Deliverable 5.2

CCAM solutions and vulnerable users: Opportunities and constraints

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Legal disclaimer

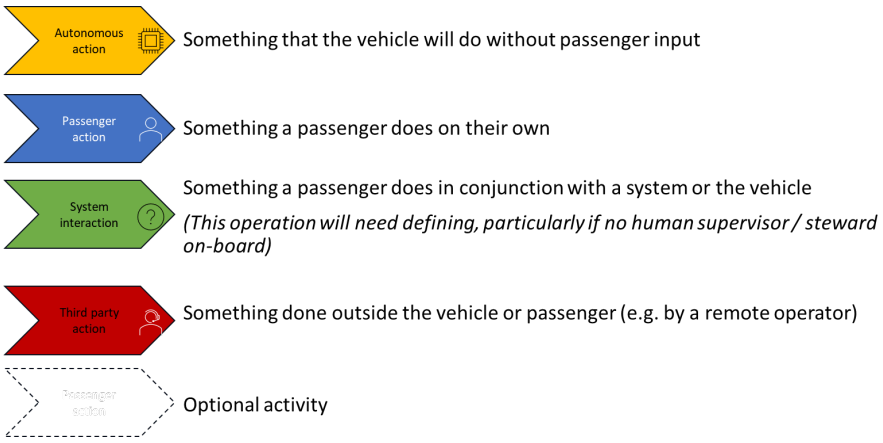
Executive Summary

This deliverable draws on input from the SINFONICA D5.1 (Equity practices and social indicators), developing an overview of inclusive features of a Connected Cooperative and Automated mobility (CCAM) operation. It focuses on the opportunities and constraints of public and shared transport using CCAM regarding users with specific needs. It assesses recent and ongoing CCAM demonstrations in Europe which provide public or shared transport services to citizens. In addition, it contains different end to end journey flows to illustrate the use of different autonomous vehicles and what should be considered for vulnerable users.

This deliverable is one of the first documents within the CCAM network that focuses on inclusion of all persons while using autonomous or connected/semi-autonomous vehicles. This will give insights and input for future projects focused on building CCAM services for all.

The deliverable starts with an overview of the outcome of a questionnaire drafted for this deliverable to get an overview about the different existing CCAM operations and if they considered special features for inclusivity. Eleven responses were received from different European, national or regional projects or pilots, covering 16 different CCAM services for public or shared transport. Specific features for vulnerable groups were not considered in most cases, but usually in such pilots there has been an assistant or safety driver who is able to help users who need assistance. One aspect was to check the roles of such personnel, and under which circumstances certain services could be unstaffed, and the effects this would have. Another main focus was the technical functioning aspect, and whether the vehicle needed to be hailed or booked with an app. This causes often difficulties for different vulnerable groups such as non-digital active people, people with cognitive vulnerabilities, people with visual impairment and elderly. However, there were many vehicles with a ramp for a wheelchair. Specified information regarding the use and functionality of such ramps were not given. Regarding payment, for most of the trials analysed this was not an issue as the service was free to users. For those requiring payment, an assistant or safety driver collected fares or checked tickets or passes, in the same manner as for a normal bus service.

The chapter on journey flows focuses on a few different aspects that need to be considered when creating a CCAM operation from an operator and fabric point of view. The chapter uses the different steps below which results in a few main considerations to create an inclusive CCAM operation and summarised in the last chapter.



These main considerations are as follows:

- **Assistance:** either staff present within the vehicle, at bigger hubs or a travel assistant available to help people with their journey. According to EU law, there must be an option to get travel assistance when needed and wanted. What happens if a passenger feels unsafe, has a question or other issue in an unstaffed vehicle? Button/app/virtual assistant to help.
- **Communication:** staff can help when present, otherwise static screens with audio information regarding stops and change of course. At the stations and in vehicles there could also be a video column at which a traveller could get extra personal assistance and information.
- **Payment:** it cannot only be via an app or online. This will exclude certain groups.
- **Technical:** when will the vehicle start driving? Does everyone need to wear a seatbelt. What about people with a walker or in a wheelchair? Who opens the doors and how? What happens if a passenger blocks the doors and delays the vehicle for the other passengers on board?
- **Layout:** There is a potential need for a general layout or specific features for autonomous buses or shuttles, so users become more familiar and know what to do. Similarly, such vehicles should also be signalled to other road users (especially from the front and back), when driving in autonomous mode – for example warning that it might brake sharply.

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Abbreviations

ACT	Automated and Connected Transport
ADAS	Advanced Driver Assistance Systems
AV	Automated Vehicle
CAD	Connected Automated Driving
CAV	Connected, automated vehicle.
CCAM	Connected, cooperative and automated mobility.
DRT	Demand Responsive Transport
GoI	Group(s) of Interest
HMI	Human Machine Interface
IoT	Internet-of-Things
KPI	Key Performance Indicator
MaaS	Mobility as a Service
OEM	Original Equipment Manufacturer
PMC	People with Mobility Challenges

SDG	Sustainable Development Goals
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-vehicle
VRU	Vulnerable Road User
WP	Work Package

1. Introduction

1.1 Background

This deliverable focuses on the opportunities and constraints of public and shared transport using Connected Cooperative and Automated Mobility (CCAM) regarding users with specific needs, such as (potentially) vulnerable users and other people with mobility challenges (PMC). It assesses recent and ongoing CCAM demonstrations in Europe which provide public or shared transport services to citizens.

This work builds further upon SINFONICA Deliverable 5.1 “Equity practices and social indicators” which focused on completed CCAM projects and the equity practices and social indicators used in them. The present report focuses on the accessibility of the vehicle for different vulnerable groups and considers practical demonstrations and public services, both past and ongoing.

This deliverable focuses principally on CCAM public and shared transport use cases (types of services, vehicles, staffing levels, etc.) in current and recent trials, what has been considered with respect to PMC users, what emerging use cases exist and different aspects of the journey flow of a trip made by a person that is classified as a vulnerable user by European definition. Chapter 3 will elaborate on this definition and explains which vulnerable user groups have been chosen to focus on in this deliverable. Other topics include a state of the art of CCAM projects and if and how they are incorporating accessibility. An overview of technical specifications needed in CCAM and some recommendations.

As a result, the deliverable will contribute to D5.3 which includes policy recommendations and D5.5 which focuses on recommendations for large- scale demonstration projects. Finally, this deliverable will be one of the first documents within the CCAM network that focuses on inclusion of all persons while using one of the vehicles. This will give insights and input for future project focused on building a CCAM operation for all.

1.2 Structure of the document

The first chapter after this introduction will focus on setting the scene with regards to existing and recent CCAM applications for public and shared transport. A questionnaire was drafted for the purpose of this chapter and sent to different CCAM projects to ascertain the different CCAM use cases for public or shared transport, their levels of accessibility and what focus (if any) was put on the requirements of people with mobility challenges. This allows us to see the most common current use cases as well as emerging ones, as well as challenges from an operational perspective. This will feed into recommendations in later deliverables, in that user requirements need to be balanced with cost and operational perspectives.

Following this, Chapter 3 introduces the concept of People with Mobility Challenges (PMC – vulnerable and potentially vulnerable users) from an international point of view and the European one. This adds context to who is considered a vulnerable user, considering that any person can be vulnerable at some times: not just the typically considered groups but also people who do not normally have mobility challenges but might be making an unfamiliar journey, experiences disruption, feels threatened, does not have their regular smartphone available, etc.).

Chapter 4 provides a selection of journey flows demonstrating the different type of CCAM operations that exist or could exist in the near future. It focuses on what to consider making these operations inclusive to set the scene for operators and manufactures to think about features making it inclusive, whether technological, other design features, or human presence and which roles or situations need a member of staff.

Finally, the Conclusions present a short overview of “must haves” in current public transport as well as desirable but possibly non-essential “nice to haves”. Note that these might vary according to the type of service being provides (length, speed, vehicle capacity, scheduled or DRT).

1.3 Links with other SINFONICA outputs

The outputs of this deliverable will feed into recommendations to create an inclusive CCAM operation for all, to be covered in the following two subsequent deliverables in SINFONICA WP5:

- D5.3: Vison and policy recommendations for user-centric CCAM
- D5.4: Guidance and recommendations for demonstrating and implementing user-centric CCAM.

Elements such as a synopsis of the questionnaire survey results (typologies of CCAM-based public transport services) will also be incorporated into the SINFONICA Knowledge Map Explorer, an online resource developed in WP4 of the project.

2. CCAM for public transport: Use cases, vehicle types and existing trials and solutions

2.1 Approach

The approach to this task was to build up information on existing and recent CCAM applications for public and shared transport, in order to create typologies from which the scenarios described in Chapter 4 are based. These comprise the most common types of service being provided in trials now and recently, but also evolving scenarios that are expected in the near future.

