategies is to achieve a mode shift from private car use towards environmentally friendly modes of transportation such as public transport, walking and cycling or carsharing. As the result of this mode shift, it is foreseen that the future of transportation will be e.g.:

- Less emitting;
- More energy-efficient;
- Available for more people;
- More resilient;
- More efficient in terms of use of public space and infrastructure.

Therefore, the main competitor for DRT would be the private car. The competitive goal of DRT should be to attract people from the use of private car towards the use of demand responsive transportation. DRT should not compete with other environmentally friendly modes of transportation. Therefore, DRT should offer services that are cheaper, more flexible, and at least as fast as the private vehicles in the given context (e.g. rural or suburban areas).

There are many stakeholders involved in this broad definition of DRT, yet whilst there could be collaboration between stakeholders there is often competition, and, as a result, there is often a duplication of services available to the market.

To avoid this duplication through competition with these transport services, the best use of DRT services (in space and time) could be defined as modelling tools and demonstration projects like SHOW. DRT should be the preferred transport mode in those areas and in those timeframes, where and when DRT is the most efficient way of transportation. To help the effective implementation of DRT services, a collaborative environment is needed with the participation of all stakeholders such as government, municipalities, transport providers, suppliers and users. Because of lack of cooperation, DRT will not only attract customers from private cars, but also from public transport, taxi services and active travel modes such as cycling and walking. [26]

#### 3.4.2.2 Roles within the DRT system

The most significant role of a DRT system is the DRT provider itself since it has a connection to all other actors of the ecosystem. DRT provider is situated in the middle of the next diagram that highlights the relationship between the various roles. Vehicle manufacturers, software companies and infrastructure providers ensure all physical and digital solutions (materials, goods, and services) that are necessary for the implementation and the long-term operation of a DRT system. Software solutions (such as booking or driver apps) developed for DRT services are one of the most fertile ground for start-ups.

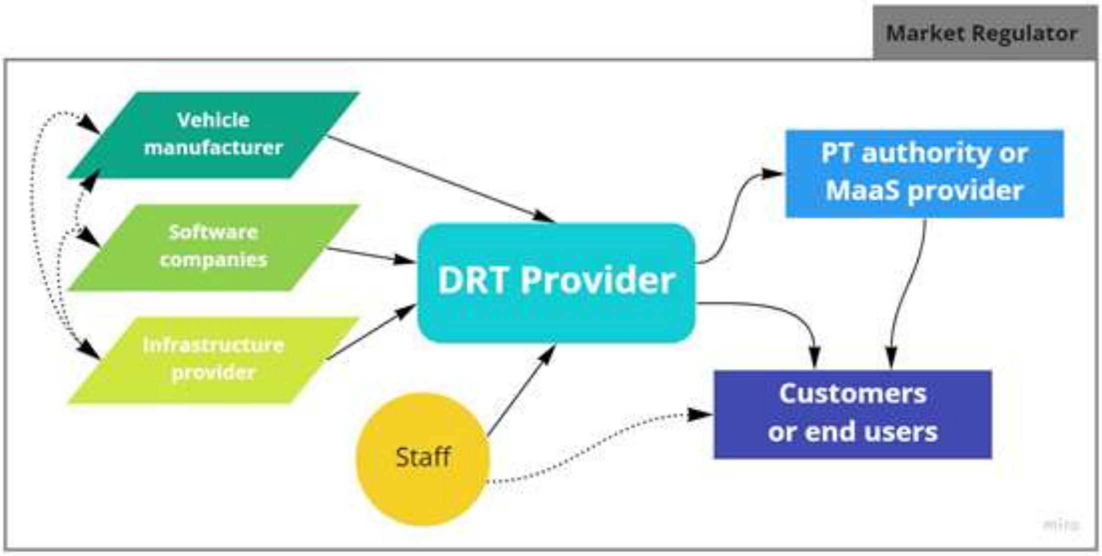



**Figure 35 - Roles within the DRT system [Source: Davison et. Al (2012) [26]].**

The staff of the DRT provider have enhanced their importance during the operation. On one hand they provide labour for the DRT company, on the other hand they (especially the drivers) are the main personal contact for customers. They can provide information about the details of the service, and at the same time they can collect feedback from passengers. A DRT provider may have direct contact with its end users (private customers) through sales channels, but they can sell their services to a traditional PT operator or a MaaS broker/integrator as well. Last, but not least, market regulators (governance, municipalities and permitting authorities) have the significant role to enable and regulate the relations and collaboration in general among the actors of the whole ecosystem. [26]

Beyond the above-mentioned roles, CCAM based DRT services need additional roles that cover the provision of digital infrastructure and services (such as sensors, detectors and communication units), cyber security solutions and services (identification, authentication, data encryption), interoperability (open standards, ontologies, registry, etc.) and solutions in the field of big data and artificial intelligence.

### 3.4.2.3 Mobility drivers

The main goal of a DRT scheme is to provide tailor-made, flexible transport solutions for user segments such as people with reduced mobility, population of peri-urban and rural areas or to small group of people with similar travel characteristics e.g. kindergarten/school traffic. Shared DRT services that generate a modal shift from less efficient modes of transportation have enormous potential to reduce emission of transport. At the same time, the use of DRT can result in better use of the existing infrastructure. Due to the shared use of vehicles, the average occupancy rate will increase. Increased occupancy will decrease the number of private cars and can result in seamless traffic on the roads. Additionally, vehicles being in motion all day long can save valuable public space for cities. Most of the private vehicles are used less than an hour daily, while parking on public space has a negative impact on the quality of life. Last, but not least, a flexible DRT system can be attractive for users, and therefore can generate new trips that would not be realized without such a service.

### 3.4.3 Cost structure and new revenues

#### 3.4.3.1 Types of DRT based on their cost structure

It is suggested that there are four types of DRT in terms of their cost structure [27]:

- **Commercially viable DRT**

Commercially viable DRT, which makes a profit from its operations, is more common than is generally thought with most taxi and minicab services falling into this category along with airport shuttles and jitneys in some cities.

- **Acceptable subsidy DRT services**

Acceptable subsidy DRT operates at a subsidy level which may be like other forms of fixed route transport. In the United Kingdom several DRT schemes appear to have achieved subsidy levels akin to those enjoyed by conventional buses. A review of DRT schemes showed that many of the schemes reviewed were operating at a subsidy level exceeding 2.18€ per passenger, with slightly over half having a subsidy exceeding 5€ per passenger trip. According to the report this would be viewed as an acceptable subsidy level within the industry, based on the cost of operating conventional bus services. The researchers also found that schemes that offered a season ticket tended to have lower subsidy levels.

- **Justifiable subsidy DRT services**

Justifiable higher subsidy services may be sustainable as long as the justification remains valid. Many community transport operations would come under this definition. Others, such as patient transport services, may appear to come under this rubric although often the higher subsidy may not be really justified on the basis of the high-quality nature of the service but rather because of operational inefficiencies. For many DRT schemes, the continuing need for subsidy focuses upon a longstanding rationale for DRT services. This is that, on a per trip basis, DRT is still often far cheaper for public authorities to provide than conventional specialist health, education, or social service transport services. This is a justifiable higher subsidy rationale. DRT may be expensive, but for the markets it serves it is cheaper than the alternatives. This is how DRT became established as a public transport service for people with disabilities – dial-a-ride and ring-and-ride.

- **Financial unsustainable DRT services**

Unfortunately, many trials and pilots of DRT services have proven to be financially unsustainable. This may happen for several distinct reasons including flawed service design, unrealistic expectations, failure to work with the users in the service development stage and not explaining how the services are to work to prospective passengers.

#### 3.4.3.2 Cost reductions for DRT services

Several ways of reducing the cost of demand responsive transport have been suggested including:

- the use of established stops or collection points;
- limiting the number of off-route requests accepted per vehicle trip;
- accepting last-minute requests (including those made at the time of boarding) only on a space available basis;
- reserving the right to pick up or drop off passengers several blocks from their actual origins or destinations.

A key issue towards creating a commercially viable DRT is to decrease the costs of the provider. The next paragraphs will summarize some of the potential solutions and their impact on the change of the costs. Although it is always hard to decrease the overall costs of an already running service, there is the enormous potential of decrease the variable costs (fuel, energy, maintenance) per passenger. The more people share a ride, the more revenue will flow in, while costs will slightly decrease due to lower kilometre performance. These altogether mean a relative decrease of the costs per passenger. Therefore, one of the main goals of an operator could be to maximize the number of passengers per ride. A big challenge is to avoid the decline of the level of service by having more people onboard at the same time and increased travel time due to detours. Dynamic pricing, discounts, and other incentives, and furthermore the use of artificial intelligence for better routing, can be used to increase the average pooling rate.

Simply having more passengers will not necessarily decrease variable costs, but fixed costs (depreciation of vehicles and infrastructure, software, garage) per passenger will be lower by a high probability. Thus, it is important to propose a high value service that meets the needs of passengers and to support ticket sales with appropriate marketing to address potential customers. Another possibility to decrease fixed costs per passenger is to extend operating hours. This approach may result in better use of the existing asset and infrastructure but might increase personal costs and require different communication messages towards the various target groups (e.g. commuters in peak hours vs. leisure at the weekend).

Increasing the number of vehicles will increase the fixed costs for vehicles, but might decrease the relative costs of infrastructure, premises, and software. More vehicles mean more capacity, flexibility, and a potential to attract more passengers to use DRT services. [27]

#### 3.4.3.3 New revenues

The White Paper published by the MaaS Alliance in September 2017 [28] stated that ‘A fundamental principle and core motivation behind deployment of MaaS is that it is a user centric, customer-centric, market-centric proposition within a societally grounded context.‘ MaaS aims to become the best value proposition for both private and business users, by helping them meet their mobility needs and solve the inconvenient parts of individual journeys, as well to improve the efficiency of the entire transport system.

The debate around MaaS has often centred on how to make those who can already access transport able to access a different mode of transport. To reimagine transport as a public good we must also consider how MaaS can broaden and deepen the impact of our transport network. In order to achieve this, regulators, businesses, and community organisations, must consider how the allocation of subsidies can encourage marginal travel.

MaaS platforms provide a fantastic opportunity for DRT companies to get more visibility and to attract new customers.

Another innovation for DRT can be the introduction of **dynamic pricing** systems. Shared mobility providers such as car sharing and scooter sharing companies already apply dynamic prices that may vary in both space and time based on the actual demand and the available supply. Although the current shared mobility services usually take travel distance and/or duration into account while calculating the final price of a trip, in case of DRT pooling can be a key factor as well. For example, the price/person of a trip could be lower in case of shared trips compared to single occupation trips. Dynamic pricing can be a fair solution to incentivise the use of services outside peak periods. With such a solution, customers can get a better offer, while service providers can increase their income.

With the rise of the internet and digital marketing, it seems like more traditional **advertising** strategies have fallen in disgrace, however, some of these remain as powerful as if they were in their prime. Transit OOH advertising – ads on buses, taxis, planes, and other vehicles – has proved to remain highly effective at reaching audiences of all ages and backgrounds. Indoor transit advertising refers to all kinds of ads located inside the vehicle. Nowadays we can find them in a multiple mean of transport, taxis and underground. And they come in a different variety of formats: posters, audio and screens. Outdoor advertising refers to all kinds of ads placed on the outside of vehicles and transportation shelters, they can be located either on the sides of the vehicles or on the roof. According to statistics from the Outdoor Advertising Association of American, transit advertising is by far the cheapest form of advertising, it costs 15 cents per thousand impressions. At the same time, it can be a reliable source of income for DRT providers too. [27]

**COVID-19** may have an impact on the revenues of DRT services as well. While the use of public transport decreased in 2020 due to the pandemic all around the world, more people started to choose individual transport modes like cycling or private cars. Additionally, in most countries, the maximum number of passengers per DRT vehicle is also regulated. For example, in the city of Berlin, the local DRT service Berlkönig limits pooling up to 3 passengers. The use of the Austrian ISTmobil is only permitted if only 2 people sit in each row of seats including the first row. At the same time, the reduction in passenger numbers leads to lower incomes and threatens service providers. Since governments and municipalities have an interest to maintain DRT services, new ways of financial support might appear for DRT services in the close future.

### 3.4.4 Market growth, outlook and trends

A study published by the International Transport Forum (ITF) in 2015 stated, that nearly the same mobility (in terms of motorised road traffic) can be delivered with 10% of the cars. The study used transport modelling based on data of an existing city. The proposed solution could remove 9 out of 10 cars from the roads if mobility needs would be realized through the combination of high-capacity public transport and shared autonomous taxis. The study emphasizes that the transition period (that leads to the sufficient number of autonomous shared vehicles) would be challenging and it would take a long time. Additionally, an increase in the overall volume of car travel is expected as well that may lead to more congestion on short term.

The growth of Mobility-as-a-Service (MaaS) solutions, which integrate multiple modes of transport into a single platform, is changing the way passengers commute. But millions of people who live in rural areas or are mobility impaired, cannot benefit from this innovative technology. [29]

The market for DRT shuttles is growing, with reports predicting it will account for 50% of the shared mobility market by 2030. Smart city initiatives are shifting the transportation world towards multimodal and intermodal mobility, providing a fertile ground for this type of shared and combined services to grow.

Growing adoption of car rental services on airports and increasing investments in car sharing by automobile manufacturers in Germany will attract more people towards the shared use of vehicles instead of ownership. Since one of the main goals of MaaS is to provide access to multimodal services instead of private car use, it can significantly contribute to achieve a mind shift of individuals towards the more frequented use of shared services.

One of the most significant DRT growth drivers in the coming years will be the economic growth itself. Increasing economic activity necessarily generates an increase in mobility and therefore require extended and new solutions on mobility. Governments will invest in efficient transport solutions to reduce congestion and pollution and they will change regulations to enable the growth of DRT services.

Based on the Vehicle Type, Four-Wheeler segment is expected to hold the largest share in the On-Demand Transportation market during the forecast period. On-demand four-wheeler are earning notice not only for their use in urban areas, but also as a potential means of resolving the current challenges in running public transportation systems in regional areas sorely impacted by depopulation. Four-wheeler are also increasingly viewed as a feasible approach to lowering the burden on the natural environment.

In terms of region, Asia Pacific is expected to hold the largest share in the On-Demand Transportation market during the forecast period (20129-2027). [30]

### 3.4.5 Connected and Cooperative Automated Vehicles (CCAV)

The deployment of CCAV will further grow the potential of DRT services. Although fully flexible schemes due to the status of technology development cannot be implemented in complex urban environment, AVENUE project made a major step towards the successful testing of an on-demand service with autonomous shuttles in limited traffic environment at the area of a hospital in Geneva. CCAV based DRT will enable people to move in a vehicle individually without car ownership or a driver license. On longer term, they will most likely decrease both pollution and costs of transportation in the aspect of individual mobility needs. Until CCAV won't have the ability to provide door-to-door service in a complex environment, autonomous DRT services will most probably focus on first/last mile services on fixed routes.

One of the most critical issue during the implementation of a DRT scheme is to find an economically viable business model that meet the needs of the target group. In case of special services such as paratransit or school transit, subsidies are necessary and acceptable. The type of the DRT (e.g., linear, feeder, zonal or door-to-door) must match customer needs to supply an efficient service. Another critical issue is the appropriate regulatory environment that is necessary to handle the business conflicts with traditional public transport and private taxi services. Similarly, to shared mobility and MaaS, DRT services require new regulations in most of the cities all around the world. Therefore, it is of high importance to create a regulatory environment that enables cooperation instead of generating unnecessary conflicts among stakeholders.

There is an enormous potential of DRT in the short- and mid-term development of the mobility sector. MaaS providers will try to integrate a rich palette of services into their system to fulfil the needs of MaaS customers. Therefore, integration into MaaS platforms is essential for DRT providers as well, to increase their visibility and to reach new segments of customers.

New digital solutions can help the further development of DRT. Future big data and AI solutions can help to predict mobility demand and result in better routing to foster shared trips, to increase vehicle occupancy. On longer-term, CCAV can have an enormous impact on the deployment of DRT services. The large-scale deployment of shared autonomous shuttles together with high-capacity PT network (metro, bus rapid transit and tram) can achieve a revolution in mobility and decrease the use of private cars significantly. [31]

### 3.4.6 Conclusion

The rapid development of automated vehicles and the introduction of shared mobility services hold great potential for the development of automated public transport systems. However, their expected performance under alternative conditions and with alternative design factors remains unknown, especially for demand responsive transportation. Due to its very nature – elimination of last miles in Urban or peri-urban areas DRT has always been a local business model that differs from location to location. Moreover, the definition of future mobility services often includes the factor of demand responsiveness. The best way to assess the actual possibilities of self-driving DRT could be a simulation based on different experiences of cities that already use traditional DRT. As the research on operating automated DRT is only at its beginning, there is no established method to model or simulate automated DRT yet. This is presumably also related to the complexity of dynamically operating a large fleet of vehicles in a demand-responsive fashion. It is especially challenging to establish an optimization method for solving the dynamic DRT vehicle routing problem with time window constraints because small changes in the solution structure can result in highly infeasible solutions Research in this field currently focuses on the implementation of new data sources and data transmitting technology, large scale applications and ride-sharing in urban areas. But in the end, DRT will benefit from the introduction of CCAM, as travel times will go down and comfort will go up. Future technological trends like Artificial Intelligence and deep learning will come even more important for advances services like DRT, to calculate the perfect vehicle occupation rates and eliminate most empty trips and long routes.

## 3.5 Car Sharing

### 3.5.1 State of the art

#### 3.5.1.1 Definition of car sharing and applied mobility services

At this stage, car-hailing and ride sharing are already a reality and are increasing both presence and importance at high rates, not only in Europe but also globally. According to many studies it is poised to keep growing for the upcoming years (except for 2020 for obvious reasons), keeping up with the trend presented by Monitor Deloitte and represented in forecast graphs below.

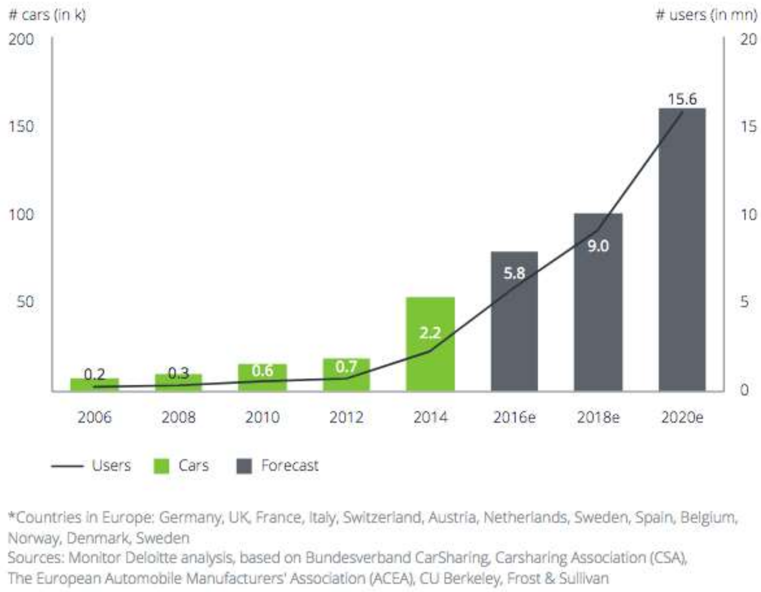



**Figure 36 - Car sharing market development for Europe (2006-2020) [Source: Deloitte analysis, based on CSA].**

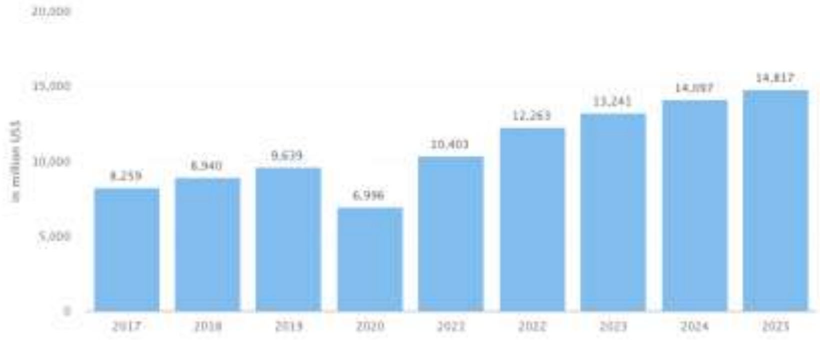



**Figure 37 - Forecast of car sharing market in US$ [Source: Statista].**

As a result, there are many approaches and operating models found throughout the world, every player trying to make their way to the top or find their spot; some focused on short trips, some on long ones, some B2C, others P2P... Generally, and as presented in D2.1 [20], here is a clear initial distinction as per how the fleet is distributed. The most common types of car sharing mobility concepts are:

- Peer-to-peer car sharing;
- Stationary car sharing;
- Free-floating car sharing.

A graph looking into some more transport solutions is presented below. Here, another crucial player is introduced; private car. Car sharing is currently, and will be in the future, a perfect substitute for those who do not own a private car or prefer to use a shared one when needed rather than having all the associated senses of owning one.

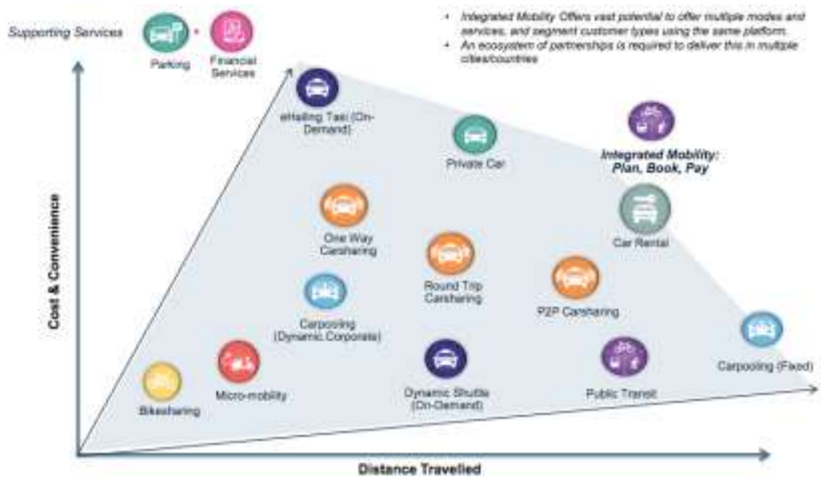



**Figure 38 - Urban mobility landscape [Source: Frost & Sullivan].**

Again, CS is in the centre of needs and requirements, now presenting a new differentiation between One Way, Round Trip and P2P car sharing solutions. However, it is an uncertain spot for CS and its future, as increasingly often solutions have things in common and services cross borders from one kind of service to another while creating new business lines or models. A mapping of such relations within basic transportation modes and car ownerships is presented below, with CS located at the centre of widely known solutions and traditional modes such as car rentals or privately owned cars.

