SHared automation Operating models for Worldwide adoption

SHOW

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D13.3: SHOW impact assessment on society

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Executive Summary

This deliverable reports the findings of the research conducted within SHOW on the societal impact of shared, connected and automated vehicles (CCAV). To investigate wider societal impacts of CCAV, which are currently still uncertain. This report combines insights stemming from a review of existing literature on the topic, the results of a modified Delphi study using a consensus method with an expert and stakeholder panel (n=78), and interviews conducted with pilot sites deploying CCAV in real-word environment, as well as external to SHOW experts from various European initiatives.

This study assesses both direct consequences of introducing CCAV – e.g., on accessibility and equity of public transport, user perceived safety, impact on job creation/destruction and need for re-skilling – as well as indirect effects – e.g., in terms of housing prices or urban planning. These impacts have been assessed within four scenarios related to different services and business models being deployed and tested across Europe in the SHOW project: Automated shuttle(s) for first/last mile, Door-to-door delivery of persons and goods, Mass transit AV services, and Shared Robotaxis.

The findings suggest that while CCAV technology holds great promise for improving accessibility to public transport, particularly through innovations such as shared robotaxi services, challenges remain. These challenges include issues of affordability and inclusivity, which need to be addressed to ensure widespread benefits.

In terms of employment, the shift towards automation in public transport presents both opportunities and challenges. While no significant workforce reductions are expected, except in the case of robotaxis, there will be a growing need for upskilling and reskilling of professionals, as well as the creation of new job roles. The pace of this transition will depend largely on technological advances and regulatory frameworks, underscoring the importance of proactive workforce planning to mitigate potential disruption and maximise opportunities.

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Other authors involved:	Ignacio Magallón (BAX)
Internal Reviewers:	Evy Rombaut (VUB) Delphine Grandsart (EPF) John McSweeney (UITP) Maria Gkemou (CERTH)
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Abbreviations List

Abbreviation	Definition
AV	Automated Vehicle
BM	Business Model
CCAV	Connected Cooperative Automated Vehicles
CCTV	Closed Circuit Television
IT	Information Technology
LaaS	Logistics as a Service
MaaS	Mobility as a Service
OEM	Original Equipment Manufacturer
PTA	Public Transport Authority
PTO	Public Transport Operator
SAE	Society of Automotive Engineers
SUMP	Sustainable Urban Mobility Plan
WP	Work Package

1 Introduction

1.1 Purpose and structure of the document

CCAV is developing rapidly, but there are still uncertainties about their impact on society. Over the past decade, major improvements in industry and research have increased the testing of automated vehicles on roads, even more so since 2023, when three U.S. cities allowed automated vehicles to operate on their streets, and numerous pilots have been running across Europe. However, the current stage of these pilots and operations are still not sufficient to assess the societal impact of CCAV.

This study, aiming at understanding the societal impacts of CCAV, is developed as part of the impact assessment within the SHOW project. SHOW aims to support the deployment of CCAV in public transport by testing in real-life urban environment in more than 20 cities across Europe.

The goal of this deliverable is to understand and assess the societal implications of CCAV (Connected, Cooperative, Automated Vehicle) in public transport both from a wide perspective and from the experience of the SHOW pilots.

This report focuses on the societal impact of CCAV by integrating in the findings from existing literature on this topic and from various European initiatives, combined with the results from a modified Delphi study and from expert interviews, conducted as part of SHOW. The main societal impacts addressed are accessibility to public transport, equity, housing prices, perceived safety, and impact on jobs.

The Delphi method, originally developed by Dalkey and Helmer of the RAND Corporation in the 1950s to forecast the effects of technology on warfare (International Post Corporation, 2022), has since been widely used across various fields such as health, education, management, and environmental science. For our study, we have employed a modified version of the traditional Delphi method. Instead of beginning with an open-ended questionnaire distributed to a panel of experts to solicit specific information, the modified Delphi technique as applied in our research begins with a predetermined set of items. These items may be derived from a range of sources, including relevant competency profiles, comprehensive literature reviews, and interviews with select content experts (Custer et al., 1999). This approach allows for engagement with experts and stakeholders involved in public transport in a structured consensus-building process to identify and assess the multiple impacts of CCAV deployment on different aspects of society, such as, in our case, accessibility and equity, user-perceived safety, impacts on house prices and land use, and impacts on jobs, including creation, destruction, and re-skilling.

The pilot site interviews within the SHOW project provide us with examples of the implementation of CCAV in a real-world environment. The direct experience and contact with passengers and value chain employees give us valuable insights into how these services affect the most immediate users. It is also an opportunity to validate the consensus of the Delphi responses.

Additionally, the impact on jobs is explored building on recently completed European projects such as Skillful[1] (SKILLFUL D5.4 et al., 2019), WeTransform[2] (Kremenovic et

[1] Skillful is a project funded by the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement number 723989, https://skillfulproject.eu/

[2] WeTransform is a project funded by the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement number 101006900, https://wetransform-project.eu/

al., 2022), and other studies carried out by the European Commission (Ecorys et al., 2021).

The different sections of the deliverable include section 2 with the literature review of the societal factors assessed. Section 3 the methodologies used, including the Delphi study and the interviews. Section 4 includes the results of the Delhi study while section 5 the insights from the pilot site interviews and section 6 the external interviews. Finally, section 7 explains the final conclusions.

1.2 Intended audience

The intended audience addressed is both internal and external to the consortium, and includes all stakeholders involved in CCAV development. Societal implications of CCAV are key for public authorities planning to include automation in public transport to assess the effect on their citizens and workers, as well as effects on public space.

1.3 Interrelations with other SHOW WPs and tasks

This task is internally interrelated with A13.5: *User experience, awareness and acceptance impact assessment* and with A13.6: *Overall impact assessment and cross pilot comparisons*, which compiles all the impact assessment, besides, the same scenarios have been used in both tasks. The interviews to the pilot sites, have been developed together and in coordination with WP2: *Business / operating models* and particularly *A2.3: Business / operating Models application in Pilot sites and their validation*.

2 Literature review

The societal impacts of CCAV have been researched and discussed in the literature. Some of these are direct impacts of CCAV, while others are more indirect outcomes resulting from the broader societal and urban changes induced by CCAV technologies.

2.1 Societal Impacts studied

2.1.1 Accessibility

Accessibility is defined by Cohen and Cavoli as “the relative ease with which individuals are able to gain access to the locations, goods and experiences that are important to them” (Cohen & Cavoli, 2019). This relates to the 15-minute city concept, originally proposed by Carlos Moreno in 2016 (Moreno et al., 2021). According to this concept, essential basic services should be accessible within 15 minutes by active mobility modes, a principle which has since been adapted to other time intervals and modes of transport, including public transport at region level, for example in the Ile-de-France Master plan, which aims to create coherent living basins within the "20-minute region” concept (Institut Paris Region, 2024).

Shared automated vehicles could improve accessibility, especially in peripheral areas, triggering further urban expansion. City centres could also be affected by a shift of parking to the periphery, and thus an increase in the density of economic activity in city centres (Milakis et al., 2017). In the long term, if the overall cost of moving is significantly reduced, this can lead to urban sprawl, with people moving further away from centres (Brown, 2014). Thus, the introduction of CCAV potentially not only has an impact on accessibility for people, but also on urban areas and urban planning.

2.1.2 Equity

Equity in transport has been approached from different angles and it still has different interpretations. For instance, Bruzzone et al. (Bruzzone et al., 2023) relates it to concepts such as justice, convergence, and fairness. In this deliverable, we have considered physical accessibility to the vehicles (i.e., boarding and alighting) (Whitmore, 2022), (Litman, 2024), social integration, and community cohesion aspects (Litman, 2024), whereby public transport is argued to be a catalyst for this development (Litman, 2024). Vehicle automation can have both positive and negative impacts on social equity, as it can bring social justice by enabling people with travel limitations, such as the elderly or persons with disabilities, to travel more easily (Harper et al., 2016), while it can also have negative effects, such as an induce of traffic demand of up to 14% from current non-drivers (Eby et al., 2016). To make sure that those communities that need more robust transportation options are benefited by introducing shared automated vehicles, policymakers must regularly solicit public input (Whitmore, 2023).

2.1.3 Housing prices

Gelauff et al. (Gelauff et al., 2017) show that the automation of public transport leads to a higher concentration of population in urban centres, while the automation of private cars leads to an increase in population in rural areas and suburbanisation. These changes in population distribution have a direct impact on housing prices, especially if they increase the density of the already most attractive places for people to live.

Still, housing prices can be affected by the type of services that automation can bring. The growth of automated vehicle-sharing services could reduce the need to build off-street parking, potentially increasing housing affordability (Milakis et al., 2017).

2.1.4 Actual and Perceived safety

A strong correlation is found between the perceived safety of automated vehicles and the intention to use them (Koul & Eydgahi, 2020). Also, road accidents involving AVs will affect the public perception and trust in using them (Zhang et al., 2024).

Several studies suggest that AVs could dramatically reduce the number of car injuries. For instance, recent studies from Waymo (Scanlon et al., 2022) in the U.S. claim a big increase of effectiveness and avoidance of 75% of collisions, leading to 93% reduction of serious injury risk. Still, one of the main barriers in achieving those safety goals, seems to be rather phycological and not technological (Shariff et al., 2017) suggesting that it is crucial to understand the recognition and the criticality of the factors affecting people's acceptance and, thus, AV adoption (Xu et al., 2018).

2.1.5 Impact on jobs

Research suggests that shared vehicle automation will lead to changes in the type jobs and skills required in the transport sector, including the disappearance of some jobs and the emergence of others. The number of typical driver jobs will be reduced, while an increase in the number of computer specialists is expected, as well as new high-skilled jobs requiring ICT competences, e.g. in manufacturing, maintenance and transport-related tasks. The skills required for driving a vehicle will also change as automation gains full control of the vehicle, e.g. requiring more supervision and selective skills (Raposo et al., 2018), (Ciuffo & Raposo, 2019).