A questionnaire survey was developed (see Appendix) and sent by SINFONICA partners in May and June 2024 to over 20 ongoing or recent European, national and regional projects and trials involving CCAM for public or shared transport. The criteria for inclusion were that it involved a public or shared transport service that ran for at least one month and was available for use by the general public (not closed trials with chosen/invited users only). This involved a higher number of actual services because some projects (mostly large European ones) had multiple pilot or trial sites.

Eleven responses were received, representing 16 operations or pilot sites, as shown below.

Belgium:

- IF-20-AUTOVEHI, Grottes de Han and Braine l'Alleud sites

Germany:

- ALIKE, Hamburg
- Shuttle Modellregion Oberfranken, 3 operations in rural Bavaria, website

Greece:

- SHOW (EU project), Trikala pilot site, website

Netherlands:

- Autonoom vervoer / The Future Mobility Network, Drimmelen and Noordwijk sites, website
- Autonoom Vervoer in Groningen, Fryslân en Drenthe, Scheemda site, website
- FABULOS, Helmond pilot site, website
- ParkShuttle Rivium, Rotterdam, website

Sweden

- SHOW (EU project), Linköping pilot site, website

United Kingdom:

- CAVForth, Edinburgh/Fife, website
- MultiCAV, trials on two routes in Oxfordshire, website

In addition, data was collected from public secondary sources (e.g. project websites and articles) from several other projects, including other pilot sites from SHOW, from AVENUE (website) and Sohjoa Baltic (website). Some of the projects contacted (in particular EU ones like IN2CCAM and

ULTIMO and the German project ALIKE) were not eligible because although the project was running at the time of this survey, the CCAM public or shared transport demonstration or trial had not yet started or was not yet usable by the general public. Others were out of scope because as their use cases were not linked to any service that could be used by citizens, while some did not respond because of holidays or because the project had finished and the questionnaire was considered to be too long and complex (although we specified that not all questions are obligatory and respondents can just answer the ones for which they have the relevant information).

With the addition of secondary sources, 16 projects were analysed (some with only partial data), covering 40 individual pilot sites or services. These are shown in Table 1.

Table 1: Responses to survey of CCAM-based public and shared transport trials and operations

Project	**Type of project** (EU, national)	**No. of services /sites/ pilots**	**Locations** (**bold**: questionnaire received; *Italic*, info found from other sources)	**Services ongoing or completed**	**Characteristics**
AVENUE	EU	9	*FR (Lyon)* *LU (Esch-sur-Alzette, Pfaffental, Contern)* *CH (Meyrin, Thônex – Geneve)* *DK (Slagelse, Nordhavn, Ormoya)*	Completed 2020/2021	Demand-responsive minivan /shuttle, 1 to 9km. Assistant at stops
FABULOS	EU	4	*NO (Gjesdal)* *NL (Helmond)* *GR (Lamia)* *EE (Tallinn)*	Completed 2020/2021	Fixed route minivan /shuttle, 2 to 3km. On-board assistant
SHOW	EU	5 mega sites (containing 12 individual trials), 5 satellite sites[1]	**GR (Trikala)** **SE (Linköping)** *ES (Madrid Villaverde)* *DE (Monheim)* *AT (Pörtschach, Klagenfurt)*	Most completed in 2023 or 2024, some ongoing to later in 2024	Mixture of services, fixed route and demand-responsive using minivan/ shuttles, 1 to 9km
Sohjoa Baltic	EU	3	*EE (Tallinn)* *FI (Helsinki)* *PL (Gdansk)*	Completed 2019	Fixed route minivan /shuttle, 1 to 2.5km. Safety driver

[1] Not all sites were analysed, only the six listed here.

Project	**Type of project** (EU, national)	**No. of services /sites/ pilots**	**Locations** (**bold**: questionnaire received; *Italic*, info found from other sources)	**Services ongoing or completed**	**Characteristics**
IF-20-AUTOVEHI	National - BE	2	*BE (***Caves of Han – Han sur Lesse***, Waterloo historic site - Braine l'Alleud)*	Completed 2018/2019	Fixed route minivan /shuttle, 0.5 to 2.4km. Safety driver
SmartShuttles	National – CH	2	*CH (Sion, Uvrier)*	Completed 2019/2021	Minivan /shuttle, 1.5km (fixed route and timetable) and 6.5km (fixed route, demand-responsive). On-board assistant
ABSOLUT	National - DE	2	*DE (Leipzig)*	One completed 2020, one ongoing 2024	Minivan /shuttle, 7km (fixed route and timetable), in 2nd phase (ABSOLUT II) it was demand-responsive). Safety driver
AutoNV_OPR	National - DE	1	*DE (Ostprignitz-Ruppin)*	Completed 2019	Minivan /shuttle, 8km (fixed route and timetable). Safety driver
See Meile	National - DE	1	*DE (Berlin)*	Completed 2019	Minivan /shuttle, 0.6km (fixed route and timetable). Safety driver
Shuttle Modellregion Oberfranken	National – DE	3	**DE (Kronach, Hof, Bad Steben)**	Ongoing to Sep 2024	Two fixed routes with no timetable, one demand-responsive. 3 to 5km, shuttle/mini-bus with safety driver

Project	Type of project (EU, national)	No. of services /sites/ pilots	Locations (**bold**: questionnaire received; *Italic*, info found from other sources)	Services ongoing or completed	Characteristics
Val Thorens shuttle	National - FR	1	*FR (Val Thorens, Savoie)*	Completed 2020	Minivan /shuttle, 3.26km (fixed route and timetable), safety driver. In ski resort (snow conditions)
Parkshuttle Rivium	National – NL	1	**NL (Rotterdam)**	Ongoing in 2024	Automated mini-shuttle, 1.8km, fixed route. Remote operator, no on-board staff
Autonoom vervoer / The Future Mobility Network Regional pilots	National – NL	2	**NL (Drimmelen, Noordwijk)**	Completed 2019/2023	Automated mini-shuttle, 1.5 to 2.5km, fixed route and timetable. Safety driver/on-board assistant
Regional pilot, Scheemda	National – NL	1	**NL (Scheemda)**	Completed 2020	Automated mini-shuttle, 1.2km, fixed route and timetable. Safety driver/on-board assistant
CAVForth	National – UK	1	**UK (Edinburgh Park – Ferrytoll, Fife)**	Ongoing in 2024	Full size bus, 22.5km, fixed route and timetable. Safety driver and on-board assistant
MultiCAV	National – UK	2	**UK (2 services: within Milton Park and from Didcot to Milton Park, Oxfordshire)**	Completed 2023	Mini/midi bus, 1.5 to 5km, fixed route and timetable. Safety driver.

2.2 Use cases for public and collective transport

2.2.1 Bus service with fixed timetables and stops

The majority of services surveyed had a fixed route, timetable and stops. The main reason was that these projects had the key objective of demonstrating autonomous or semi-autonomous vehicles, and that making the service demand-responsive as well was a complication both operationally and potentially reducing the number of people who would use it.

The frequencies ranged from one service per hour to a service every four minutes. Most were every 15 or 30 minutes. Most ran during the daytime only, sometimes only at peak periods or only in the off-peak (for example afternoons only). Very few ran on Sundays and none ran in the evenings, except for ParkShuttle in Rotterdam, which runs until 21:00. This is mostly for operational reasons (only one vehicle being trialled, so needs to take recharging breaks) and also because of the nature of most of the services, for example serving business parks where there is little or no demand at evenings or weekends.

The route length varied from 0.5 km to 22.5 km, the latter being a full-size bus with a safety driver (CAVForth). However most were in the 1.5 to 5 km range (only three services surveyed were over 5 km in length). There have therefore been no known trials in Europe of CCAM public transport operating a full service (early morning to late evening, seven days a week).

Regarding road types, almost all were on low-speed urban roads, with a few on low-speed rural roads. Only one (CAVForth) used motorways or expressways and one (MultiCAV) used a major road outside a built-up area. Both of these services were controlled by a safety driver.

2.2.2 Semi-flexible bus service

Nice services identified ran on demand: one in France (Lyon), two in Switzerland (Geneva) and three each at different locations in Denmark and Luxembourg. In all cases, the route remained fixed, only the timings were flexible according to user demand, usually with booking using an app or website.

There were no examples of flexible routing using automated vehicles. This is an unexplored area of research with many challenges (suitability of the roads, safety of pick-up/drop-off points, how to prioritise conflicting travel demands from different passengers, how to treat late or no-show bookings, etc.).

2.3 Vehicle types and driver/personnel

Where the automation level was known (SAE scale), this was normally level 2 or level 4. On over 80% of the services surveyed, standing passengers were not permitted.

2.3.1 Midi, mini or micro bus

Most services surveyed used an automated or semi-automated mini-shuttle, with between 4 and 12 seated positions. Where standing was allowed, standing space was for between 4 and 14 passengers, and all vehicles had space for one wheelchair.