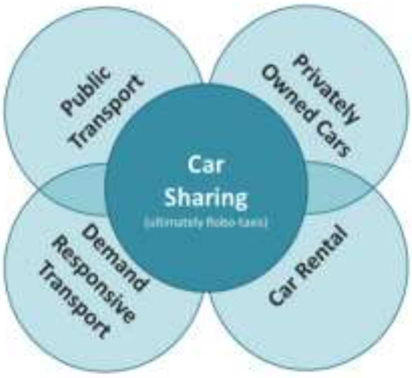



**Figure 39 - Mapping of current mobility solutions [Source: Bax & Company].**

In all, every business model is unique, and general classifications can be useful but are not correct enough to understand the market. Every BM can and does respond to many factors apart from the above mentioned, such as who is investing, where is the service provided, who are the users, is the city or region involved, what are the revenue sources

### 3.5.1.2 Existing solutions

For a best classification and SotA analysis, more in-depth explanation, and presentation of players in the market (big, small, start-up, local…) is needed. As a result, a comparison table is presented below.

Specific companies or services are included in the table for readability reasons, for the best understanding of the table further knowledge on the services offered by the presented examples is recommended.

**Table 7 - Existing car sharing solutions [Source: Bax & company].**

| | BlaBlaCar | TURO | uberPOOL | ubeeqo | FREENOW | Car rental | Shuttle |
|---|---|---|---|---|---|---|---|
| *Model* | P2P | P2P | Free-floating | Free-floating | Free-floating | Stationary | Free-floating |
| *Type of trip* | One way | Round Trip | One Way | "Round Trip" | One Way | Round Trip/One Way | One Way |
| *Fleet owner* | Private | Private | Private | Company | Company | Company | City |
| *PT related/City involvement* | No | No | No | No | No | No | Yes |
| *Main area of service* | Inter-city | All | Urban | Urban/All | Urban | All | Urban |
| *Sharing* | Ride | Vehicle | Ride | Vehicle | Vehicle | Vehicle | Ride |
| *Looking into AV for near future* | No | No | Yes | Yes | Yes | No | Yes |
| *Time of service* | Medium | Long | Short | Medium | Short | Long | Short |
| *Vehicle capacity* | 4 | 5 | 4 | 5 | 2-5 | 5 | +8 |
| *User drives* | No | Yes | No | Yes | Yes | Yes | No |

### 3.5.1.3 Moving towards automated vehicles

As seen in the comparison table presented previously, each company or service provider has its own structure, nature, target and plans towards the future. Here is where automation comes in. Most of the presented BMs are already functioning successfully and are growing, which therefore represent a clear path for the inclusion of automated vehicles in our streets. Providers of AVs are looking into CS as an opportunity for them to implement and sell their products as the presence of car sharing vehicles in our streets is expected to grow over the upcoming years. According to the previously presented Monitor Deloitte study where the numbers of cars destined for this kind of mobility solution grew over the forecasted period and the actual market value is expected to continue growing too, as seen by Statista, presenting a constant growth up until 2025 both in market penetration and millions of users.

CS players looking into what will be normal in the near future are taking a stand in the automation race, some of them pushing or even basing their strategies on AVs. This trend, converging into robo-taxis, is presented through the following graph, which further confirms the previously presented flower-like figure.

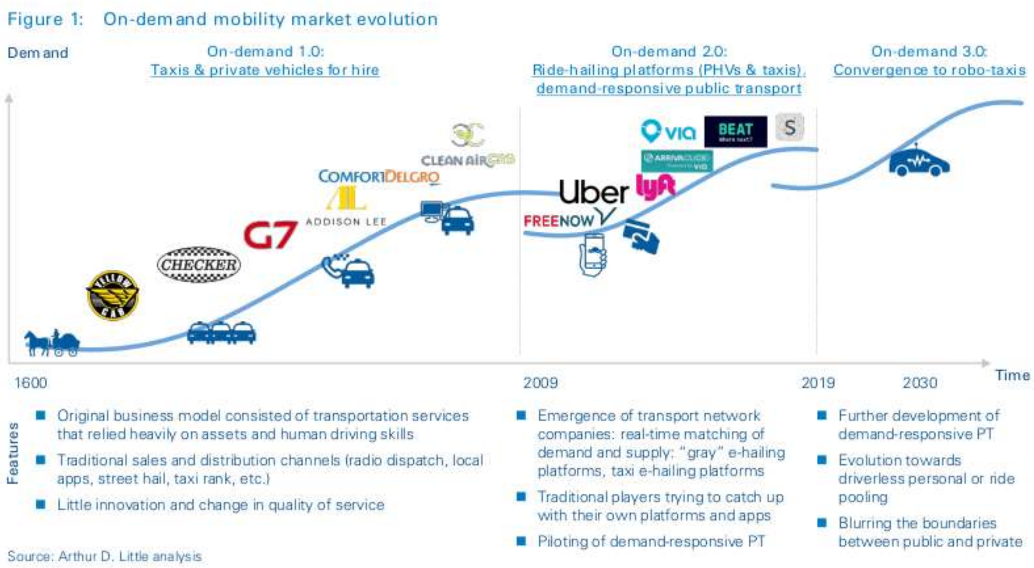



**Figure 40 - On-demand and mobility market evolution [Source: Arthur D. Little].**

Further knowledge on the transition requests some more detail on strategies and key players in the AV world and furthermore within CS. On top of that, as seen in the presented visual, players from different areas such as DRT and ride-hailing solutions are moving in parallel but following a similar path, most probably ending by converging into one unique kind of service, known as robo-taxis.

### 3.5.1.4 Future concepts

In addition, or complementing with AV, other initiatives and innovative solutions and BMs are rising throughout. Many ideas and concepts for urban mobility touching upon car sharing exist. Some examples worth mentioning or pointing out are presented below.

- e-GO;
- Scania NXT;
- Toyota e-Palette;
- Vision URBANETIC – Daimler.

These new concepts for future urban vehicles have AV as the core similarity, however, each concept explores different areas or solutions in combination with such. What is common to most is the fact of having, not only a car sharing solution but more specifically, vehicle sharing itself.

This innovative concept tries to address multiple issues or services at the same time, including logistics, retail, PT, car sharing, food or even leisure. Based on modular vehicles that can easily be personalized or transformed depending on the final use the provider wants to destine the AV for. As a result, one vehicle can be actually used as a robo-taxi, carrying goods at the same time in a multi-modal fashion during the day and as food delivery or even food truck at night or some other day. Ideally/hypothetically the possibilities are uncountable.

The goal is to be able to share the vehicle as a whole, not only in its car-associated uses but also for many other aspects, by slightly modifying the main module of such, which can be easily done as mentioned. Below, a quick example on pre-identified solutions or specifications for Toyota's e-Palette.


**Figure 41 - Toyota e-Palette concept vehicle specifications [Source: Toyota].**

From retail to restaurant, to moving logistics hub or regular transportation of goods or people and even real e-commerce floating around our streets. These solutions are looking into the next level of car sharing by introducing actual vehicle sharing and exploring new ways to combine and share our vehicles at a much broader scale, all based on AV, personalization, security, user experience and optimization of space and time.

### 3.5.2 Competitive landscape, roles and mobility drivers

The car sharing market has uncountable players world-wide, and especially in Europe, the market is flooded with companies and service providers. Below is an example of service providers in the domain, not only for CS but also some from DRT, which are two close, and often co-related services, up to the point that they can be even combined or be part of the same predominant structure or company. As mentioned previously, they are pointed to move towards similar solutions or even identical through the implementation of robo-taxis, which creates an even more complex competitor landscape in the long-run and immediate future as well.


**Figure 42 - Overview of transport network companies by region [Source: Arthur D. Little].**

This is a clear response to what has been presented and the actual trend and growing demand of these type of solutions, but what are the main drivers and needs that are making this possible?

### 3.5.2.1 Overall prioritizations, needs and expectations

Today's world and current situation is asking for certain changes and demanding specific approaches to evolve and move forward, in all industries, and CS is no exception. Aspects and KPIs such as technology readiness, safety, inclusivity, integrability to PT, willingness to pay, emissions reduction, employment, adaptability to public roads and infrastructure, amongst many other, are all looked into while this trend and number of companies and service providers keeps growing globally.

For the issue under study, new highly connected road transit through hyper-connectivity and 5G solutions that allow users and providers to function in ways never seen before, the urge and social shift towards rising expectations on all being sustainable and clean opposed to the traditional polluting solutions as well as increasing road safety by reducing accidents too, all are key features that push and act as enablers both for CS to increase its share in the market and for AV to make an appearance.

Such appearance is even expected to be at several levels in the cities of the future, not only in private cars, but also in the form of robo-taxis, car sharing solutions and as part of the public transport (shuttles, buses…). Also, cities and regions have the will to serve all their citizens in a fair way, so affordable transport solutions for citizens living in remote, difficult to access areas are constantly on demand. All those trends and desires coming from different sides, work as clear drivers for AVs to evolve quicker and in a more certain way both in CS and in other models.

On top of that, the impressive number of competitors presents the undoubted need for low prices and affordable solutions, both for companies and for users. From one side to be competitive and from the other due to current low acquisition levels of target population. In addition, this population is responding to an on-going trend, already part of our day to day lives where on-demand economy is growing and increasing its presence across industries. Young adults, millennials, and citizens are turning towards improvisation and fast-paced lives, which implies quick, comfortable responsive solutions 24/7, being it mobility, food, retail or many other. As a result of this existing trend, on-demand mobility is gaining presence too, both through DRTs and CS, which adjusts in many ways to what the users are looking for.

In addition, while observing logistics under this presented umbrella of opportunities for instance, the need to deliver goods at low costs, fast and through extremely optimized procedures is also higher than ever. Again, logistics can and will be adopted by CS solutions and other future concepts of vehicle sharing to be able to take advantage of existing infrastructure and increase vehicle use as a whole, how this will be done will depend on the model of each provider.

#### 3.5.2.2 User and city needs, requirements and trends

Having mentioned the earlier market drivers looking at the overall picture, it is worth presenting the users' point of view and behaviour enabling AV and CS to enter the whole mobility market.

There are many opinions and approaches while considering buying a private car, however, car ownership levels have stabilised and even decreased in some urban areas, or the actual fact of having a car has different values or connotation nowadays. For today's society, where fixed costs are consistently unwanted, owning a car represents a huge controversy. The fact that the acquisition value is high, it brings other associated fix costs, there is only pay-per-parking spaces in the cities, until now it is a polluting means of transport and many other factors, contribute on the actual decrease of car ownership and even in the actual interest in having a driving license even. In addition, many cities such as San Francisco or London, are considering, or have done it already, including fees to enter the city centres in a means to reduce congestion, pollution and at the same time, free parking space in the city for other purposes and enhance the market share of PT and other clean solutions such as micro-mobility, currently experiencing a boom, as clearly seen when observing US' NACTO (National Association of City Transport Officials) numbers, presenting an increase from 35 million trips on shared micro-mobility vehicles on US streets on 2017 to an incredible 84 million trips in 2018.

AV and CS solutions rise as a great alternative to all those problems or issues, existing as a mode where you pay per use, avoid parking fees, have no inner-city charges, split possible variable costs, and can be perfectly combined with micro-mobility solutions and even with last-mile eco-friendly delivery of goods through capacity sharing.

However, it must be said that the decrease of car ownership or private car usage in urban areas is not due to existing good CS services, but it is mostly affected by the deployment and availability of fast and high-quality public transport networks, successful on-demand services both in rural, urban and sub-urban areas, well connected and efficient train and other micro-mobility solutions even. This all serves in favour of CS to have so many citizens even considering the fact of not owning a private car.

On top of that, international mobility is nowadays something extremely common and looked for, as, among other, today's young adults live more international experiences throughout their lives, not only traveling but also studying and even work-related stages abroad too. According to a study made by the Institute of International Education, up to 16% of all students graduating from a bachelor's degree have studied abroad for some months at least. This fact also stands as a clear barrier to buying a car as people and families are more often on the move and there is a clear tendency towards the on-demand economy, using what you need when you need it, having less attachments and forgetting about it later.

Furthermore, cities and regions see in their urban planning many reasons to push for car sharing solutions, even if some have barriers in the form of policies that make the inclusion more complicated. The goal of having cleaner, connected and liveable cities is growing bigger and bigger. By reducing congestion, freeing parking space for several potential uses, promoting and linking new initiatives to PT and offering cheap and efficient services that reach remote or hard to access areas are all enablers and clear points in favour of the topic under study and its adoption.

#### 3.5.2.3 Interested players

For these reasons, it is understandable that the number of interested parties and players is big and growing, from users, cities and regions to service providers (e.g., e-hailing platform developers, fleet operators, charging stations, cleaning services) and of course, urban planners. The presence and fit of private companies in the CS market is relevant not only for the transport providers but for many other players. These providers work at a more back-end stage together with OEMs in the creation of the vehicles which will consequently be used as AV for CS purposes. AI developers and many related research groups are actively involved in the progress of such industry.

On top of that, the fact that CS and AVs in general allow the user not to be busy driving when commuting, there is a clear increase in productivity time, being of the interest of both, users, employers and even media, advertising and leisure related companies or providers, who see a new channel through which efficiently reach their target audiences.

Also, innovative solutions are, often, well designed and as inclusive as possible, enhancing through this fact the actual interest of the elderly, kids, and citizens with reduced mobility on such kind of solutions. It is especially important to have all this in mind while developing the future of our cities and the overall urban mobility environment. On top of that, side effects such as freed urban space is also seen as desired or interest for the aforementioned sector of the population.

In addition, through solutions of vehicle sharing as presented previously, restaurants, delivery solutions, retailers, e-commerce, and logistics in general also see this trend as an opportunity to reduce their costs and improve their (last mile in particular) services through this capacity sharing and similar innovative models.

#### 3.5.2.4 Competitors and barriers

As in every innovative solution and new market players in any sector, AV CS meets many barriers and competitors to succeed in our streets. Trends driving this new means of transport based on the shared economy are also driving other solutions such as micro-mobility, DRTs and even the enhancement of traditional and maybe cheaper PT. All mobility solutions are obvious competitors.

In addition, there are barriers that can also hold behind the expansion and deployment of such solutions, or things that turn out wrong. These can be policy or local regulation issues, being unable to correctly deploy the services in planned areas or experimenting unsuccessful social uptake of certain solutions, failing to meet economic objectives, or reaching critical mass for new services being deployed, are all factors that can shape the success of CS.

Furthermore, sharing economy trends in general can be affected by health issues and threats in situations like the COVID-19 pandemic or similar, where people is reluctant to share their personal space and are keener on having their own private vehicles for mobility rather than hopping on an AV shared mini-van for instance.

### 3.5.3 Cost structure and new revenues

#### 3.5.3.1 Existing cost structure and company strategies

Car sharing solutions has quite a variable nature for cost structures, as varied as the associated business models. Some of such services are based on P2P sharing and others depend on an actual company or organisation supplying the vehicle fleet for instance.

When looking into ride-hailing solutions and its cost structures and distribution of revenues, many factors come into action, as it occurs with other transport modes too. From the OPEX and CAPEX associated with the private car costs, accountable by the driver or car owner, to the customer acquisition costs and other e-hailing platform costs associated. The following figure illustrates the economics behind an average 10 km ride based on a specific taxi pricing, operated through a ride hailing platform and by a driver who own his/her own vehicle.

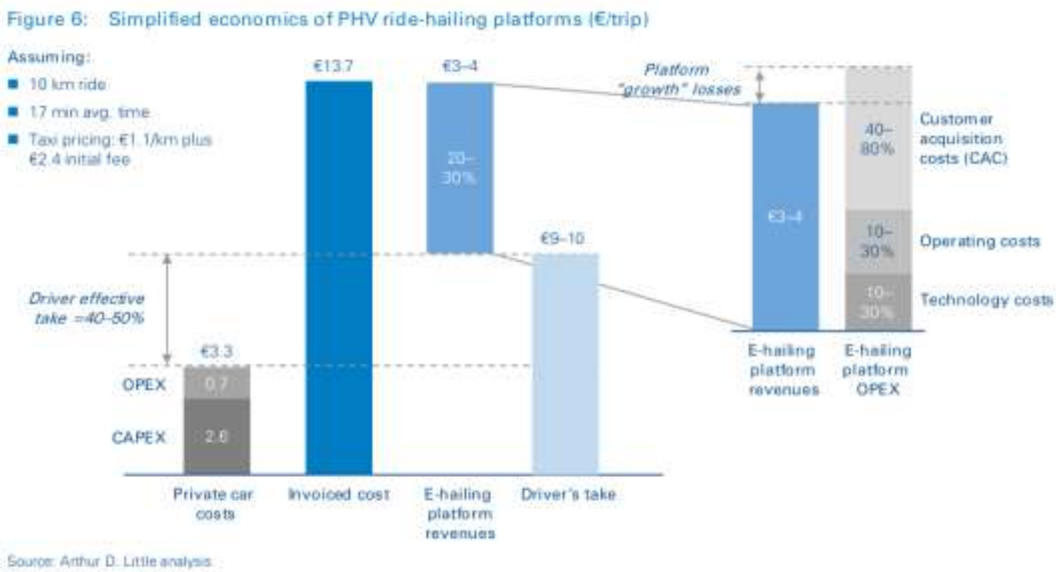



**Figure 43 - Simplified economics of ride-hailing platforms (€/trip) [Source: Arthur D. Little].**

While observing the presented figure, we can see that the revenues are distributed in many sections, with the actual e-hailing platform taking between the 20-30% of the revenues while the driver has a higher uptake (40-50%) once deducted the OPEX and CAPEX costs associated to the private car costs. Such platforms hardly cover their own expenses with their revenues currently, as the case for many start-ups and service providers, bearing in mind that the platform has obvious OPEX including technology costs and even customer acquisition costs. These numbers can vary depending on the model and ownership structures of course.

The previously detailed explanation looks into the classic e-hailing platform service. On the other side, when looking at other solutions such as P2P car sharing or other related services, the revenue distribution and associated cost structures may vary significantly, as platforms can be simpler, fleet costs reduced, and even OPEX minimized.

Mostly, in car sharing as a whole, costs include buying or financing the vehicle fleet, physical/digital infrastructure, maintenance of such fleet, depreciation of the vehicles, personnel (both drivers and cleaners), parking space, insurance, fuel consumption and even marketing and communications amongst many other costs which again, vary widely depending on the business model.

Companies may opt to own their own fleets and manage to increase the usage of their vehicles to make the best of their lives, reducing other associated costs on the way to try and retain higher share of the income. But of course, this brings many organisational and continuous issues and need for attention, which at the same time have high costs associated. As a result, each BM, both current and future, needs to evaluate the fit with their plan and the associated costs and potential benefits to decide between basing their service on own fleet operation versus vehicles privately owned by the drivers. All of these and more should be looked into when evaluating existing or innovative BMs.

To do so, the following figure provides a clear view of the whole value chain of the car sharing market. Ideally, end users will have to create revenues for all the previous stakeholders involved. This of course can be reached through increasing the percentage use of each vehicle or providing services with clear market differentiations which customers are happy to pay for, amongst other revenue streams techniques.

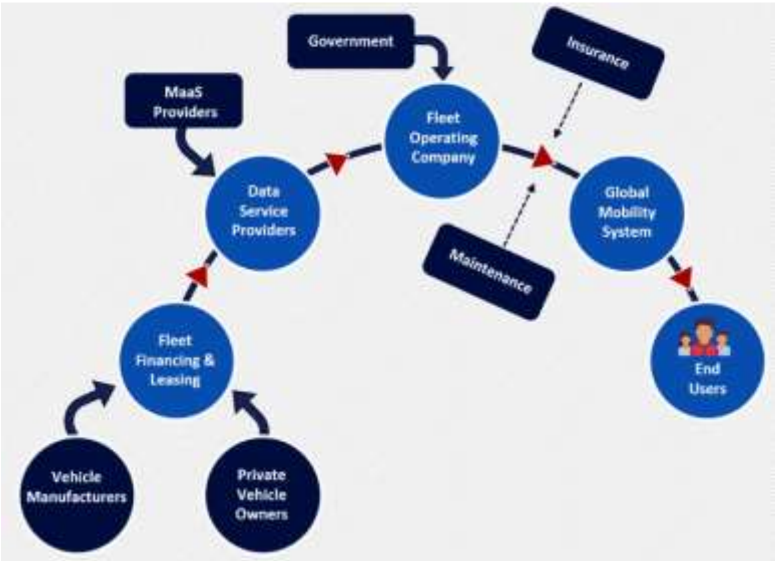



**Figure 44 - Value chain analysis of global car sharing market [Source: Prescient & Strategic Intelligence].**

Worth mentioning is the fact that privately owned cars spend around 90% of their lives parked (according to the RAC Foundation), that is another benefit for car owners, either being it fleet operators or private owners providing their services in P2P solutions. Through these kinds of CS business models, where private car owners may share their cars with neighbours for instance (Turo and Getaround for example), the use of the vehicle can be dramatically increased, resulting at the same time in income both for the vehicle owner and the actual platform acting as middle-man. Such income can serve to reduce ownership related costs and even to reach benefits if done on a regular basis.

#### 3.5.3.2 Automated vehicles cost structure and strategies

Next to evaluate is not only ride hailing solutions in general but the incoming players combining AV with CS. Once the cost structure and existing business models have been tested and studied, many indicators show the potential of substituting the driver, who represented near half of the revenues in the basic ride hailing platform revenue structure. Such platforms and service providers have seen in this a fantastic opportunity to include technology to optimise their services and gather higher share of the revenues associated per trip.

Such is the case of Uber, currently exploring thoroughly the AV segment through their specifically dedicated Advanced Technologies Group (ATG). Working as an in-house central hub for developing AV amongst other innovations to make sure they are at the forefront of the market.

However, this can bring new aspects into the spotlight, such as the fact that the fleets will have to most probably be owned by the service providers, or even manufactured in the case of joint ventures and collaborations. On top of that, all the maintenance and power supplies will add on the actual costs to consider when evaluating such services being offered by a specific provider.

