Sprout

Policy Brief

Required regulatory and operational facilitators for the effective integration of new mobility solutions

February 2023

www.sprout-civitas.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814910.

Introduction

This document presents practical findings from SPROUT pilots, related research projects, and other European cities on policies to harness the positive impacts of emerging urban mobility solutions while avoiding negative consequences. It consists of a policy brief which focuses on the integration of autonomous mobility in the transport offer of cities.

The Policy Brief provides information and practical experience, from SPROUT cities and beyond, on emerging issues of urban mobility. Mains sources are the setup and evaluation reports from SPROUT cities. Complementary information was collected from other European projects, including SOLUTIONSplus, SmartHubs, and the AutoMATE Projects Group. Moreover, information was sourced from desktop research, based on the ELTIS website, primary sources, and research papers on both topics.

The Policy Brief is arranged along the following structure: The first step is an assessment of the state of the art on the topic, which is an assessment of the current technical and operative development, the capacities to act on the local level, and the main impacts of the innovation. Secondly, the policy brief derives success factors for cities to implement policy responses, based on experiences from SPROUT pilot cities. Finally, the policy brief provides suggestions in relation to European guideline documents.

1. State of the art of the autonomous/ automated vehicles

1.1. Introduction

According to a recent study by BlueWeave Consulting, (2022), the global market of Autonomous/Automated vehicles is expected to increase by almost 30% (CAGR) by 2028. The rapid evolution of the specific market is highly correlated and boosted by the development of fast-growing technologies such as Artificial Intelligence, the Internet of Things, Cloud computing, and Digital Twin, which can be deployed using real-time information to achieve automation. Regarding the level of automation, NHTSA, (2016) identified five different levels (**Level 0** – No-Automation, **Level 1** – Function-specific Automation, **Level 2** – Combined Function Automation, **Level 3** – Limited Self-Driving Automation, **Level 4** – Full Self-Driving Automation). Focusing on the higher level, these vehicles are designed to be able to navigate through the urban transportation system, prioritizing critical decisions for safety, without any human contribution. The modal shift of the passenger and freight fleet from conventional fuel types to autonomous/automated will be a revolution in (urban) mobility (Meyer et al., 2017).

The use of autonomous/automated vehicles can contribute to a more sustainable urban mobility ecosystem. On the one hand, these innovative vehicles are expected to improve the **safety** of the urban mobility network, since the data-driven decisions of these vehicles can "foresee" and save unexpected situations (Fagnant et al., 2014, Litman, 2022, Kockelman et al., 2016). Furthermore, the optimal operation of the smart urban mobility system together with the MaaS concept, will reduce the cost to the users and will make it an **affordable** transportation mode (Bösch et al., 2018). Of course, the fact that the automated transportation system fits citizen demands following the optimal number and routing of trips, the **comfort** of the users (since it is less noisy and the optimization will reduce the waiting time) and the **sustainability** of the whole system can also be improved (Anderson et al., 2014, Brown et al., 2014, Fagnant et al., 2014, Kockelman et al., 2016, Wadud et al., 2016). Moreover, the **accessibility** for people with reduced mobility (elder and disabled) could be improved through autonomous/automated transportation (Anderson et al., 2014, Burns, 2013, Fagnant and Kockelman, 2014, Lutin et al., 2013). Finally, the use of smart (autonomous/automated) vehicles will help cities to move towards specific green goals (Green Deal, etc.) EU has set. Specifically, it could result in: i) the reduction of the total vehicle fleet (Bösch et al., 2016, Burns et al., 2013, Chen et al., 2016, Fagnant and Kockelman, 2014, Martinez et al., 2014, Zachariah et al., 2014, Zhang et al., 2015) and ii) road capacity gains (Brownell, 2013, Fernandes and Nunes, 2010, Friedrich, 2015; Tientrakool, Ho, & Maxemchuk, 2011). The following figure contains the expected benefits of the Autonomous Vehicles (AVs) in smart cities Chehri et al., (2018).

Figure 1: Expected benefits of AVs (source: “MOBILITY NOW: How Autonomous Vehicles Can Help Pave the Way for Smarter Cities”, Aptive.com)

1.2. Best practices of the autonomous/automated vehicles across Europe

1.2.1 SPROUT Project - The case of Padua

As one pilot in the SPROUT project, the city of Padua implemented the Next System[1] (Massetto et al., 2020; Massetto et al., 2022). The Next System is an electric and modular mobility system based on vehicles capable of coupling and uncoupling, even on the move, to modulate the transport capacity with real-time demand.

Figure 2: The NEXT system: modular pod for passengers and cargo hitching

The main features of this disruptive transportation system are:

- Self-driving electric pods
- Modularity: pods can join and detach in motion
- Cargo Hitching: pods can carry both passengers and goods
- Real-time allocation: pods are combined according to current flows considering passengers/goods destination by a fleet management system, using a minimum number of pods/minimizing total travel distance

[1] https://www.next-future-mobility.com/

Two types of trials were deployed: real-life testing to assess the technical performance of the transport system in a selected urban area and virtual reality simulation to assess the financial and socio-economic feasibility of cargo hitching service and user acceptance. Operational parameters and data from real-life trials were used to simulate the results in a wider area where the proposed transport option is supposed to be implemented (Padua's Fair/Autobus station route). The results from the pilot implementation showed that the goals of the pilot were reached, achieving a reduction in fuel consumption of 3%, a reduction of CO_2 emissions of 4% and an improvement of air pollution (environmental quality) of 9% compared to the city's situation before the pilot implementation. When it comes to the financial dimension, the pilot concluded that the low operating costs of the pod can equilibrate the high investment costs of the mobility solution (Massetto et al., 2020; Massetto et al., 2022).