In most cases a commercially produced vehicle was selected, with criteria being the best type of vehicle to use in mixed traffic, with safety and reliability being of paramount importance. Hence,

the vehicles used are mostly small ones. Mostly, no retrofitting for accessibility was done as the vehicles were already accessible.

The main brands being trialled were:

- Navya (Arma and Autonom® Shuttle Evo)
- EasyMile
- EZIO
- ISEAUTO

The maximum permitted speeds of these vehicles were between 16.5 and 40 km/h, but mostly at 25 km/h. However actual operational speeds were lower.

All had an on-board steward or assistant, as they were trials so the member of staff was needed to reassure passengers and also ensure correct passenger behaviour. Four of the services were double-manned, having both a safety driver and an on-board steward, but it is unlikely that a CCAM service in everyday public use would have two staff members. One trial included staff members at the stops (the service only ran between two bus stops). Most services served 4 or 5 bus stops, with the lowest being 2, so in most cases the doors automatically opened at each stop. Clearly on an everyday bus service with more stops, some would have to be on request (so as not to cause delays if nobody needed to board or alight at a certain stop) and the stopping and door opening would have to be selective.

The MultiCAV service in Oxfordshire, England, used two Mellor Orion minibuses (seated capacity of 15 plus one wheelchair). These are commercially produced classic minibuses (not designed as automated) and adapted for Level 4 automated driving. The ABSOLUT project in Germany also used classic (non-CCAM) vehicle, a Volkswagen Crafter van, again adapted for automation. The MultiCAV service between Milton Park and Didcot had 19 stops, so the stopping and door control was done by the driver whenever necessary. For such retrofitted classic vehicles, the main feature added were cameras enabling complete vision inside the vehicle as well as the surrounding road environment.

2.3.2 Full size bus (single deck)

The only known service to use a full-size bus was the CAVForth service operated by Stagecoach in Scotland. This vehicle (standard diesel bus) has a capacity of 36 seated passengers and a wheelchair, as well as a traditional driving cab so the driver can take over when required. The typical top operational speed of this service is 80 km/h (50 miles per hour) on motorway and expressway sections. Although the vehicle (see Figures 1 and 2) has space and facilities for standing passengers, for this service standees are not allowed, and passengers are required to wear seatbelts.

Figure 1: Alexander-Dennis Enviro 200 diesel bus used on CAVForth service AB1 in Scotland (location: Ferrytoll Park and Ride, near Inverkeithing, Fife)[2]

Figure 2: Interior view of teh CAVForth AB1 bus[3]

In addition, the MultiCAV service, used a midi-bus with a seated capacity of 28 passengers to supplement the two minibuses mentioned above.

In both cases, there was a driver (or "captain") who took control of the vehicle when a request stop needed to be made. The driver's role is also one of customer service, including issuing and checking tickets and passes.

2.4 Reasons for use cases

The trials and services surveyed were chosen for the following reasons:

- Last mile between entrance of a restricted area to several office buildings on a site.
- Linking an economic zone or business park to a railway station.
- Interest from the owner of a business park.
- Potential to test integration of CCAM bus services with rail services (multimodal passenger journeys).
- Linking rural areas on the periphery of a small city, which are underserved by public transport.
- Access from a public transport route to a hospital site.
- Commercial interest by the bus operator.
- Types of roads used were chosen to give the self-driving technology the best chance of success (less scope for driving problems).

[2] Credit: Andrew Winder, ERTICO
[3] Credit: Andrew Winder, ERTICO

2.5 Summary of feedback and issues encountered

Some key aspects learnt from the trials surveyed were:

- Sometimes problems with GNSS caused the vehicle to stop.
- On major roads, the safety driver sometimes had to take control e.g. to exit from a junction or enter a roundabout, where the autonomous system was sometimes too cautious and a human driver could be more assertive in moving out into busy traffic, to avoid the bus waiting for long periods for a gap in the traffic.
- Similarly, badly or illegally parked cars can significantly delay the service if there is no safety driver to take control, otherwise the vehicle waits for too long if there is no gap in oncoming traffic.
- Recognition of (and autonomous behaviour with respect to) emergency vehicles was an issue in one demonstration.
- Passengers who gave positive reactions (most of them) generally felt that their perception of safety might change (safety concerns would increase) if it was a larger sized bus with no attendants on board, travelling at regular traffic speeds. Most of the services surveyed operated at very low speeds.
- On some services, passengers commented on the small size of the vehicle, saying that people are sitting too close together and that it would need to be larger to accommodate luggage and shopping bags.
- Although people generally felt safe at the low speeds at which these services operated, they were generally considered to be too slow for everyday purposes such as commuting to work, so they would be unattractive compared to other modes.
- Automated vehicles sometimes lurch when starting or stopping. For vehicles without seatbelts, some users felt that they should be provided. Sudden stops for no valid reason were sometimes reported, e.g. suddenly stopping if a plastic bag is blown in front of the vehicle by the wind or if a bird flies nearby.

3. Accessibility and vulnerable users

As this deliverable provides a comprehensive overview, but not an exclusively one, regarding different types of vulnerable users in public transport, it is necessary to have a look at the definition of accessibility. In addition, safety is also an important keyword. There will be illustrated end-to-end journey flows regarding the use of different CCAM operations and how people with mobility issues can use them. The technical features need to be safe, but there should also be given thought in creating a safe environment for vulnerable groups. The journey flow will show that there is a need for a safety button to use when someone wants to leave the vehicle due to health, emotional or any other reasons. Safety is a pre-condition for accessibility. This is confirmed by implementing different Sustainable Development Goals (SDG). To be truly inclusive, one must implement SDG 11.2 focusing on safe and sustainable transport and SDG3.6 aiming at road safety. Yet, it is crucial to link

accessibility (among others SDG 11), to a safe operation to create fully inclusive and accessible public transport and CCAM.[4]

However, we will have a look at how the international community talks about accessibility to include different vulnerable groups in this research first. The European legislation will follow this chapter and will create a bridge to the vulnerable user in public transport as that is sometimes part of legislation. As mentioned, chapter 5 will include accessibility in CCAM operations illustrating some must haves and nice to haves.

3.1 International and European definition accessibility in public transport

International definition

As the United Nations (afterwards UN) is the most well-known international institution which discusses not only security issues, but also tries to set different international standards, we will have a look at the definition of vulnerable groups within international society. First of all, the UN has created the International Bill of Human Rights containing very important rights such as freedom of movement, freedom of discrimination and the right to life. Rights that should be upheld by everyone working on CCAM to make it inclusive for all.[5]

However, the more important one for this project is the Universal Declaration of Human Rights. It is such a big milestone document in the history of Human Rights as many different countries and thus cultures, created fundamental Human Rights that need to be universally protected. The first article states the following:

“All human beings are born free and equal in dignity and rights. They are endowed with reason and conscience and should act towards one another in a spirit of brotherhood.”

The second article focuses on all rights and freedoms without distinction of any kind.[6]

This is the main declaration on which all other bills are followed and drafted. To provide more rights to vulnerable groups in society, the UN also drafted the Convention on the Rights of Persons with Disabilities. This convention reaffirms the universality, indivisibility, interdependence and interrelatedness of all human rights and fundamental freedoms and the need for persons with disabilities to be guaranteed their full enjoyment without discrimination. Yet, the project of SINFONICA is not merely focused on people with disability. It also focuses on people with other special needs based on for example gender, non-digitally connected people and people with different native language.

There are two articles from the convention that stand out for this project. One of them is article 9 that focuses on the enablement of persons with disabilities by States Parties to live independently and participate fully in all aspects of life. They need to ensure that these people that are more vulnerable in society get equal access to, among others, transportation, information and communication. Facilities and services should be public and available in urban and rural areas. It

[4] 190518-sdgs_uitpHI_LEAFLET_LRes.pdf
[5] International Bill of Human Rights | OHCHR
[6] OHCHR | Universal Declaration of Human Rights - English

points out that measures should focus on barriers to accessibility of buildings, roads, transportation, communication and more. These aspects have been asked in the questionnaire that is the base of the second chapter and will be demonstrated in the journey flows of a CCAM operation in the next chapter.

European definition

As this project is focused on Europe and part of European funding, it is necessary to have a look at inclusiveness, accessibility and the vulnerable user in the European context.