Measures to mitigate the negative impact of AV services on employment include the reskilling and upskilling of current workers. The International Transport Forum (ITF) defines upskilling and reskilling as people's willingness to adopt new skills for their current (upskilling) or for a different (reskilling) job (ITF, 2023).

At the same time, it is worth noting that many European countries are experiencing a shortage of drivers in public transport that has escalated in recent years due to demographic changes, alterations in working conditions and the introduction of new technologies, and AVs could be a way to counterbalance the situation (ITF, 2023), (Okamoto, 2019).

The reviewed literature reveals that research has been conducted on the topic of societal impact of CCAVs, employing various methodologies. However, thus far, the overall impact of CCAV on society remains unclear, with studies often focusing on isolated aspects. Our study seeks to address this gap by integrating diverse methodologies and various perspectives in order to examine the broader societal implications of CCAV. To do so, it aims for a consensual answer by experts and stakeholders on different scenarios deploying automated services in public transport through a modified Delphi study, which can then be discussed and interpreted by representatives from real-life urban pilots.

The modified Delphi method is one of the most relevant methodologies to assess problems of ambiguity and uncertainty. This approach consists of a survey conducted in an anonymised way in several rounds with a group of experts that are invited to participate through emails or online questionnaires. The experts give their independent opinions about each survey item. After each round, a report with the results from the previous round is sent to the experts for the next round, so that they can modify their opinions in order to increase the collective agreement, taking into account the results of the previous round. This process is repeated until a consensus is reached, or after a previously set number of rounds, which usually depends on the size of the sample and the consensus. With a small sample, no more than one round may be needed; however, a minimum of two rounds are usually required to allow valuable feedback and revision. The number of rounds may be set and “sacrificed” taking into account the continuity and guarantee the outcome of the study (Landeta, 2006).

Giannarou et al. (Giannarou & Zervas, 2014) review various Delphi studies and compare methodologies and even if this method measures the consensus, there is no common practice regarding the statistical analysis of the results, with this approach varying from study to study (Landeta, 2006). Hence, there are studies that measure agreement through frequency distributions and others using standard deviation or the interquartile range. For the analysis presented in the current report, standard deviation is used as an accepted measure, and in order to reach a consensus, a standard deviation of less than 1.5 should be reached (Christie & Barela, 2005).

3 Methodological Approach

The societal impacts of CCAV have been researched and discussed in the literature. The first part of the task has been focused on desk research on the topic.

Preliminary insights on societal impact of CCAV, based on the said desk research, served as a basis for our study, which uses a combination of further methods (modified Delphi, pilot site representative interviews and expert interviews) to assess the identified societal impacts of CCAV and to provide local lessons learned, embedded in real-life demonstration, that could be generalised to other European cities. Figure 1 shows the Delphi process followed for this study.

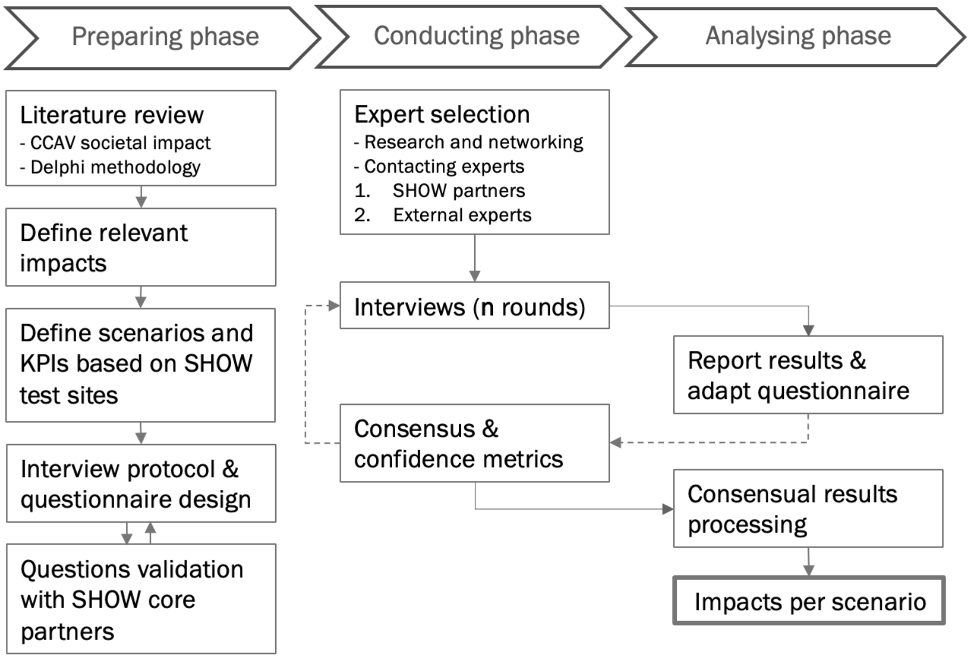


Figure 1: Delphi process in SHOW, based on Beiderbeck et al (Beiderbeck et al., 2021)**.**

The first part of the Delphi collected data from the participants, which were experts and stakeholders as shown in Figure 2, including Public Transport Operators (PTOs), city/region representatives, Original Equipment Manufacturers (OEMs), and research/academia (Figure 3). Some participants were SHOW partners, some were not (Figure 4).

Participants were asked to choose between the four different pre-selected future scenarios (Figure 5) as developed in SHOW D9.2, tested across Europe, with the hypotheses of the services described in Table 1.

Table 1: Scenarios tested in SHOW

Scenario 1 Automated shuttle(s) for first/last mile
This shared service acts as a feeder service to public transport for the first/last mile. In SHOW, these connections include hospital campuses, universities, school, and residential areas. The medium-low speed shuttles follow a fixed route to or from public transport stations with the possibility to implement on-demand stops or fixed stops. The service operates in parallel to high-capacity public transport. Depending on the area, the service operates on a fixed line with fixed stops or can serve as an on-demand service, where the user requests a pick-up at the

nearest stop. When in full operation, speeds of the shuttles could go up to 30-40 km/h, with an average of 20-25km/h inside cities. As a complement to the public transport network, this service would be priced comparably and integrated with the system both in the mapping and the payment.
SHOW sites: *Linköping, Gothenburg, Graz, Salzburg, Carinthia, Monheim, Trikala, Tampere*, *Turin*
Scenario 2 Door-to-door delivery of persons and goods
A shared, on-demand, point-to-point service with dynamic routing when or where demand is low, using automated shuttles. This service is detached from a fixed route or primary purpose (e.g. first/last mile). Passengers can be picked up and dropped off in locations of their choosing (DRT), though it may be possible that these points are fixed for efficiency purposes, and may require a short walk. Waiting times do not exceed 10 minutes, and walking time to the nearest pick up point does not exceed 5 minutes. While these shuttles would have the same speed as those in scenario 1, the nature of the service (not a fixed route) allows for faster average speeds, thus the service could operate at average speeds in cities of up to 30 km/h. Because of the additional flexibility of this service, its price is higher compared to the fixed route automated shuttles and public transport.
SHOW sites: *Les Mureaux (Ariane group private site, free service for users)*
Scenario 3 Mass transit AV services
This service is replacing existing PT (mostly bus) lines with a shared automated shuttle or bus. The route of the automated buses runs **between the city centre and points of interest for citizens**, and the bus runs on a fixed route with fixed stops. Passengers wait at the predefined bus stations and are informed for the bus arrival time via their mobile application, if available. The bus stations are also equipped with the bus schedule. The bus follows the fixed route and stops at each station where passengers are detected. The experience in the automated bus is comparable to current public transport with other/ conventional vehicles, with similar comfort and privacy levels. Flexibility is not so high considering the service runs on fixed schedules and routes. With improved efficiency, the frequency is high, with a bus every 4-6 minutes, and average speeds would be a bit higher than those of shuttles, reaching up to 40-45 km/h.
SHOW sites: *Monheim, Tampere*
Scenario 4 Shared Robotaxis
Robotaxis are a point-to-point shared service that operate like regular taxis. Journey reservation is on-demand and the user is picked up at their location. This service is available for private use and sequential sharing (sharing of the vehicle, not trips), and can be also booked in some cases via a mobile application. The service is not part of the public transport network and serves different areas (high and low demand, urban, suburban), often connecting dense urban city centers to residential areas or to any places of interest. The route is dynamic and not fixed, intermediate stops for picking up other passengers are possible if accepted by the passenger and depending the specific service policy. Total extra travel time should be no more than 10 minutes and average waiting time also around 10 minutes. The service is by nature flexible, as passengers are dropped off at their selected destination. Due to the flexible routing and small size of the vehicles compared to shuttles and buses, speeds are relatively high, and could go up to 80 km/h.

Considering the additional comfort, privacy, and flexibility factors, prices for such a service are expected to be significantly higher than automated shuttles and regular public transport services.
SHOW sites: *Graz, Trikala, Brno, Karlsruhe*

Participants to the Delphi survey were asked to rate the different impacts of each service on a scale from -100% to 100% to determine whether the implementation of a CCAV service decreases/worsens (depending on the questions) or increases/improves the current state, which is 0% and represents no impact. The questions included in the study are in Table 2.