In addition, some studies have presented an overview of what a future scenario of robo-taxis and AV services prices may suppose to the end user. Most of them conclude that the prices will be lower through AV CS than existing CS or other more traditional means. The following figure presents a clear differentiation on what is expected to look like, comparing autonomous with non-autonomous vehicles, in urban and rural areas and the prices passengers will pay in CHF per kilometre in each case.

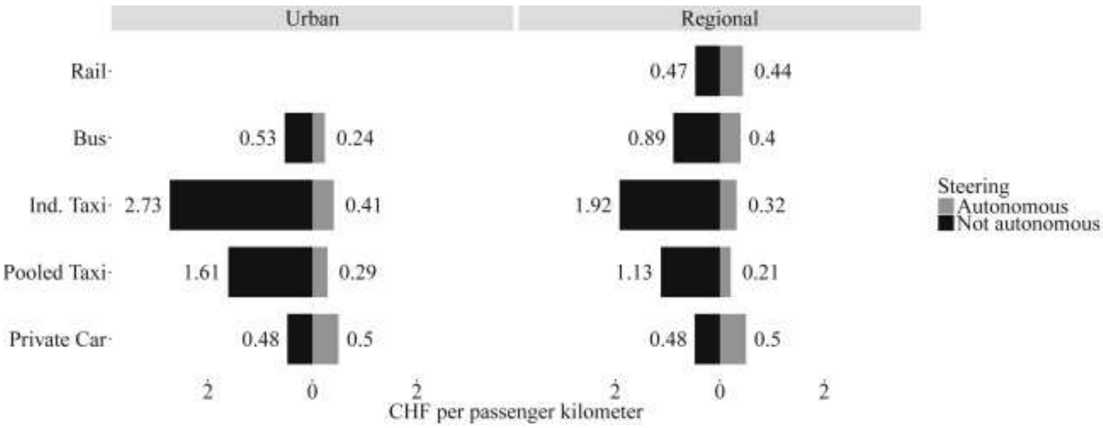



**Figure 45 - Cost comparison of different modes AV-non-AV [Source: Patrick M. Bösch et al.].**

As it can easily be seen, prices are clearly expected to decrease considerably when automation is introduced into the day-to-day transport modes. Below, another figure is presented where prices for passengers are compared, PT, privately owned vehicles, and taxi to the prices per passenger in robo-taxis.

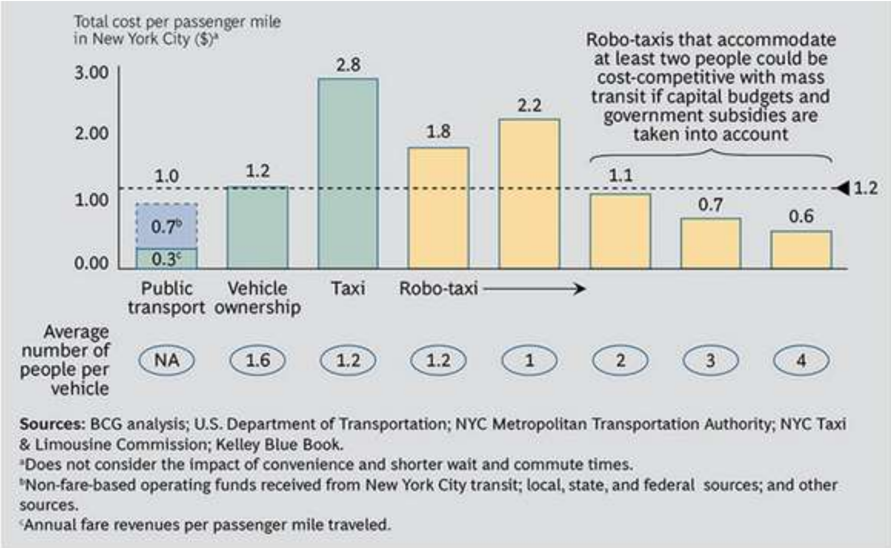



**Figure 46 - Robo-taxi price ($) comparison per passenger mile in New York City [Source: BCG analysis].**

The fact that robo-taxis are cheaper solutions than conventional taxis can be easily extracted from the figure, however, it is worth mentioning the actual price difference of CS within robo-taxis. Once the robo-taxis are shared with more than 1 passenger, the prices drop even to a lower level and become a solution to compete with mass transit in general, being able to reach even lower prices for passengers than that associated with private vehicles.

Once again, these numbers rise the fact that customers will eventually see a reduction in prices, which will result in less revenues for the service providers as a whole. However, these will have no driver associated costs and will work towards reducing the rest of associated costs to make it through and succeed in the new era.

#### 3.5.3.3 New revenue strategies

As mentioned, several times throughout, the clear connection between services and transport modes, together with the potential common ending point as robo-taxis, has pushed players in every level to explore new business lines and services in order to increase their revenues, both in size and variety.

A notable example is once again the well-known Uber. The company, originally existing as a DRT solution and platform, has expanded its service offering year after year. From different car riding options, to freight solutions (currently looking into autonomous trucking too), to bike and scoot, to air transport and others.

Such is the importance of reaching new revenue streams that according to CBInsights, close to a 14% of all Uber’s hires in 2017 were for the Uber Eats line.

In addition, many other techniques or new revenue strategies exist, from data-based BM to increasing vehicle use through multi-modal solutions combining passengers and freight for example.

On top of that, high hopes are set on AV as this can serve as new revenue streams for fleet owners or service providers, who will be able to take advantage of the passenger’s time while not driving for commercial issues, leisure, retail and more.

### 3.5.4 Market growths, outlook and trends

#### 3.5.4.1 Market growths car sharing general

Car sharing, as presented previously, is already an important player in urban mobility and it is forecasted to grow during the upcoming years for several reasons. According to the study “Global Car Sharing Market 2020-2024” by TechNavio, the car sharing market is poised to grow by $7,65 billion during the forecasted period between 2020-2024, progressing at a CAGR of 16%. Below are some graphs further elaborating on this expected growth for CS as a whole.

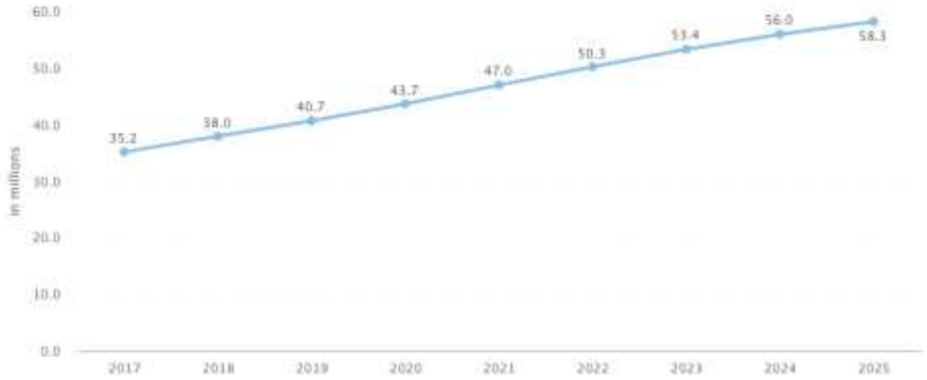



**Figure 47 - Forecast on the number of users in the car sharing segment [Source: Statista].**

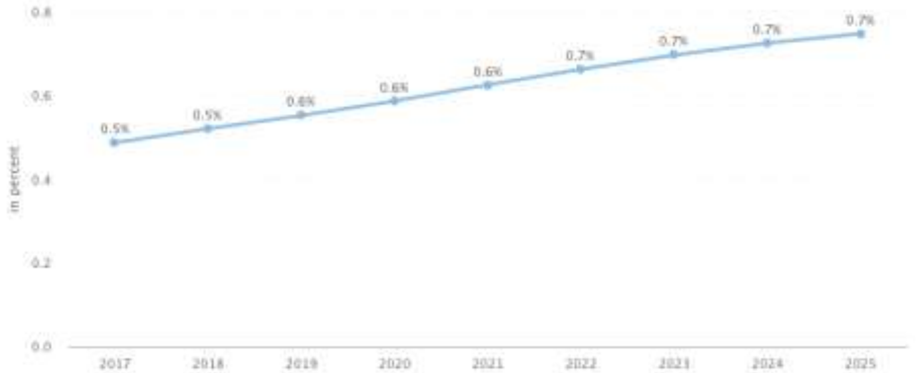



**Figure 48 - Forecast on the user penetration rate in the car sharing segment [Source: Statista].**

Such growth is related to all that has been mentioned previously in this chapter, as well as a combination of what other chapters include. Decrease in car ownership due to high unwanted associated costs, reduction of parking space in city centres, growth of sharing economy in general and improvement of ultra-connectivity and digitisation of all services, all and many more are contributing to this phenomenon.

Car sharing and ride hailing, existing as a combination of car rental, urban mobility solution and as an alternative to private car ownership, is on the right track to capture more market share over the years.

#### 3.5.4.2 Market growths automated vehicles

In parallel, the AV market is also a growing trend and many eyes are set on this technological innovation, expecting our streets to be flooded with such vehicles sooner or later. Accordingly, many OEMs are taking initial (and advanced) steps towards the success of such and numerous new manufacturers are making appearance too. New AI software providers and related start-ups are also growing both in size and number.

This is a response to the current trends, which see AV as a safe, cheap, and efficient solution to move towards a more comfortable future for most of us. Current expectations present a clear growth in the actual demand of such transportation modes, a clear indicator is the graph presented below where this can easily be seen.

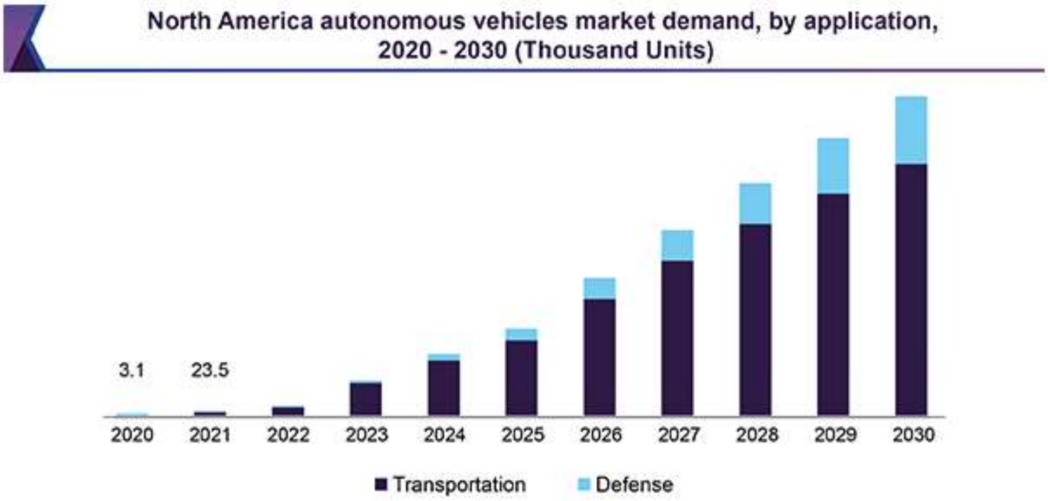



**Figure 49 - North America AV market demand by application [Source: Grand View Research].**

As seen, AV market growth and the existing trend will for sure shape the roads all over the world in the near future. Evolving into fully automated vehicles with important levels of automation functioning perfectly in our streets in an organised, clean, and safe way.

### 3.5.4.3 Market growths automated vehicles for car sharing

As a result, a clear unification of both growing trends will emerge. The combination of the increasing level of automation present in all car manufacturer's catalogue, together with the citizens' needs and growing trends of the sharing economy as a whole, represented in this chapter through the explosion of CS, will result in CS solutions using AV. Ultimately called Robo-taxis, this will be the culmination of social uptake of both trends, AV and CS. Here, as presented before, transport solutions most surely will be overlapped or combined in MaaS platforms, personalizing physical and digital services. The following graph presents an impressive figure of the expected growth of the number of robo-taxis globally for the next decade.


**Figure 50 - Expected growth of robo-taxi market [Source: Makets and Markets].**

Other sources expect this market to grow at lower paces but still at an impressive CAGR of 67,8%, reaching a robo-taxi market size of $38,61 billion by 2030 (Global Robo-taxi market opportunities and forecast, 2023-2030). As a whole, it is an obvious trend facing years of growth ahead and even growing day to day nowadays.

In fact, there is some controversy with this topic, as robo-taxis have been on the spotlight for a while and some researchers and other players consider the solution to be failing to deliver according to the expectations that were actually set on robo-taxis. Some see the autonomous taxis to be overpromising, like Daimler, who are actually focusing on other solutions currently such as self-driving long-haul trucks instead.

As a whole, many believe that the electric vehicles are still the first step to come and AVs for all urban areas and roads will come in later.

### 3.5.5 Connected and Cooperative Automated Vehicles (CCAV)

The levels of automation and the paths existing currently and being looked at in the CS market are mainly moving in line with those in privately owned vehicles. Due to the high connections of such mobility solutions which in many cases, such as in P2P car sharing, are based on the sharing of a citizen’s private vehicle with other interested users in their area.

On the other hand, solutions more related to car-hailing are in the race for higher levels of automation as most have as common ending point the deployment of robotaxis, ideally reaching these through enhanced automation in shuttles and e-hailing services.

As a whole, many OEMs are therefore in TRL9 delivering private vehicles being currently used for CS with none or close to none automation (levels 0 and 1), overall this is already shifting as modern cars include increasingly often new features based on automation, easily reaching level 2 in many cases. In parallel, others are already looking into more advanced technologies and solutions by offering levels 2, 3 and even 4, with numerous products and vehicles ranging from TRL9 to lower TRLs for the most futuristic solutions. Level 4 vehicles by manufacturers such as Waymo, Navya and Magna are being developed and already tested and deployed in some selected areas, some already partnering to be pioneers and first to enter the robotaxi world.

Overall, automation in CS is appearing at the same pace as in regular car market through one of the business models, but at the same time it is going faster and pushed more when observing the future of shuttles and robo-taxis that are already being tested at high levels of automation.

### 3.5.6 Conclusion

Car sharing has arrived to stay; it is growing fast and the numbers clearly show its expected reach and impact. Uncountable companies and service providers are either springing or transitioning into adopting this innovative solution based on the sharing economy into their services offering.

Many aspects play a significant role in this evolution and have been stated previously throughout this section, including: reduction of car ownership by young adults, city centre bans and restrictions on circulation and private vehicles, reduction of parking spaces and increasing prices in urban areas, reduction of fixed and per-trip costs for users and many more that are all together shaping our future and enabling CS to gain year after year modal share in our streets.

In addition, CS will actually be shaken in the upcoming years (as will the rest of mobility solutions) by the entrance and evolutions of AV. Based on technology readiness and functioning in a highly ultra-connected environment through 5G, the era of AV will also drive the future of CS solutions.

Fully electric vehicles that can be used when needed and where needed, combining a clean and safe solution with a convenient and on-demand service, with eventually no need for attention or driving enabling. This will all provide seamless door to door rides where productivity or rest can take place all together through a cheaper solution that requires no fix costs of vehicle ownership, human driver or parking for example.

However, to take this step into reducing costs and offering cheaper rides, service providers, both public and private, will face the important barrier of having to make high initial investments, as the amount of privately owned (usually by the drivers) vehicles provided through their platforms will be hardly none if the stated shift into AV has to take place.

On the other hand, the solution of autonomous car sharing vehicles can and is expected to result in a very obvious and widely used mode, acting as a converging point coming from traditional car rental, privately owned cars, regular car sharing, other demand responsive transport solutions and even public transport (in the form of small shuttles mainly). All of this is expected to mix and end in what is commonly known as robo-taxis.

Robo-taxis are called to appear and flood our cities in the near future, however, there has been some doubt on the readiness and timing for the expected appearance. Nevertheless, upon arrival, these will be used in many ways, both for round trips, regular ride-hailing and even through new concepts of vehicle sharing solutions serving for logistics, retail, food delivery, food trucks and many other uses.

Such innovative business models are still being looked into where the use of the AV will eventually reach impressive numbers and circular economy will appear too.

As a conclusion, autonomous shared cars will be one of the most important players in the future of urban areas and will co-exist and even mix with the rest of existing trends and mobility solutions such as PT, DRT, LaaS and micro-mobility. Many conditions will have to be fulfilled for the successful uptake in the short-term but in the long-run there are high hopes set on robo-taxis and similar car sharing solutions.

Such transport modes bring benefits to our streets in uncountable ways; as sustainable mobility solutions, reduction of personal vehicles in the streets and the associated congestion problems, saving urban space through parking freeing to be reused for more healthy and useful purposes, increase in the usage of each vehicle enhancing the circularity and sustainability of such, enhancing the shared economy with all the associated benefits and many other side effects that contribute to reaching more and more liveable cities over the years.

As mentioned, this transition depends on many factors and will not come alone. The uptake of AV CS will compete and co-live with improved PT, micro mobility, other on-demand services and of course, private vehicles. All of them are constantly being rethought and adapted to the citizen's, markets, regional and cities' needs and requirements and will all contribute to having best solutions working together as ways to reach zero emission goals, increasing liveability of cities, inclusivity and many other aspects that are moving today's societies towards the future.

## 3.6 Logistics as a Service

### 3.6.1 State of the art

The planning, execution and control of the movements and placement of people and/or goods, and the supporting activities related to such movement and placement within a system organised to achieve specific objectives (European Logistics Association).

In the past years, a change can be observed in logistics. Technological developments and changing market conditions have resulted in rising complexity in production and consequently in logistics. These changes include an increasing number of product variants, faster delivery times, and shorter product life cycles. The complexity of nowadays logistics processes has significant impact on the performance of logistics processes in terms of delivery time and delivery reliability. A new approach to deal with complexity is to increase the level of autonomous control in logistics processes [31].

The concept of autonomous control is not new in the field. It requires on one hand logistics objects that can receive local information, process this information, and make a decision about their next action. On the other hand, the logistics system must provide distributed information about local states and different alternatives to enable decisions generally. These features have been made possible also through Ubiquitous Computing technologies [32].

A permanent change of influencing factors on supply networks may be perceived. Drivers for dynamism are market- and competition-driven changes in the supply chain strategy as well as technological innovations. All of these are appearing with an increasing frequency within product life cycles; thus, resulting in a short- to mid-term need for adaptation of supply chain processes and resources. Moreover, also supply chain structures are subject to continuously growing dynamics caused by the exit of existing partners and the need for integration of new partners.

**An example of current Logistics Business: UPS**


**Figure 51 - Logistics as a Service [Source: UPS].**

The logistics supply chain and freight transport can be sub-grouped in 4 main milestones that are:

1. Feeder Operations
2. Urban Operations
3. Rural Operations
4. Energy Used

Furthermore, the logistics sector (UPS example) includes the HUBs (is a centre or specific area designated to deal with activities related to transportation, organisation, separation, coordination and distribution of goods for national and international transit, on a commercial basis by various operators), Warehouses/Centres (involves all movements of goods and information within warehouses and distribution centres. It includes activities like receiving, storage, order-picking, accumulation, sorting and shipping.), and Energy Stations (is an industrial facility for the generation of electric power).

One of the most relevant components of the logistics sector is Urban Logistics. Taniguchi et al. (2001) describe the city logistics as "The process for totally optimising the logistics and transport activities by private companies with the support of advanced information systems in urban areas considering the traffic environment, the traffic congestion, the traffic safety and the energy savings within the framework of a market *economy."* This introduction shows a full optimisation of logistics processes of businesses, connects the social perspectives and the environment, focuses on congestion and energy use, economic issues for the market economy. For urban logistics, there are four major stakeholders that are namely shippers, freight carriers, administrators, and city residents. Organisations in urban logistics sector have 5 models that have been conceived to meet current demand requirements and trends [33]. The models for urban logistics are listed in **Table 8** below:

**Table 8 - 5 models for urban logistics [Source: Mehdi el Alami, 2017]**

| **Anti-congestion** | | **Higher-service** | | |
|---|---|---|---|---|
| **Eco-regulation** | **Public service delegation** | **X-trailer powered** | **Crowd logistics** | **Automated logistics** |
| Multiplication of taxes (Ecotax, transit tax) on the initiative of cities or countries and strengthening of European or local regulatory framework | Oligopoly of carriers having the exclusive right to transport in the city and consolidating flows for the different carriers or shippers | E-retailers entering transport business in densely populated areas to gain market share in comparison to stores with their offers of same-day-delivery | Automated electronic platforms performing matchmaking between shippers and carriers – disrupting forwarders | Automated end-to-end delivery solutions |

In addition, the autonomous logistics technologies, for the expected future developments of logistics in general and of urban logistics in more specific, can be the following:

- Positioning systems and related Telematics
- Interoperability of systems
- Networking technology
- Transportation technology
- Network security
- Mobile data transfer
- Transponder technology and IoT
- Handling technology
- Machine learning
- Artificial Intelligence
- Blockchain
- Terminal technology
- Loading and Transit equipment

### 3.6.2 Competitive landscape, roles and mobility drivers

Establishing autonomous logistics processes requires a set of general conditions on the logistics system, which must be fulfilled. The following figure gives an overview of these demands according to the holistic perspective on logistics.

| Logistic System / Task Layers | New demands on Logistics Processes |
|---|---|
| Decision System / Organisation and Management | **Organisational demands**<br>• Definition of autonomous logistics processes<br>• Definition of limits of conventional and autonomous control<br>• Availability of adequate information at the correct place in time<br>• Ability to measure and evaluate autonomous logistics processes<br>• Design and structuring of dynamic distributed targets<br>• Management strategies to consider external and internal risks<br>• Methods to establish efficient distributed Quality Management Systems |
| Information System / Informatics Methods and I&C Technologies | **Technological demands**<br>• System items' ability to communicate and cooperate<br>• Distributed data management and date handling<br>• Mobile data communication technologies<br>• Data security guidelines regarding establishing mobile data communication<br>• Localisation's ability<br>• Mobile hardware components (transponder etc.)<br>• Software requirements (new PPC-/ERP-functions) |
| Execution System / Material Flow and Logistics | **Process-related demands**<br>• Development of autonomous decision algorithms<br>• Development of strategies to use the process immanent intelligence<br>• Ability to model autonomous logistics processes<br>• Adaptation/development of PCS- and logistics-functions<br>• Robustness (resource, object, part)<br>• Divisibility of orders / mergence of intelligent items (e.g. assembly stage)<br>• Logical and physical reactivity |

**Figure 52 - Demands on logistics processes [Source: Scholz-Reiter et al., 2004].**

As shown in the figure above, the new demands on logistic processes can be assigned to the system layers such as the decision system, information system and execution system and its task layers such as organisation and management, informatics methods, I&C technologies and material flow and logistics. As a result, the demands can be categorised in organisational demands, technological demands and process-related demands.