The European Accessibility Act follows the UN convention on Rights of Persons with disabilities. It is an EU law that upholds the rights of persons with disabilities to have the possibility to use everyday products and services. The act will make life easier for at least 87 million people as almost 1 in five Europeans have a disability. This includes many older people that have a temporary impairment. This illustrates that also elderly, included in this research, belong to the vulnerable group. [7]

In 2011, the Commission consulted stakeholders and experts on accessibility and published an impact assessment to accompany the proposal Directive on approximation of the laws, regulations and administrative provisions of the Member States as regards accessibility requirements for products and services. This was the result after a fragmentation of the internal market and the neglection of requirements related to goods and services for vulnerable groups. An interesting outcome of the consultation was that citizens wanted to give priority to increase accessibility for disabled and elder people. They pointed out that information and communications, and transportation were the top two priorities which are topics of discussion and research within this project.[8]

The Commission published *Sustainable and Smart Mobility Strategy – putting European transport on track for the future* in 2020. Point 8 in this strategy focuses on inclusiveness of all within mobility. It should be available, affordable and better connected. In addition, it should be accessible for persons with reduced mobility and persons with disabilities. The horizon-2020 projects contribute to this point as it launches calls to produce science, removes barriers to innovations and makes it easier for the public and private sectors to work together in delivering innovation beneficial for all.[9]

Lastly, all nation states are mandatory to implement the EU accessibility law since 2022. The European Commission adopted the Strategy for the rights of persons with disabilities 2021-2030 to improve the lives of said groups in Europe and around the world. Accessibility to the built and virtual environments including information and communication and transport is mentioned as an enabler of rights and prerequisite for the full participation of persons with disabilities on an equal basis with others.[10] In addition to this, there is a revised passenger rights regulation. One section gives special attention to the needs of passengers with disabilities or reduced mobility. There needs to be free assistance available at connecting points by carriers and operators. Furthermore, they are obliged

[7] European accessibility act - Employment, Social Affairs & Inclusion - European Commission (europa.eu)
[8] EUR-Lex - 52015SC0264 - EN - EUR-Lex (europa.eu)
[9] EUR-Lex - 52020DC0789 - EN - EUR-Lex (europa.eu)
[10] Publications catalogue - Employment, Social Affairs & Inclusion - European Commission (europa.eu)

to report on the number of persons with disabilities to whom they deny transport and the number of complaints received plus their outcome.

3.2 Vulnerable users within the SINFONICA project

This next paragraph will explain who are considered vulnerable users within the SINFONICA project. This is of course not an exclusive list, but merely a focus to not have a broad scope. Other paragraphs will show some features that are already implemented in regular public transport and what needs to improve. Finally, there will be a table with features mandatory in CCAM to assist vulnerable users in their journey.

In Deliverable 5.1 of the SINFONICA project, transportation equity as accessibility has been researched. This paragraph lists the vulnerable groups researched within SINFONICA. In case there is a need for more in-depth information, the project can provide Deliverable 5.1.

List of vulnerable groups within SINFONICA:

- Young people (18 – 25 years old)
- Older people (65 years old and over)
- Persons with disabilities
- non-digitally connected people
- Women and gender related vulnerabilities
- Persons at risk of poverty
- People affected because of their place of living (rural-urban areas)
- Other potential users, e.g., single parent family, university students, cyclists, etc.

4. Journey flows

This chapter will focus on the journey flows of different CCAM operations. When considering how vulnerable users will interact with Automated Public or Shared Transport services, it is important to consider the whole end to end journey. Within SINFONICA, we have considered four core scenarios, representing the near-future operating approaches of Automated Public Transport services. We have focused on road-based transport, although the approach could apply to automated trams if they are not operating on dedicated right of way or stations. These Scenarios have two main aims:

1. Identify considerations for vulnerable people about automated services
2. Provide an approach that can be used in the development of future automated services

The four core scenarios we have considered are:

> **Scenario 1: Autonomous Shuttle, operating in a campus environment, no payment, Safety Steward on board**
>
> Examples: various projects, e.g. SHOW[11] (Horizon 2020 funded)
>
> **Scenario 2: Autonomous Bus, operates as bus with stops, tap-in-tap out payment, Safety Steward in driving location**
>
> Examples: CAVForth[12] (Innovate UK funded project)
>
> **Scenario 3: Autonomous shuttle, flexible service, hailed or paid for by App, No staff on-board**
>
> Examples: currently none operating in Europe in this fashion but considered as a scenario representing a near-future possibility. This is similar operating regime to Waymo taxis in the US, although that is not a public transport service.
>
> **Scenario 4: Low speed shared Autonomous shuttle, no bus stops, working in mixed traffic, no staff on-board**
>
> Examples: Zoox[13]

In each Scenario we have listed a comparable service. This is to illustrate a similar type of service, but for each Scenario, we developed a generic operating approach not based on a specific service and identified the likely steps of a passenger completing an end-to-end journey (e.g. from home to destination). For each step, we determined who carries out the action.

The Scenarios assume that an automated service but could also be delivered via a human operating the vehicle via remote control if not present in the vehicle.

[11] https://show-project.eu/
[12] https://www.cavforth.com/
[13] https://zoox.com/

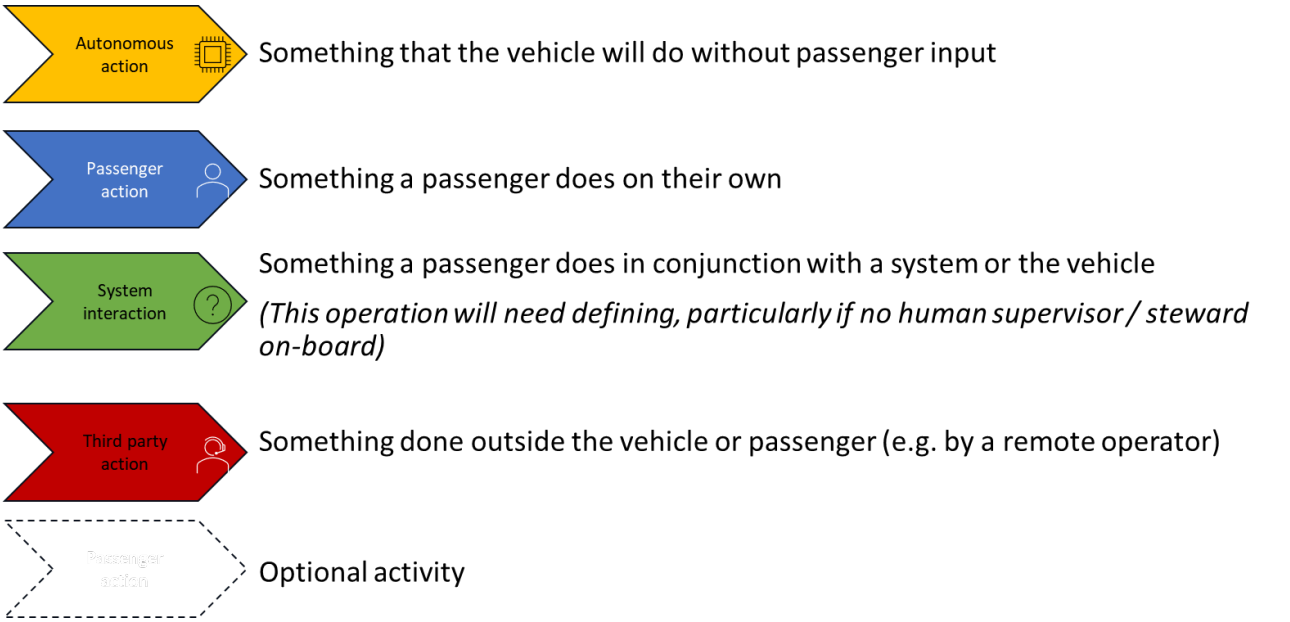


Figure 3: Types of interaction between a passenger (users) and vehicle

Presented in the following sections are our end-to-end journey steps. Note: as these are generic approaches, the exact operating regime may vary in practice. In considering these scenarios, our focus is on the elements that differ from typical public transport services. For example, ticketing will be an important consideration for automated services, but it is likely to be similar to current services with drivers or staff. Therefore, it is not a focus of the flow, but there should be considerations for non-digital active persons. The project also assumes that any services would be integrated into approaches / systems used for non-automated services.

A key question for the design of service operations (and the specific implementation of journey flows) is whether services need to be provided are for targeted at certain groups or demographics and segments. Publicly operated services are typically assumed to be open to all, whereas private services might be more limited. National and regional legislation around equalities (either applying to a specific mode or in general) is an important consideration.