Table 2: Questions of the modified Delphi

Number	**Impact**	**Question**	**Answer slider scale**
1	Public transport accessibility	How much do you expect Public Transport accessibility to change *(in terms of number of transport services in reach within a given time buffer)*	***-100%**: high decrease,* ***0%**: no effect,* ***100%**: high increase*
2	Public space consumption	How do you expect public space consumption to be affected?	***-100%**: less space used, meaning more space freed up and available,* ***0%**: no variation,* ***100%**: higher levels of space usage*
3	Public transport equity	How much do you expect Public Transport equity and inclusion to change? (regarding physical accessibility, social integration, cohesion, and equality)	***-100%**: high decrease,* ***0%**: no effect,* ***100%**: high increase*
4	Housing prices	How much do you expect housing prices in the area to vary?	***-100%**: high decrease,* ***0%**: no effect,* ***100%**: high increase*
5	Perceived safety	How much do you expect users' perceived safety in the area to vary?	***-100%**: high decrease,* ***0%**: no effect,* ***100%**: high increase*
6	Job creation / destruction	What direct effects do you expect to take place in terms of job creation/destruction?	***-100%**: high job decrease,* ***0%**: no effect,* ***100%**: high job increase*

Number	Impact	Question	Answer slider scale
7	Job modification / reskilling	What direct effects do you expect to take place in terms of job modification/re-skilling?	***-100%****: heavy job simplification,* ***0%****: no effect,* ***100%****: strong job re-skill increase*

The standard deviation (SD) of the answers was used to measure consensus among the participants, and to calculate standard deviation the values -100 to 100 were divided by 10 to match the literature examples scales. According to Christie & Barela a standard deviation smaller than 1,5 reaches consensus (Giannarou & Zervas, 2014).

In addition, when assessing each scenario, participants were asked to distinguish between three phases of implementation: from testing (phase 1) to full autonomy[3] (phase 3) with an evolving maturity of the technology, penetration rate, and regulatory framework as described below:

- **Phase 1** corresponds to a situation where the service is introduced for testing, to see if the route, the service, and the model are a good fit. This phase also serves to validate whether the innovative service meets the needs, expectations, and daily journeys of citizens. Vehicles and technology are at an early stage, travelling at low speeds and requiring a driver for safety and emergency reasons, as automation and infrastructure are not fully prepared. Penetration rate and technology maturity are still low. Effects on cities and public are expected to be low, however new needs in employment or infrastructure may be found. This phase serves as a baseline for comparison and corresponds to the SHOW pilot cases interviewed.

- **Phase 2** represents a higher penetration rate than phase 1, where the service has been tested and acceptance is clear, as evidenced by a higher number of users, clearly defined routes, and citizens' awareness of the service, both in terms of use and coexistence with the ordinary services. Accordingly, the infrastructure and vehicles both are characterised by a higher technology readiness, as is the automation of the service, allowing for less dedicated human control, although still needed.

- **Phase 3** represents the full deployment of automated services and a high penetration rate, through consolidation and even replication. The benefits are clear, and citizens massively use the new solutions and benefit from them. Similarly, infrastructure and vehicles are progressively upgraded to SAE level 4+ of automation, eliminating the need for on-board human support.

After completing the modified Delphi process, a workshop session was held on Monday, February 19, 2024. Using the Miro platform, Delphi participants and SHOW partners were invited to review the results of the Delphi, provide feedback, and discuss

[3] "Full autonomy" refers to SAE Level 5 of automation by the J3016 standard, that defines six levels of automation, from 0 to 5, source: SAE International (SAE, 2021).

the reasons of the findings. Participants would write down their thoughts and then open the discussion for each of the topics.

In parallel to the modified Delphi study, **interviews with the pilot sites** were conducted to verify the assumptions from the literature and the results from the Delphi study, and to unveil potential unique issues of their pilot sites. These interviews aimed to understand the needs of the sites in terms of employment and skills requirements, as well as the real-life experiences in the practical case of a test implementation as in SHOW (Phase 1).

The pilot sites were asked about:

1. **Job loss**: *Percentage of jobs that have a high probability of being replaced by computer automation within the next two decades*

    - How many job positions have been reduced in the last 5 years due to automation?
    - How many do you expect to reduce in the coming 10 years?

2. **Job creation**: *Number of jobs created by the implementation of computer automation, and other systems (sensors, cameras, etc.) used in autonomous vehicles within the next two decades*

    - How many new job positions have been created in the last 5 years due to automation?
    - How many new jobs do you expect to create in the coming 10 years?

3. **Public space**: *Has public space been affected by the implementation of autonomous shuttles? Sidewalks? Short-term vs long-term forecast?*
4. **Users**: H*as the implementation of the pilot affected the type of users? Increased/reduced (particular type) users? Affected accessibility?*
5. **Jobs**: *Others. What response did you experience from the workers and drivers? Are they willing to change activities? Are you providing benefits other than training to change?*

Table 3: Interviews with SHOW pilot satellite sites

Satellite sites		
Site (City, country)	**Interviewee**	**Type of organisation**
Brno, Czech Republic	Adam Skokan (CDV)	Research
Tampere, Finland	Mika Kulmala (Tampere)	City
Trikala, Greece	Elena Patatouka (e-Trikala)	Agency for city
Frankfurt, Germany	Sofia Pavlakis (RMS consult)	Consultancy for PTA

Table 4: Interviews with SHOW pilot Mega sites

Mega Site

Site (City, country)	Interviewee	Type of organisation
Karlsruhe, Germany	Katharina Karnahl (DLR)	Research
Carinthia, Austria	Petra Schoiswohl (Suraaa)	Research & consulting
Carabanchel, Spain	Sergio Fertnandez (EMT Madrid)	PTO
Linkoping, Sweden	Anna Anund (VTI)	Research
Gothenburg, Sweden	Cilli Sobiech (VTI)	Research
Les Mureaux, France	Nicolas Moral (Transdev)	PTO
Graz, Austria	Dominik Schallauer (Austria tech), Karl Lambauer (V2C2)	Research, consultancy
Monheim, Germany	Anja Holermueller (Bahnen Monheim)	PTO
Salzburg, Austria	Markus Karnutsch (Salzburg research)	Research

External expert interviews (n=4) were also conducted to gather further input and feedback and support the outcomes of the literature review, Delphi study and pilot interviews. These interviews were conducted online with experts in urban mobility and CCAV with long experience in CCAV testing and European projects. Interviews lasted about one hour each and covered the topics described in the literature review. In particular, experts were asked about their views regarding the impact of CCAV on society and employment, and were invited also to provide future recommendations.

4 Modified Delphi study

4.1 Results of the modified Delphi

For this study two rounds were required to reach consensus, with 78 participants in the first round and 40 participants in the second round.

The first part of the survey served to collect data from the participants, which consisted of experts and stakeholders as shown in Figure 2, including Public Transport Operators (PTOs), city/region representatives, Original Equipment Manufacturers (OEMs), and research/academia along with their years of experience (Figure 3). It is also denoted whether participants are SHOW partners or not (Figure 4). Participants were asked to choose between the four different pre-selected scenarios (Figure 5), that are described in table 1 of the methodology.

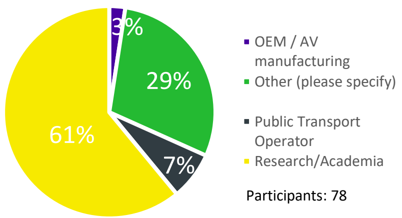


Figure 2: Sector

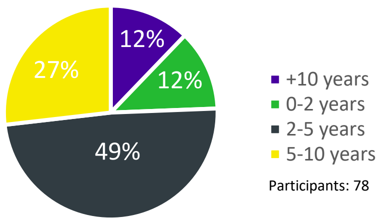


Figure 3: Years of experience in AV

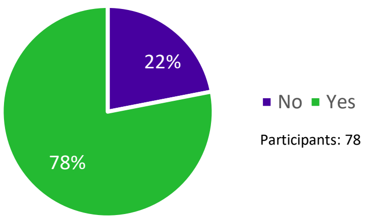


Figure 4: SHOW partner

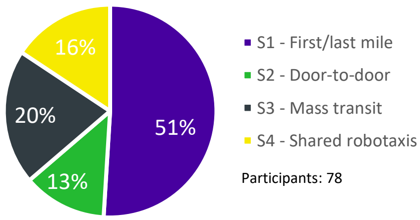


Figure 5: Scenario

Table 5 below shows the questions, the average responses, and the standard deviation for the two rounds, across each scenario and throughout the three (3) phases of implementation that they were asked to rate. In most cases where consensus was reached in the second round (SD<1,5), this is highlighted in bold.