1.2.2 The AutoMATE Projects Group

Beyond the work carried out in the SPROUT project, supported by the European Commission's Horizon Results Booster[2] programme (HRB), the H2020-projects SHOW[3], AVENUE[4], HARMONY[5], SPROUT, FRONTIER[6], and PASCAL[7] join forces in a Project Group called AutoMATE based on commonalities between their work in the field of Automated and Integrated Transport. HRB aims to bring a continual stream of innovation to the market and maximise the impact of public funded research within the EU.

AutoMATE objectives and results aim at responding to the EU programme "SOCIETAL CHALLENGES - Smart, Green and Integrated Transport", and more specifically, to:

- Deploy, test and evaluate automated shared mobility through large-scale demonstration in urban environment in order to understand the potential of the future driven by automation, electrification, cooperativeness, and inclusiveness (SHOW).
- Create the ultimate integrated network and traffic management systems, that will favour driverless automation, seamless transfer among different modes of transport, better collaboration among different stakeholders, reduction of accidents and transport emissions, in this way contributing to better standard of living to Europe's citizens (FRONTIER).
- Validate the advantages that autonomous vehicles will offer to public transportation, linked with new innovative passenger service and guaranteeing road and passenger safety. It also aims to identify the issues, barriers, societal changes and economic consequences of the introduction of autonomous vehicles in the public transportation services' offer (AVENUE).
- Provide a new city-led innovative and data driven policy response to address the impacts of the emerging mobility patterns, digitally enabled operating & business models, and transport users' needs. (SPROUT).

[2] https://www.horizonresultsbooster.eu/
[3] https://show-project.eu/
[4] https://h2020-avenue.eu/
[5] https://harmony-h2020.eu/
[6] https://www.frontier-project.eu/
[7] https://www.pascal-project.eu/

- Enable metropolitan area authorities to lead a sustainable transition to a low-carbon new mobility era (Harmony).
- Improve understanding of the implications of the introduction of connected and automated vehicles (CAVs) into society (PASCAL).

The following table collects the projects that currently are part of the AutoMATE group. Apart from the description of each project, the table contains the most significant differences which constitute the uniqueness of each project and their contribution to the research of autonomous/automated vehicles.

Table 1: AutoMATE projects group (source HRB, 2021)

Project	Description	Uniqueness
SHOW	During this project, 70 Connected and Autonomous Vehicles (CCAV) were implemented in 15 European cities for a 1 to 1.5 year to promote DRT, MaaS and LaaS models.	• Variety of vehicles with speed: 18-50 km/hr • Operation under all weather conditions • Synergy of many providers under same operator • Combination of passenger and freight transport business models by one vehicle
FRONTIER	For this project, a collaborative project with team members from different fields (transport engineering, business intelligence, social analysis, computer science, machine learning solutions etc.). During the project, different solutions were developed to build a holistic, optimized traffic management network to integrate AVs.	• Traffic Management of AVs • Data-driven decision tool to prevent problems • Communication with users to do suggestions • Organizational, Business and Arbitration Models for multi-stakeholder Partnerships • Data fusion and data analysis applications for dynamic traffic management • Simulation of cooperative AV schemes • Data analysis for future multimodality
SPROUT	This project aims to provide a new city-led innovative and data driven policy response to address the impacts of the emerging mobility patterns, digitally enabled operating & business models, and transport users' needs. Amongst the different pilots, Padua implemented an Autonomous and Automated vehicle.	• Combination of freight and passenger transport in the same vehicle • Dedicated infrastructure for the AV • Standard route and time schedule • SUMP recommendations to support the implementation of AVs
PAsCAL	This project aims to improve the public acceptance for Connected and Autonomous Vehicles (CAV) by identifying critical problems to five pilots in Europe.	• Use of shared CAVs • Factors that affect public acceptance • Challenges and potential of using CAVs for vulnerable users
HARMONY	The scope of the project is the development of a model (Model Suite) which will harmonize the spatial and multimodal transport planning models. The outcome of this project will be the dynamic change of the urban transportation to have the optimal system. The Model Suite was implemented in four pilots.	• Development of integrated, software-agnostic, and multiscale model system • Can implement combined passenger and freight data • The modelling is conducted both in Strategic, Tactical and Operational levels • Recommendations to update SUMPs and roadmaps

1.2.3 SPACE project

Shared Personalised Automated Connected vEhicles (SPACE) project

The Shared Personalised Automated Connected vEhicles (SPACE) project aimed to place public transport at the centre of the automated vehicles revolution and help build a combined transport ecosystem. The project ran from March 2018 until September 2021 (UITP, 2018). Different pilots with automated road transport systems were implemented and assessed and the two major outcomes of the most pilots were that: i) a significantly low number of accidents/incidents was reported and ii) after the use of the AV, the general perception of the users is good and people were satisfied and felt safe. The use of AV fleets for public (shared) transport can play a big role and support cities' improvement regarding sustainability and green goals. The SPACE project was a consortium of EU partners (cities) that have implemented mobility solutions with AVs and assessed the acceptance and the possible dangers in the pilots. The results of these pilots were determined interesting to be included in this brief since they are the first lessons learnt and users' perception of the use of an AV for public transport. Specific unique cases were selected and to be presented below:

In the Netherlands and specifically in Capelle aan den Ijssel (**Park Shuttle System**), the autonomous vehicle **2getthere** covered a 1.8km trip (with 5 stops) based on the current demand and the results from about 8M people showed a reliability of 99.7% and people's satisfaction of 9/10. In the case of Belgium, an AV service (**Autonomous shuttle service Brussels Health Campus**) was launched in 2019 in Jette to cover a predefined route following a specific schedule and the score of people's satisfaction was found to be 8/10. Moreover, the autonomous on-demand service (**First On-demand service in Europe**) that took place in Trondheim of Norway should be mentioned. The specific service did not operate on a fixed route, but the paths were defined by the demand of the users to specific city stations (20). The results showed a good operation since no operational issue occurred. In 2018, the **S3 Shared Shuttle Services** started in Gothenburg of Sweden and provides both a first/last-mile parking shuttle and a shuttle route with specific stations and the results showed customers evaluated it with 9/10. In the context of this project, a circular route was installed in the city centre of Trikala for passenger transportation (**CityMobil2**). People using a wheelchair could also use the vehicle. During the implementation, about 12k users used the service and did about 3.5k kilometres. Problems were detected during the operation of the vehicle under high rain conditions. Customer satisfaction was rated almost 4.5/5.0. Generally, no serious accidents or incidents were reported during the different pilots. It should be mentioned that one important incident happened during the operation of the service when the vehicle left its track and climbed the pavement.