4.1 Scenario 1: Autonomous Shuttle, operating in a campus environment, no payment, Safety Steward on board

In this scenario, we assume that the Autonomous Shuttle is operating on a fixed route which pre-defined stops. The pre-defined stops mean that the passenger is assumed to go to a specific location and the Safety Steward handles the safe entry and exit of the passenger. This scenario assumes a campus environment where the campus owner pays for the service and there is no cost to the passenger. The end-to-end journey flow is shown below:

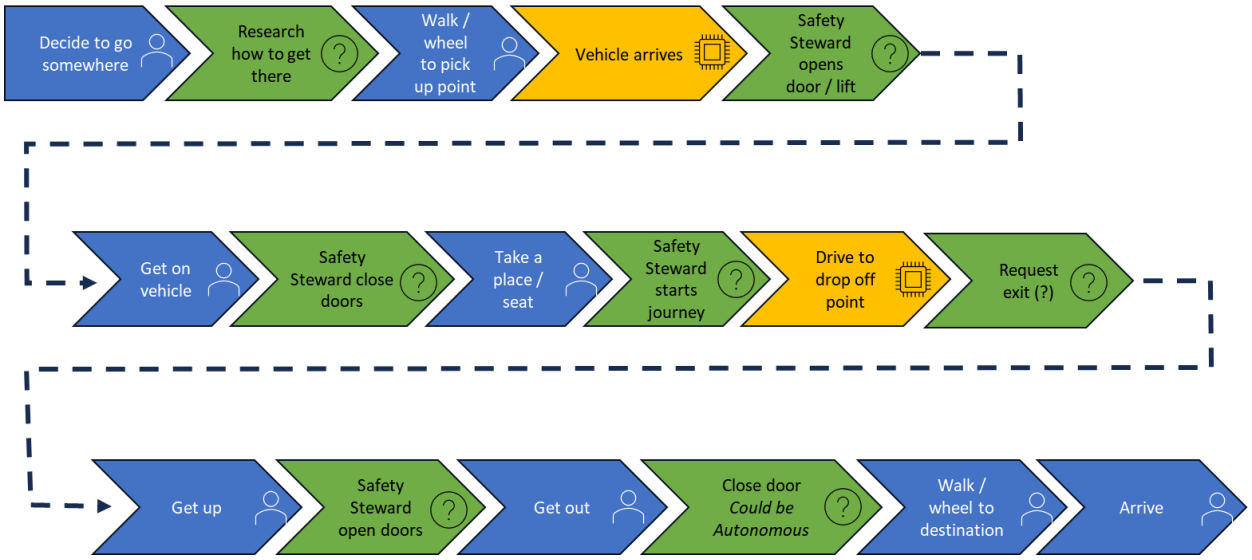


Figure 4: Scenario 1 end to end journey steps

Key considerations

This is a relatively simple scenario, with the Safety Steward present and is not that different to how campus-based shuttles operate now. It is expected that in the near future these operations will continue to grow.

4.2 Scenario 2: Autonomous Bus, operates as bus with stops and tap-in / tap-out payment, Safety Steward in driving location

In this scenario, we assume a bus service similar to one operating in most regions today. The main difference being that the bus driver is not actively driving the vehicle but monitoring the service. There are some additional complexities compared to Scenario 1, particularly around payment and the storage of luggage.

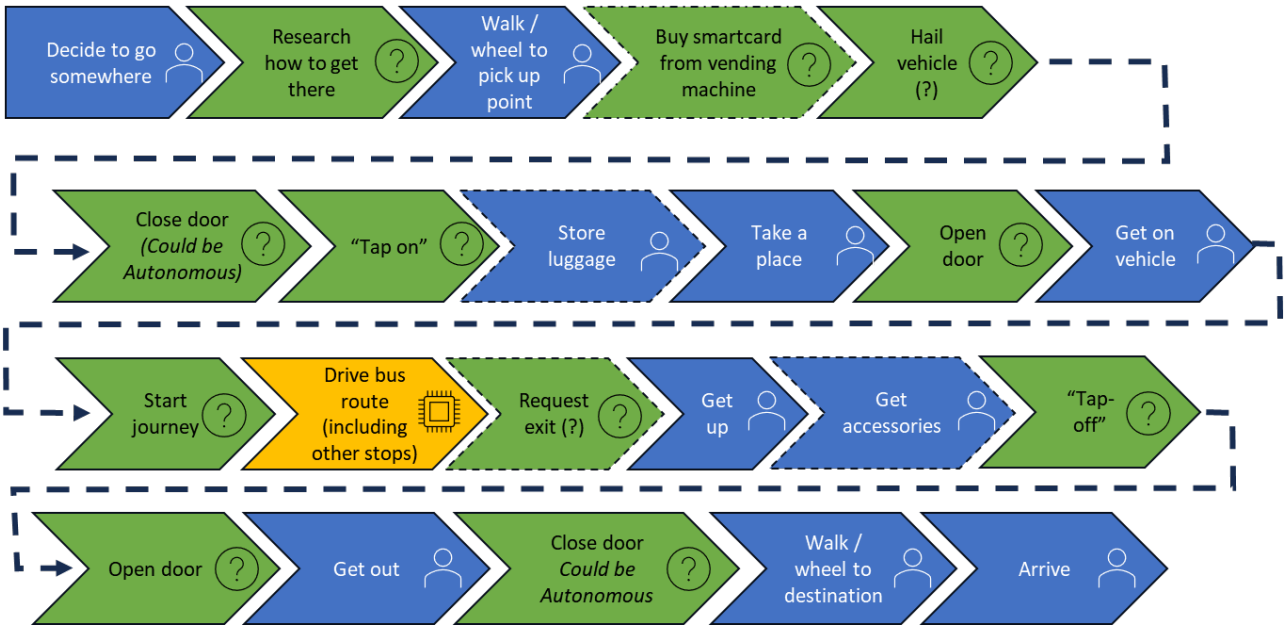


Figure 5: Scenario 2 end to end journey steps

Key Considerations

In the journey flow above, the vehicle is only assumed to leave a stop when the passenger has safely sat down but this might not happen in practice, as it would add additional dwell time compared to a human driven bus (with negative possible impacts on congestion and operational efficiency). If an automated driving system is to start with the passenger still moving, it needs to be smooth and avoid sudden stops.

The role of the Safety Steward is important in this Scenario and whether they interact with passengers is important and needs detailed consideration. For instance, the Safety Steward may be responsible for checking whether passengers have hailed the vehicle. Otherwise, a technological solution is required.

4.3 Scenario 3: Autonomous shuttle, hailed by App, No staff on-board

This scenario assumes a future development of Scenario 1, where there is no longer a safety driver and an autonomous shuttle can be hailed to pick up from any or a range of locations similar to demand responsive transport services today.

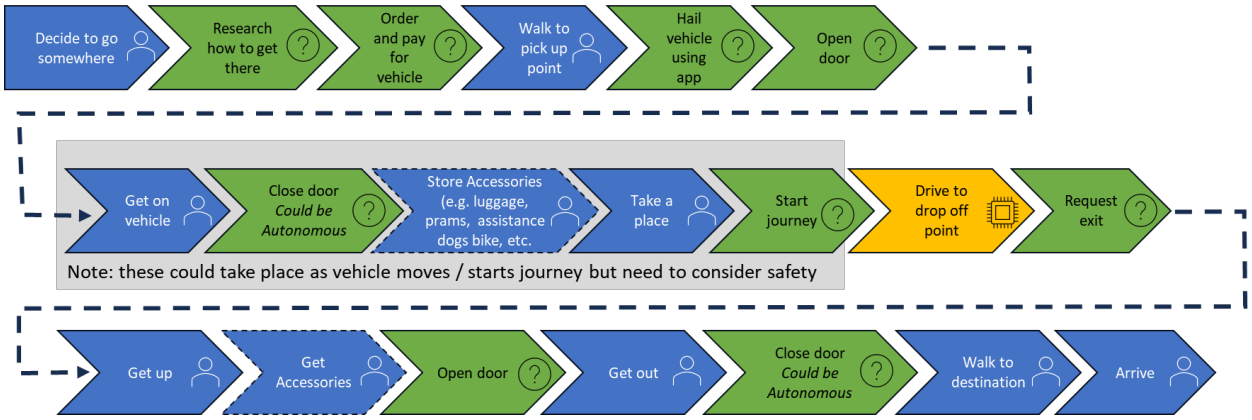


Figure 6: Scenario 3 end to end journey steps

Key Considerations

With no staff on-board, there is a need to open the door by a passenger. This will require some kind of technological solution, such as:

- Pressing a button on the vehicle door (but this might introduce security issues)
- Using an app (for example this is how Waymo works[14])
- Using a public transport smartcard on a reader (for example, this is a typical approach with car clubs)
- Machine vision or other technology to recognise an individual

[14] https://support.google.com/waymo/answer/11020106?hl=en (visited on 12/07/2024)

For services aiming for inclusion, it is important to consider whether multiple approaches are needed. For example, an app might not be accessible to those with impairments or not digitally literate and not everyone would be able to touch a button at the door.

4.4 Scenario 4: Shared, Low-speed Autonomous shuttle, no bus stops, working in mixed traffic, no staff on-board

This scenario is similar to Scenario 3, but we have assumed that a passenger can order the service by phone and that it is shared. The mixed-traffic nature of the service will make the automated driving task more challenging as the vehicle will need to interact with other vehicles.