Table 5: Results of the modified Delphi

	Scenario 1 Driverless shuttle for first/last mile				**Scenario 2** Door-to-door delivery of persons and goods				**Scenario 3** Mass transit AV services				**Scenario 4** Shared Robotaxis			
	Round 1		Round 2		Round 1		Round 2		Round 1		Round 2		Round 1		Round 2	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD
Public transport accessibility																
Phase 1	12,6	1,6	**6,4**	**0,7**	12,5	1,1	**6,7**	**0,5**	9,4	1,7	**8,5**	**0,8**	6,0	1,7	**2,9**	**0,5**
Phase 2	28,6	1,6	**20,9**	**0,8**	29,2	1,7	**16,7**	**0,5**	26,5	1,5	**18,6**	**1,3**	2,1	1,7	**4,3**	**1,4**
Phase 3	44,7	2,3	**36,1**	**1,3**	58,3	2,5	**26,7**	**1,0**	37,4	2,7	30,0	1,9	-2,9	3,6	0,0	3,3
Public space consumption																
Phase 1	3,8	1,3	**1,8**	**0,4**	4,0	1,2	**2,5**	**0,5**	-7,7	1,6	**-1,8**	**0,9**	2,2	1,0	**2,9**	**0,5**
Phase 2	8,3	2,2	**4,0**	**0,9**	1,8	2,3	**2,5**	**0,5**	-2,1	2,2	**-1,0**	**0,7**	3,6	2,0	**5,7**	**1,6**
Phase 3	13,4	3,6	**5,7**	**1,4**	-4,2	3,7	**0,0**	**0,8**	4,4	3,6	**0,0**	**1,1**	-7,3	3,5	-5,7	3,7
Public transport equity																
Phase 1	7,8	1,7	**5,7**	**0,7**	9,2	1,2	**6,7**	**0,5**	8,1	1,4	**6,7**	**0,5**	1,8	1,2	**5,0**	**0,9**
Phase 2	23,5	1,6	**16,8**	**0,9**	19,2	2,8	**10,0**	**1,1**	16,8	1,6	**15,7**	**1,2**	-2,1	2,5	**7,5**	**1,2**
Phase 3	35,5	2,0	**28,3**	**1,3**	36,7	4,1	13,3	1,9	28,9	2,7	26,4	2,0	-3,6	5,0	11,3	3,2
Housing prices																
Phase 1	2,8	1,2	**1,3**	**0,3**	3,3	0,5	**0,0**	**0,0**	4,2	1,4	**2,9**	**0,6**	1,7	0,4	**2,0**	**0,4**
Phase 2	9,2	1,0	**7,1**	**0,7**	15,7	1,4	**6,7**	**0,5**	15,0	1,4	**9,3**	**0,9**	13,3	1,5	**5,0**	**0,8**
Phase 3	16,4	1,6	**12,2**	**1,0**	19,1	1,7	**10,0**	**0,6**	24,4	2,6	**17,1**	**1,3**	25,0	2,2	**10,0**	**1,3**
Perceived safety																
Phase 1	-0,5	1,6	**-1,9**	**0,7**	0,0	1,1	**0,0**	**0,7**	0,6	2,7	**-2,7**	**0,9**	-5,5	1,8	**-6,3**	**0,7**
Phase 2	12,8	1,9	**5,5**	**0,9**	11,1	1,8	**5,0**	**0,5**	10,6	2,0	**6,9**	**1,0**	5,0	1,9	**2,9**	**1,5**
Phase 3	23,6	2,4	**12,7**	**1,2**	14,5	2,2	**8,3**	**0,8**	21,5	2,4	16,4	1,7	16,4	3,8	15,0	3,6
Job creation/destruction																
Phase 1	4,9	0,8	**3,2**	**0,5**	6,7	0,7	**4,0**	**0,5**	12,1	3,0	**5,0**	**0,5**	-2,5	1,0	**0,0**	**0,8**
Phase 2	3,0	1,2	**3,3**	**0,8**	6,4	1,3	**2,0**	**1,3**	3,3	1,8	**2,7**	**1,0**	-10,0	1,4	**-1,3**	**1,7**
Phase 3	0,7	2,1	**0,0**	**1,1**	0,0	2,6	-7,5	1,9	0,0	2,2	-2,7	1,8	-19,3	2,6	-11,3	2,9
Job modification/re-skilling																
Phase 1	9,5	1,3	**6,2**	**0,5**	8,6	0,7	**6,0**	**0,5**	12,9	1,8	**6,4**	**0,7**	7,1	0,8	**5,0**	**0,5**
Phase 2	17,6	2,2	**15,9**	**0,9**	22,7	0,9	**13,3**	**0,5**	22,8	1,8	**17,5**	**0,9**	13,8	1,4	**16,3**	**1,1**
Phase 3	28,0	3,3	**24,1**	**1,5**	40,8	1,6	**20,0**	**1,3**	31,0	2,4	**24,3**	**1,3**	22,1	2,4	31,3	1,9

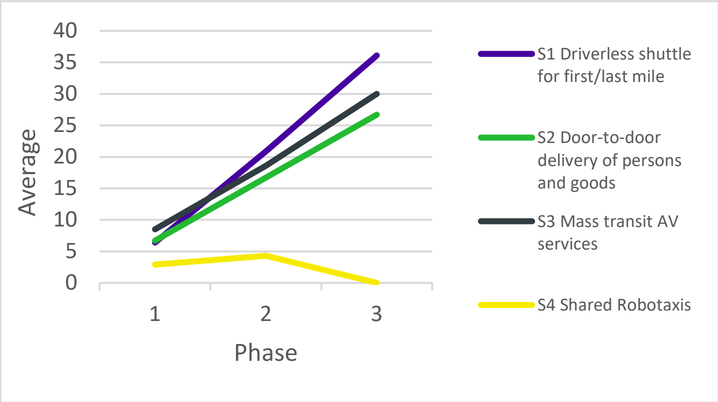


Figure 6: Accessibility to public transport

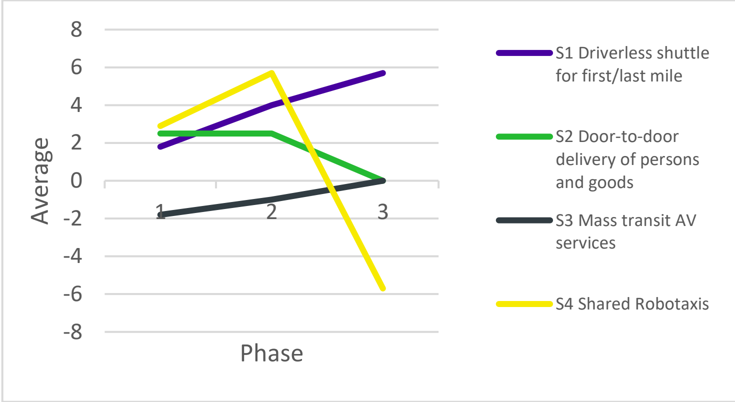


Figure 7: Public space consumption

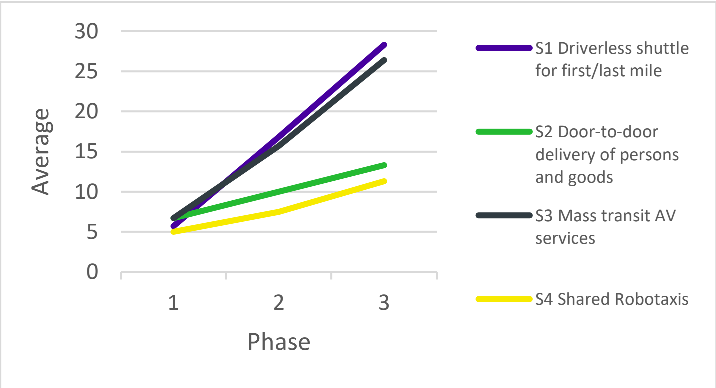


Figure 8: Public transport equity

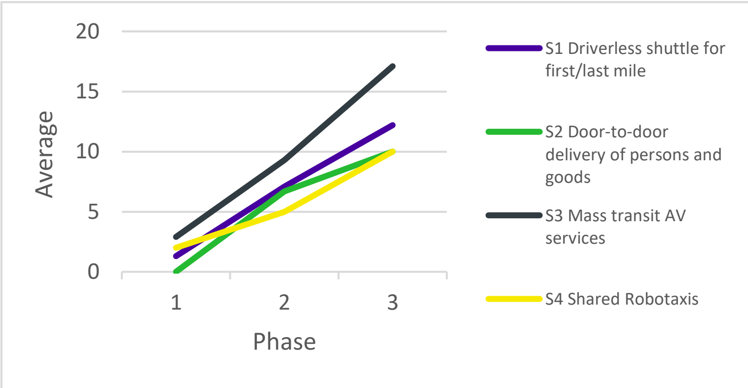


Figure 9: Housing prices

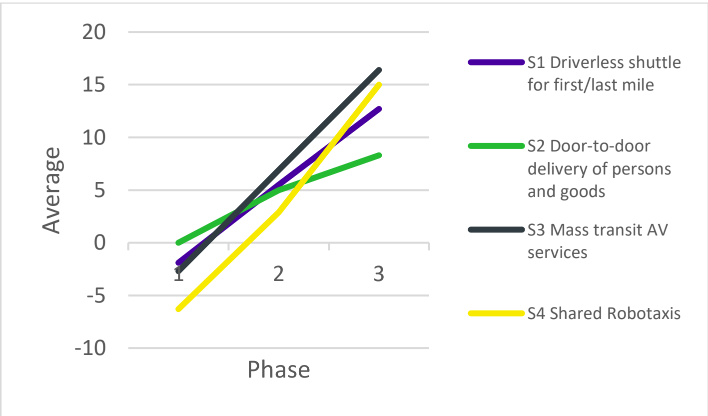


Figure 10: Perceived safety

4.2 Discussion of the results

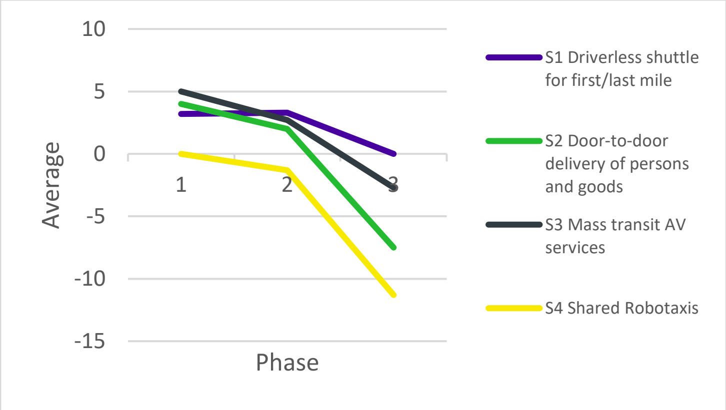


Figure 11: Job creation/destruction

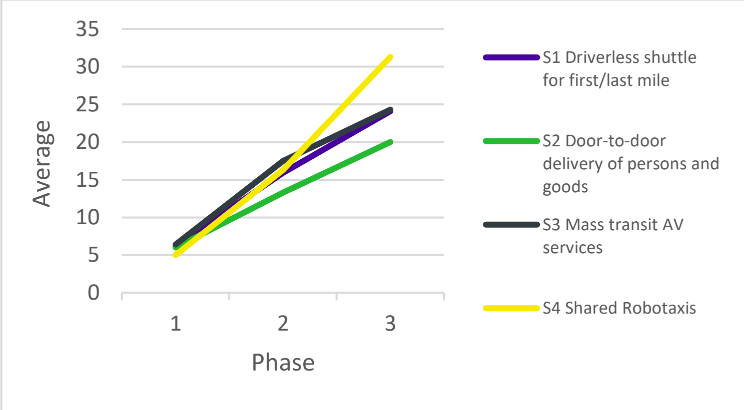


Figure 12: Job modification/re-skilling

Overall, Delphi participants reached an agreement with a standard deviation of less than 1,5 in the second round. There tends to be less agreement regarding Scenario 4 (shared robotaxis), likely due to its limited deployment in Europe compared to the other scenarios, with participants generally more familiar with the latter. Similarly, there is less agreement on phase 3 than on the other 2 phases, as it is a more distant future situation and there is more uncertainty among the participants.