1.2.4 Other best cases

The study by Boersma et al., (2021) present the results of the implementation of AVs in Public Transport. Until 2019, 118 different pilots were implemented across Europe (among 18 countries). The innovative mobility solution was the installation of AVs, smaller in size and slower in speed to facilitate connections such as universities, shopping areas, airport, etc. The implementation showed that only 1/3 of the pilots had detailed documentation and 8.5% of the documentation was done based on research. In the case of Appelscha, an AV was installed on a bike lane outside the boundaries of the city with a maximum speed of 15 km/h. The case showed that the pilot was implemented successfully with very few changes to the infrastructure (warning signs, yellow line on lane etc.). When it comes to the case of Wageningen, two automated vehicles with instruments such as radars, computers and cameras were implemented. This pilot mainly pointed out some challenges; specifically, the legal framework of the implementation had to be changed in order to include AVs by adding exceptions to the Netherlands Vehicle Authority (RDW). The third case concerns an automated bus implemented outside Rotterdam which is already operating for 10 years. The pod has a maximum speed of 32 km/hour and operates a trip from a metro station to a park. The successful implementation is validated by regular operation of the pods without interruptions (infrastructure was suitable) which opened the way to move to the next generation AVs which will be even smarter and will also be autonomous (with remote control).

1.3. Challenges and lessons learnt from pilots' implementation

The AutoMATE Projects Group identified the following challenges towards the AVs implementation. The challenges can be characterized either scientific/technological or industrial. From the SPROUT project, challenges regarding legislation were also crucial even to allow the whole project, for this reason, a new group was introduced: the Administrative and Legislative Challenges.

Scientific and Technological Challenges

- Advances in sensorial systems, communication technologies and especially to the interfaces between AVs and non-equipped traffic participants (through IoT, mobile networks, intelligent map services, etc.), AI-based situational awareness, prediction, and, finally actuation as well as optimum PDI support are not mature yet to support the required extended Operational Design Domains (ODD) that is needed for the penetration of CCAM (also working a safety and user acceptance prerequisite).
- Business models are not clarified and validated – CCAM would genuinely result in more vehicles unless it is combined with shared mobility business models.
- Awareness & readiness: Future passengers are yet skeptical and hesitating to use; Operators and Cities in some cases neither. Early involvement of all participating stakeholders through co-creation approaches needs to be applied. Moreover, understanding the new functionalities and their limitations as well as driver behavior and road users' attitude patterns toward transport automation is also required.
- Financial challenges: 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 unsecured financing beyond the next decade. However, long-term financial planning and commitment to public transport are vital for the sector.

Industrial Challenges

- Lack of compatibility with major industrial, traffic management, mobility and infrastructure standards; lack of a standardized way the definition of Operational Design Domains (ODDs) for CAVs, as these require data from multiple sources. The effect of this challenge is a lack of adoption of innovative technology solutions.
- Lack of interoperable solutions and data-sharing protocols for the industrial, traffic management, mobility and infrastructure sectors. This hampers the deployment of holistic response plans for resolving inefficiencies on the network, has an unmanaged impact on the operations of some stakeholders due to decisions taken by others (i.e. the impact of congestion on the reliability of public transport) and prevents the fulfilment of sustainable mobility practices. This can also generate aggregation of risks (i.e., when CAVs from different providers are scattered in the network).

Administrative & Legislative Challenges

- Safety and security risks have restricted the urban use of AVs to dedicated lanes and low speeds. This strongly diminished their usefulness and efficiency as in most city environments there is a lack of space and a high cost to keep/build such dedicated lanes. This also challenges user acceptance, as the current AV speed is barely faster than walking, it is for most people, not an attractive solution.
- When creating a dedicated lane, public space relocation is required. It demands careful stakeholder management. In general, it is advised to involve relevant stakeholders as soon as possible in the process of implementing this type of innovative solution, in an active role. This allows also to initiation of strategic alliances between stakeholders with different needs, which also increases the viability of the business model.
- Current legislation doesn't allow a total driverless scenario. Regulations should evolve into an adequate framework to allow for the future autonomous driving on public roads. Trials and pilots can be seen as a first step towards the implementation of autonomous vehicles.
- Long administrative procedures and lack of coordination between different public offices or departments.
- Sometimes, municipalities lack of enough know-how regarding freight issues and have no specific procurement procedures for innovative mobility solutions.
- When the vehicle technology implies platooning, the coupling systems require well maintained roads and regular elevation profiles.

2. The success factors for the autonomous/ automated vehicles adoption

The European Green Deal includes a target to reduce transport-related greenhouse gas emissions by 90% by 2050. The EC adopted a comprehensive strategy to meet this target and ensure that the EU transport sector is fit for a clean, digital and modern economy. Objectives include:

- increasing the uptake of zero-emission vehicles
- making sustainable alternative solutions available to the public & businesses
- supporting digitalisation & automation
- improving connectivity & access.