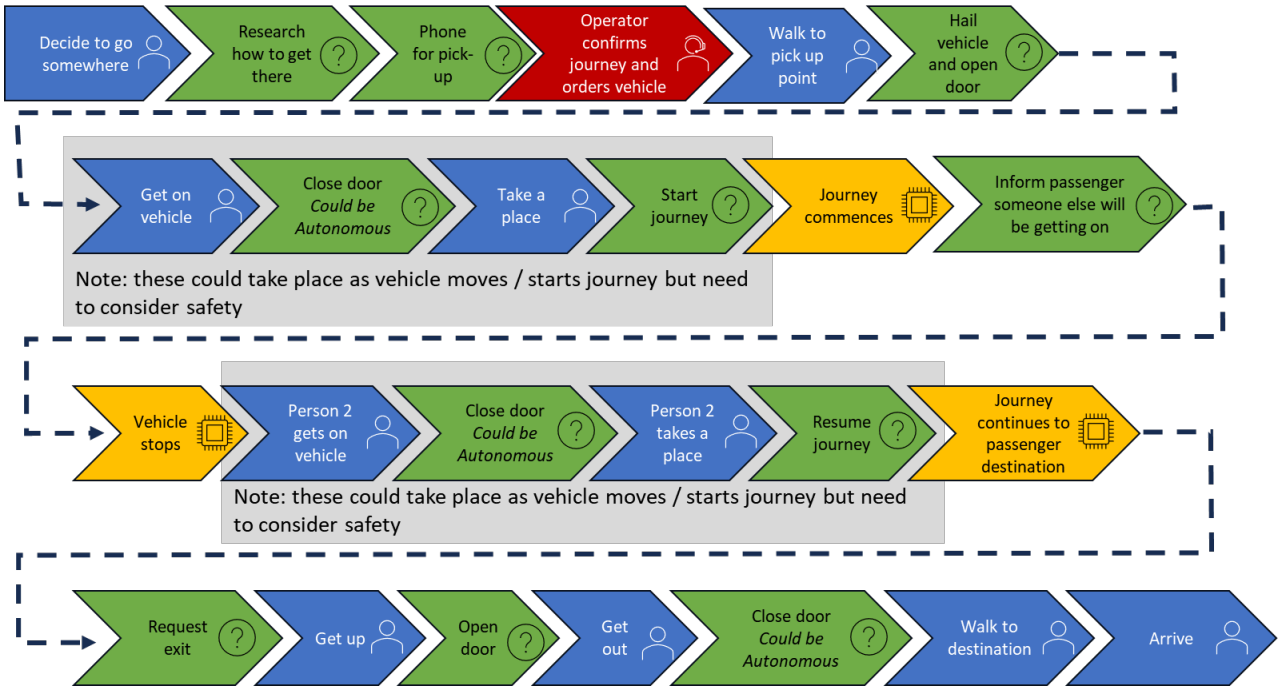


Figure 7: Scenario 4 end to end journey steps

Key considerations

As a shared service, the routing could change mid-journey so that there needs to be a way of informing the passenger of the journey change. Also, the other passenger boarding and successfully starting journey needs to be considered so that all passengers are safely seated before the journey resumes.

Without an App to hail the vehicle or open the door, a different approach is required.

4.5 Scenario variations – catering for different needs

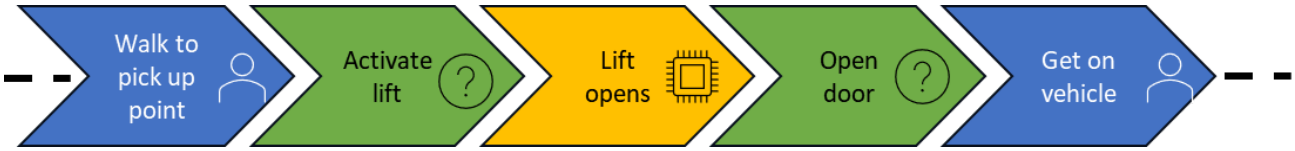
Different types of users will have different needs and it is important to consider the variations of different people. To illustrate this, we have included some examples below, but these are not exhaustive.

Wheelchair access ramp for entry: applies to Scenarios 3 and 4, could apply to Scenario 1 and depending on role of safety steward

In the core journey flow of Scenarios 1 and 2, passengers re assumed to walk and wheel to and from the vehicle. This is because it is assumed that the vehicle has a wheelchair lift / boarding lift - see example below. The safety steward can manually operate the vehicle wheelchair lift.

Figure 8: Ohmio (New Zealand based) Shuttle showing step / retractable wheelchair lift just under door[15]

However, in the core flows for Scenario 3 and 4, only walking is assumed. This is because a different flow will be required to operate the lift if a safety steward is not present to manually trigger it. The variation is shown below. (Note: a similar approach applies to exit from the vehicle)



In this journey flow, the person in the wheelchair needs a way of triggering the lift. This could be included via:

- Pressing a button on an App (but this might not be suitable if the user has additional impairments as well as reduced mobility)
- Pressing a button on the outside of the vehicle (this also might not be suitable if the user has additional impairments as well as reduced mobility).

[15] Credit: John Paddington, ERTICO

- The ability for the shuttle to detect the person in the wheelchair automatically. This could be done in different ways. An example is through machine vision or if the wheelchair user or detecting an RFID token or by Bluetooth from the wheelchair users' phone.

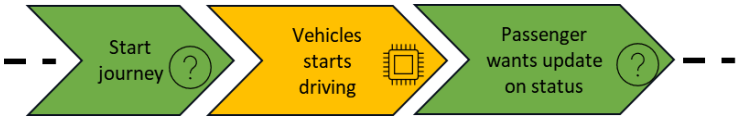
An alternative is to have level boarding where the vehicle stops are raised so that the wheelchair user can simply wheel into the vehicle. However, this will require the pavement to be elevated to the entry height of the vehicle (at additional cost) and the automated vehicle being able to park precisely close to the stop, ensuring that there is limited gap between stop and vehicle. This infrastructure approach also restricts exit in an emergency as the vehicle needs to stop at an appropriate location.

In-journey requirement / Request Information requirement (applies to all scenarios)

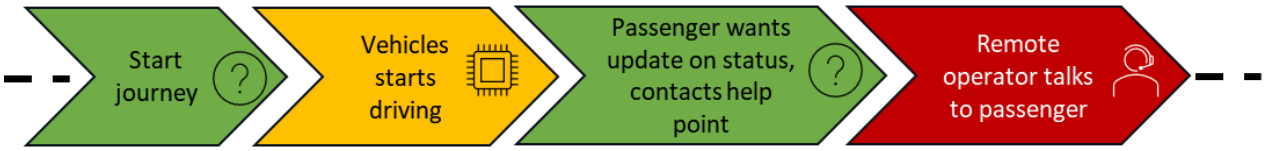
Providing information to passengers during their journey will provide reassurance about their journey and to provide safety and information messages. Especially if a human (safety steward) is not present or their role is purely to monitor the safety of the vehicle and not interact with passengers while the vehicle is moving.

It is important to consider people with neuro-diverse needs and that different people would prefer a different way of obtaining this information. These two variations fulfil the same need but could be delivered differently:

Systems based approach:



Talking to a remote operator



The first is a systems-based approach. This could be delivered in different ways – the simplest would be a screen with information (but that would not cater for people with sight impairments) or audio announcements (but does not cater for those with hearing impairments), so both approaches might be needed for the service to be inclusive. This is already included in many public transport operations, so this would not be a special new technical feature. However, there is a downside to this. Screens are not interactive and therefore do not tailor all needs.

More advanced versions would be to provide a virtual assistance who can interact with the passengers either audibly or visually.

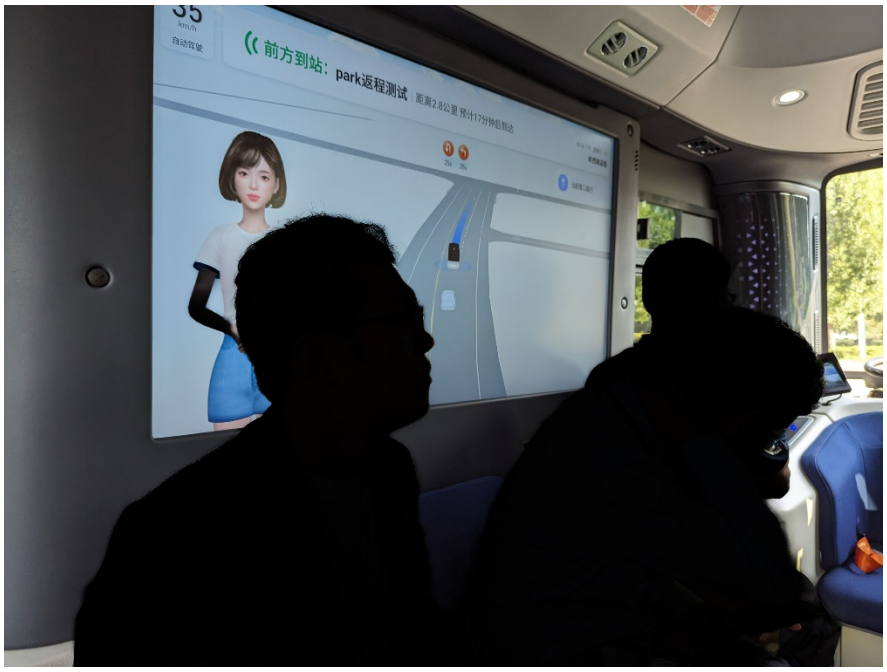


Figure 9: Example of information screen and virtual assistant panel from Baidu autonomous shuttle in China[16]

The second approach is where the passenger can be put in contact with a remote operator who talks to a passenger. How a passenger can contact help is an important consideration (especially if someone is alone in a vehicle) and there could be different approaches, such as:

- Pressing a help button in the vehicle (but this could add additional safety issues if people have to move in the vehicle to reach the button)
- Using the App to contact assistance (if there is an App)
- Video recognition of a gesture or unexpected behaviour from people
- Voice recognition or permanent audio connection to an operator

A truly inclusive approach would allow different approaches to cater for different people.