**Organisational demands:** The creation of some new organisational general conditions is essential to be able to establish autonomous logistic processes.

**Technological demands:** Regarding the information system layer there are some new technological demands that must be considered with respect to the paradigm shift. New or changed technological demands result from a relocation of planning and control functions to parts or resources, especially regarding the data management (consistency of data, high amount of memory, etc.), data handling (coverage of information overload, standardised interfaces etc.) as well as the ability of the system items to communicate and to cooperate.

**Process-related demands**: In addition to the organisational and technological demands, certain process-related demands on the material flow system and logistics system must be fulfilled to enable autonomous logistics processes.

An example of what can be conceived as a blueprint of Logistics as a Service can be found in the DeliveryMatch initiative. The aim is to increase sales and reduce costs with the shipping. DeliveryMatch has world-wide software and it has more functionality. For each order DeliveryMatch will real-time calculate the complete supply chain for the best fitting and/or cheapest delivery options. DeliveryMatch can also manage the complete logistic operations from checkout towards doorbell in a straightforward way. Expensive peaks and drops while processing the orders will be history, as well high transport costs. On top of that the sales will increase because the consumer will reward the logistics service and the reliability of it (deliverymatch.eu). Three main targets of the DeliveryMatch are "Reliable shipping options in the web-shop checkout", "Simplification and cost reduction for order processing and transport", and "More sales (new sales)".

The logistics service's stakeholders and their interests are the following:

**Table 9 - Logistics stakeholders and competitors [Source: Prof. Andrea Campagna, University of Rome].**

| CATEGORY | STAKEHOLDERS | INTERESTS |
|---|---|---|
| **SUPPLY CHAIN** | Shippers | Optimal pickup and delivery |
| | Transport companies | Low-cost high-quality transport |
| | Receivers | On-time delivery, short lead-time |
| | Consumers | Availability of goods |
| **RESOURCE** | Infrastructure providers | Cost recovery, Performance |
| | Infrastructure operators | Accessibility and use |
| | Landowners | Profitability of local areas |
| **PUBLIC AUTHORITIES** | Local government | Attractive cities |
| | National government | Minimum externalities |
| **OTHER** | Other economic actors | Site accessibility, on-time deliveries |

### 3.6.3 Cost structure and new revenues

Logistics can be simply described as coordination of the movement of products/items from an origin to a destination. During these movements, there are some processes such as transportation by ships/trucks/trains/planes, warehouses for storage, production sites and their raw material/product flows, packing, administrative issues, management, and official works. Logistics as a Service (LaaS) works on the simple movement process with help to organize all these steps as a single circle movement like “Business – LaaS – Customer”. Autonomous logistics interests in the logistics services to provide unmanned, autonomous transfer of equipment and/or vehicles, baggage, people, information or resources from point-to-point with minimal human intervention.

In order to meet the expectations and requirements from both customers and businesses, in logistics and urban freight transport, LaaS provides visibility, collaboration, and efficiency within the supply chain with a simple process. Logistics as a Service enables to access and share of information, as a platform for collaboration and integration between customers, suppliers, and service providers with the acquisition of heterogeneous (non-structured) data (location, situation, movements), effective and collaborative management of operations throughout the supply chain.

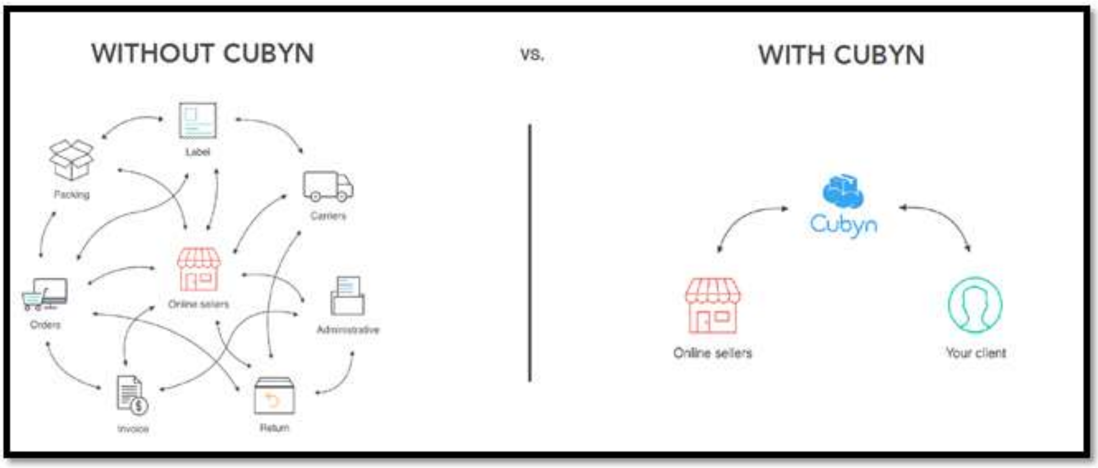



**Figure 53 - Logistics process scheme [Source: CUBYN presentation 2017].**

As seen in the above figure, Logistic as a Service aims to reduce the complexity of the logistics service and provide easy-use logistics for the customers by reducing the process steps, that can be done by an application or software, and pay-less strategy for both producer and consumer.

#### 3.6.3.1 Cost structures

Logistics as a Service considers some expected costs to be managed for the service quality and development. The following costs are the current expenses of the service:

- Research and development cost for more sufficient and efficient service implementations
- Personnel dost for who work on the service development and manage
- Computer and IT-equipment costs for the service monitoring and organisation
- Office costs for existing personnel and computer, heating, electricity, internet, and bills
- Certification cost for the software to aim of use for LaaS
- Transport cost from origin to destination
- Handling and packaging cost
- Marketing and advertisement costs for the service use level increase
- Update and maintenance costs for being always new and preferable
- Stock-keeping costs for stocking, management and personnel (if non-autonomous)
- Transport costs for transport from factory to warehouse, transport from warehouse to stores, warehouse inside operations (if non-autonomous)
- Production costs for flow of material and flow of information (if non-autonomous)

#### 3.6.3.2 New revenues

The Logistic as a Service aims to manage the customers' delivery transport network organisation with including road, rail, air, and maritime transportation inbounding logistics from production site to warehouses, retailers, end-users, consumers. It expects to reduce paper-works, spend less money, provide better and faster logistics. With this purpose, the new kind of tools, such as software/application, are using to organise and manage the logistics movements. This causes new revenues that can be gained:

- Subscription for the service and maintenance, monthly/yearly fee for the service access, for premium services
- One-off solution to access the service for one time to check delivery status
- Mobile applications and some additional revenues for access further features of the service
- Reliable shipping options in the web-shop checkout
- Simplification and cost reduction for order processing and transport
- More sales (new sales)

The trade of member states of OECD, concerning their GDP, is getting more connected to each other this is calling "globalisation". The globalised economy is requiring more "import" and "export". Moreover, it provides more needs for logistics and freight transports between countries and inside the countries. The economy is affected by the 2008 crisis and the 2019-2020 Covid-19 pandemic. During the global Covid-19 pandemic, economies and trade are strongly affected. However, the demand of the people provides more needs for delivery transfer. The trade is affected but the delivery-demand from citizens is increased.

The logistics sector should focus on the "non-human" solutions because the users mostly do not want to face human-carrier to avoid the global Covid-19 pandemic. In the meantime, the customers do not want to deal with lots of paper-works and bureaucracy. It means that Logistics as a Service will be more important and more needed during the pandemic term and post-pandemic.

### 3.6.4 Market growths, outlook and trends

Increasing Dynamics and Complexity, the increasingly rapidly changing conditions in present markets have an extensive impact on logistic processes. The worldwide presence and market development of a growing number of companies implicate the development of global and complex intra- and inter-corporate logistics networks. The shift from seller to buyer markets pushed by the emergence of the internet economy and the increasing importance of customer orientation and individualization involve a simultaneous atomization of payloads and increase of shipment frequency as well as overall transport volume. There are naturally and economically limited infrastructure expansion possibilities. In such an environment, today's concepts of planning and controlling of logistic processes are starting to fail. The complexity and dynamics of widely ramified and distributed value chains complicate the supply of all relevant information to a central entity. This development requires new methods of planning and control in production, transportation, and procurement, which means that instead of having central control of complexity and dynamics, decentralized autonomous logistic processes are implemented. One assumed characteristic of autonomous processes or items is the adaptation of its behaviour in a more effective manner on changing constraints. Due to this development, the achievement of logistics performance figures shall be improved so that a distinction between autonomous acting and conventionally managed processes can be made [34].

The following graph shows the logistics costs for retailers as share of net sales [%]. Amazon's net sales are increased around +4.5%, Brick Mortar's net sales are increased +0.5% between 2010-2016. Forward years, we may understand the effect of Covid-19 pandemic.

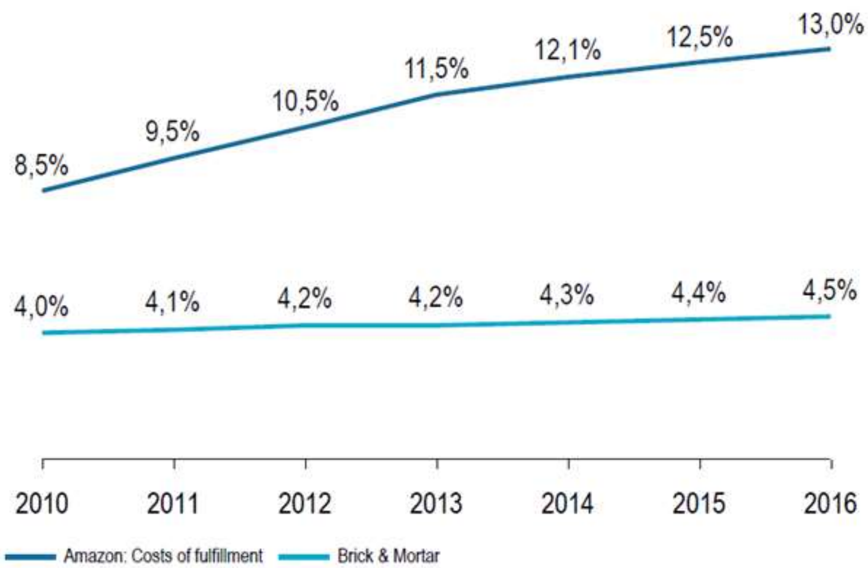



**Figure 54 - Amazon and Brick&Mortar net sales [Source: Statista].**

The logistics market in European Union (EU27) is quite competitive between the member states. For the information on logistics market size in Europe is shown in the following graph. It shows that European logistics-dominant member states are Germany, France, UK, Spain, and Italy.

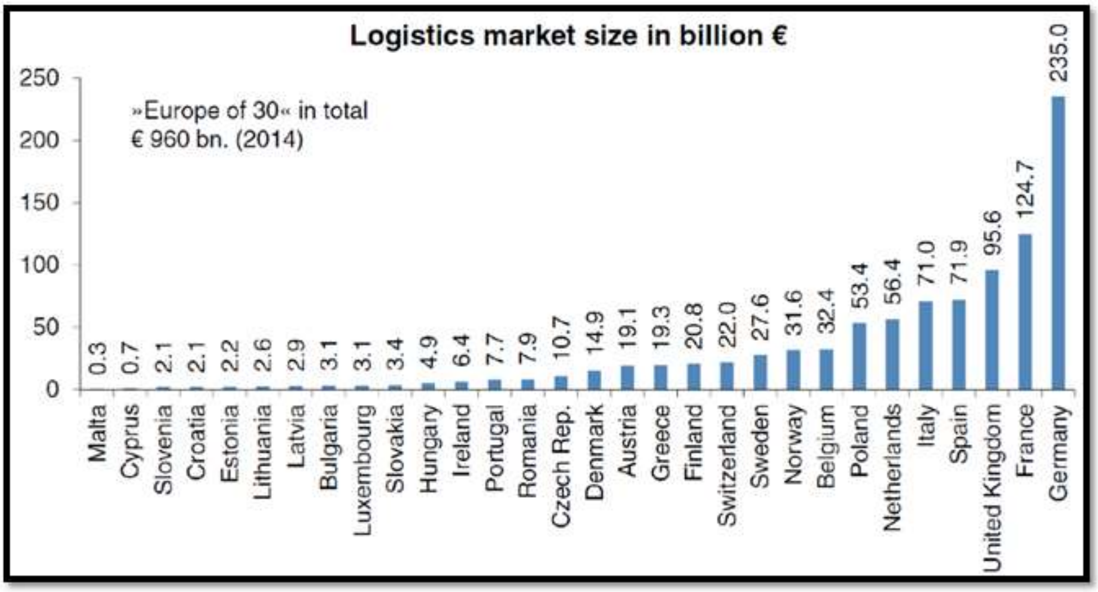



**Figure 55 - Logistics market size in Europe [Source: Fraunhofer, 2016].**

After that, the question can be asked for the further steps: What does the future look like? [35]

- Whilst B2C remains unaffected by franchise/ sponsorship arrangements the EU/USA origin will continue to grow with most competition coming from Asia as a developing e-commerce origin;
- Cost effective DDP calculations will become more important as competition pressures margins;
- Some market consolidation in last mile will occur as critical mass become more important and domestic postal authorities develop competencies;
- Customers buying habits are becoming more intelligent;
- Be ready for more disruption, ensure all systems do not become a legacy burden.

### 3.6.5 Connected and Cooperative Automated Vehicles (CCAV)

The automation and intelligence technology are the key element of the Logistics as a Service. The high-level technologic connection, between delivery and both customers and businesses, will be the solution for less paperwork, lower costs, efficiency and sustainability.

For instance, drone deliveries and digital mapping for easy-to-access walking and cycling routes could soon be a reality for people living in rural areas across the UK, following the launch of a call for evidence to help develop the government's Future of Transport: rural strategy. Opportunities for drones to make deliveries in rural or isolated towns and areas are also being explored. Particularly suited to the greater distances in rural areas, drone deliveries could cut down delivery times and help to reduce pollution, allowing rural locations the potential to be a trailblazer for low-carbon deliveries. Evidence will also be sought on how 'micro-mobility' transport methods – such as e-cargo bikes – could be integrated into rural transport networks, helping drive the changing face of rural economies and making home-based businesses more accessible to markets. The feasibility of fully automated and passenger services operating in rural areas will also be examined, and small electric aircraft may be able to move goods and people efficiently, particularly in communities.

SHOW project aims to understand what the expected and possible impacts, benefits, and user/business expectations of the autonomous logistics vehicles that can operate with also passengers. The automation in the logistics sector will be interesting for exploitation at the demo/pilot sites.

### 3.6.6 Conclusion

Logistics as a Service (LaaS) is considering providing an easier service for the stakeholders to avoid some process that could be done by customers or suppliers. The logistics sector is in an era of unprecedented change as digitalisation that deals with customer expectations to make an easier process. The new technologies are enabling greater sustainability, efficiency, and more collaborative operating models, which also can be the reason for reshaping the marketplace, and in ways, these are only just beginning to become apparent. Furthermore, new entrants, which can be start-ups or the industry's own customers and suppliers, are also helping for the improvement and development of the logistics sector.

In the last decades, customer expectations and demands have increased. The stakeholders, both individuals and businesses, expect to have fewer paper-works, get goods faster and more flexibly with low or no delivery cost. Stakeholder demands and logistics processes are becoming more customised that is good for customers but difficult for the logistics businesses. This causes that the logistics sector is under a pressure for deliveries with a better and easier service process at an ever-lower cost.

For this purpose, the solution can be a maximum and intelligent use of technology, from data analysis to automation. But digitalisation and/or intelligence of the process and service requires the development of a strategy for management and organisation. In the meantime, this digitalisation of logistics is creating a business models sharing that help both customers and businesses.

In the future of the logistics sector, the increased demand and expectations from both customers and businesses, the growth of collaborative working, more standardised shipment sizes, labelling, and systems, easier processes, tracking and controlling by IT systems will lead the improvements and developments.

The expected challenges may be costly, last mile of delivery becomes more fragmented and exploiting new technologies like platform and crowd-sharing solutions. Moreover, the competition of new technologies evolves in a different direction, as large industrial or retail customers and suppliers become players in the logistics market themselves, not just managing their own logistics but turning that expertise into a profitable business model. Furthermore, the current market leaders will compete to protect their market position by acquiring smaller players, achieving scale through consolidation, and innovation through the acquisition of smaller entrepreneurial start-ups.

In the end, automated Logistics as a Service will be the key element of the future's deliveries and freight transport because the increase of demand, expectations from both customers and businesses, easy delivery process, efficiency, sustainability, and tracking will continue to be implemented and expected with no or lower costs.

## 3.7 Mobility as a service

### 3.7.1 State of the art

The urban mobility landscape is evolving fast and new solutions are being offered to citizens all over the world: From e-scooters, to bike- car- and ridesharing to the rise of (e-) cycling and ride-hailing. As the number and diversity of urban mobility services is rapidly growing all over the world, it is no wonder that Mobility as a Service (MaaS) is such a hot topic. Is this the mobility revolution everyone is talking about? Or are these niche services publicised by the media and huge capital investments? And how should public authorities and local public transport companies act in response?

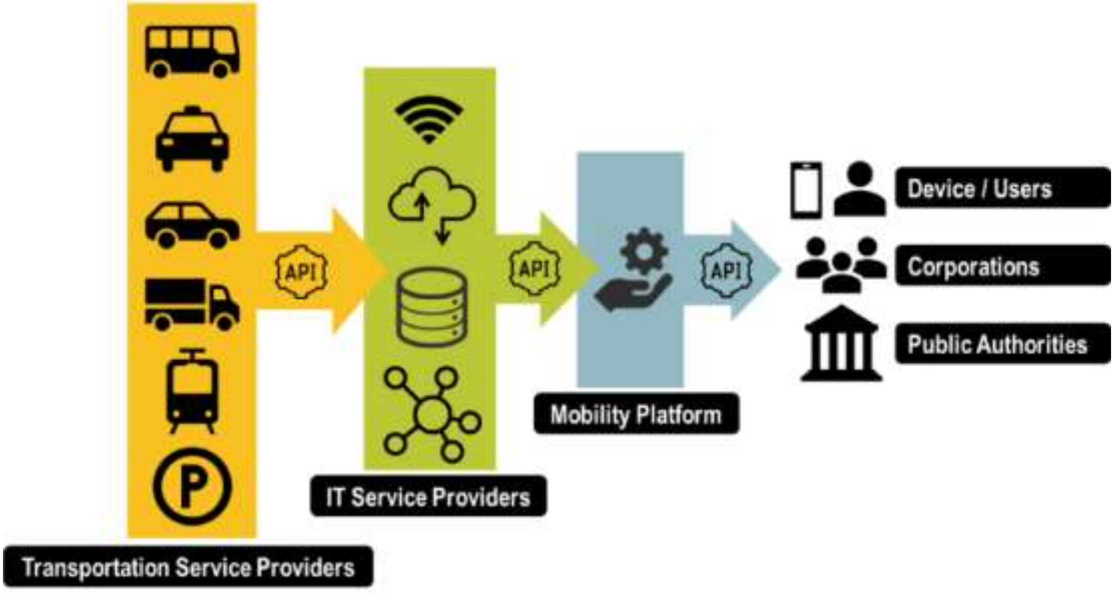



**Figure 56 - Mobility as a service (MaaS) system [Source: Adapted from International Transport Forum (2018) Blockchain and Beyond: Encoding 21st Century Transport, Paris: OECD].**

### 3.7.1.1 Definition of Mobility as a Service

Mobility as a Service (MaaS) is the integration of, and access to, different transport services (such as public transport, ride-sharing, car-sharing, bike-sharing, scooter-sharing, taxi, car rental, ride-hailing and so on) in one single digital mobility offer, with active mobility and an efficient public transport system as its basis. This tailor-made service suggests the most suitable solutions based on the user's travel needs. MaaS is available anytime and offers integrated planning, booking and payment, as well as en route information to provide easy mobility and enable life without having to own a car. [36]

While it is crucial to place the user at the heart of MaaS, this mobility solution has benefits for more than just the users. City authorities aiming to reach their public policy goals, and public transport operators looking to provide better services and increase the number of public transport users, can also take a slice of the action. With this in mind, MaaS should be created in collaboration with all relevant stakeholders to ensure impartiality, trust and benefits for all.

With this collaboration comes the need for a regulatory framework that guarantees high-capacity public transport and active modes remain the backbone of any MaaS.

MaaS has been investigated, documented, analysed and described very intensively by the Maas Alliance on behalf of the ERTICO. The Maas Alliance is a PPP creating the foundations for a common approach to MaaS, unlocking the economies of scale needed for successful implementation and take-up of MaaS in Europe and beyond. The main goal is to facilitate a single, open market and full deployment of MaaS services.

The main concept of mobility as a service is to put the user at the centre of the transport service and to offer customised mobility solutions based on their individual needs.

For the first time, it will provide end-users with easy access to the most appropriate mode of transport or service in a bundle of flexible travel service options, using mobile devices and local apps for the engagement to the services offered.

#### 3.7.1.2 Importance of Mobility as a Service

MaaS is an important and unavoidable step in building a better mobility system, because:

- **The importance and thus number of mobility services will continue to increase** in the future. New services will grow out of their niches and customer expectations will continuously evolve. The arrival of automated vehicles will be the ultimate game changer, helping car- and ridesharing and ride-hailing services to become a common reality.
- The mobility services are merging to form a ‘continuum’ of different options. Consequently, the traveller’s choice will depend more on the price and performance (quality, comfort, flexibility, etc.) than on the mode. But **help to make the right choice of mode is expected.**
- **If organised in a smart way, MaaS is a key to change travel behaviour towards more sustainable mobility** options, reduce private car use and provide better and more affordable mobility.
- Central components of an alternative mobility system, that gets by with far fewer vehicles are already recognisable today. On the one hand, this includes automated vehicles that are no longer in the old logic of the private car, but rather as flexible building blocks of a public transport offer are: These as “automated shuttles”, “pods” or “people Mover «vehicles are vehicles that mostly as minibuses with currently nine, twelve or twenty sitting and completely without a control cabin and with automatic doors are created. When they are optimal can be linked to existing offers a significant expansion at a comparatively low cost of the public transport network.