The results of the modified Delphi show an expected increase of **accessibility to public transport** on average with higher penetration rates of the service in S1, S2 and S3, while on shared robotaxis (S4) no consensus was reached. This may be a response to the uncertainty of its potential customers, as some experts argue that the prices of the service are likely to be higher than in the other scenarios, which could affect affordability and, therefore, accessibility. These outcomes align with the results of the interviews with the pilot sites, who foresee, for the long-term vision, which foresees an increase in accessibility in the future.

During the workshop session, some questions arose regarding robotaxis (S4). Participants questioned the service they provide and whether they can be considered public transport. These considerations depend on various factors, including the business model, contractual agreements, and the operator managing the service. Potential decrease of value of travel time was mentioned as well, leading to an increase of urban sprawl.

Equity results show a clear improvement for scenarios 1 (first/last mile) and 3 (mass transit), and less improvement for scenarios 2 (door-to-door) and 4 (shared robotaxis), probably due to the cost of service for the customers. Indeed, during the workshop concerns were raised with regard to cost of the trips for the users, which would need to match public transport tariffs in order to have a positive effect on equity. The pilots, as discussed during the workshop, received a generally positive response and acceptance from the users. However, depending on the shuttle, accessibility for people with disabilities is still not fully optimised. For example, when the ramp is not fully integrated, usage is not seamless. Additionally, some pilots did not receive a good response from other road users, who mostly complained about the low speeds.

Most European cities are in the process of removing space for cars and parking, and shared AVs can help free up **public space**, which is, according to the Delphi results, more likely with a high penetration rate for S2 door-to-door delivery of people and goods, and S4 shared robotaxis, but not for regular lines services (S1). This result can be interpreted in different ways. When asked, pilot representatives predicted that when the AV service is largely extended, a shift from usage of private cars to automated public transport could free up space; however, some experts argued that the shift could be small and so would be the impact on space. Additionally, some experts argued that if private AVs are eventually allowed, it could negatively impact on the public space, increasing the demand for vehicle deployment areas. Furthermore, if AVs would be mainly smaller vehicles, such as shuttles or robotaxis, traffic could potentially increase.

Pilots are currently using existing infrastructure without the need to build new street infrastructure, other than reserving some space for their operations by removing parking spaces. In the long term, it is expected that fewer private cars will be needed, and public space will be gained (second to third phase of implementation).

The impact on **house prices** is expected to have an increase in all scenarios, confirming previous studies which argue that better public transport including automated services increases land prices and house prices respectively. Experts also argue that AV deployment could lead to potential urban sprawl, mostly with S4, which could imply an increase of land prices in suburban areas.

Perceived safety by users is one of the key prerequisites to scale up automated services and the results of the Delphi show that it is expected to improve as penetration rate increases and technologies evolve. Perceived safety will depend largely on the technology improvements, but also on the general acceptance of riding an automated shuttle without human assistance, which is likely to increase in the future according to the average answers. The absence of a driver gives some users a feeling of insecurity, which may discourage them from using AV services in the early stages, but in general experts believe that the public's perception of safety will increase with experience. It is also important to emphasise that shuttles (S1) and buses (S2) are currently perceived as safer than cars, and for robotaxis (S4) which are currently perceived as less safe, perceived safety is also expected to increase in phase 3.

In the early stages of automated vehicle deployment, **employment** opportunities are expected to increase, as regular services will continue as usual, and new automated services will require to hire or train new profiles of employees. This will come along with a clear trend towards re-skilling across all services, which will increase as penetration increases. However, as penetration rates increase, the overall employment landscape is expected to stabilise, reflecting the current scenario. In particular, for S4 shared robotaxis there was no clear consensus and Delphi results show a decrease in employment, which can be explained by the easy scalability of the service once the technology and regulations allow it to be fully automated and monitored with minimal human intervention. The SHOW pilots have also had an impact on employment, as explained in detail in section 5.

Appendix I contains the Miro board of the Delphi workshop.

5 Pilot site interviews

5.1 Topics and business models

The pilot sites were asked about three overarching topics that include the topics treated in the Delphi.

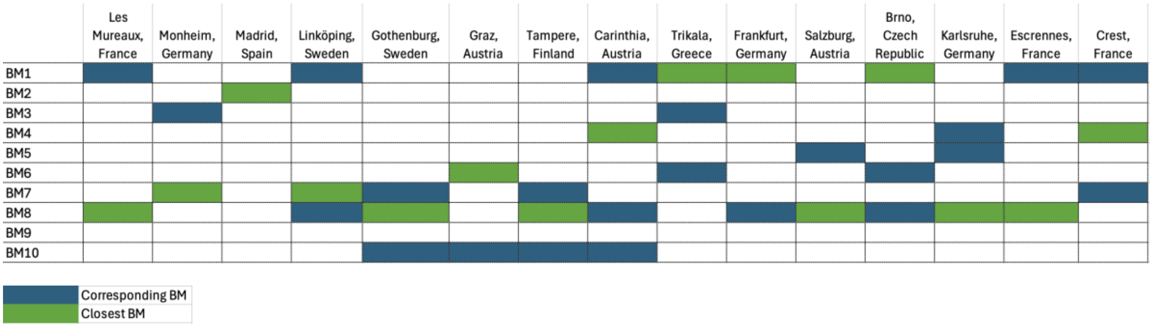
- Impact on jobs/employment
    a. Job loss (current and future)
    b. Job created (current and future)
    c. Response from workers
- Impact on public space (land use)
- Impact on users
    a. Type of users
    b. Accessibility to public transport

Appendix II contains the template of the interviews that were conducted with pilot representatives. The interviews were done online, at the same time and coordinated with the business models interviews (WP2) and also contained questions related to CCAV integration into SUMPs (WP17). Table 6 shows the Business models studied in WP2.

Table 6: Business models analysed in WP2

BM	Description
BM1	Autonomous PT in combination with additional on-demand services
BM2	Autonomous bus depots
BM3	Advanced MaaS in urban environments
BM4	Combined MaaS and LaaS
BM5	Peri-urban automated transportation and C-ITS connectivity
BM6	Robotaxi services for short distance trips
BM7	Sustainable living areas with autonomous public transportation
BM8	Fist/Last mile autonomous transportation to mobility hubs
BM9	Integrated automated and electric shuttle buses for large scale events
BM10	Interoperable IoT platforms for automated mobility

Table 7: Sites and business models



The Scenarios assessed in WP13, created initially for the MAMCA process (D13.6) are scenarios related to the business models:

- Scenario 1: Automated shuttle(s) for first/last mile (BM 1,
    a. *Linköping, Gothenburg, Graz, Salzburg, Carinthia, Monheim, Trikala, Tampere*, *Turin*
- Scenario 2: Door-to-door delivery of persons and goods
    a. *Les Mureaux*
- Scenario 3: Mass transit AV services
    a. *Madrid (Villaverde), Brno, Monheim*
- Scenario 4: Shared Robotaxis
    a. *Graz, Trikala, Brno, Karlsruhe*

Not assessed for societal impact: BM2: Bus depot

5.2 Impact on Jobs

When evaluating the different pilots, it is important to consider the varying nature of these pilots in terms of their duration, scope, and the service provided.

The interviews with pilots provided a diverse range of insights into the impact on jobs, including both job loss and creation, as well as the response from the workers.

Table 8: Impact on jobs

Site (City, country)	Current impact on number of jobs	Future impact on number of jobs (10 years)
Brno, Czech Republic	No reduction nor expansion in number of workers (researchers)	Slight increase, if operations continue
Tampere, Finland	Hired around 15 people	Increase of jobs, around 10 new hires
Trikala, Greece	No reduction nor expansion in number of workers	- Could reduce the number of drivers, if deployed by the city - Need to increase other profiles: IT, control centre, etc.

Site (City, country)	Current impact on number of jobs	Future impact on number of jobs (10 years)
Frankfurt, Germany	Not reduced. New positions come from current metro drivers.	Not expected to reduce, as those reduced will be needed somewhere else (total count). For the long run for robotaxis, up to 50% less. Depending on technology, vehicles per controller, etc.
Karlsruhe, Germany	Not reduced, 10 safety operators were trained for the shuttles.	It depends on whether there will be any other pilots.
Carinthia, Austria	No changes	Around 2 new additions
Madrid, Spain (Carabanchel)	No changes	Not expected to reduce, if needed to reduce, retired people would not be substituted.
Linköping, Sweden	No changes. Workers were trained to undertake new roles. Current drivers by Transdev, partially working here and other sites.	Expected to increase, in Transdev.
Gothenburg, Sweden	Shortage of drivers was an issue, 7 took training, only 3 could continue due to other work obligations. Workers were already part of Keolis.	Up to 3 more, depending on the expansion of the service and the technology.
Les Mureaux, France	Trained drivers to become safety operators and supervisors	Not applicable
Graz, Austria	2 new hires. Other trained profiles.	If it scales up, PTO would need to lead the operations.
Monheim, Germany	6-10 new people hired, mostly for onboard supervision.	Expected to increase if operations scale up.
Salzburg, Austria	2 people hired for the operator training.	Not applicable
Crest, France	3 people hired, 2 safety drivers 1 for supervision Trained safety drivers and supervisors	In ten years would expect to have 1 supervisor and 1 safety driver for 7 vehicles

Site (City, country)	Current impact on number of jobs	Future impact on number of jobs (10 years)
Escrennes, France	Hired 2 safety drivers Trained safety drivers and supervisors	In ten years would expect to have 1 supervisor and 1 safety driver for 7 vehicles

Although the impact on jobs has been limited due to the scale of the operations, we can provide some preliminary insight into what will be needed in the future. The impact has been assessed in terms of job loss, job creation and employee response.