The EC's Sustainable and Smart Mobility Strategy drives cities towards smartness and innovation. This section catches the success factors for the adoption of autonomous/automated vehicles through i) a literature review and ii) the outcomes of SPROUT and related projects.

2.1. Literature review

The successful adoption of AVs is important to achieve this sustainable transition in urban mobility and has to do with the legal framework, the infrastructure, the data availability and the different stakeholder (Berrada et al., 2020). Three categories of factors (Alawadhi et al., 2020; Mushtaq et al., 2018) were found to be the most important to support the adoption of AVs: i) **infrastructure & technology**, ii) **legislation** and iii) **user perception**. Technology describes the capabilities of the passenger and freight fleet within the city in terms of sensors and automation in order to provide data and ensure the safety of the network. Infrastructure on the other hand can be either physical or not; in other words, it describes the physical infrastructure needed to support AVs (e.g., devices on road to collect data) and also has to do with the infrastructure that the city has to collect, store and process the available data. Then, it is important to consider the legislation which includes the political framework dedicated to AVs in order to allow and support their implementation but also strengthen privacy and security issues. Finally, user perception is one of the most important aspects to achieve successful adoption. This category has to do with the cost of the trip, the trust of users to the new mode and some marketing issues. The study by Berrada et al., (2020) and Othman, (2021) related user acceptance to many factors regarding the user (sociodemographic, ownership of alternative modes, number and habits of trips, willingness to use AV and experience with autonomous modes). Indicatively, young and educated people were more positive to use Avs, while the reported accidents discourage users to try.

Recently, the PAsCAL project[8] published the Connected and Autonomous Vehicle 360° Acceptance Map (PAsCAL, 2021). Conclusions from this report are based on a large survey among more than 5000 participants. The number of participants and their country of origin was defined by a panel company to be representative for the survey and was supported by the European Blind Union. Socio-demographics, visual impairment, mobility behaviours and motivations were descriptively analysed, with an additional focus on the geographical location of residence of participants, aiming to understand Connected and Autonomous Vehicles acceptance. The analysis allows to extract useful conclusions regarding the factors that affect user perception and acceptance of this mobility solution.

- From the perspective of **demographics**, it was found a clear relationship between age and the intention to use CAVs, with older participants having lower intentions.
- A **gender** variation was also found for intention to use, with men providing higher mean ratings than women on average.
- **Education** played a role in the sense that university-educated participants were more willing to use CAVs.
- When comparing the attitudes of participants with **visual** impairments to sighted participants, results showed that visually impaired citizens seem to be more optimistic towards CAVs, with a higher intention to use across almost all age groups, and even when they don't use public transport normally.
- Intention to use a CAV was the lowest for participants who did not **own a vehicle** and did not use public transport. On the other hand, motorized participants reported expecting CAVs to be less efficient in terms of time spent on the road and speed of travel overall. Usage of mobility services such as car sharing, or ride-hailing also went together with a higher intention to use.
- Differences in acceptance are not large when considering **owned vs shared** CAVs, so CAVs do have the opportunity to enable a modal shift from privately owned vehicles to shared modes of transport.
- In terms of **geography**, there was a relatively large variability in almost all expected consequence factors, and intention to use. Central European countries seemed to be the least receptive to CAV technology today. On the other hand, southern and eastern European countries seemed to be more open to adopting private CAVs.

PAsCAL results confirm that the case of acceptance and **user perception** of autonomous vehicles is a multi-faceted issue that requires managing many demands from a large variety of stakeholders and individuals from different socio-demographic strata (Berrada et al., 2020). Important conclusions were drawn from the study of Manfreda et al., (2021) where they stated that the user perception of their personal and social benefits from the AV strengthens their adoption and also, the safety perception can outweigh technological and legislation limitations. AVs also face an issue with ethical dilemmas such as the trolley paradox (Othman, 2021). The ethical problem has to do with the "optimized" handling of a crash situation where the vehicle will do the choice with less impact such as a fatal accident. However, the algorithmic way of deciding means that even the life of a person is translated into a value that the model has to

[8] https://www.pascal-project.eu/

optimize. The same study pointed to human fear of these new autonomous modes as one of the most important limitations towards a successful adoption.

A more general but also an important factor that affects user acceptance is the fear of users losing their jobs due to the adoption of automation (Ivanov et al., 2020). The transport service sector over the next two decades is expected to face two distinct transition periods. In the first decade, a growing shortage of drivers will have to be addressed. Afterwards, when vehicles with a higher level of automation are deployed, a reduction of traditional driver jobs, combined with requirements for re- and up-skilling towards other employments, including mobility operators, will be the central topic (Ecorys, 2020). In 2017, Ahern et al. studied the evolution of training requirements (in the field of transportation) due to technological development and mapped future training requirements and scenarios. The analysis showed that the job is going to shift thus the training requirements will change. The SKILLFUL project[9] assessed future requirements for skills and jobs across transport modes and systems, including automation, and proposed future training curricula and courses for the transport sector. It is of big importance that people should be edified (informed and guided) about the evolution of the job and training requirements to feel confident about their future, and the potential for autonomous/automated mobility solutions to lead to job creation and job growth remains strong[10].