MaaS has the potential to increase the modal share of all mobility services at the expense of single-car usage. Therefore, it will not only benefit travellers but all mobility providers. It is in the traveller’s interest to set up an integrated mobility- ecosystem, including all public and private mobility services, based on an optimised system to enjoy total freedom of mobility. It is in the community’s and city authorities’ interest that the integrated offer is built with high-capacity public transport and active modes at its heart.

So far, MaaS concepts seem to work only in cities with highly developed local public transport if this is (normally) coordinated and organised by the established transport company. I. E. Helsinki, London and Singapore can be named as examples, but also many more to plan and to offer additional services. It is also questionable whether MaaS leads to a reduction in overall traffic or whether high-availability cheaper transport leads to more traffic due to higher traffic volumes and thus to associated environmental pollution.

Mobility services can be offered by various providers and should be offered and billed as a combined multimodal service, ideally using a state-of-the-art platform for customers and service provider in common. This requires both a joint route and service planning for the individual mobility requirements and their joint billing.

We want to put an emphasis on the fact again that in this document we only focus on services with autonomous vehicles (busses, cars, rail-based solutions) and not the overall Mobility as a service market.

With respect to the Report “Business models digital mobility platforms” by IKEM, Germany, June 2020” [39] there will be a strong need for integration platforms to support mobility as a service (MaaS) to the public especially with the view on autonomous vehicles.

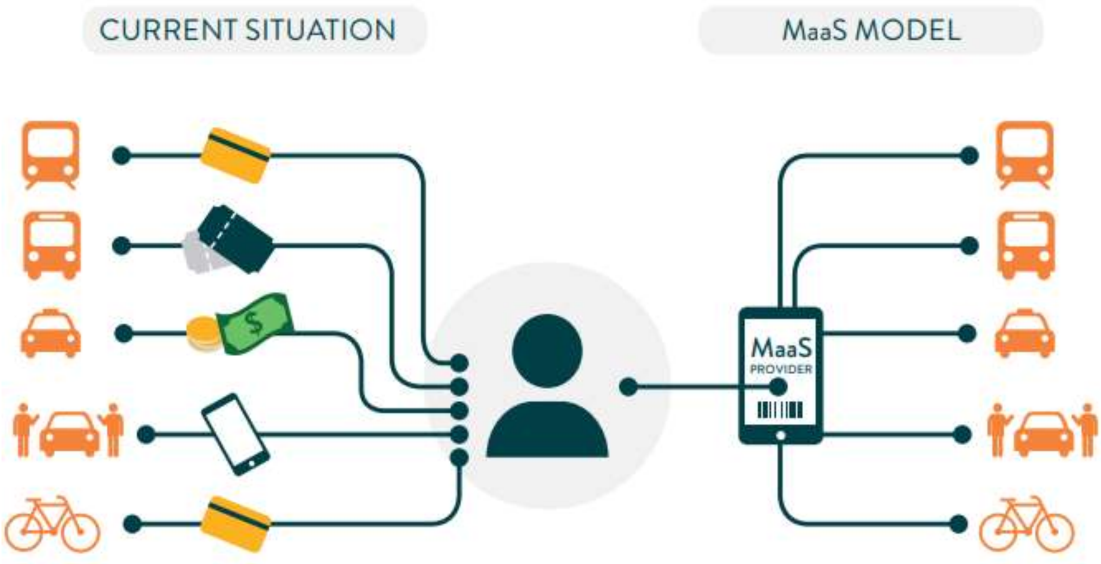



**Figure 57 - Current situation vs MaaS Model [Source: Transdev].**

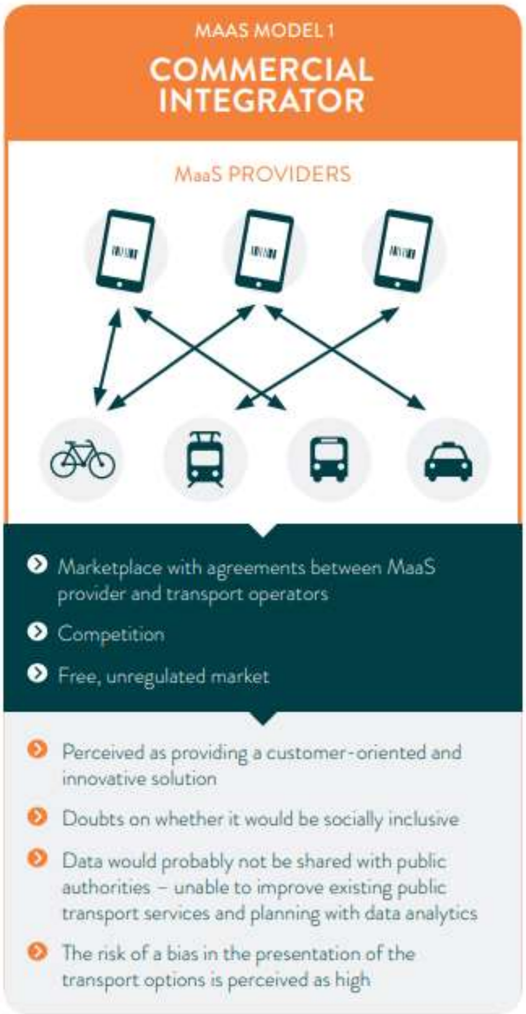
#### 3.7.1.3 The role of the MaaS provider and the integrator

To build a MaaS solution there are different layers of actors involved. The integrator is responsible for the integration of data from multiple transport operators and infrastructure data and the MaaS provider builds the solution on top of the integrated layer. The integrator could be different from the MaaS provider, but sometimes these roles are taken by the same actor.

An important question in this context is: who will be the MaaS integrator? But the key question is rather who is able to attract the maximum customers to produce the maximum benefits for sustainable and affordable mobility? Therefore, the role of the integrator is to make MaaS fly. Only by having happy customers and happy business partners will a MaaS provider be able to scale and create maximum benefits for sustainable mobility.


**Figure 58 – MaaS, Governance and Contracts [Source: Transdev].**

### 3.7.1.4 Other MaaS operator models




There are many different ways to build a MaaS, and pilots are taking place around the world. They all have advantages and disadvantages depending on the perspective of each involved player. Local context matters. When contemplating which model would work best for one's city it might be helpful to look at the following basic MaaS models described here below to see how they could perform against the following set of objectives:

- Mode shift towards public transport, walking & cycling;
- Number of users / Market penetration;
- Social inclusion;
- Innovation;
- Customer orientation / usability;
- Alignment with public policy goals;
- Integration of local mobility providers;
- Non-discriminatory approach;
- Sharing data back with public authorities;

**Figure 59 - MaaS commercial integrator [Source: Transdev].**

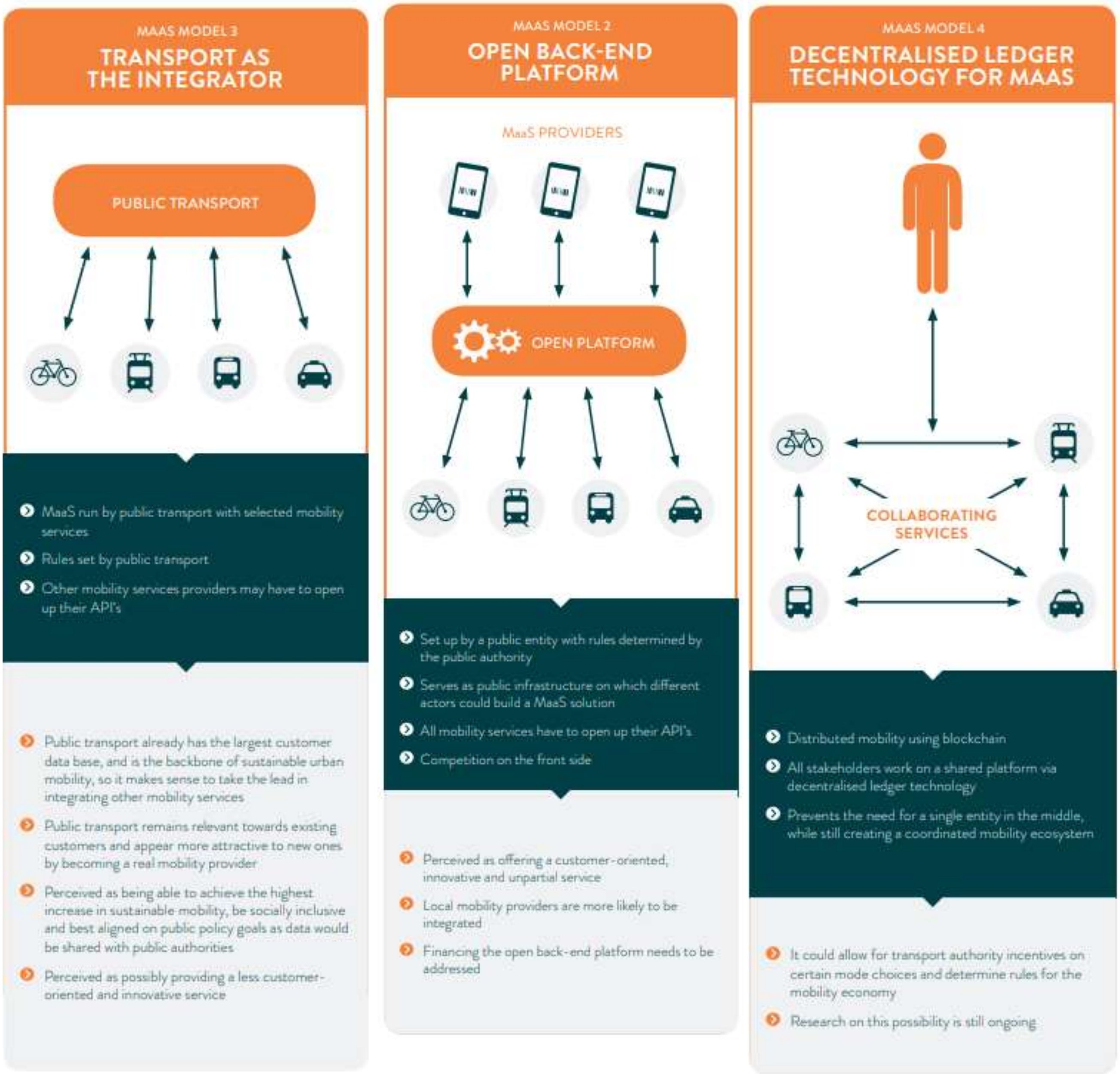



**Figure 60 - MaaS models 2 – 4 [Source: Transdev].**

### 3.7.2 Competitive landscape, roles and mobility drivers

#### 3.7.2.1 Competition

When different mobility companies decide to join a MaaS system (e.g. companies for: scooters, bikes, car sharing, PT, etc.) they will act as competitors within the MaaS system. Instead of being the most prominent way of transport, the user has a quick overview of the best mobility service for their specific needs on one click. Figure 61 shows different mobility brands grouped in services and their relation to different MaaS platforms, on which they now have competition with not only their own mobility category, but also all other kinds of services.

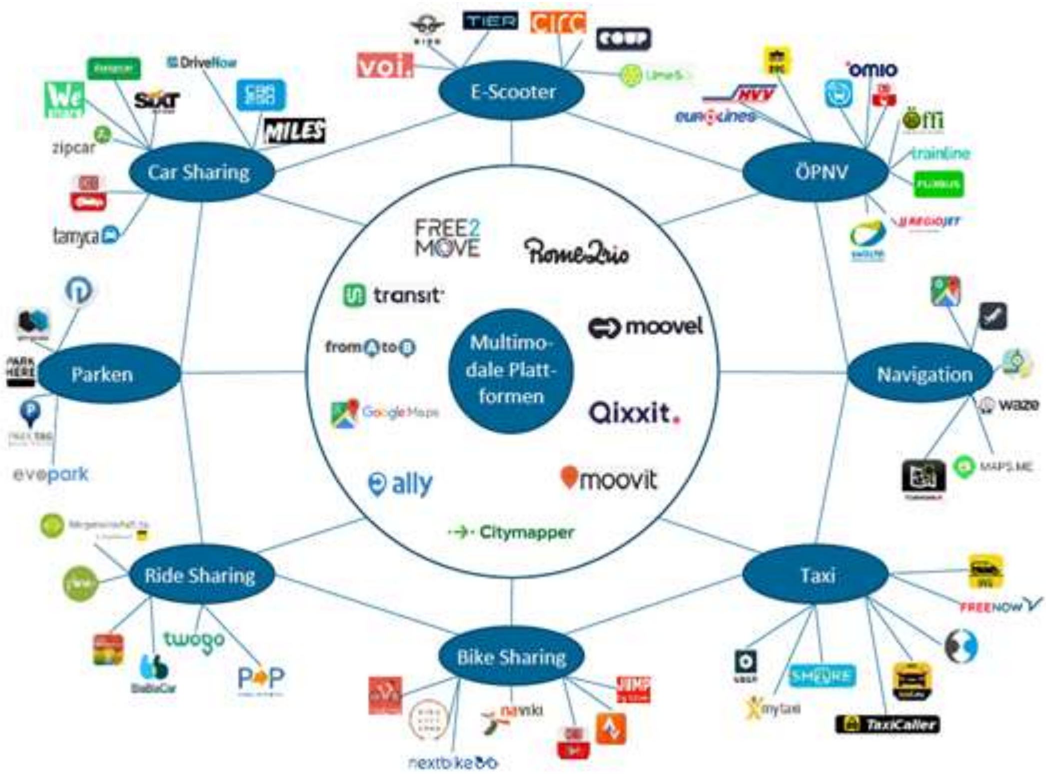



**Figure 61 - Competition on Mobility as a service platform [Source: Klinge et al (2020)].**

Within the last years several MaaS-initiatives have entered the market and are well established. An example for Germany could be the DB-Navigator. It is the MaaS solution of the German Railway company and combines all their railway services with car sharing, bike sharing, scooters, etc. but also other added value services for the booking of a trip. If you buy a train ticket via the MaaS app you can “check-in”, stating which seat you took in the train and the conductor will not have to check your ticket and you can enjoy a ride without interruptions. Most of the projects offering specific automated MaaS solutions are still in planning status or doing trials within cities or wider areas. For the entire SHOW consortium all projects are planned for 2021 and later. Very little figures of vehicles or public transport organizations are really offering or operating autonomous driving.

As “Mobility as a service” is a rather local phenomenon, it makes most sense to offer multimodal mobility solutions on a regional level, which is why, the competing organisations will be found locally (mostly). Only a few organisations are expected to act globally. The threat for smaller organisations are global players (e.g. Google, Amazon) that widen their portfolio to mobility services and/ or cooperate with OEMs.

In order for a MaaS solution to be able to do all of the required services, cooperation and by this massive coordination is essential: vehicle manufacturers, transport service providers, software providers and in addition public transport providers must join forces, also infrastructure companies, like traffic lights.

A situation that would create huge competition to the overall MaaS (platform) market competitions, would be the cooperation between a big software company like Google teaming up with a global acting OEM.

The overall situation will change massively with more liberal laws and traffic regulations in parallel with massive cost reduction or business efficiency given by lower prices for infrastructure and vehicle with increasing user figures.

### 3.7.2.2 Intermodal vs. multimodal trips

To define the term and explain the use of the term multimodal mobility platform the difference to intermodal mobility is shown first.

Intermodality lies before, if a combination of means of transport (e.g. bike and train) during a trip is used. The frequency of the change, from which point the journey can be described as intermodal depends on the definition. This means that intermodal connections are a special form of multimodality, which denotes the widespread use of various means of transport for getting around (also for different ways). How many different modes of transport in which period must be used to designate the traffic behaviour as multimodal depends again on the definition. The opposite of multimodal is monomodal, and therefore the exclusive one use of only one mode of transport.

For a much deeper dive into MaaS with all regulative elements, political influence and technical future aspects we refer to the MaaS-Alliance hosted by ERTICO – ITS Europe [37] or for a more Public Transport perspective one can consult the policy briefs the activity that UITP - The international Association of Public Transport [38] published.

### 3.7.2.3 Roles

To name the roles which are involved in autonomous MaaS the list is massive:

- **Road** and **City-Planner** for local need with a view on public services and social change.
- **Other** traffic **infrastructure owner** like harbours, airports, logistic hubs.
- **Automotive industries** and all their **suppliers** incl. **governmental services** like **PTI** (German abbreviation for technical observation) for development, engineering and research institutes of vehicles (busses, cars, trucks, railway vehicles like trams, underground).
- Public and governmental organisations for **research** like PWC, IKEM... and many more ore done by universities and transport related organisations.
- **Financial marked** incl. **Insurances** to support all the changes with cheap and liquid money.
- **Schools, universities, training organisations** for education the users and the offering site.
- **PTC/PTO** as the business companies offering the public transport
- SME’s for additional transport offered as MaaS like MOJA-Hamburg, UBER and many others.
- **Sustainability organisations** (I.e. UNFCCC) to underline the sustainability effects.
- **Energy industry** to support the required energy, electric power, hydrogen propulsion,
- **Software and communication industries**, like Deutsche Telekom.
- **People**, the public to accept the autonomous services.
- **Societies/clubs** for local services, I.e. community houses offering shuttle services for disabled people, visitors…
- **Event organisations** for offering shuttle services.
- **Ethics** to research effects on people, society, environment.

For a deeper view on existing researches, refer to Klinge et al, 2020 [39].

### 3.7.2.4 Mobility Drivers

Stakeholders for autonomous Maas are automotive industry (buses, cars, railways), software companies (Deutsche Telekom, PTV-Group, Sony, and many more), financial services (PayIQ...Visa), communication service (Deutsche Telekom, Vodafone) Tolling Services, IoT-Solution providers (for the use of private vehicles...), sustainability (for the reduction of air pollution) insurances (for the massive reduction of accidents using autonomous vehicles) PTO, Health Services (campus internal transport services for sick and disabled peoples) touristic effort and social community for any kind of transport outside the public offer. To be especially pointed out, are cities and municipalities with sustainable urban mobility plans, bringing together all important actors of the ecosystem.

The following chapters summarizes overall societal, technical and cost-related drivers for mobility.

### *3.7.2.4.1 The ethical change of individual car ownership*

The car density increases year after year. In the past decade, the car fleet in Germany rose by 12 % to almost 48 million. Private vehicles are a big problem when it comes to climate protection. Individual car traffic has returned to its pre-Corona level, often times overtaking it, because it is harder than ever for public transportation. Many incentives switching from the private car to environmentally friendly alternatives is fading.

To change the view on vehicles it is essential to take a look at a city without cars by winning space, lower noise and finally in quality for life.

The transport sector is the only one that has not reduced its emissions with an 18% increase since 1990. Out of the total emissions from transport, 23% concern urban areas. Most of these emissions come from private car use. Yet it is not in the city centres that car use is the highest but, in the peripheries, and in their links and connections with the city centres. It is therefore in these areas that the main challenges related to the decarbonisation of mobility in Europe are polarised. It is by acting on this daily mobility of the citizens of urban areas that the EU will succeed in reversing the curve of $CO_2$ emissions for transport.

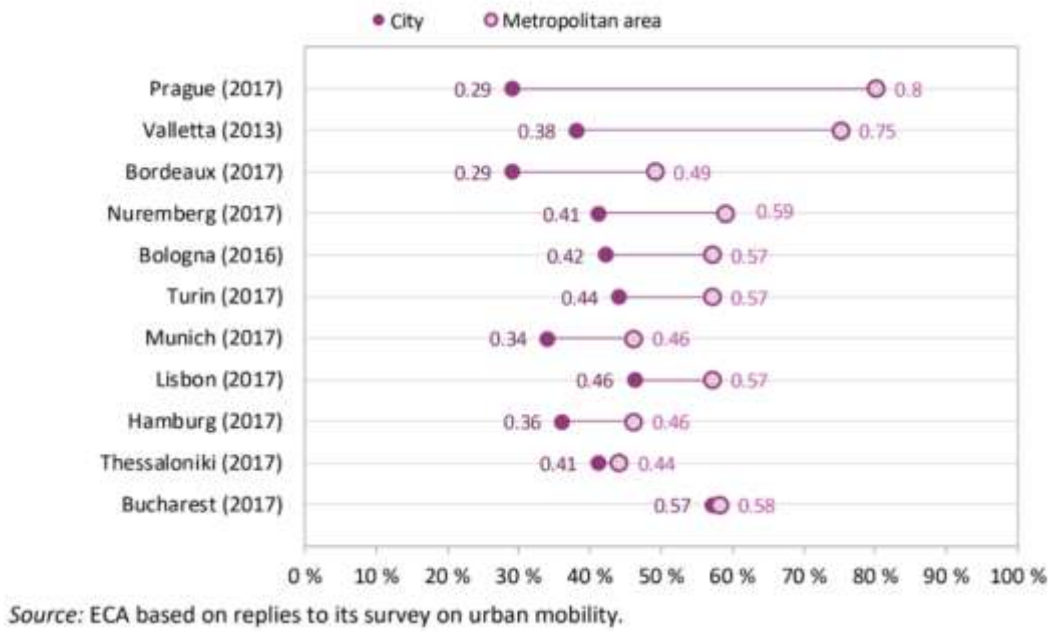



**Figure 62 - Modal share of private vehicles in 11 cities and metropolitan areas surrounding cities.**

Figure 62 shows the car usage in percentage for different European cities, within and outside the city. “Mobility as a service” solutions lowering the private car usage are best within the cities.

Even more so, because automation technologies are not mature enough to tackle the complex situation of metropolitan area – e.g., higher speed. No automated MaaS can handle this right now.

### 3.7.2.4.2 Management of the public space

Public space for traffic, parking, walking, working, meeting places … is limited and very much used for traffic and parking. This will change in the future, as this change has just started. Underlined with the use of so-called parking apps, the change of parking lots management and payment has started already in public spaces.

Tomorrow, more efficient public transport will be needed to link the peripheries to employment centres in order to curb GHG emissions, ensure air quality and finally preserve public spaces in city centres, which are part of our common goods.

### 3.7.2.4.3 Sustainability

The carbon emission increased dramatically by massive traffic within cities and suburban areas during the last years. Traffic increased enormously over time due the incentives on private car ownerships/ economical gain through the automotive industry in competition to public transport services, also in city areas. Nevertheless, there is reversal in thinking about our environmental use and pollution ongoing and this will lead to a change in traffic.