5.2.1 Job loss

Across all pilots, no jobs have been lost for the pilot phase (1st phase of the Delphi) of the different use cases. As expected, and discussed in the Delphi, the initial phase of deployment does not reduce employment, as the usual services remain the same, and the pilots are an additional service to the current transport offer.

Future predictions on the reduction of employees are generally hard to assess by the pilots, as such changes are often seen as distant. Answers vary among different dependencies:

- Technology advancements: The reduction will depend on the maturity of the technology to enable the removal of drivers and the number of vehicles that one remote controller can oversee, which is still uncertain.
- Legal: As long as regulations do not allow for AVs to operate without a safety driver, there will be no potential reduction in jobs.

Most sites do not anticipate a reduction in jobs in the coming years. Instead, what is most expected is a change in worker roles, such as drivers becoming remote operators.

In some cases, such as Madrid, if fewer workers were needed in the future, the transition is expected to be gradual, avoiding the need for layoffs by not hiring new workers as old drivers retire.

5.2.2 Jobs created

For this question, as mentioned above, answers differed, depending on the size, scope, duration of the pilot. Pilots with longer duration and bigger scale of operation such as Monheim, have needed to hire new employees (between 6 and 10 people) for the automated vehicle on-board supervision. This case, which is led by a PTO, is also the one that has trained more drivers to become safety drivers, around 50 people, however not all wanted to continue with this new role after trying it, and around 30 remained as safety operators.

In most cases, no new workers needed to be hired. This is usually the case for other sites led by researchers, who might have hired someone specifically for the pilot, but as researcher and to undertake some actions. The operations are in such cases relatively small and handled by the group of researchers, who perform the different roles, such as safety driver, themselves. In these pilots led by research institutions, if new people have been hired, then it was not for a particular role in the AV operations, but rather as researchers who have worked on the pilot and will continue their work as researchers (e.g. Graz).

For the future, it is again difficult for the pilots to estimate the number of new people who will be hired. However, many sites anticipate that new profiles will be needed in the coming years, such as IT specialists, on-board control centre operators, and people to explain the lessons learned and apply them within the municipal transport department. Other roles will be needed in tendering positions. These new profiles require some skills in terms of technological knowledge and applicants will not need to be drivers or have previous experience in the field.

While some consolidated pilots, such as the one in Tampere, could give a rough estimate of the employment needs for the deployment of AVs in public transport– predicting around 10 new employees over the next 10 years, the current size of the pilot is of 7 vehicles –, other sites, which have tested services independently of the public transport operator, do not anticipate any increase in employment, as they do not expect to expand or continue operations.

Gothenburg is an example of the current personnel shortage that affected the pilot. Seven people completed the safety driver training, but only three were able to stay on because the other 4 had to take on other roles outside the project.

As mentioned above, future estimates depend heavily on the type of service provided, together with evolutions of technology and regulations. In the case of robotaxis, there would be a significant loss of driver jobs, including taxi drivers, whereas regular bus line automation would have less of an impact but could address the current driver shortage.

5.2.3 Worker’s response

Response from workers varies across sites, due to the nature of each pilot.

In the case of Monheim, about 50 people were trained to become on-board operators, about 30 of which remained in this new role and were needed to supervise the shuttle. Around a third of drivers did not want to continue this type of operation and returned to regular driving. The main reasons for this were conflicts with other road users (e.g., angry drivers not used to having automated vehicles on the road), new challenging or more demanding tasks arisen in their new role and the fact that they had to stand in the vehicle for a long time. This differs from other pilots where safety drivers found the task unchallenging and boring, so we can see that the context and nature of the service is important in the experience of on-board operators.

In the case of Les Mureaux, the drivers trained for the new role as on-board operators and remote operators were preselected and willing to participate, and the response from the employees was mostly positive. They had to undertake one (on-board) or two (remote) trainings, and those that remained until the end faced some kind of difficulties when going back to their original role of driving a manual bus. Some drivers did not want to go back to the previous roles and, instead, they pursued the role of a trainer for automated on-board driving supervision. This transition resulted in an upgrade from their previous tasks.

Frankfurt is another case where safety operators were highly motivated to learn the new role, and were open to talk and be interviewed.

These new functions, such as safety operator, are usually more demanding and require training, which is often compensated in salary or bonuses. And when it comes to hiring new people, they have different profiles than any type of employee hired before, focusing on automated driving supervision skills.

5.3 Impact on Public Space

In most cases, there has been no significant impact on public space during the pilot phase. The automated vehicles operate primarily on public roads, driving alongside conventional vehicles in a mixed traffic environment. This integration into existing traffic patterns has minimised disruption to the public space, but has in some cases caused problems with other road users.

To improve safety and awareness, additional signage has been installed on the roads. These signs are strategically placed to alert drivers, cyclists and pedestrians that they are entering an area where automated vehicles are operating. The presence of these signs helps to ensure that all road users are more alert and prepared to share the space with these new forms of transport.

In addition, some parking spaces have been removed to create designated stops for the shuttles. These dedicated shuttle stops are critical to the efficient operation of the pilot programme, providing safe and convenient locations for passengers to board and disembark. While the removal of parking spaces may cause minor inconvenience for some, it is a necessary adjustment to accommodate the new technology and improve overall accessibility.

Overall, the careful planning and implementation of such measures allows the pilot phase to proceed with minimal disruption to the public realm, paving the way for the wider introduction of automated vehicles in the future.

Other problems encountered by the pilots in the field relate to the interaction of the sensors with environmental elements such as snow (Gothenburg) and grass (Linköping). In particular, when the LiDAR sensors detect grass or snow, they have experienced several problems. For example, the presence of tall grass or snowbanks can interfere with the accurate operation of the sensors, resulting in false readings or degraded performance. As a result, it was necessary to manually cut the grass or remove the snowbanks to ensure the sensors worked correctly.

These challenges highlight the current limitations of technology in dealing with natural obstacles. However, advances in sensor technology and software algorithms are expected to address these issues in the future. Improved LiDAR systems will be able to distinguish between actual obstacles and natural elements such as grass and snow, allowing seamless operation without the need for manual intervention. This would greatly improve the efficiency and reliability of the system in different environmental conditions.

5.4 Impact on users

A wide variety of users have tested the different pilot services across Europe, including the elderly, children, middle-aged people, people with disabilities, students and workers, tourists, etc. However, the most common users are those who have less access to private cars, or users targeted because of the specificity of the service, such as employees in pilots targeting workplaces in Les Mureaux or Gothenburg.

Most of the pilots did not have people with disabilities as their main target group, and the vehicles were sometimes not fully prepared for them. Nevertheless, the testing of the services has provided valuable lessons in this area. The pilot in Linköping identified a problem with hard braking and developed a handle to hold on to and an accessible website to enable visually impaired people to call the service.

In terms of price, most of the services were free, which was taken into account when analysing the business models and the willingness of users to use the services, and makes it difficult to assess users' actual willingness to pay.

Tampere specifically tested the service with different types of users, including visually impaired people and people with mobility impairments. The aim was to identify areas for improvement, such as necessary equipment and accessibility features. These users were able to provide valuable feedback and were generally satisfied with the service.

Other road users, such as private car drivers or cyclists, have expressed dissatisfaction with some of the pilots (Karlsruhe, Monheim) because of the AVs' low speed or sudden hard braking. Both of these problems are expected to diminish in the future as the technology matures.

5.5 Accessibility to public transport

Another aspect to assess in the pilots was the improvement of accessibility of certain areas by public transport. This impact depends on how the pilots were designed and the nature of the route. In most cases, the pilots were adding a new line or service, such as on-demand or during times when public transport was not operating. Hence, these services improved the accessibility of the areas in which they were operating.

The impact on accessibility was not assessed in the same way across the different pilots, but some did pay particular attention to it and, due to the routes and target groups of the services, improvements in accessibility could be seen.

In Carinthia, the target group of tourists was provided with a shuttle service to the lake that was not available before, so the impact was positive in terms of accessibility to a tourist destination.

The pilot in Monheim has implemented automated bus lines connecting the old town to a bus terminal and has improved accessibility for groups such as the elderly and children, as narrow streets not accessible by regular buses now have a public transport service. The shuttles also travel to Monheim's health campus, serving workers and patients, many of whom being elderly.

Similarly, in Frankfurt, the service proved to be beneficial for elderly people and individuals with disabilities, including wheelchair users, due to its speed and accessibility. The public transport offer was particularly attractive to residents in the neighbourhood where the shuttle operated, as the only metro station was a 15-minute walk away.

In the case of Trikala, the AV service operates for more hours than the previous regular bus service, thus giving users better access to more activities, work and basic services.

6 External interviews

The interviews with external experts corroborated the findings regarding the impact on jobs from the modified Delphi and added additional insights in terms of challenges faced and potential fields of study.

The experts we interviewed highlighted that it is too early to say what impact automation can have on employment, but it will be directly linked to the business model, as seen in the Delphi results.

The regulatory framework is also key to steer the impact on society, as well as the role that public authorities take on while implementing these technologies. The U.S. and Europe approach this in different ways. In the U.S., services and technology are being rolled out and tested faster, but with more uncertainty about the societal impact. Europe has had extensive experience with the consequences of automation, which goes hand in hand with digitalisation, and according to experts, one of the main drivers for automation is the reduction of labour costs.

An illustrative example of the impact on jobs is evident in the implementation of the automated metro line in Turin, which has not resulted in fewer employees but rather in a shift towards different profiles, such as the replacement of drivers with engineers. This relates to the challenge faced by public authorities and PTOs in recruiting and retaining talent, especially IT professionals, due to the competitiveness and high demand for such profiles. This is added to the potential challenge posed by automation, which could potentially move digital jobs, such as IT support abroad, with implications for both employment and the economy.