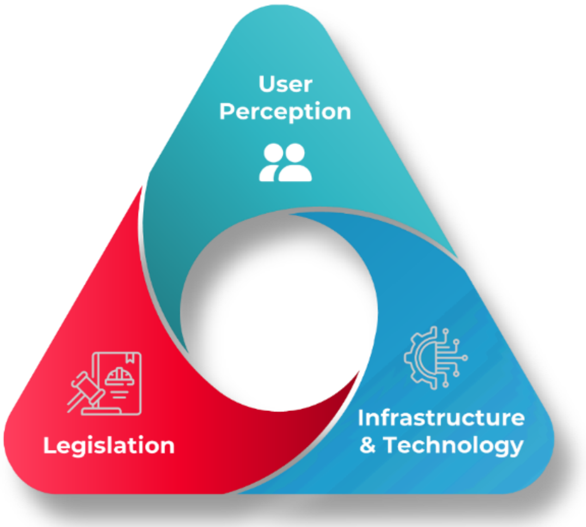

Figure 3: The factor categories that support the AV adoption (source: self-created)

[9] https://skillfulproject.eu/

[10] HORIZON-CL5-2023-D6-01-05: CCAM effects on jobs and education, plans for skills that match the CCAM development, and prerequisites for employment growth (CCAM Partnership)

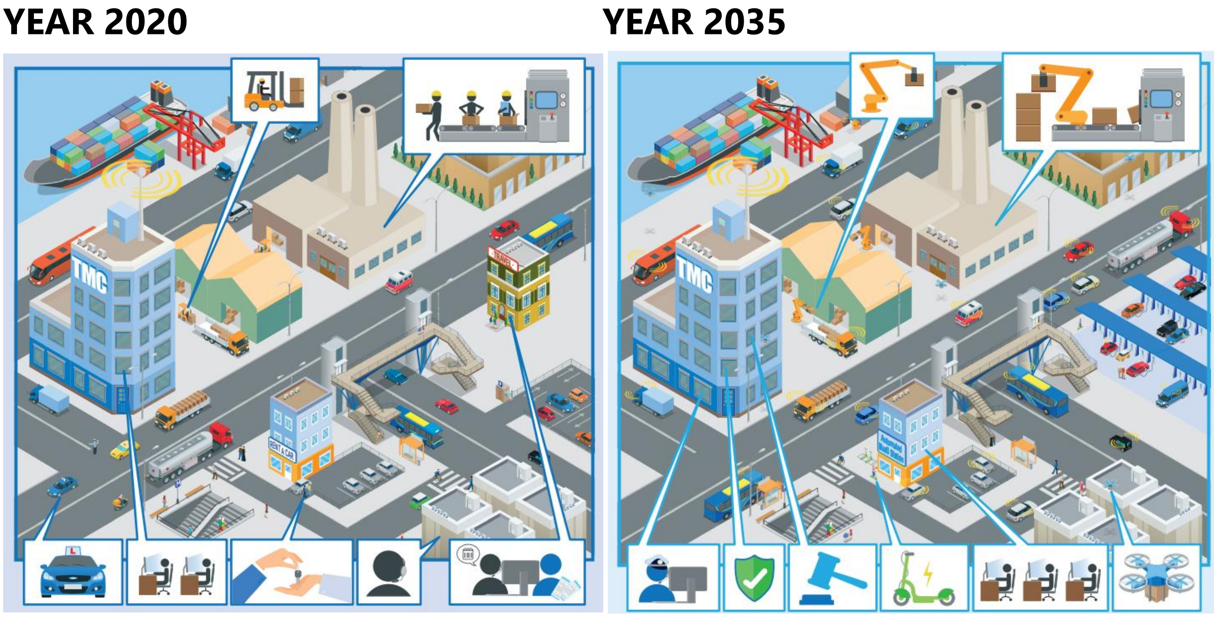

Figure 4: The job shifts from 2020 to 2035 in the road sector (source: https://skillfulproject.eu)

2.2. SPROUT outcomes

The real-life implementation in Padua highlighted specific success factors that supported the adaption of the NEXT pod. Regarding self-driving autonomous/automated pod determining routes based on the live demand (no fixed routes), users should be able to use mobile phone apps to use them. Thus, the use of mobile apps must be accessible and inclusive to help users (especially elder, vulnerable users and impaired vision users (Papí et al., 2021)). In the Padua case, volunteers and elderly people were involved in the UI/UX development of the application (Massetto et al., 2020).

Recently, the use of AVs is increased, since they can improve the sustainability and the safety of the (urban) mobility system. These success factors were first identified by the literature review and then validated and enriched by the outcomes of SPROUT in the WP devoted to determining the impacts of emerging urban mobility environments. The following table contains these factors. The data is split into two clusters based on their source: factors (KPIs) from the SPROUT project and factors from literature review.

From the legislation angle, the policy response is the consequence of a policy measure to the urban mobility system; its role is to help the city overcome their problem/limitations. During the implementation of a new mobility solution, it is usual that problems and situations occur and either delay or block the whole procedure. At that point, it is important to respond quickly with specific policy measures in order to overcome the problems. At the same time, automated/autonomous mobility solutions were recently introduced to specific European cities. Therefore, since all the previous years, the urban mobility system of the cities was running under the same framework, probably, similar problems would occur during the introduction of the same mobility solution in different cities. For this reason, the formulation and the application of a policy package have value for other cities since it will prevent possible problems which will occur directly or indirectly.

Table 2: The important categories and factors that help cities to adopt AVs

Source	User Perception	Infrastructure & Technology	Legislation
SPROUT project	• User acceptance • Accessible UI/UX • Inclusive UI/UX	• Safety • Physical infrastructure (e.g. dedicated road lanes and road maintenance)	• Regulation for AVs • Regulation for combined transportation (passenger & freight) • Political commitment
Literature review	• Cost of use (AVs) • Trust the AVs • Sociodemographic of user (e.g. age) • Willingness to use AVs • Previous experience with AVs • Marketing of the AVs • Edification of public for future jobs	• Vehicle technology • Ethics • Communication systems • Technology of roads and traffic signs • Available Infrastructure • Data servers • Data-driven mobility models • Interoperability standards	• Privacy • Security • Cyber-security

In the framework of the SPROUT project, the city of Padua selected specific alternative responses (or policy measures) which constitute a policy package; the role of this package was to support the implementation of the mobility solution. The policy measures applied in Padua aimed to support the implementation of an innovative mode by setting appropriate procurement procedures. Also, for the problems of regulations, except for procurement, a new department dedicated to freight logistics and local public transport was founded. Moreover, policy measures to encourage users to use the NEXT system were applied.