### 3.7.2.4.4 Social Change

Sharing-economy is a trend that people no longer long for ownage as much. As a result, families, younger well-educated people or elder people are increasingly interested in environmental protection and other investments for their comfort while maintaining their flexible transportation means. This boosts the development of MaaS solutions.

I.e., the city of Hamburg is constructing an additional district in the harbour site without any individual traffic. In addition to this, other traffic like logistics or maintenance, workers traffic will be limited. To support the people in the district the public transport service will be optimised and enhanced with MaaS.

### 3.7.2.4.5 Costs

The social and economic cost of urban congestion in Europe is estimated at 270 billion euros per year.

For the first time the change to more autonomous or MaaS oriented services will increase and by subventions of governments and industry it will be manageable to step forward for a change. With an ongoing and increasing volume of autonomous and electric driven vehicles (any) the cost will equalise and decrease in the future.

Investments in alternative energies will lead to an easier change from minerals to renewables. For traffic, private use and institutional needs like industrial environments.

### 3.7.3 Cost structure and new revenues

#### 3.7.3.1 Cost structure

Main cost drivers for MaaS are: Vehicles, Personnel, Financial-costs (depreciation), Maintenance, Energy (Fuel, Electric-Power), Other Costs (Administration, Customer Service, Insurance, Taxes, Education...)

Staffing is essential, as an operator has to be in the vehicle during service. Additional education and training are required, and by these above-mentioned cost elements it is expected to add 0,2 inspectors while offering autonomous services.

To offer MaaS Solutions and software, apps, maintenance and communication in any location of the offered service is essential. The permanent optimization of software, platforms, ticketing and the entire payment solution up to date software development and distribution must be available 24/7 and of course barrier-free.

#### 3.7.3.2 Cost and quantity structures for modernized public transport with automated vehicles

In a study by Bösch et al. (2018) [40] the main question is how much the relative costs of mobility offers sink, if the personnel costs through automation in others too transport segments fell away.

To support the assumptions, the author compared the operating costs of conventional private cars, trains, buses, individually used and pooled taxis on one side and autonomous counterparts on the other hand.

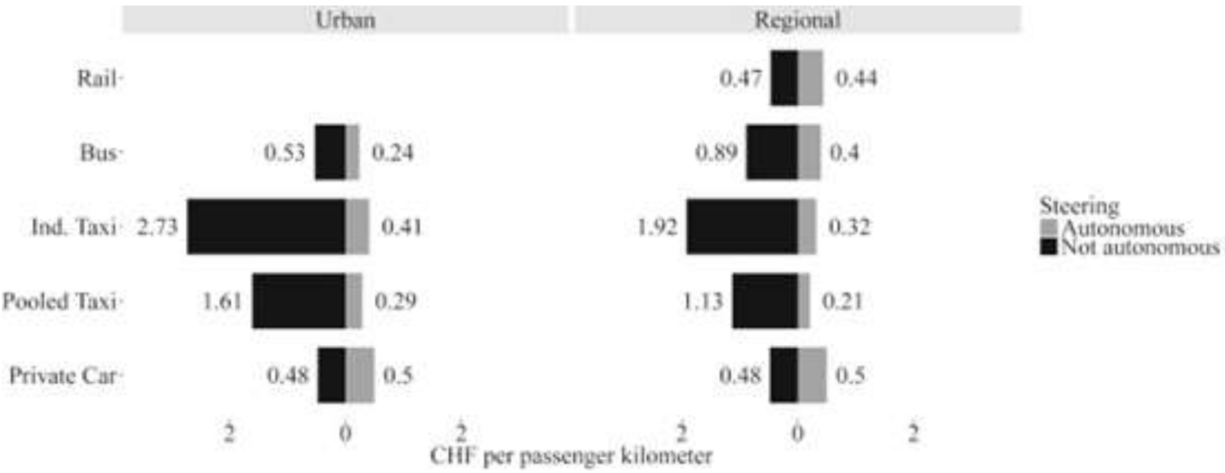



**Figure 63 - Cost comparison of different modes AV-non-AV [Source: Patrick M. Bösch et al.]**

Taken from the study "Comparative economic evaluation of the Use of conventional and self-driving vehicle units in public transport" [41] the individual cost components for two lines in the city of Braunschweig are shown and compared for a conventional and an autonomous bus operation. The annual operating costs result from the sum of the cost components.

| Annual Operation Costs Line 420 | | | | |
|---|---|---|---|---|
| | | Dimension | conventionel | autnomous |
| 1. | Vehicle depreciation | €/y | 162.750,00 € | 432.710,05 € |
| 2. | Return on capital | €/y | 60.243,75 € | 160.172,51 € |
| 3. | Personnel costs | €/y | 1.060.200,00 € | 340.380,00 € |
| 4. | Workshop costs | €/y | 177.795,00 € | 183.510,00 € |
| 5. | Fuel costs | €/y | 352.184,40 € | 316.965,96 € |
| 6. | Other costs | €/y | 114.000,00 € | 108.000,00 € |
| **7.** | **Annual Operation Costs** | **€/y** | **1.927.173,15 €** | **1.541.738,52 €** |
| 8. | Annual Mileage of the Line | km/a | 586.974 | 586.974 |
| **9.** | **Cost per Mile (km)** | **€/km/a** | **3,28 €** | **2,63 €** |

**Figure 64 - Cost comparison of AV/ nonAV Line 420 Braunschweig**

| Annual Operation Costs Line 421 | | | | |
|---|---|---|---|---|
| | | Dimension | conventionel | autnomous |
| 1. | Vehicle depreciation | €/y | 75.000,00 € | 279.141,00 € |
| 2. | Return on capital | €/y | 29.375,00 € | 109.330,23 € |
| 3. | Personnel costs | €/y | 703.080,00 € | 223.200,00 € |
| 4. | Workshop costs | €/y | 59.040,00 € | 60.820,00 € |
| 5. | Fuel costs | €/y | 104.599,04 € | 93.184,00 € |
| 6. | Other costs | €/y | 76.000,00 € | 72.000,00 € |
| **7.** | **Annual Operation Costs** | **€/y** | **1.047.094,04 €** | **837.675,23 €** |
| 8. | Annual Mileage of the Line | km/a | 232.960 | 232.960 |
| **9.** | **Cost per Mile (km)** | **€/km/a** | **4,49 €** | **3,60 €** |

**Figure 65 - Cost comparison of AV/ nonAV Line 421 Braunschweig**

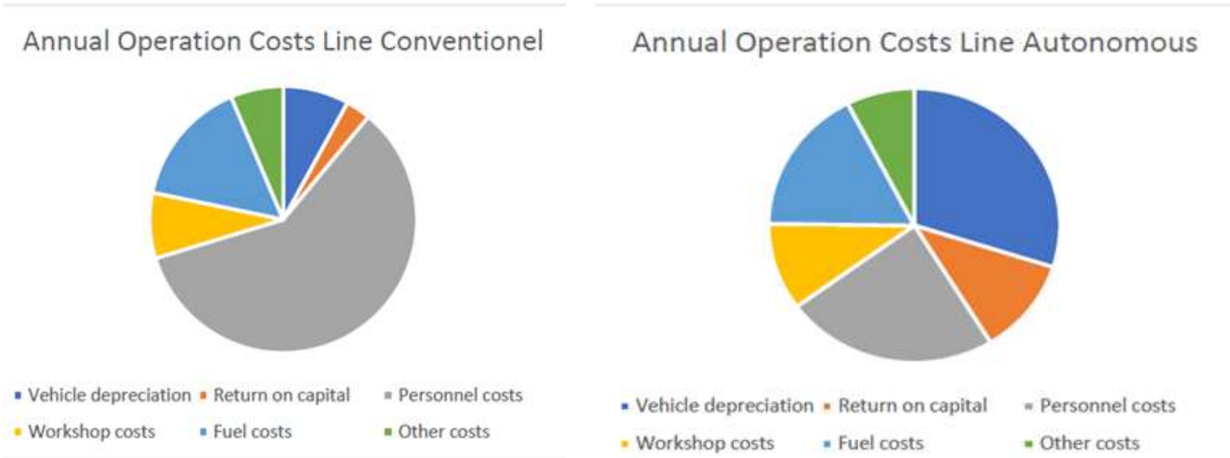



**Figure 66 - Comparison of conventional and autonomous bus in Braunschweig**

The results of this work give an insight into the possible cost structure and the influence of a driverless bus on the operating costs. It has been found that the effects of an autonomous bus affect every cost component of the annual cost of ownership. Autonomous buses have the greatest impact on capital and personnel costs. These change on the one hand because of the high expected acquisition costs of such an autonomous bus and on the other hand because of the changed personnel structure with lower personnel costs. The other cost components such as workshop, fuel and other costs are indeed changed in their amount by the operation of driverless buses, but the influence is very small compared to the changes in capital and personnel costs. The results also show that the significant reduction in personnel costs, despite the significantly higher acquisition costs of autonomous buses, results in economic advantages.

#### 3.7.3.3 New revenue and benefits

As MaaS is still a new market to be explored, a lot of new entrants will keep generating successful new business. This leads to an exponential growth in revenue of the MaaS segment within the mobility sector. Figure 67 shows the exact numbers provided by statista of growths between the year 2017 and a forecast until 2025.

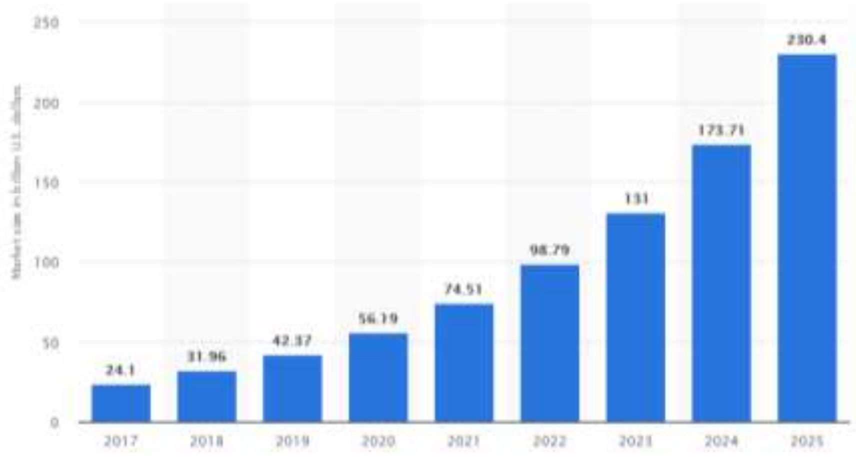



**Figure 67 - Revenue growths (billion $) 2017-2025 MaaS [Source: Statista].**

The main benefits identified are the enormous reduction of insurance costs due to a massive reduction of accidents and other negative events with the introduction of autonomous vehicles. It is a remarkably interesting and common understanding that autonomous vehicles are reducing negative traffic events by up to 80 %.

### 3.7.4 Market growths, outlook and trends

MaaS is a revolution that will redefine the mobility in the upcoming years. New mobility services and global development are expected to increase global passenger transport. Overall market drivers will be increasing urbanisation and middle-class wealth in developing nations. The graphic below shows the expectation of change within the next years for individual traffic and transport requirements overall.

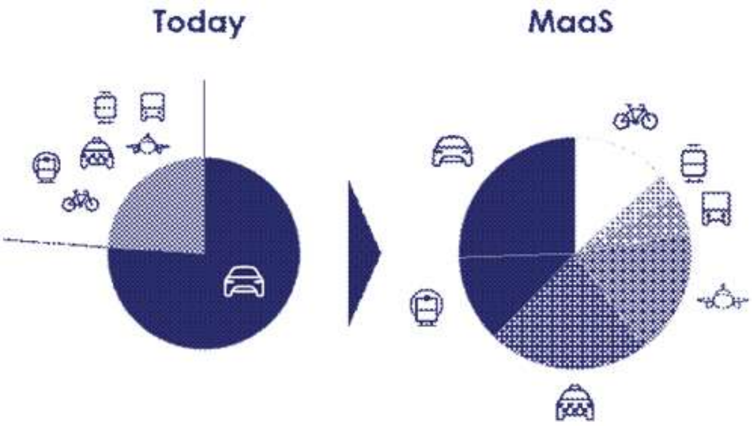



**Figure 68 - Current and future mobility mix [Source: McKinsey].**

The change from individual traffic to shared vehicles and other traffic management services in the MaaS context are essential and important for all of us. Car and ride sharing as well as other innovative mobility concepts are pushing the own car back and in addition to its positive effects on the environment, the use of MaaS can also save time and money.

The trend away from one's own car and towards sharing and using public transport is urgently needed - on the one hand to protect our environment and keep the air cleaner, but on the other hand also to relieve the roads, especially in the steadily growing cities. Urbanisation is another trend in modern society. In 1950 29% of the world's population lived in cities, in 2000 it was already half, today 55% and in 2050 it will be 70% according to forecasts. And since not only the proportion of city dwellers in the world population is growing, but also the absolute number of the world population itself, this means rapid growth in urban regions and metropolises.

Switching to sharing offers and local public transport not only saves city dwellers an average of 24% of the cost of their own car, but also saves time and nerves by avoiding traffic jams and the often annoying and time-consuming search for a parking space.

**Towards sharing**

The alternative to having your own car is shared mobility - whether in a shared car or public transport. A study from Great Britain shows that new users of a car sharing app reduce the use of their own car by 10% while increasing their use of MaaS by 7%. Another study from the USA shows that 9% of people who sold their car now rely exclusively on on-demand services such as the UBER trip booking app. Another 9% prefer to use a mixture of different modes of transport. This multimodal mobility consists of sharing as well as public transport or bicycles. Another notable advantage of MaaS is that a single car that is used in ridesharing can save ten private cars.

### 3.7.5 Connected and Cooperative Automated Vehicles (CCAV)

Mobility-as-a-service has attracted significant attention as it holds the potential to disrupt the business model of the traditional automotive industry and the way people travel. Previous in this chapter mobility service companies such as Uber, Lyft and others have been stated to offer ride-hailing services which have now become part of our daily travel options. Large auto incumbents have all invested in various forms of shared mobility services such as ride-hailing and car-sharing, claiming a transformation from an auto manufacturer to a mobility service provider.

But how will automation further influence the development and place of MaaS on the mobility market? Autonomous driving will revolutionize the way people travel and add several benefits to upcoming mobility services [42]:

- Enhance road safety and efficiency
- Improve travel convenience for those who are unable to drive.
- Reduction of harmful emissions
- Reduction of congestion and travel times

From a business point of view, autonomous MaaS will allow fleet operators to eliminate the biggest operation cost – the human driver – leading to MaaS being a cheaper alternative than the private car for consumers (travelers).

Autonomous driving is changing the existing automotive supply chain from the traditional system of OEMs and suppliers to a collaborative ecosystem comprising OEMs, mobility service providers, software and hardware solution providers, as well as infrastructure providers. Former competitors will more often join-hands and even form some unlikely sounding alliances to further reduce the costs of AD development, as well as to share resources and capabilities. [43] When comparing the uptake of private AV sales, shared AV sales and AV mobility services (MaaS) it is expected, that autonomous vehicles will first enter the market in the high-tier private car market.

In Figure 69 one can see the development of these market segments. Autonomous MaaS solutions will enter the market a bit later, but will be the biggest market segment by 2036.


**Figure 69 - Global autonomous car market value forecast [Source: IDTechEx].**

Apart from the current development of vehicles, hardware components and connectivity for the automated cars, once this is settled, the next technological barrier has to be handled when it comes to automated driving. Non-hardware elements will play an important role in the far future, speaking about artificial intelligence and deep learning which mimics neuron activity, supports functions like object recognition and classification, semantic segmentation, path planning in dynamic environments and complex decision making and execution.

### 3.7.6 Conclusion

In the future, autonomous driving will also offer mobility companies the potential to reshape their business model or will allow new market entrants to disrupt the market. Specialized IT providers, either for hardware, software or connectivity and communications will play a much more important role for the OEMs, enabling them to become more than “just” suppliers. The markets for these suppliers will grow significantly. OEMs and new shuttle manufacturers will generate more profit by reducing their operating costs and have the potential to generate new revenues with the introduction of multimedia/ infotainment systems and advertisement, once the MaaS services will be automated.

At the moment, especially in rural areas, many lines cannot be operated in a financially sustainable way due to a low number of passengers, because the costs for drivers and for the operation of large buses far exceed the income from low passenger numbers. On the other side, the last mile is as costly for the consumer. If walking is not an option, the consumer must rely on taxis or a private car. Thanks to their experience and their central role as integrator, PTOs should be able to either set up their own MaaS system, participate in cooperative MaaS systems, or regulate third-party MaaS system(s) on their territory. Missing out on these opportunities might lead to them losing their position on the market.

MaaS for the future requires modernisation of the Passenger Transport Act (European wide harmonised), increased flexibility of Public Transport Organisations and a harmonised licensing for mobility services in cities and surrounding areas.

# 4 Competitor analysis

## 4.1 Competition of SHOW with other demo sites

When it comes to competition of demos/pilot sites worldwide there have been plenty of tests, trials, and pilots/demos especially between 2015 and 2020. The analysis made showed that there are more than 140 identified sites, either preparing or carrying out demos and pilots. Many of these sites have had planning and piloting in several projects and initiatives and thus the number of pilots and demos is remarkable. A reliable source of information in the demo site study has been Bloomberg Philantropies web site dealing with cities that are getting ready for autonomous vehicles. [44]

The biggest mega cities with population of over 5 million, that have been testing and developing autonomous vehicles and services are located mainly in China such as Guangzhou, Shenzhen, Wuhan, etc. When it comes to metropolis size cities, with population between 1 to 5 million, there are cities from all over the world such all over the world such as Adelaide, Calgary, Copenhagen, Dubai, Edmonton, Hamburg, Kaohsiung, Montreal, Phoenix, Rotterdam, San Antonio, Toulouse, Wuhu, etc.

Going towards mid-sized cities with less than 1 million population, especially the amount of US cities is rather strong. But the size does not always matter only. Many of smaller cities have seen the development of autonomous transport important for the future mobility and sustainable living environment.

However, there are not too many sites that would be in so called “commercial phase” in autonomous driving and mobility services. There are several pilots and tests that have been either running or are still running, but final breakthroughs and deployments have not yet been there.

The study showed that even though there is a lot of development on-going with autonomous cars by WAYMO, Tesla, Ford, Daimler, Chrysler, Argo, Aptiv, GM, Nissan, Zoox, nuTonomy, Baidu, Nuro, Hyundai, etc., the strong interest of cities and regions is on autonomous buses, shuttles & pods, and passenger transport. In fact for instance Toyota has announced that they will be manufacturing also autonomous shuttles.

The identified cities have been piloting especially shuttle buses that are manufactured by SHOW-partners EasyMile, NAVYA and also Sensible 4. In addition, there have been other bus, shuttle and pod manufacturers and vehicles such as Local Motors, ST Engineering, Ohmio, Neolix, ELA, Optimus Ride, Pod Zero, Aurrigo, Kingwaytek, May Mobile, Auve Tech, Toyota, etc. It also became clear that even though logistics and delivery services have been trialled and piloted in a few cities, the emphasis has been on passenger transport services.

Most of the pilots have been operating on isolated or geo-fenced areas and corridors, but the future plans are to expand the services to public roads and mixed traffic. However, this is not going to very easy and it seems that services will be at least in the near future local or regional using limited operational domains.

With autonomous services almost all the sites seem to aim to tackle challenges related to sustainability, emissions, congestion, accessibility, and traffic safety etc. and thus increasing the quality of life. Many of the sites aim at the seamless integration with the existing public transport. To see the full competitor analysis please refer to the before mentioned excel spreadsheet **D16.1a_competitor analysis_fullstudy**. It is confidential and available for Consortium members upon request.

**Table 10 - Excerpt competitor analysis demo sites.**

| Country/City | Type of service | Vehicles | SAE level | Status | Remote monitor. 1=yes; 2=no | Environment (1=fenced, 2=urban, 3=peri-urban) | Integration with existing public transport? | Users in focus 1=children <15; 2=youth 16-18; 3=adult 19-65 4=elderly 66-90; 5=special users | Acessible | Anticipated impact on the city life | Further plans | Comments | Links & contacts |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Canada/Edmonton | Several trials and pilots in several environments | ELA Shuttle | 4 | Pilots and testing | n/a | 1 (?) | n/a | All | Yes | Gathering feedback about AVs and facilitating cold weather testing at Univ. of Alberta. | n/a | | https://www.edmonton.ca/city_government/initiatives_innovation/automated-vehicles.aspx |
| Germany/Hamburg | Trials of AVsas part of Hamburg Electric Autonomous Transportation project | IAV shuttle buses | 4 | Tests and trials | 1 | 1,2 | n/a | n/a | n/a | n/a | n/a | | https://www.iav.com/en/news/first-autonomous-shuttle-bus/ |
| Taiwan/Kaohsiung | Tests on a kilometer-long route linking the city's New Bay Area to the Siziwan mass rapid transit station in 2017. | NAVYA Arma | 4 | Pilot and testing | 1 | 1 | Yes | All? | Yes | n/a | Expanding trials to use driverless shuttles as an extension of the tram and metro. | NAVYA involved | https://www.taipeitimes.com/News/biz/archives/2016/12/16/2003661283 |
| Canada/Montreal | Pilots and tests of driverless shuttles | 2(?) EasyMile EZ10 shuttles | 4 | Pilots | 1 | 1 | n/a | At least 3, 4 and 5 | Yes | n/a | n/a | EasyMile and Transdev involved | http://transdev.ca/about/news/av-shuttle-pilot/ |
| USA/Phoenix | Valley Metro and Waymo to develop travel solution for the metro Phoenix area. | Waymo/Chrysler Pacifica | 4 | Pilot | n/a | 1 | Yes | At least 3 | n/a | Re-define a vibrant, expanding multi-modal public transportation. | Deployment and installations. | | https://www.valleymetro.org/sites/default/files/uploads/event-resources/driving-the-future-factsheet.pdf |
| Netherlansd/Rotterdam | Electric autonomous shuttles to run from Kralingse Zoom metro station to Rivium business park | 6(+) ParkShuttles by 2GetThere | 4? | Commer-cial (?) | 1 | 1, 2? | Targeted | All? | n/a | n/a | Etension in mixed traffic foreseen for late 2020 | https://en.wikipedia.org/wiki/ParkShuttle | https://www.2getthere.eu/projects/rivium/ |
| USA/San Antonio | AV pilots connecting downtown's South Texas Medical Center corridor along Fredericksburg Road. Several Innovation Zones identified | Waymo/Chrysler Pacifica, also shuttles targeted (brand open) | 4 (and 5) | Pilots | 1 | 1,2,3 | Targeted | n/a | n/a | AVs are seen as a part of public transport services. | Deployment | | https://webapp1.sanantonio.gov/RFPFiles/RFI_3598_201807200359261.pdf |
| France/Toulouse | Trials demonstrated how AVs could supplement the traditional public transport network. | EasyMile EZ10 | 4 | Pilot | 1 | 1 | Targeted | All? | Yes | n/a | https://www.toulouse-metropole.fr/documents/10180/26319797/SmartCity_2018_Anglais.pdf/f45e56a6-441a-47da-83f5-[illegible] | EasyMile involved | https://www.toulouseatout.com/sites/www.toulouseatout.com/files/atoms/files/a_mobilite_en.pdf |

## 4.2 Competition of manufacturers of PT vehicles

We have identified a lot of organizations involved in changing the individual transport or traffic. Changes range from individual vehicles to public transport, transport on demand, autonomous services, logistics as a service, establish IoT-Services in cities and overland. SHOW and therefore our competitor spreadsheet focus on manufacturers of automated PT vehicles, like the state of art OEMs in the consortium. But before analysing them, the following paragraphs give an overview of the different competition going on outside the scope of the SHOW project. The following chapters point out parts of the competitor analysis for OEMs which is available for confidential use upon request.