In terms of accessibility, impact can be seen as very positive in some cases, for example in areas where there is little demand for public transport, an AV may be interesting to explore the potential cost reduction and provide basic services (for peri-urban or rural areas). However, it will depend on the needs: For example, if there are children, a steward will probably be needed anyway.

Another important issue raised is the impact that the automation of shared vehicles may have from a gender perspective. The absence of drivers in automated vehicles could potentially increase the risk of sexual harassment. It is therefore crucial to investigate and implement measures to prevent such incidents. Although CCTV is already used in current buses, the response mechanisms and their effectiveness should be further evaluated and improved to ensure the safety of passengers in automated vehicles.

7 Conclusions

Through a combination of desk research, a modified Delphi study and interviews with experts and stakeholders, we gained insights into the evolving transportation landscape and how CCAM fits into that.

The different methodologies have provided insights regarding different societal impacts that the inclusion of AVs in public transport can bring. Experts discussed about broader and long term effects such as the increase of accessibility to certain urban areas or equity in public transport, depending on the service provided. SHOW pilots have been able to provide more tangible and specific feedback, thanks to the real-life testing, for example on impact on jobs, providing real figures on new hired people.

In summary, our study shows the potential impacts of CCAV deployment on public transport in terms of accessibility, equity, and employment dynamics. Our findings suggest that while CCAV holds promise for enhancing accessibility to public transport, challenges persist, particularly regarding affordability and inclusivity, notably with regard to the deployment of shared robotaxi services.

Moreover, the transition to automated services presents both opportunities and challenges for employment, emphasising the importance of proactive measures in workforce planning. It will be highly dependent on technology advancements and legal regulations. And, although no major shortcuts of personnel are expected, except for robotaxis, upscaling and reskilling of professionals, as well as hiring new profiles is expected in the coming years, as more automated services will be deployed.

It is important to acknowledge the limitations of the study. The reduced participation in the second round of the Delphi study (40 participants compared to 78 in the first round) may have influenced the consensus reached. In addition, the scope of the study was limited to certain regions and sectors, which may affect the transferability of our findings, for example, considering the limited examples of shared robotaxis in Europe.

We recommend future research to further investigate the societal implications of CCAV deployment to ensure a smooth transition towards a more sustainable and equitable transportation ecosystem.

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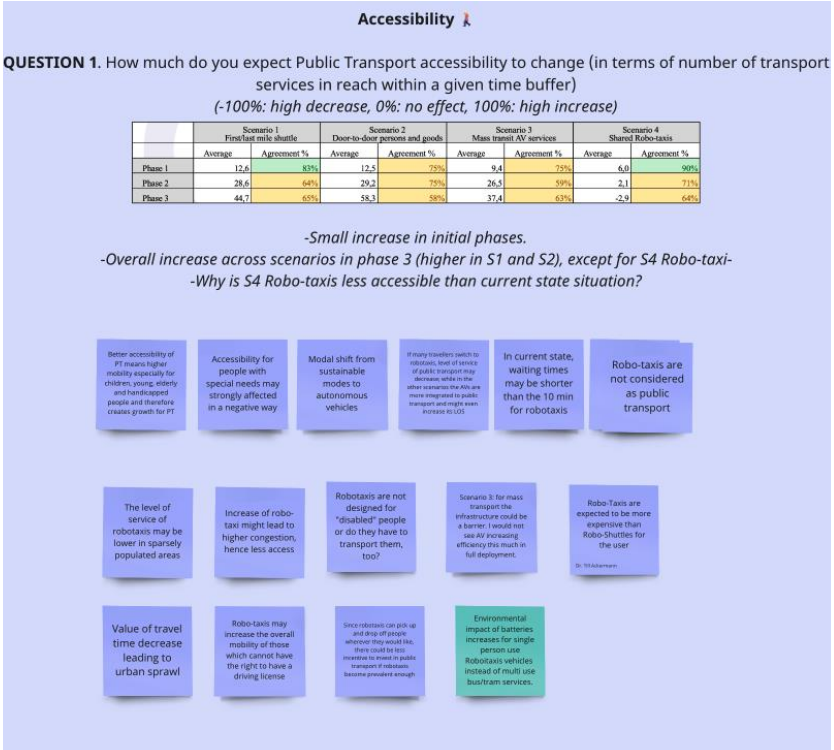
Appendix I

Delphi Session

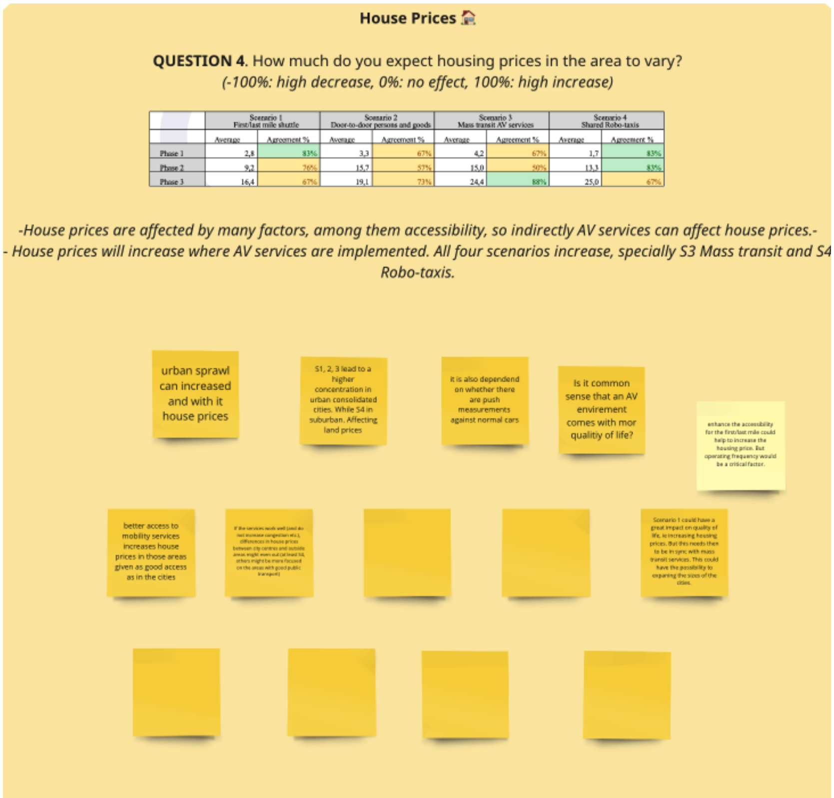


Accessibility

QUESTION 1. How much do you expect Public Transport accessibility to change (in terms of number of transport services in reach within a given time buffer)
(-100%: high decrease, 0%: no effect, 100%: high increase)

	Scenario 1 First/last mile shuttle		Scenario 2 Door-to-door persons and goods		Scenario 3 Mass transit AV services		Scenario 4 Shared Robo-taxis	
	Average	Agreement %	Average	Agreement %	Average	Agreement %	Average	Agreement %
Phase 1	12,6	83%	12,5	75%	9,4	75%	6,0	90%
Phase 2	28,6	64%	29,2	75%	26,5	59%	2,1	71%
Phase 3	44,7	65%	58,3	58%	37,4	63%	-2,9	64%

-Small increase in initial phases.
-Overall increase across scenarios in phase 3 (higher in S1 and S2), except for S4 Robo-taxi-
-Why is S4 Robo-taxis less accessible than current state situation?



House Prices

QUESTION 4. How much do you expect housing prices in the area to vary?
(-100%: high decrease, 0%: no effect, 100%: high increase)

	Scenario 1 First/last mile shuttle		Scenario 2 Door-to-door persons and goods		Scenario 3 Mass transit AV services		Scenario 4 Shared Robo-taxis	
	Average	Agreement %	Average	Agreement %	Average	Agreement %	Average	Agreement %
Phase 1	2,8	83%	3,3	67%	4,2	67%	1,7	83%
Phase 2	9,2	76%	15,7	57%	15,0	50%	13,3	83%
Phase 3	16,4	67%	19,1	73%	24,4	88%	25,0	67%

-House prices are affected by many factors, among them accessibility, so indirectly AV services can affect house prices.-
- House prices will increase where AV services are implemented. All four scenarios increase, specially S3 Mass transit and S4 Robo-taxis.

	Scenario 1 First/last mile shuttle		Scenario 2 Door-to-door persons and goods		Scenario 3 Mass transit AV services		Scenario 4 Shared Robo-taxis	
	Average	Agreement %	Average	Agreement %	Average	Agreement %	Average	Agreement %
QUESTION 6. What direct effects do you expect to take place in terms of **job creation/destruction**? *(-100%: high job decrease, 0%: no effect, 100%: high job increase)*								
Phase 1	4,9	89%	6,7	89%	13,8	85%	-2,5	63%
Phase 2	3,0	63%	6,4	55%	3,3	80%	-10,0	64%
Phase 3	0,7	83%	0,0	64%	0,0	74%	-19,3	57%
QUESTION 7. What direct effects do you expect to take place in terms of **job modification/re-skilling**? *(-100%: heavy job simplification, 0%: no effect, 100%: strong job re-skill increase)*								
Phase 1	9,5	84%	8,6	57%	12,9	76%	7,1	86%
Phase 2	17,6	80%	22,7	73%	22,8	78%	13,8	77%
Phase 3	28,0	83%	40,8	75%	31,0	75%	22,1	79%

Public Space

QUESTION 2. How do you expect public space consumption to be affected?