- **PM1:** Integration of NEXT with Local Public Transport and development of modal shift
- **PM2:** Development of innovative solutions as support for logistics operators
- **PM3:** New function/office dedicated to the development and management of freight logistics and Local Public Transport
- **PM4:** Set-up of specific procurement procedures for innovative mobility solution

Apart from the applied policy measure, the study of Herrera et al., 2022 assessed the factors that affect the transferability of the Padua's Use Case (Self-driving pods). The term of transferability refers to a process of verifying the chances of a successful implementation of a measure from previous experience to the adopting city at operational or implementation level. The transferability assessment for the case of Padua showed that the regulations/legislation for autonomous vehicles of the target city/country was the most significant characteristic that should be considered.

3. Suggestion and relations with EU guideline documents regarding autonomous/ automated vehicles

3.1. Suggestions to guide the successful implementation of an autonomous/automated vehicles solution

During the last years, in the context of moving to sustainability, cities are interested in implementing innovative mobility solutions, such as autonomous/automated vehicles in the context of achieving climate neutrality. However, neither cities (legislation) nor people (user acceptance) are yet not ready to fully adopt this innovation. Knowledge from pilots with AVs together with desktop research, highlighted specific activities which cities should do prior to support the AV implementation. The whole analysis showed that there are four important actions:

1. **Acknowledge the autonomous/automated vehicles** as new modes of passenger and freight transport.
2. **Review the regulatory framework** at the different levels (city, region and country) and include:
   - Regulations for autonomous/automated vehicles,
   - Regulations for combined passenger and freight transportation.
3. **Create a dedicated task force** team of people to support mobility projects with new modes of transport.
4. **Strengthen people's awareness** and trust regarding AVs:
   - Involve end-users in the planning and testing processes, including vulnerable groups,
   - Marketing campaigns.

3.2. Relations with relevant documents and guides

The European Commission has set different objectives (climate, environment, society, digitalization, etc.) for the cities in order to confront the climate crisis taking place on Earth. In the context of these objectives, and specifically in the mobility sector, cities and industry tend to become smarter and more innovative by building new infrastructure and implementing new mobility solutions. During the last few years, the technological development resulted in a big increase in the autonomous/automated vehicles market. In the H2020 Framework Programme, the "Smart, green and integrated transport" societal challenge aimed to boost the competitiveness of European transport industries and achieve a European transport system that is resource-efficient, climate-and-environmentally-friendly, safe and seamless for the benefit of all citizens, the economy and society. Autonomous/automated transport was considered in it as one of the means to fulfil its objectives. Horizon 2020 has been replaced by the new Programme, Horizon Europe, which still considers this type of transport in Cluster 5: Climate, Energy and Mobility, specifically in the Destination devoted to Safe, Resilient Transport and Smart Mobility services for passengers and goods.

Additionally, the European Commission promotes different initiatives to support cities in taking the transition in urban mobility.

European Partnership on Connected, Cooperative and Automated Mobility (CCAM)

The Connected, Cooperative and Automated Mobility (CCAM)[11] partnership's vision is to ensure European leadership in safe and sustainable road transport through automation. The four main goals are:

1) increase safety in road transport;
2) reduce negative impacts of road transport on the environment;
3) ensure leadership through targeted knowledge and capacity building;
4) strengthen the competitiveness of European industries.

Advancing CCAM is a multi-stakeholder's effort, involving public and private actors across industries and value chains. CCAM activities are articulated around 7 interlinked clusters. The findings of this report were aligned with the aforementioned clusters and are included in the following figure.

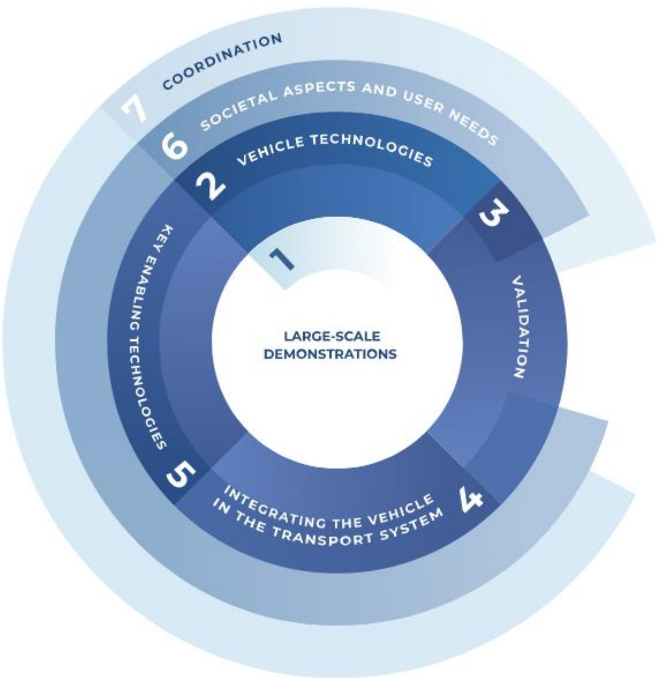

Figure 5. The 7 Clusters structure the activities of the CCAM Partnership (from [https://www.ccam.eu/our-actions/clusters)](https://www.ccam.eu/our-actions/clusters)

[11] https://www.ccam.eu/

The Strategic Research and Innovation Agenda (SRIA)[12] is a comprehensive roadmap for implementing the CCAM Partnership and its objectives. It provides a flexible background for identifying and defining call topics for research and innovation activities to be included in the Horizon Europe Work Programmes. It also serves as a basis to develop shared activities with national programmes and other Horizon Europe Partnerships.