### 4.2.1 Competition and change ongoing in the automotive sector (OEM and supplier)

All known OEMs are working on electrified vehicles, with a lot of assistance systems, like radar, speed limiters, etc. toward line assists, steering support and automatic parking support. To develop autonomous driving vehicles, several OEMs are cooperating with IT-companies like IBM, Google, Microsoft and many more. Former harsh competitor like BMW or Daimler are now working on a collaborative way to develop autonomous service, identification solutions and especially common communication interfaces for future infrastructure services like traffic lights, traffic signs and other driving relevant infrastructure.

Ford and VW are actually co-developing an electric driven vehicle for the worldwide market of both companies.

As a conclusion we can identify the willingness to ensure their established business and stepping into the future by cooperation for research, development and engineering.

To develop autonomous vehicles in a mixed traffic infrastructure it is essential that vehicle and IoT are working perfectly. In Kista, for example, there is a cooperation foreseen between Ericsson and KEOLIS, represented also in the context of SHOW.

### 4.2.2 Competition and change ongoing in the automated mobility services

The third and well-known initiative and competition is related to the market of autonomous driving shuttle (busses). With a size up to 12 persons the size of the vehicle is much easier to establish and prepare with all the relevant supporting systems compared to a big bus. Most of the development projects ongoing in this sector because it is to be seen, these vehicles are much easier to establish in addition to the existing public transport systems. As an example, is the service in Monheim (Germany) to drive a line within the public service. From the knowledge of this ongoing study for SHOW we found out that this is actually the best known and shown competition in the autonomous public transport business.

### 4.2.3 Mapping to SHOW vehicle manufacturers

**Navya** is a French company whose “Autonom” vehicle is at or near the top of the list for many local authorities and organizations when they consider new mobility options for residents in remote areas.

The startup has sold many units across the world, including one to Masdar City, a picture-perfect ultra-modern, hi-tech and eco-conscious town being built in Sharjah, a tiny emirate in the United Arab Emirates; as well as one to the Henry Ford foundation.

Total funding raised by Navya so far amounts to almost $65 million, according to Crunchbase, and the company generated revenues of €4.7 million in the first six months of 2020, down 23 per cent compared to the first half of 2019.

**EasyMile** (France) is an autonomous shuttle maker that has found success for its people-carrying vehicle. With funding so far totaling more than €22 million, EasyMile has some very powerful backers.

Continental, one of the world's largest automotive systems suppliers, most famous for tires, has been a shareholder in EasyMile for some time, and the two companies partnered to develop autonomous vehicles in several German pilots.

EasyMile has quickly moved on in terms of technology, recently launching an autonomous tow tractor, which it developed and built in partnership with Groupe PSA.

The startup **e.Go** has partnered up with German automotive component suppliers ZF and Bosch, so it's ideally set up for success. The production of the vehicles is on-going, even if the COVID-19 pandemic gave the start-up a rough business year in 2020.

e.Go aims to build their vehicles not only for MaaS services, but offer a similar base vehicle (with less windows/ no seats) for logistics services.

The Finland-based company **Sensible4** has a partnership in place with global automaker Toyota and has developed special sensors which can remain operational in the harsh Finnish winters, when temperatures regularly dip to around minus 40 degrees Celsius.

Sensible4's autonomous shuttle is called Gacha and has so far been operated under direct supervision of a human driver. However, the company says it has successfully completed tests in difficult weather conditions, including snow, wind, and heavy rain.

## Table 11 - Excerpt competitor analysis vehicle manufacturers

| | OEM name | Vehicle name | Type of vehicle | Country | Commercially available; 1 = Yes, 2 = No | Amount sold/being used | SAE level; 1=Not automated to 5=fully automated | Robustness of the service | Readiness, operational or planned. | Remote monitoring; 1=yes; 2=no | Remote control; 1=yes; 2=no | Operational in harsh weather (winter conditions, etc.); 1 = Yes, 2 = No | Acessiblility and inclusiveness; 1=yes, 2=no | Anticipated impact on the city life | Business model viability | Further plans |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2getthere a ZF company | CyberCab | Shuttle | The Netherlands /Germany | 1 | 40 in total since 1997 (https://www.2getthere.eu/) | 5 | yes | Operational | 1 | 1 | 1 | n/a | n/a | n/a | projects ongoing, zf is to be one of the global player for autonomous vehicle, but |
| 2 | ADASTEC | None | Bus | USA | 1 | 1 Project in Romania | 4 | n/a | planned | 1 | 1 | 1 | 1 | n/a | Development and delivery of software for assistance systems | |
| 3 | Alphaba (Shenzhen Bus Group) | Spac E | Bus | China/Denmark | 1 | 6 | 3 | yes | operational pilot | 2 | 2 | 1 | 1 | n/a | Could become local and public service | Ongoing Trial and Pilot; no further steps to be found |
| 4 | Aptiv (ex Delphi/nuTonomy) | None | Car | USA | 1 | n/a | 3 | yes | operational | 1 | 2 | 1 | 1 | n/a | Development and delivery of software for assistance systems | to be established partner for transport organizations |
| 5 | Argo.AI | None | Car | USA | 1 | n/a | 3 | n/a | planned | 1 | 2 | 1 | 1 | n/a | | become partner for transport and automotive |
| 6 | Aurora Innovation Inc. | Nexo | Car | Korea/USA | 1 | n/a | 4 | n/a | planned | 1 | 2 | 1 | 1 | n/a | Development and delivery of software for assistance systems and | exclusive cooperation between Aurora Innovation and |
| 7 | Aurora.tech | None | Trucks | USA | 1 | n/a | 2 | n/a | planned | 1 | 2 | 1 | 1 | n/a | Development and delivery of software for assistance systems | to be established partner for transport organizations |
| 10 | COAST autonomous | P-1, AV Utility Vehicle, AV Golf Cart | Shuttle | USA | 1 | n/a | 4 | n/a | planned | 1 | 2 | 1 | 1 | n/a | n/a | The COAST P-1 Shuttle is designed to operate safely on pedestrian |
| 11 | Daimler / Mercedess | Daimler Trucks/Waymo | Bus / Truck | Germany | 2 | n/a | 4 | n/a | planned | 1 | 2 | 1 | 1 | n/a | n/a | establish partnership with waymo for freightliners |

## 4.3 Competition of SHOW and other research projects

### 4.3.1 Strategy followed within SHOW

There is a clear and committed strategy for clean, safe efficient transport within Europe as well as a single digital market. All automated transport strategies and papers concur that the development of electric powered automated transport within cities is a key milestone but that the difficulty of this vision is still pushing its implementation towards 2030. This will be a major change to urban living but one that is a “stretch target”.

SHOW needs to address the questions of:

- Autonomous vehicle miles increasing overall vehicle miles;
- How we plan for sustainable transport;
- How we integrate AV fleets with public transport;
- How we integrate AV fleets with other means of transport e.g. e-bikes and traditional bicycles;
- Integration of private AV and other connected mobility services;
- Integration of personal mobility and LaaS;
- The demands that will be placed on the cityscape (think of dedicated or mixed traffic lanes for AV);
- How new technologies (sensors, IoT, intelligent mapping) can contribute to allow the mix of AV and non-AV traffic);
- Funding;
- Data.

*“SHOW is a truly Pan*-European effort; bringing together all key stakeholder across 13 EU states (namely 12 automated vehicle manufacturers and operators, 12 Tier 1 suppliers and other Industries, 13 Municipalities and other citizen representation *associations, 8 SME’s and 24 research performers) in a unique quest to find together the “Holy Grail” of Automation; make seamless and integrated urban mobility through* automated fleets (PT, DRT, MaaS, LaaS) a reality of tomorrow and not of the next *decades.”*

### 4.3.2 Competing project summaries

#### 4.3.2.1 Overview of SHOW and other large-scale programs

The main trends that the automotive experts point out is that the future vehicle will be autonomous, shared, connected, cooperative and electrified [45]. The most significant trends include **autonomous and shared vehicles**. Adopters of such technology will be taxi companies, car sharing agencies, private cars providers; all of which will use relevant apps. Shared autonomous vehicles will be more optimally used in terms of capacity in comparison to today; **connected vehicles**. The global market for connected cars is expected to increase by 270% by the year 2022, and more than 125 million passenger cars with embedded connectivity technology are estimated to be shipped worldwide [46] and **electric vehicles**, the share of which is expected to reach 3-3.5 million in 2019, with a monthly record at ~500,00 [47]. SHOW builds upon the above 3 key trends, optimising their impacts and effects achieving sustainability by integrating them. Relevant projects include **CityMobil2** [48] (45 projects, concluded in August 2016); which applied in several cities across Europe automated low speed shuttles in real life city environments; but mainly on dedicated lanes. Remote control of vehicles was also applied. A relevant project is also the Japanese **SB Drive** [49] that was established in 2016 by Softbank and demonstrates in four cities in Japan. Public road tests with shuttles commenced in 2018. **MAVEN** [50] is an H2020 project developing algorithms and communication standards for automated urban transport but does not include big city Pilots. **AUTOPILOT** [51] focuses on IoT enabled AV applications and is linked to SHOW through several Partners, mainly its Coordinator ERTICO and CERTH. **AVENUE** [52] is the biggest relevant project so far; incorporating 4-10 automated shuttles in each of its 4 Pilot cities. Avenue Pilot sites data will be interfaced to the SHOW Architecture and Data Collection Platform by its Coordinator (and partner in SHOW) UNIGE. In addition, several automated services are emerging at city level, including automated metros and automated bus lines (i.e. around Brussels airport and/or for airport to city centre). Finally, automated MaaS fleet operation has been announced by several OEMs but it's yet to be defined.

In that respect, **SHOW is unique** (as shown in the Figure below) as it does not only constitute the bigger AV fleet (over 70 vehicles) and the higher number of sites (14, covering 20 cities only in Europe) but it is the only one that integrates automated DRT (as PT feeder or PT replacement) with MaaS and even LaaS fleets (also combining passenger and cargo transport by the same vehicle at various times of day and/ or different compartments. And all these under all-weather, in real traffic environments with SAE 4 and 5 vehicles, in complex city environments and in higher speed; integrating to local TMC and applying urban platooning.

| | CityMobil2 | UKAutodrive | AUTOPILOT | DRIVEN | [illegible] | AVENUE | SHOW |
|---|---|---|---|---|---|---|---|
| **Validation in different cities** | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ |
| Validation in open road | ✓ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Complex situations (long-term testing)** | ✗ | ✗ | ✗ | ✗ | ✓ | ✓ | ✓ |
| Innovative services | ✗ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Transportation in urban and suburban regions** | ✗ | ✗ | ✗ | ✓ | ✗ | ✓ | ✓ |
| Fleet of vehicles in real conditions | ✗ | ✓ | ✗ | ✓ | ✗ | ✓ | ✓ |
| **Beyond first/last mile** | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ | ✓ |
| Capacity for mass production | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ | ✓ |
| **Integration with automated PT for passenger and cargo** | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ | ✓ |
| Integration with automated MaaS | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| **Integration with automated LaaS** | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| Integration with automated big data/AI enabled mobility services | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| **Local TMC integration** | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |

**Figure 70 - Relation to other projects (extended from AVENUE project).**

### 4.3.2.2 Further project summaries and classification

#### *4.3.2.2.1 Automated Driving*

The following projects were assessed as being associated with automated driving:

- autobus.Seestadt [53]
- AVENUE [52]
- AVINT [54]
- MAVEN [50]
- TransAID [55]
- TrustVehicle [56]

- VI-DAS [57]

The automated driving themed projects cover a range of objectives, from focused projects with a very specific geographical target such as autobus.Seestadt which aim to implement an autonomous busline in Seestadt, Vienna to the Maven project which is looking at the generic issue of managing automated vehicles at signal controlled junctions.

None of the projects are yet in an operational phase.

#### *4.3.2.2.2 Technologies for automation*

The following projects were assessed as being associated with technologies for automation:

- CO-EXIST [58]
- Galileo For Mobility [59]
- INFRAMIX [60]
- Interact [61]
- L3Pilot [64]

Projects in the technologies for automation theme vary in SAE level from level 3 (conditional automation) to level 5 (full automation). The technology scope envisaged addresses both macro issues, such as traffic signalling systems and lower level, vehicle specific location and navigation services such as in the Galileo For Mobility project.

The Galileo For Mobility project is already operational whilst others are still in the planning and development stage.

#### *4.3.2.2.3 Social acceptance*

The following projects were assessed as being associated with social acceptance with regard to AV:

- BRAVE [62]
- Drive2thefuture [63]

The BRAVE project aims to provide a toolkit of services and products that can be used to provide stakeholders in the safety of all transport interface users (including pedestrians) with assurance of the safe operation of automated vehicles. The tools to be provided under the terms of the project range from physical, articulated pedestrian dummies to virtual reality simulations.

Drive2thefuture plans to prepare automated vehicle “drivers”, passengers and operators to accept and use future transport modes by the use of pilots and simulators which have already been taken into account into both user need explorations phases in SHOW WP1.

#### *4.3.2.2.4 Driver/ Passenger safety*

The following projects were assessed as being associated with driver/passenger safety:

- ADAS&me [65]
- AUTOMATE [66]
- Headstart [67]

The projects grouped under the theme of driver and passenger safety range in scale and ambition from the very specific driver state monitoring and prediction (e.g. fatigue) of ADAS&me to the Headstart project that aims to bring a level of standardization and harmonization in procedures, tools and methodologies in testing and validation of automated transport. None of the projects are live indeed AUTOMATE does not plan to deliver an SAE level 5 service until 2030.

#### *4.3.2.2.5 Policy*

The following projects were assessed as being associated with policy issues:

- Connected automated driving EU [68]
- LEVITATE [69]

The Knowledge Base on Connected and Automated Driving (CAD) is the one-stop shop for data, knowledge and experiences on CAD in Europe and beyond.

The sharing of knowledge, data and experiences is essential for the development of connected and automated driving. Combining the knowledge sources enables all stakeholders to get a clearer picture of what the future impacts of road automation will be.

Developed as part of the Horizon 2020 Action ARCADE (Aligning Research & Innovation for Connected and Automated Driving in Europe), the Knowledge Base gathers the scattered information among a broad network of CAD stakeholders to establish a common baseline of CAD knowledge and provide a platform for a broad exchange of knowledge.

The LEVITATE project aims to develop a contingent methodology for assessing the time-bound impacts of automated vehicles within urban environments.

#### *4.3.2.2.6 Conclusion*

The projects listed in this section demonstrate that there is a lot of wide range going into CCAV development and adoption but that there is still a significant amount of work to be done. SHOW must consider and address the gaps that appear to exist in the range of projects examined. That is, a lack of vigorous business models and business cases further consideration of the robustness of the services envisaged and maybe most importantly how to address social inclusion. It is also big fleets in urban environment in real life conditions, as well as the collaboration of all stakeholders of the urban transport context.

**Table 12 - Excerpt competitor analysis demo sites**

| | Acronym and name | Objective/target/scope | City/region (all if several) | Partners involved | Main results (targeted and/or achieved) | SAE level; 1=Not automated to 5= fully automated | Robustness of the service | Readiness, operational or planned. | Integration with the existing public transport? | Specific Users in focus 1=children <15 years; 2=youth 16-18; 3=adult 19-65 4=elderly 66-90; 5=persons with |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ADAS&me | Development of robust detection/prediction algorithms for driver/rider state monitoring of fatigue/drowsiness, stress, inattention/distraction and impairing emotions. Development of multimodal, user oriented and | Barcelona | Hellenic Insititute of Transport. Sapienza. DLR. Ecole Polytechnique Federale de Lausanne. | Final results video at https://www.adasandme.com Advanced Driver Assistance Services for all vehicle types | 2 | Development of robust detection/prediction algorithms for driver/rider state | Autononmous driving use cases researched ibcluding motor bikes and bus | Yes | 3 |
| 2 | autobus.Seestadt | The project aims to enhance the operational quality of future autonomous bus routes by means of planned technological innovations. The goal is to sustainably increase the efficiency and operational safety of autonomous vehicles, with the ultimate goal of operating a bus line in | Sseestadt, Vienna, Austria | Wiener Linien, AIT, KfV, TÜV Austria, Siemens Navya | The first fully autonomous minibus to drive the route will be the "AUTONOM SHUTTLE" produced by NAYVA. It is powered by an electric motor, can take up to 10 passengers and is already navigating various test around the world routes today. The bus travels at speeds of up to 20 km/h and one of the 11 | 5. Fully autonomous minibus | This includes the robust monitoring of the environment of the automated vehicle, a trust-building interaction | Planned | Planned | 3 |
| 3 | AUTOMATE | Viewing driver and automation as members of one team that understand and support each other in pursuing cooperatively the goal of driving safely, efficiently and comfortably from A to B. Driver state modelling (DMS), V2X, Driver intention | All | OFFIS. Broad bit. Continental. CRF. Deutsches Zentrum fur Luft | The objective of AUTOMATE is to develop, evaluate and demonstrate the "TeamMate Car" concept as a major enabler of highly automated vehicles. This concept consists of viewing driver and automation as members of one team that understand and | 5 | No service yet | Planned | Not until 2030. | 3 |
| 4 | AVENUE | In order for AVENUE to successfully realize its vision, different objectives have been set, covering the project's scientific and technological aspects throughout its duration, as well as the exploitation of the project's results after its end. The overall project success will be defined by the efficiency and effectiveness of the appropriate | Lyon, Luxembourg, Geneva, Copehagen | Universite de Geneve. Navya. Centrale Supelec. HS PF. Tpg. Bestmile. SIEMENS. | AVENUE aims to design and carry out full-scale demonstrations of urban transport automation by deploying, for the first time worldwide, fleets of autonomous minibuses in low to medium demand areas of 4 European demonstrator cities (Geneva, Lyon, Copenhagen and Luxembourg) and later on of 3 replicator cities. AVENUE revisits the offered | 5 | Not yet specified | On-going project so this aspect needs updating | Yes | All |
| 5 | AVINT | In the AVINT project, participating partners will study the urban transport context in Trikala city and will implement a bus line supported by automated buses in a full integration mode with the city transport network. The specific bus line will provide a viable service for the city interconnecting the city center with the Sport | Trikala, Greece | e-trikala. ICCS. SPACE HELLAS S.A. | In the AVINT project, participating partners will study the urban transport context in Trikala city and will implement a bus line supported by automated buses in a full integration mode with the city transport network. To accomplish this, AVINT will perform all the necessary tasks: feasibility study, implementation study, infrastructure adaptation, | 5 | Promises a robust service | Still inresearch phase. | Yes | All |
| 6 | BRAVE | The **main objective in BRAVE** is **to improve safety and market adoption of automated vehicles**, by considering the needs and requirements of the users, other road users concerned (drivers and vulnerable road users) and relevant stakeholders (i.e. policy makers, standardisation bodies, certifiers, insurance companies, driving schools), assuring safe integration of key enabling | All | vti. UTC CERAM. Ifes. Universidad de Alcala. Fraunhofer IAO. Mov'eo Imaginer mobility. AMZS. RACC. | Five recommendations are to be retained. Firstly, the use of a fully articulated pedestrian dummy. Secondly, the pedestrian combination of a longitudinal and crossing scenario should be the first milestone of advanced anticipation scenarios could be set up in the future. These would deal with pedestrian's reaction anticipation. Secondly, the pedestrian combination of a longitudinal and | 5 | Guarantee system robustness and reliability under any possible scenario and condition. | Planned | Yes | All |

# 5 SWOT Analysis

To give an overview of the changes to the project and the overall situation of the mobility market, the complete initial SWOT analysis is stated in the following chapter. Additionally, the new comments to this initial SWOT are highlighted in italics.

## 5.1 Strengths and weaknesses of the SHOW project

**Strengths:**

1. SHOW brings together a multi-stakeholder Consortium, encompassing in each site all stakeholder ecosystem (as Partners, third parties, with LoI or LoS), complemented by a vast and multicultural Advisory Board and Twinning network. The project members managed to expand the dialogue with other actors on the market, e.g.**, City of Monheim with their CAV shuttle operation in the City (Line A01)** or PTO Hochbahn in Hamburg with their pilot project HEAT, within the first year.
2. SHOW is covering all urban AV types (bus, shuttle, pod, car), analysing the cost-benefit structure per transport mode to find out best-fit Go-to-Market strategies.
3. SHOW is integrating PT (including BRT) with DRT, MaaS and LaaS fleets in fully automated multimodal transport chains with a special focus on the operational feasibility of the service (Lessons learned from Autopilot).
4. SHOW is covering passenger, cargo and mixed transport under varying schemes and use cases in seamless, long duration, real traffic demonstrators, involving hundreds of thousands of citizens across the whole Europe (13 states, 20 cities) that will be experiencing CCAM in varying urban and peri-urban environments.
5. Bringing under one open, extensible and parametric architecture and data platform 13 different AV OEMs and operators, 5 Tier 1 suppliers and Telco's, 6 more industries and 7 SMEs; thus, developing and aligning with the de facto standards in the area.
6. SHOW is bringing solutions **(also IoT)** to the actual problems of deployment; higher speed, complex environments, mixed traffic, linked to city TMC and with enhanced safety (for passengers and the rest non-automated traffic participants) and security (cybersecurity included).
7. SHOW is using AI and big data analytics to develop added value metaservices and a relevant AV enabled marketplace bringing together OEM driven ADAS modules and design for PT CCAM operator services to develop a roadmap for an CCAM economy of scale.
8. SHOW is preparing, applying, validating through demonstrators, optimizing and replicating business models for AV deployment under different local operational and socioeconomic conditions with a special focus on supplier-vendor specifications and technical requirements between OEMs and PT operators.