4.6 Scenario variations - contingencies

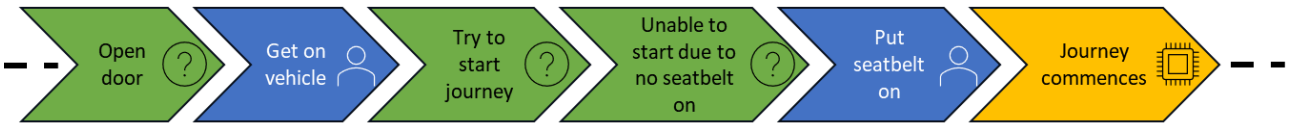
It is important not to just consider core operating scenarios, it is also important to consider variations, for instance where something goes wrong. These scenarios are particularly important as they may introduce new accessibility and inclusivity requirements. The following are some examples (but again not exhaustive but aim to illustrate the types of scenarios and thinking that will be required):

Safety (seatbelts / standing etc.) detection: applies to all scenarios

Depending on the operating rules (either set by the Operator or Regional / National legislation) there might be a requirement to enforce certain rules, for example that people cannot stand, or seatbelts must be worn.

[16] Credit: John Paddington, ERTICO. Passengers blurred for their privacy.

In this variation, there will be a need to perform checks that the safety conditions are met. For example, the flow for a passenger not initially wearing a seatbelt would be as follows:



This could be performed using sensors on the market and common in passenger vehicles. The flow for other safety rules (such as no standing) would be similar but need to use other technologies such as machine vision detection.

The variation assumes that the passenger rectifies the situation and puts their seatbelt on. If they continue to not do so, intervention of a Remote Operator to interact with the passenger may be required.

An extended consideration of this variation for consideration by operators, is then what happens if someone removes a seatbelt during the journey. Would a vehicle provide a warning or would it stop and pull-over until the passenger puts their seatbelt back on?

This variation could also apply to the safety steward (if present) as well, depending on what rules apply to them.

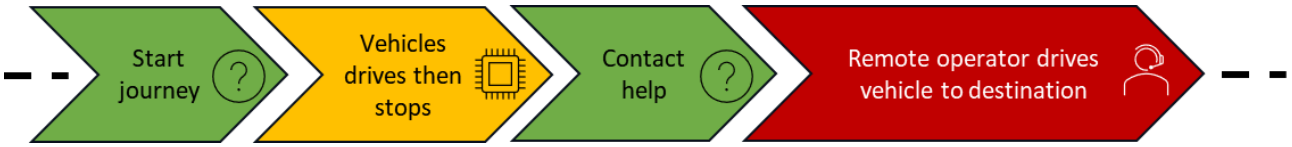
Evading parking vehicles: applies to scenarios 3 and 4 but may also apply to Scenario 1 and 2 depending on role of the Safety Steward

There may be a situation where an automated vehicle tries to arrive at a drop-off point but finds itself blocked by another vehicle. There are many ways an automated vehicle might handle this eventuality, but the simplest one is that it waits for the blocking vehicle to move away, as shown in this variation:

Ignoring the functionality of the automated driving system, the operational consideration for this variation is whether to inform passengers of the reason for the delay and what is happening. There could be either audio and / or visual announcements, either delivered directly in vehicle or via app (if applicable). It is important to consider the needs of passengers – some may find additional information reassuring or other might find it intrusive. Exploring options for passengers to choose the appropriate level of information is needed. The App-based approach could allow this or individual screens for each seat may give flexibility (but potentially increase costs).

Automation fail (remote operator option): applies to all Scenarios

This scenario represents a situation where an automated vehicle has stopped. Most likely due to encountering a situation that its Automated Driving System cannot handle (outside its Operational Design Domain) or due to a fault. In this scenario, there needs to be a way of the passenger(s) to contact help and for a Remote Operator to take over:



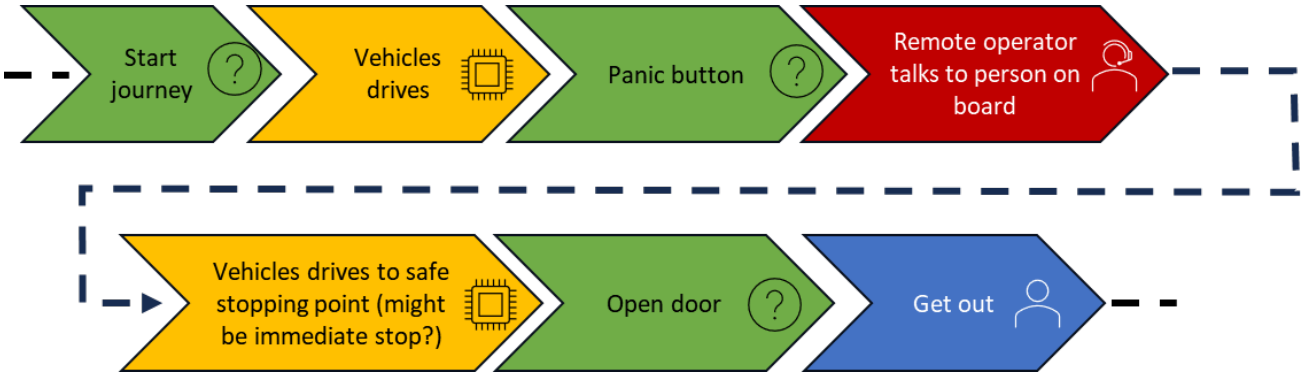
Depending on the situation, the vehicle stopping might be a sudden "Emergency Stop". How this is preformed needs consideration and depends on whether there are standing passengers, passengers are wearing seatbelts, etc.

There could also be a notification to passengers that the vehicle is about to stop or is stopping to keep them informed.

Note: if the scenario has occurred due to a fault in the hardware / software, this might also limit the safe remote operation of the vehicle.

Emergency / passenger wishes to exit early – no Safety Steward: Applies to Scenario 3 (possibly Scenario 2)

This scenario represents a situation where a passenger needs to leave a vehicle early (for instance if they have a health situation).

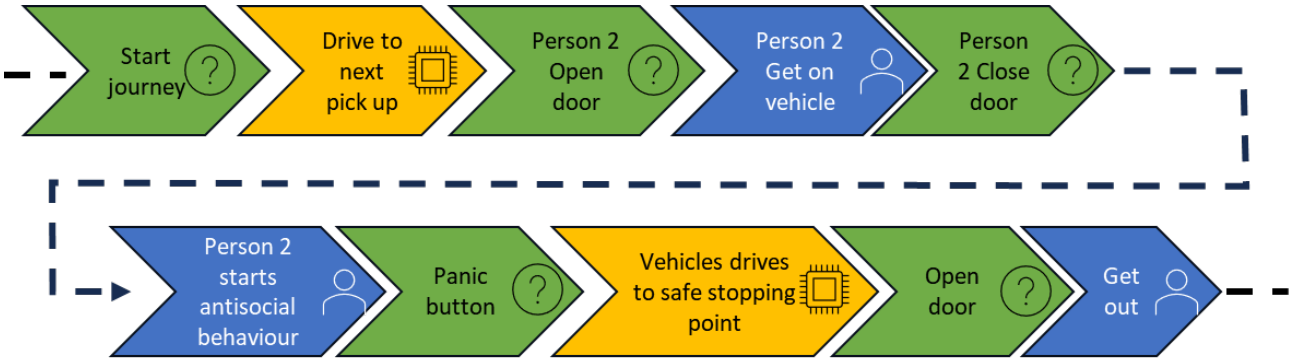


Like the previous scenario – the panic button or contacting help is a key consideration. The safe stopping is also another important consideration (which is discussed below in Section 4.5)

If the vehicle can accommodate wheelchairs, the stopping location needs to allow safe exist (either via a ramp or at a designated stop).