The New EU Urban Mobility Framework

The new European Urban Mobility Framework is part of the wider "Efficient and Green Mobility Package". Released on December 2021, it aims to make urban mobility more sustainable, smart, and healthy. *(European Commission, 2021)*

The key conclusion of this EU document regarding autonomous/automated vehicles are the following:

- Connected and automated mobility will play a key role in the transition to the city's climate-neutral future.
- Automated deliveries and drones should be used as alternative solutions for inland deliveries.
- The increment of autonomous/automated public transport will potentially put the job of the drivers at high risk.
- EU funding for research and innovative activities usually supports the implementation of connected cooperative automated mobility (CCAM).
- EU Commission will invest in urban mobility innovation (through Horizon programmes), focusing on PT, active transport to support AVs and their connection to the local charging system.

Roadmap towards innovative transport solutions for the EIT Urban Mobility

(Brand et al., 2021)

EIT Urban Mobility is an initiative of the European Institute of Innovation and Technology (EIT), co-funded by the European Union. The roadmap is a response to EIT Urban Mobility challenges and should be perceived as a strategic pathway towards the deployment of effective innovative solutions, agile embracement of new services and technologies, and encouragement of creativity in City Club member cities. The foundation of its development lays in the urge to shape the future of the EIT Urban Mobility programme and its five components: City Club, Academy, Innovation, Business Creation and Factory. EIT Urban Mobility offers an excellent framework to support the deployment of sustainable and efficient transport solutions and to promote the decarbonisation of urban transport systems. This guiding document will forge the framework for long-lasting partnerships between public and private sectors and directs efforts towards uptake of innovative transport solutions across the EU. This roadmap's

[12] https://www.ccam.eu/our-actions/sria/

primary target audiences are EIT Urban Mobility, cities (City Club members) but also the private sector and, to a lesser degree, research organisations. As an overarching ambition, this document aims to equip these partners with the necessary skills to undertake mutually beneficial Public-Private Partnership models that can deliver on city innovation agendas on the long term. It will align the purposes of public and private actors and answer to key questions like: What is my interest? What do I really want (e.g., to test, to deploy, to market, to profit)? How eager are actors to negotiate/ tailor their services? Is this the right solution to my city's objectives?

Other documents

(European Commission, 2019)

"Guidelines on the exemption procedure for the EU approval of automated vehicles". This document mainly aims to harmonize the different assessments of autonomous vehicles in different countries. Also aims to i) guide the manufacturers about the expected regulations, ii) harmonize the regulation of the AVs with relevant international and iii) help how to overcome the countries' legislations about AVs.

References

Alawadhi, M., Almazrouie, J., Kamil, M., & Khalil, K. A. 2020. A systematic literature review of the factors influencing the adoption of autonomous driving. International Journal of System Assurance Engineering and Management, 11(6), 1065–1082. https://doi.org/10.1007/s13198-020-00961-4

Anderson, J. M., Kalra, N., Stanley, K. D., Sorensen, P., Samaras, C., Oluwatola, O. A., Rand Corporation, & Rand Transportation, S. 2014. Autonomous vehicle technology: a guide for policymakers. RAND Corporation.

Berrada, J., Mouhoubi, I., & Christoforou, Z. 2020. Factors of successful implementation and diffusion of services based on autonomous vehicles: users' acceptance and operators' profitability. Research in Transportation Economics, 83, 100902. https://doi.org/https://doi.org/10.1016/j.retrec.2020.100902

Boersma, R., Zubin, I., Arem, B., Oort, N., Scheltes, A., & Rieck, F. 2021. From Pilot to Implementation: What are Potential Deployments with Automated Vehicles in Public Transport Based on Knowledge Gained from Practice?

Bösch, P. M., Becker, F., Becker, H., & Axhausen, K. W. 2018. Cost-based analysis of autonomous mobility services. Transport Policy, 64, 76–91. https://doi.org/https://doi.org/10.1016/j.tranpol.2017.09.005

Brand, R., Böhler-Baedeker, S., Rupprecht, S., Juliat, M., Saran, L., Saran, L., Ogunkundi, G., & Ayfantopoulou, G. 2021. Roadmap towards innovative transport solutions for the EIT Urban Mobility.

Brown A. and Gonder, J. and R. B. 2014. An Analysis of Possible Energy Impacts of Automated Vehicles. In S. Meyer Gereon and Beiker (Ed.), Road Vehicle Automation (pp. 137–153). Springer International Publishing. https://doi.org/10.1007/978-3-319-05990-7_13

BlueWeave Consulting. 2022. Europe Autonomous Cars Market, By Vehicle Autonomy (Semi-Autonomous Car and Fully Autonomous Car), By Vehicle Type (Internal Combustion Engine (ICE), Hybrid Electric Vehicle (HEV), and Battery Electric Vehicle (BEV)), By Application (Personal and Commercial), By Country (Germany, UK, France, Italy, Spain, and Rest of Europe), Trend Analysis, Competitive Market Share & Forecast, 2018-2028.