Other:

- Connection to vast funding outside the project (i.e. half the AV fleet and all infrastructure available at no cost to the project).
- Managed by a very experienced strong team, with proven capacity of managing EC projects of this size.
- Co-developing and co-applying all solutions with the local ecosystem and societies.
- Projecting to wider populations through simulation tools and studies.
- Enabling the exchange of lessons learned in the project but also the broader deployment of its results through its replication activities and mechanisms.

- Contributing to CCAV policies through participation and membership in the Working Groups and other initiatives in the field, roadmaps and recommendations as well as through the policy support and decision-making tools that will offer to authorities and stakeholders for the aligned adoption of CCAM in their SUMP/SULP.
- Respecting local ecosystems, current practices, infrastructure and business and operational models and, at the same time, aligning them under one common vision and centralised (digital) infrastructure easy to interface.
- Proving interoperability respecting IPR of competing participating vendors.
- Aiming to collect data for its own operational and assessment purposes; still making them open to the wider CCAM community.
- Learning from the variety of its piloting Cities and structuring recommendations for regulations harmonisation in shared CCAM as a contribution to the sector.
- Leading to a sustainability driven traffic environment
- The greater number of demo sites managed to plan out their piloting phase for 2021 and built a baseline for starting the real-life demonstrations for next year.

**Weaknesses:**

1. Scarcity and high cost of AV fleets are leading to the need to disperse efforts across cities/ sites to reach a truly big fleet of all types of vehicles and different OEMs/ operators.
2. High diversity of communication infrastructure, protocols and lack of standardisation are leading to high efforts to achieve interoperability and common architecture.
3. Half of the AV fleet is to be purchased through public tenders with secured funding, which however is out of the project's budget and acquisition tenders may delay Pilot demonstrations' execution (though are always well ahead of Pilot phase).
4. In Automotive Industry, all Economy of Scale driven software **and IoT**-modules are developed under strict OEM IPR regulations and therefore not designed for open standards. In especially, the transfer from OEM standard components to CAV design is IPR sensitive and willingness towards standardization for CAV production might take longer than assumed in the original SHOW business framework.

## 5.2 Opportunities and threats of the SHOW project

**Opportunities:**

1. The fast maturing of AV technology with industrial initiatives outside the project will result in improved vehicles and infrastructure functionalities even before project own development, i.e. initiatives linked to the deployment of Automated Truck Platooning moving from Highways to urban road networks as known from several German Truck manufacturers.
2. High political and industrial interest in Europe and beyond and link to external initiatives (AVENUE, US and Chinese demonstrators, …) multiplies own data and resources.
3. Emerging AV business models (especially for connected MaaS) offer more deployment options States Readiness Level and enabling legislation for AVs is constantly improving.
4. For automotive suppliers, SHOW offers a marketing platform for presenting AV modules and multi-sensor fusion AV shuttle kits. By linking PTO requirements, AV manufacturer product road maps and automotive suppliers market standards can be elaborated and offered world-wide, i.e. in the now biggest automotive Chinese market where all OEMs and suppliers are located and need product differentiators.

5. For Mobility service provider, SHOW presents a pilot service test ground where joint business models with OEM customers can be linked to other service offering modules such as Telematics Service Provision, an important core business of ICT companies with OEM manufacturers. An interesting option of CAV fleet services might come up with the complex supply chain in medical services due to the large-scale impact of COVID-19.

**Threats:**

1. Change of priorities and/ or policies at local (pilot site) level are often big threats.
2. Sparse accidents/incidents occurring across the world creating trust issues (such as the Tesla one in the US).
3. OEMs/ operators fierce competition resulting in lack of critical mass of open data affecting really interoperable (and cross-border) CCAV.

Other:

- Challenging data collection and governance.
- Non-harmonised regulations with respect to shared CCAV affecting interoperability and liability among other.
- COVID -19 pandemic effects; economic but also shift of priorities in mobility, in especially a weaker position of shared mobility solutions including shared space in Buses, car sharing or e-Shuttle services.
- *Shift of some OEM's internal roadmaps with regard to shared CCAM (later* commercialisation and deployment than planned).
- The automotive industry is suffering a similar brake in their profit and produce, on a similar level like 2008, due to strong COVID-19 impact.

# 6 Data within the transport sector

Following recent innovations, the **transport sector relies** increasingly on the exchange of large amounts of **personal and non-personal data** between multiple actors.

These innovations include the **development of vehicles' automated functions, connected vehicles, smart cities** and **digital mobility platforms**.

These solutions have led to **an increase in data generation** with transport operators typically **generating data** and technology companies **processing and using these data**.

In early 2020, the main organisation of the transport sector started to meet under the Stakeholder Forum of Data[1], to share their views and expectations on the current and future challenges in regulating data and digitalisation.

In the transport, logistics and mobility sectors, innovation relies increasingly on the processing and exchange of large amounts of personal and non-personal data between multiple actors. In addition, innovative solutions in goods and passenger transport such as connected vehicles, smart cities and digital platforms have led to an increase in data generation. We know how crucial data is to gain insights on customers, routes or vehicle loads, as well as how commercially sensitive such data can be.

Data and digitalisation provide new opportunities throughout logistics and mobility systems, and for EU citizens and businesses. Moreover, efforts to digitalise the transport sector will also contribute to achieving the EU Green Deal objectives. Nevertheless, we are acutely aware of the challenges to be overcome to unlock the potential of the data economy, including:

- Stakeholders' **lack of trust** that data will be used in line with or even without contractual agreements, given the unequal bargaining power between the parties.
- The **lack of economic incentives**, including concerns over competitiveness and protection of commercial interests.
- The **risk of misappropriation** of data by third parties, resulting in potential consumer protection and liability issues.
- A **lack of legal clarity** surrounding the governance of data access and use (including co-created data, such as from the Internet of Things) and re-use/re-distribution.
- A **lack of understanding** of the total costs associated with data generation, data processing, storage, and distribution.

[1] The Stakeholders Forum on Data is a platform for key industry stakeholders – including high-level representatives from the Community of European Railway and Infrastructure Companies (CER), the European Association of Automotive Suppliers (CLEPA), the International Association of Public Transport (UITP), the European Shippers' Council (ESC), the European Automobile Manufacturers Association (ACEA), Airlines for Europe (A4E), and World Road Transport Organisation (IRU).

Given these challenges, steps must be taken to ensure equal opportunities for all business partners in the digital economy. To this end, a fair and transparent governance structure for business-to-business (B2B) data is needed.

**It is important to have an EU framework on data governance that explicitly sets out the following principles for the provision of B2B data**:

i. **The voluntary provision of data**: The forced provision of business data could hamper the competitiveness of European businesses by increasing the power of a few large companies at the expense of smaller players such as SMEs. B2B data exchange should continue to rely on **voluntary contractual agreements**, as this is a flexible and efficient option. This principle should apply to all companies, whether public or private, operating a purely commercial service or under a public service contract and regardless of their ownership structure.

ii. **Responsible actors**: The obligations and liability of data aggregators should be clearly defined at EU level and the rights of data generators explicitly recognised. In particular, the collection, storage, processing, sharing, use, re-use, access, and security of data should be clearly defined in B2B contracts. This can boost the trust and mitigate concerns of data misappropriation.

iii. **Standardisation and interoperability**: The lack of commonly agreed interoperable and multimodal specifications at EU level, for example, for APIs or data formats, is an issue that makes interoperability between platforms difficult and increases the risk of lock-in with platform. The standardisation efforts must factor the economic and operational realities of transport companies and not represent an excessive burden. In this respect, initiatives like the delegated acts under the ITS Directive are useful for establishing certain standards for the transport sector as a whole. Data spaces should be supported through cloud infrastructure based on the principles of security, interoperability, and data portability.

iv. **Boost skill development to boost competitiveness:** Innovation and technology in the transport sector should be underpinned by a strong focus on skills. Skills need to be upgraded to take full advantage of the opportunities provided by data-based business models. To achieve the full potential of digital transformation and more competitiveness of the EU, businesses need incentives to upskill their talent in critical areas such as artificial intelligence (AI), machine learning (ML) and cloud computing.

v. **Financial support**: the impact on the industry of the transition to a digital economy should not be underestimated, as the fixed costs are high and the margins are low. To embrace digitalisation, the transport sector requires legal and regulatory clarity but also financial support, including for small- and medium-sized enterprises.

# 7 Conclusion

The main goal of D16.1 is to give a thorough market analysis that can be used over the whole project duration about the SHOW mobility services covering different types of services (PT, DRT, CS, LaaS, MaaS) explaining their state of art, competitive landscape, roles, mobility drivers, cost structure, revenues, market growths, outlook and CCAM applications. This market study is supported by a competitor analysis, which is not just limited to the submission of this deliverable. D16.1 reports on the findings of the competitor analysis up until M12 of the whole project duration but encourages the Consortium and external stakeholders to use and enhance the analysis with their insights, also after M12. Last but not least the market study is scaled down into detail regarding the changes for the project itself. The methodology for this is a SWOT analysis, stating initial and updated content from the experiences made in the first 12 months of SHOW.

In this market research several challenges that new mobility services have to take account for were mentioned. The uptake of CCAM solutions in public transport will greatly help to reduce pollution, emissions and most likely congestion – and therefor play a major role in the upcoming battle of fighting climate change. Nevertheless, the basis of the solutions in the technology. The digitalization of public transport services will most likely happen in two major steps. The first step is the development of advances driver assistance systems and hardware components to its maturity. Costs for this will decrease and the vehicles will become affordable for fleet managers. Once the first fleets are in operation on the market, a second wave of digitalization will happen, disrupting the old OEM / supplier relations. Software components such as artificial intelligence and deep learning will become more important for CCAM solutions, boosting the traffic safety with smart decision making and optimizing the business models with better route and capacity planning. IT providers will become a major player in the automotive world. Stakeholders will rather work together as partners than in the old customer-supplier relationships.

SHOW as a truly Pan-European effort, is working towards this goal by bringing together all key stakeholder across 13 EU states, with the vision to support the **deployment of** shared connected and electrified automation in urban transport chains through demonstration of real-life scenarios, promoting seamless and safe sustainable mobility. Moreover, SHOW is of strategic significance for all involved actors, involving:

- European OEMs of automated vehicles
- Mobility services and PT operators to
- A wide portfolio of ITS and connectivity providers with expertise in infrastructure, IT, communications, etc.
- SMEs to gain a favourable ecosystem and added value services

Based on the full market analysis, the following conclusions can be made:

Among the most frequently chosen answers in the survey for acceptance, respondents think that automated vehicles will reduce the need for professional drivers and take over their jobs, but that they will also reduce accidents and travel stress.

Travelling by public transport already is much safer than travelling by private car. The trend with automation for public mobility services will make our future transportation not only more sustainable but even more secure.

Competition within each mobility service is high, but all shared, cooperative mobility service are competing with the private car usage. Work together to build local mobility ecosystems and build up upon the different advantaged to make mobility in the urban, sub-urban and even rural areas more time-efficient, comfortable, cheaper and sustainable.

If a private and flexible trip is inevitable, autonomous shared cars will be one of the most important players in the future of urban areas and will co-exist and even mix with the rest of existing trends and mobility solutions such as PT, DRT, LaaS and micro-mobility. The timely-uptake of robo-taxis is still unclear, but we expect them to have a high market impact and especially cover user needs at the very last, or first mile of their trips.

The way that private cars (electrified or not) were previously beneficiary of politically consciously needs to be shifted to benefit cities and future urban areas, as well as the SME and start-up cluster of future mobility services. The weight should not only be on big cooperation to invest and widen their mobility portfolio.

A regulatory framework is needed for both new vehicle types as well as the diverse new mobility offers, that are created based on digital platforms, legally enabled and clears the way for their abilities to try out optimal links with classic public transport.

For the project itself the following conclusions can be made:

All the conclusions about the market "Connected and Cooperative Automated Public Transportation Services" together with the competitor analysis, as well as the initial and updated SWOT are helping to build the "development ecosystem, especially considering the SHOW approach which focuses on SME, start-ups and new entrants, integrate PTO (and do not cannibalize them) and consciously disregarding the basic investments (which is a major barrier for any business especially for a new one).

The results of D16.1 will be feeding other analyses that will follow in the project, especially regarding the building and implementation of business models at the pilot sites (A2.3), the total-cost of ownership, cost-benefit and cost-effectiveness analysis (A16.2) and other impact assessments to be conducted within the project., e.g. influence from the market entry of SME/start-ups/new entrants in the field of OPEX or effects of new or extended mobility service portfolio for specific stakeholder groups (IT service provider, marketing provider, municipalities…). The results of D16.1 will also be the basis for the building of the beneficiary's exploitation plans.

# References

[1] SHOW (2020). Grant Agreement of Horizon-2020 SHOW project No. 875530.

[2] EC Eurobarometer EUROPA – TRIMIS, Transport Research and Innovation Monitoring and Information System, https://trimis.ec.europa.eu/content/eurobarometer-survey-expectations-and-concerns-connected-and-automated-driving , 2020

[3] SHOW (2021). D2.2 Business models and mapping to pilot sites. Deliverable of the Horizon-2020 SHOW project, Grant Agreement No. 875530

[4] European Commission (2020) State of the Union Report https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_20_1655

[5] European Court of Auditors - Special report 06/2020: Sustainable Urban Mobility in the EU: No substantial improvement is possible without Member States' commitment

[6] European Commission (2018) A European Strategy for low-emission mobility https://ec.europa.eu/clima/policies/transport_en

[7] European Environment Agency A European Strategy for Low-Emission Mobility, 2020

[8] UITP, Autonomous Vehicles: A potential game changer for urban mobility. Brussels: International Association of Public Transport https://www.uitp.org/publications/autonomous-vehicles-a-potential-game-changer-for-urban-mobility/

[9] One planet (2020) climate manifesto https://OnePlanet.UITP.org/Manifesto/Climate-Action-Manifesto

[10] EMTA European Metropolitan Transport Authorities (2020) https://www.emta.com/?lang=fr

[11] UITP (2019) Taxi benchmarking study https://www.uitp.org/publications/global-taxi-benchmarking-study-2019/

[12] Patrick M. Bösch, Francesco Ciari, Kay W. Axhausen: Transport Policy Optimization with Autonomous Vehicles et al., 2018

[13] Aybike Ongel, Erik Loewer, Felix Roemer, Ganesh Sethuraman, Fengqi Chang: Economic assessment of autonomous electric microtransit vehicles, 2019

[14] Zia Wadud: Fully automated vehicles: A cost of ownership analysis to inform early adoption, 2017

[15] Jessica R. Lazarus, Susan Shaheen, Stanley Young: Shared automated mobility and public transport 2018

[16] Jerome M. Lutin: Not if, but when: autonomous driving and the future of transit, Journal of Public Transportation,2018).

[17] UITP policy brief (2020) Full free fare public transport: Objectives and alternatives https://cms.uitp.org/wp/wp-content/uploads/2020/09/Policy-Brief-FullFreeFarePT-DEF-web.pdf

[18] Metroautomation, 2020, www.metroautomation.org

[19] UITP, SPACE map, https://space.uitp.org/initiatives

[20] SHOW (2020). SHOW Deliverable 2.1 Benchmarking. Deliverable of the Horizon-2020 SHOW project, Grant Agreement No. 875530

[21] KonSULT, project by ITS department University Leeds, http://www.its.leeds.ac.uk/projects/konsult/private/level2/instruments/instrument048/l2_048a.htm

[22] Laurent Franckx (2017), Article on DRT published on mobilitybehaviour.eu https://mobilitybehaviour.eu/2017/08/04/demand-responsive-transit-drt/

[23] Currie, G. & Fournier, N, 2019 Valuing public transport customer experience infrastructure: an international expert Delphi study of methods & application Australian Transport Research Forum, ATRF 2019

[24] Interreg Europe Policy Learning Platform on Low-carbon economy (S.Hunkin, K.Krell, 2018) https://www.interregeurope.eu/fileadmin/user_upload/plp_uploads/policy_briefs/2018-06-27_Policy_Brief_Demand_Responsive_Transport.pdf

[25] List of services for Demand Responsive Transportation- https://en.wikipedia.org/wiki/Demand_responsive_transport

[26] Lisa Davison et. Al (2012) Identifying potential market niches for Demand Responsive Transport, Research in Transportation and Business Management available under: https://www.sciencedirect.com/science/article/pii/S2210539512000089?via%3Dihub

[27] Community Transport Organization (CTA) The future of demand responsive transportation (2019) https://ctauk.org/wp-content/uploads/2018/05/The-Future-of-Demand-Responsive-Transport-1.pdf

[28] MaaS alliance (2017) White paper – Guidelines & Recommendations to create the foundations for a thriving MaaS Ecosystem https://maas-alliance.eu/wp-content/uploads/sites/7/2017/09/MaaS-WhitePaper_final_040917-2.pdf

[29] International Transport Forum (2020) Urban Mobility Systems Upgrade – How shared self-driving cars could change city traffic https://www.itf-oecd.org/sites/default/files/docs/15cpb_self-drivingcars.pdf

[30] Maximize Market Research ( 2019) Global On Demand Transportation Market – Industry Analysis and Forecast (2019-2027) – by Services Type, Vehicle Type and Region. https://www.maximizemarketresearch.com/market-report/on-demand-transportation-market/25844/

[31] Oded Cats et. Al (2016) Designing an Automated Demand-Responsive Transport System: Fleet Size and Performance Analysis for a Campus–Train Station Service https://www.researchgate.net/publication/309884210_Designing_an_Automated_Demand-Responsive_Transport_System_Fleet_Size_and_Performance_Analysis_for_a_Campus-Train_Station_Service

[32] Elgar Fleisch, Friedemann Mattern: Das Internet der Dinge: Ubiquitos Computing und RFID in der Praxis: Visionen, Technologien, Anwendungen, Handlungsanleitungen

[33] Mehdi el Alami: Presentation VeRoLog: The sixth meeting of the EURO Working Group on Vehicle Routing and Logistics optimization, Amsterdam 2017

[34] Berd Scholz-Reiter, Katja Windt, Michael Freitag: Autonomous Logistic Processes – New Demands and First Approaches, Juli 2014

[35] David Harris, Amsterdam 2017: Presentation VeRoLog, The sixth meeting of the EURO Working Group on Vehicle Routing and Logistics optimization )

[36] UITP 2019, policy-brief-autonomous-vehicles: a potential game changer for urban mobility

[37] MaaS Alliance https://maas-alliance.eu

[38] UITP publications https://www.uitp.org/resources/publications/

[39] Klinge et al A., Torliene, L., Poestges, N. 2020. "Betreiber und Geschäftsmodelle Digitaler Mobilitäts-plattformen zur Verzahnung von On-Demand- und Taktverkehr. Hub Chain Ergebnisreport Arbeitsschritt, Juli 2020

[40] Patrick M. Bösch, Francesco Ciari, Kay W. Axhausen: Transport Policy Optimization with Autonomous Vehicles et al., 2018

[41] Philip Loos, Prof. Karsten Lemmer: "Comparative economic evaluation of the Use of conventional and self-driving vehicle units in public transport"

[42] Thales (2017) 7 benefits of autonomous cars https://www.thalesgroup.com/en/markets/digital-identity-and-security/iot/magazine/7-benefits-autonomous-cars

[43] Dr. Luyun Jiang (2020) Autonomous Cars and Robotaxis 2020-2040: Players, Technologies and Market Forecast https://www.idtechex.com/en/research-report/autonomous-cars-and-robotaxis-2020-2040-players-technologies-and-market-forecast/701

[44] Bloomberg Philanthropies (2020) Initiative on Cities and Autonomous Vehicles: Cities are getting ready for AVs, https://avsincities.bloomberg.org/y

[45] PWC (2018) Five trends transforming the Automotive industry https://eu-smartcities.eu/sites/default/files/2018-03/pwc-five-trends-transforming-the-automotive-industry.compressed.pdf

[46] Internet of business (2020) Connected cars report: 125 million vehicles by 2022, 5G coming, internetofbusiness.com/worldwide-connected-car-market-to-top-125-million-by-2022/

[47] Internet of business (2020) Connected cars report: 125 million vehicles by 2022, 5G coming, internetofbusiness.com/worldwide-connected-car-market-to-top-125-million-by-2022/

[48] CityMobil2 project, https://civitas.eu/tool-inventory/citymobil2-experience-and-recommendations

[49] SBDrive project, http://www.softbank.jp/drive/

[50] MAVEN project, http://www.maven-its.eu/

[51] AUTOPILOT project, https://european-iot-pilots.eu/project/autopilot/

[52] AVENUE project, https://h2020-avenue.eu/

[53] auto.Bus Seestadt, https://www.wienerlinien.at/eportal3/ep/channelView.do/pageTypeId/66528/channelId/-4400525

[54] AVINT project, https://www.avint-project.eu/index.php/en/

[55] TransAid project, https://www.transaid.eu/

[56] TRUST vehicle project, https://www.trustvehicle.eu/

[57] VI-DAS project, http://www.vi-das.eu/

[58] CO-EXIST project. https://www.h2020-coexist.eu/

[59] Galileo 4 mobility project, http://www.galileo4mobility.eu/

[60] INFRAMIX project, https://www.inframix.eu/

[61] INTERACT project, https://www.interact-roadautomation.eu/

[62] BRAVE project, http://brave-h2020.eu/socialmedia

[63] DRIVE project, http://www.drive2thefuture.eu/

[64] L3pilot project, https://www.l3pilot.eu/

[65] ADAS and me project, https://www.adasandme.com/

[66] AUTOMATE project, http://www.automate-project.eu/

[67] Headstart project, https://www.headstart-project.eu/

[68] Connected automated driving project, https://connectedautomateddriving.eu/cad-knowledge-base/

[69] LEVITATE project, https://levitate-project.eu/