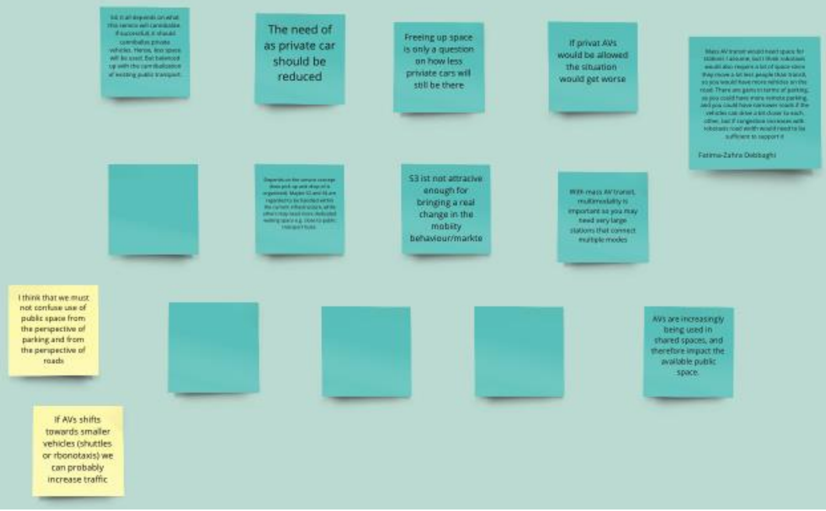
(-100%: less space used meaning more space freed up and available, 0%: no variation, 100%: higher levels of space usage)

	Scenario 1 First/last mile shuttle		Scenario 2 Door-to-door persons and goods		Scenario 3 Mass transit AV services		Scenario 4 Shared Robo-taxis	
	Average	Agreement %	Average	Agreement %	Average	Agreement %	Average	Agreement %
Phase 1	3,8	55%	4,0	70%	-7,7	77%	2,2	67%
Phase 2	8,3	70%	1,8	73%	-2,1	50%	3,6	64%
Phase 3	13,4	66%	-4,2	83%	4,4	83%	-7,3	67%

-Not big changes in public space consumption across the different scenario

-S2 Door-to-door and S4 Robo-taxis free up space, while S1 First/last mile and S3 Mass AV transit use more space. Although not big changes from the current situation, why do you think this happens?

-Why S3 Mass AV transit (station based) does not free up space compared to the current situation?



Equity

QUESTION 3. How much do you expect Public Transport equity and inclusion to change? (regarding physical accessibility, social integration, cohesion and equality)

(-100%: high decrease, 0%: no effect, 100%: high increase)

	Scenario 1 First/last mile shuttle		Scenario 2 Door-to-door persons and goods		Scenario 3 Mass transit AV services		Scenario 4 Shared Robo-taxis	
	Average	Agreement %	Average	Agreement %	Average	Agreement %	Average	Agreement %
Phase 1	7,8	83%	9,2	85%	8,1	81%	1,8	45%
Phase 2	23,5	72%	19,2	75%	16,8	29%	-2,1	64%
Phase 3	35,5	57%	36,7	83%	28,9	74%	-3,6	73%

-Equity is increased in all scenarios except for S4 robo-taxis, which is close to 0.

-Which of the subtopics did you evaluate the most in terms of equity? In case one is more affected which one is it?

-Accessibility for people with disabilities, economic equality, connect isolated neighbourhoods...?

-Why do you think S4 robo-taxis will reduce equity?

Perceived safety ⚠️

QUESTION 5. How much do you expect users' perceived safety in the area to vary?
(-100%: high decrease, 0%: no effect, 100%: high increase)

	Scenario 1 First/last mile shuttle		Scenario 2 Door-to-door persons and goods		Scenario 3 Mass transit AV services		Scenario 4 Shared Robo-taxis	
	Average	Agreement %	Average	Agreement %	Average	Agreement %	Average	Agreement %
Phase 1	-0,5	73%	0,0	90%	0,6	65%	-5,5	82%
Phase 2	12,8	77%	11,1	67%	10,6	43%	5,0	64%
Phase 3	23,6	77%	14,5	73%	21,5	88%	16,4	79%

Consensus increase in all scenarios. Related to the evolution of technology and public opinion, rather than the type of service.
-Security/safety. IT security. Safety is being secure against unintended threats, while security is the protection against deliberate threats. Threat monitoring and video surveillance are some of the many ways that the public transport sector can predict and prevent risks, ensuring the safety of its employees and passengers.
-Why do you think S4 robo-taxis has less perceived safety in phase 1 than the other scenarios while in phase 3 all scenarios score similar higher perceived safety?
-How do you think cybersecurity will affect users' perceived safety? (i.e. accidents caused by cyberattacks)

Appendix II

SHOW WP2, Interview BM, Societal impact, SUMP

Date and time of call:	
Interviewee(s) case	
Role of the interviewee (PTO, city)	
SHOW partners	

1 Business Models (30 min)

1	*Confirm Business model - Depending on the pilot site*
2	*How does the main stakeholders (City, PTO, Tiers, etc.) define that a **Pilot** has been successful? Which are the objectives? How are they evaluated?* o *Relate to the 5 Goals*
- **O1: Accessibility, Equity and Community vitality** - **O2: Economic** - **O3: Environment (noise, emissions, congestion, etc.)** - **O4: Business ecosystem and development** - **O5: Technology and safety**	
3	*How does the PTO/city define what has been a successful **business model**? Any consideration regarding this? (Note the difference with the previous question: Pilot vs Business model)*
- **O1: Accessibility, Equity and Community vitality (Social)** - **O2: Economic** - Cost too high to have a business case - **O3: Environment (noise, emissions, congestion, etc.)** - **O4: Business ecosystem and development** - **O5: Technology and safety**	
4	How mature are the current services?
Social (to increase attractivity, accessibility, equity, etc.) - *Indicative questions:* o *What are the main benefits for active population and users with special needs?* *Not specifically addressed, it had a ramp,* o *How much are these services integrated into the existing transport system?* o *Were the services attractive to the local community?* **Economic** - *Indicative questions:* o *What were the main economic challenges?*	

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Expensive development. Pilot run thanks to the project, otherwise not possible. o *Could you rate the economic performance regarding OPEX and CAPEX? (1 = affordable, 5 = expensive)* **Environmental** - *Indicative questions:* o *Did the service contribute to private car usage reduction? The increase of public transport use?* o *Any insights regarding emissions and noise pollution?* **Development of the Business ecosystem** - *Indicative questions:* o *Did the project allow to integrate a diversity of stakeholders? Were they interested; how did they contribute?* **Technology and safety** - *Indicative questions:* o *Maturity of the technology? (supervision, detection robustness, etc.)? safety operator mandatory* o *Rate the experimentation regarding safety and accidentology (number of accidents reduced)?* o *Other Features (Real-time information for users)? real time operations on the website*		
5	What are the biggest challenges for a seamless service operation and customer acceptance?	
Social (to increase attractivity, accessibility, equity, etc.): **Economic** **Environmental** **Technology** **Legal aspects** **Political:**		
6	What will have to change in the future? to make it operational and economically successful?	
7	*Are there plans to* ***transfer the use cases*** *to other parts of the city? Have citizens requested the* ***expansion of the service*** *to other parts of the city? Similar parts (in terms of configuration/environment) or different ones? Is there any plan to* ***increase the number of vehicles****? In the same area or a different one?*	
8	*Which* ***collaborations*** *are required to* ***scale-up*** *the business? Who would be expected to be the* ***main investor*** *for the development of this business? Which* ***service characteristics*** *would be needed to have to consider investing? The investment would be* ***directed*** *at tech startups,*	

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	*PT providers, cities (including **subsidies** or infrastructure), others? What could be the **willingness to pay** from users for the service?* Affordability?
9	*What is the expected effect of **fleet increase** on investments, costs & revenues? Improvement of infrastructure?*

2 Societal Impact KPIs (30min)

1	*Percentage of jobs that have a high probability of being replaced by computer automation within the next two decades* o How many job positions have been reduced in the last 5 years due to automation? o How many do you expect to reduce in the coming 10 years?
2	*Number of jobs created by the implementation of computer automation, and other systems (sensors, cameras etc) used in autonomous vehicles within the next two decades* o How many **new** job positions have been created in the last 5 years due to automation? o How many new jobs do you expect to create in the coming 10 years?
3	***Public space:** Has public space been affected by the implementation of autonomous shuttles? Sidewalks? Short-term vs long-term forecast?*
4	***Users**: Has the implementation of the pilot affected the type of users? Increased/reduced (particular type) users? Affected accessibility?*
5	***Jobs**: Others. What response did you experience from the workers and drivers? Are they willing to change activities? Are you providing benefits other than training to change?*

SUMP (30min)

- Current state of SUMP on CCAV

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1	Can you share the local SUMP of your city here (official link):
2	Does your local administration consider CCAM innovation as part of their local climate plans/SUMPs?
	Yes *No* *Don't know*
3	If yes; how do you expect CCAM to contribute to achieve the climate objectives? (Can select several)
	- Ensure all citizens are offered transport options that enable access to key destinations and services. - Improve safety and security. - Reduce air and noise pollution, greenhouse gas emissions and energy consumption. - Improve the efficiency and cost-effectiveness of the transportation of persons and goods. - Contribute to enhancing the attractiveness and quality of the urban environment and urban design for the benefits of citizens, the economy and society as a whole
4	*Is there any regional or national legislation on CCAM?*
	-

- Needs from the site to integrate CCAV in the SUMP

1	What type of obstacles have you encountered in implementing the pilot in your city? (Regarding **SUMP** or city **regulations**)
2	Is there a policy or a regulation currently stopping the pilot from **scaling up**?
3	Does the city government have the **will to implement** the necessary policies to scale up CCAM deployment (implement bigger operations, bigger region...)?

- Other questions (SUMP)

1	How and to what extent is your organisation involved in decision-making processes linked to transport & CCAM?
2	*Which stakeholders do you think should be involved in the planning/inclusion of CCAM in SUMPs (you can tick as many as you think)?*
City PTA	

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Regional/National government EU Public Transport operators Private Transport operators Citizens, CCAM users Citizens, not CCAM users (PT) Researchers, academic community CCAM industry manufacturers Others:

3	*In which form have the previous groups been involved during the planning process of your pilot?*

Other questions

1	
2	