Burns, L. D. 2013. A vision of our transport future. Nature, 497(7448), 181–182. https://doi.org/10.1038/497181a

Chehri, A., & Mouftah, H. T. 2019. Autonomous vehicles in the sustainable cities, the beginning of a green adventure. Sustainable Cities and Society, 51, 101751. https://doi.org/https://doi.org/10.1016/j.scs.2019.101751

Chen, T. D., Kockelman, K. M., & Hanna, J. P. 2016. Operations of a shared, autonomous, electric vehicle fleet: Implications of vehicle & charging infrastructure decisions. Transportation Research Part A: Policy and Practice, 94, 243–254. https://doi.org/https://doi.org/10.1016/j.tra.2016.08.020

Ecorys 2020. Study on employment and social impacts of connected and automated driving (CAD) Final report. https://www.ecorys.com/sites/default/files/2021-03/CAD_Employment_Impacts_Main_Report.pdf

European Commission. 2019. Guidelines on the exemption procedure for the EU approval of automated vehicles. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0283

European Commission. 2021. The New EU Urban Mobility Framework. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0400&qid=1623311742827

Fagnant, D. J., & Kockelman, K. M. 2014. The travel and environmental implications of shared autonomous vehicles, using agent-based model scenarios. Transportation Research Part C: Emerging Technologies, 40, 1–13. https://doi.org/https://doi.org/10.1016/j.trc.2013.12.001

Fernandes, P., & Nunes, U. 2010. Platooning of autonomous vehicles with intervehicle communications in SUMO traffic simulator. 13th International IEEE Conference on Intelligent Transportation Systems, 1313–1318. https://doi.org/10.1109/ITSC.2010.5625277

Friedrich, B. 2015. Verkehrliche Wirkung autonomer Fahrzeuge. In J. C. and L. B. and W. H. Maurer Markus and Gerdes (Ed.), Autonomes Fahren: Technische, rechtliche und gesellschaftliche Aspekte (pp. 331–350). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-45854-9_16

Herrera Meek, D. & Meyer, M. 2022. D5.1: Validation of the pilot results' wider applicability. SPROUT project.

HRB D1.1 Portfolio of Research and Innovation Project Results of AutoMate (2021)

International Transport Forum. 2021. Micromobility, Equity and Sustainability. Summary and Conclusions.

Ivanov, S., Kuyumdzhiev, M., & Webster, C. 2020. Automation fears: Drivers and solutions. Technology in Society, 63, 101431. https://doi.org/https://doi.org/10.1016/j.techsoc.2020.101431

KPMG. 2018. Autonomous Vehicles Readiness Index: assessing countries openness and preparedness for autonomous vehicles.

Litman, T. 2022. Autonomous Vehicle Implementation Predictions: Implications for Transport. www.vtpi.org/avip.docx

Lutin, J., Kornhauser, A., & Lerner-Lam, E. 2013. The Revolutionary Development of Self-Driving Vehicles and Implications for the Transportation Engineering Profession. Ite Journal, 83, 28–32.

Manfreda, A., Ljubi, K., & Groznik, A. 2021. Autonomous vehicles in the smart city era: An empirical study of adoption factors important for millennials. International Journal of Information Management, 58, 102050. https://doi.org/https://doi.org/10.1016/j.ijinfomgt.2019.102050

Massetto, C., & Mazzarino, M. 2020. D4.4: Set-up report.: Padua pilot. SPROUT project.

Massetto, C., & Mazzarino, M., Ciccarelli G., Rubini L., Coin L. 2022. D4.5: Impact assessment and city-specific policy response: Padua pilot. SPROUT project.

Martinez, L., & Crist, P. 2015. Urban Mobility System Upgrade–How shared self-driving cars could change city traffic. International Transport Forum, Paris, 14, 24.

Meyer, J., Becker, H., Bösch, P. M., & Axhausen, K. W. 2017. Autonomous vehicles: The next jump in accessibilities? Research in Transportation Economics, 62, 80–91. https://doi.org/10.1016/j.retrec.2017.03.005

Mushtaq, A., Riaz, S., Mohd, H., & Saleh, A. 2018. Perception and technology adoption trends for autonomous vehicles: Educational case study. 2018 Advances in Science and Engineering Technology International Conferences (ASET), 1–5. https://doi.org/10.1109/ICASET.2018.8376923

National Highway Traffic Safety (NHTS). 2016. Administration Preliminary Statement of Policy Concerning Automated Vehicles. https://www.nhtsa.gov/staticfiles/rulemaking/pdf/Automated_Vehicles_Policy.pdf

Kockelman, K., Loftus-Otway, L., Stewart, D., Nichols, A., Wagner, W., Li, J., Boyles, S., Levin, M., & Liu, J. (2016). Best Practices Guidebook for Preparing Texas for Connected and Automated Vehicles.

Othman, K. 2021. Public acceptance and perception of autonomous vehicles: a comprehensive review. AI and Ethics, 1(3), 355–387. https://doi.org/10.1007/s43681-021-00041-8

Papí, J. F., Kühl, F. L., & Díaz-Guardamino, I. 2021. PAsCAL: D6.2 – Pilot Setup.

PAsCAL (2021). D3.2 – Connected and Autonomous Vehicle 360° Acceptance Map.

Sparrow, R., & Howard, M. 2020. Make way for the wealthy? Autonomous vehicles, markets in mobility, and social justice. Mobilities, 15(4), 514–526. https://doi.org/10.1080/17450101.2020.1739832

Tientrakool, P., Ho, Y.-C., & Maxemchuk, N. F. 2011. Highway Capacity Benefits from Using Vehicle-to-Vehicle Communication and Sensors for Collision Avoidance. 2011 IEEE Vehicular Technology Conference (VTC Fall), 1–5. https://doi.org/10.1109/VETECF.2011.6093130

UITP. 2018. Shared Personalised Automated Connected vEhicles (SPACE). https://space.uitp.org/initiatives

Wadud, Z., MacKenzie, D., & Leiby, P. 2016. Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles. Transportation Research Part A: Policy and Practice, 86, 1–18. https://doi.org/https://doi.org/10.1016/j.tra.2015.12.001

Zachariah, J., Gao, J., Kornhauser, A. L., & Mufti, T. 2014. Uncongested Mobility for All: A Proposal for an Area Wide Autonomous Taxi System in New Jersey.

Zhang, R., Spieser, K., Frazzoli, E., & Pavone, M. 2015. Models, algorithms, and evaluation for autonomous mobility-on-demand systems. 2015 American Control Conference (ACC), 2573–2587. https://doi.org/10.1109/ACC.2015.7171122