Other Person Boards – anti social behaviour and no Safety Steward: Applies to Scenario 3 (possibly Scenario 2)

Anti-social behaviour will be a particular issue for unstaffed automated vehicles. A method will be required for someone to raise an alarm and the vehicle drive safely to a stopping point.



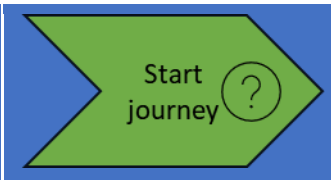
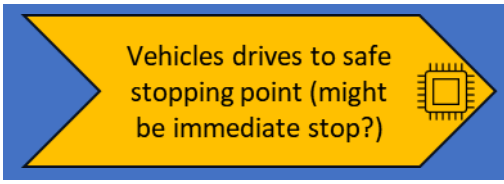
This scenario is similar to the previous one but has a further consideration – there could be a need for a discreet way of raising an alarm to prevent escalation of a situation.

4.7 Journey step considerations

The scenarios listed above are generic and as such don't reflect the specific operating approach of the Automated Public Transport Service. For those steps that require interaction between the Passenger and a System (green arrows) or fully automated actions (yellow arrows), it is important to consider the specific implementation of that step. The table below presents an example of the type of analysis that should be developed.

Table 2: Journey step considerations

Examples of Journey Steps	Start journey	Vehicles drives to safe stopping point (might be immediate stop?)
Goal / aim ("As a passenger, I want to…"	Confirm to the vehicle that I am ready for the vehicle to move.	Get the vehicle to stop so I can exit the vehicle
If operator present	Assume the operator will confirm	Operator will be in charge of emergency stop process
If no operator present	The passenger will need to do this (but what happens if multiple passengers?)	There will need to be a way for a passenger to activate an emergency stop
Technology considerations	Could be automatic: machine vision? Or button based or voice based?	Button based, voice based? Manual override for operator to drive? Remote monitoring / validation?

Examples of Journey Steps		
	Remote monitoring / validation?	
Accessibility considerations	Interface needs to be accessible for those with impairments / disabilities	Interface needs to be accessible for those with impairments / disabilities
Legal needs	Safety regulations – e.g. should passengers be seated? Wearing seatbelts?	Safety – liability of stopping vs not stopping (and resultant impacts)
Safety considerations	Ensuring vehicle only moves when safe for passengers Passengers will want to feel safe and there is a way of contacting help / that their journey is being monitored.	Would an emergency stop provide more issues? Should doors open?

5. Conclusions

As Deliverable 5.1 already summarised the vulnerable users, their needs and different KPI's that should be taken in consideration creating an inclusive CCAM operation, this chapter summarises the must haves in common public transport and CCAM operations. Many inclusivity features of a current public transport bus operation can be copied to a CCAM operation. However, there is a need for some extra features and considerations to create a proper inclusive automated operation that can be used by different types of vulnerable groups. Following this introduction, the first paragraph will focus on inclusivity in public transport bus operations. This will be followed by extra considerations for CCAM. Once again, this is not an exhausted list of features, merely a first step to consider more features than only technical ones for CCAM.

5.1 Features in current public transport

To understand special needs and must haves for a CCAM operation to be fully inclusive, there is a need for summarising the current accessibility features in regular public transport at the moment and their improvements. The province of Utrecht in the Netherlands has assigned research[17] about accessibility to a mobility research group to investigate the current state of accessibility in public transport and this can be improved in an upcoming tender.

This paragraph describes some interesting outcomes of the research focused on a few research groups of SINFONICA. This includes people with visual impairment, people in wheelchairs and people with walkers/elderly.

For people with a visual impairment, travel by public transport is based on a continuous reconnaissance. They need to investigate where stop buttons are, how the door opens, on which side there is a machine to scan your ticket, are there other obstacles like bags and is the sound on of the public address system. The research concludes that 52% of the respondents with visual impairments are associating travels by bus as something negative. This is also the result of a non-existing coherent outline of busses and the stops. This summary of a bigger research about inclusiveness of public transport confirms one of the features mentioned in the journey flows. There should be screens with information within the vehicle with information including an audio version. Moreover, it would be best to start with a general outline of the autonomous vehicle now the market is still developing. People with visual impairment, but also people on the spectrum will profit from one outline and way of working.
According to this research, people with a walker have big troubles with reaching the stop which is of course the first part of the physical journey. Apparently, the bus stops are well designed for wheelchairs, but less for walkers. In addition, people with walkers are confused about the spot they are allowed to take in the bus. Many spots are designed for wheelchairs, but the walker also needs a spot. Who has preference when both a person with a walker and a person in a wheelchair want to take the bus. The research also shows that both visually impaired people and people with a walker want to have a handle with contrasting colour so they know where they can hold onto when moving in and out the bus.

[17] Goudappel (2022), Toegankelijk busmaterieel provincie Utrecht

People in wheelchairs cannot enter and leave the bus without any help. Even though the bus has an electric ramp. This is the result of the bus stop and the height of the bus, and the inclination of the ramp. This causes physical troubles, but also mentally. Especially with electric wheelchairs that are less agile. This emphasises that there should be some form of assistance at bus stops or within the vehicle when a person in a wheelchair wants to use a CCAM operation.

The following table is based on the research of the province of Utrecht. However, it is a summary of a longer table with more suggestions to add in a bus that are vulnerable group specific. The table below gives an overview of suggestions that could be included in all buses to improve the journey of different vulnerable groups.

Table 3: Public transport vehicle features per user group

Feature	**User group**	**Responsible party**	**Priority** *(+ high, 0 middle, - low)*	**Effort** *(+ high, 0 middle, - little)*
Screen for people driving backwards	Wheelchair, walker, motoric vulnerable, auditive vulnerable	PTA, PTO, Fabric	+	-
Sufficient grips with contrasting colour	Visual vulnerable, walker, motoric vulnerable	PTO, Fabric	+	-
Contrasting colours at the doors to mark difference in height	Visual vulnerable, walker, motoric vulnerable	PTO, Fabric	+	-
Less distance between stop and bus	Visual vulnerable, walker, motoric vulnerable, wheelchair	PTA, PTO, Fabric	+	0
Places for luggage	Visual vulnerable, motoric vulnerable, wheelchair	PTO, Fabric	+	0
Multifunctional places for wheelchairs, strollers, walkers	Wheelchair, Walker, parents	PTO, Fabric	+	0
Improving inclination ramp	Wheelchair, walker	PTO, Fabric	+	0
Inner mirror big enough to check on passengers	All	PTO, Fabric	0	+

Feature	User group	Responsible party	Priority *(+ high, 0 middle, - low)*	Effort *(+ high, 0 middle, - little)*
Same lay out all busses	All	PTO, Fabric	+	+
Sound when doors are opening and closing	Visually impaired	PTO, Fabric	+	-
Handrails at all sides of the chairs	Motoric vulnerable	PTO, Fabric	+	-

5.2 Musts within CCAM

SINFONICA Deliverable 5.1 already contributed to some requirements and must haves for an inclusive CCAM operation. The deliverable states that automated mobility could provide access to mobility for people with physical constraints, such as those with diverse mobility, the elderly, or those living in remote areas. For these groups, automated vehicles could improve social inclusion, providing them with increased access to a range of services and a degree of social life that was previously denied to them.

The deliverable also states a few points that are confirmed by this research paper namely inclusive design, mobility assistance, user interfaces, communication and training and support. In addition, there are some must haves to consider for an inclusive CCAM operation.

Communication: travel route information should be always available and clearly visible on the vehicle, especially in case where no driver or assistant is present. Onboard real-time updates on deviations and unforeseen events must be provided promptly, along with possible alternative routes. This could be via static screens with text and announcements so people with hearing or a visual impairment get all the information. The information should be designed to be accessible to all users and available inside the vehicle, at bus stops, and online. For example, there could be video screens that one can use to get extra assistance in the vehicle and at the stops. They could talk to a person that provides extra assistance and information. Making the service a lot more personal than digital.

Costs: the CCAM operation should cost the same as a normal public transport operation. People do not tend to pay more for public transport even it is a new modern type of service. In addition, it should be financially attractive to take CCAM so people use more often public transport that helps to decrease traffic jams and CO2 emissions.

Distance and Destination: distance to a destination plays a significant role in the decision to use a CCAM operation as well. If it is an on-demand operation for a short distance, it can be very useful for different vulnerable groups such as elderly.

Staff: as described in D5.1, mobility assistance is needed. In the journey flows, one can read that staff for assistance within the vehicle, a remote assistant or assistance at the bus stop is helpful for vulnerable groups using a CCAM service. They can interact with passengers to talk about the service and make them comfortable using the service. In addition, it can help people to get in and out of

the vehicle and help when there is an issue at hand. They can help people of vulnerable groups as well when arriving to big hubs. Another option for staffing is at the stations or a travel assistant. For example, in Amsterdam the regional transport authority did some pilots to create more inclusive public transport. They introduced a public transport coach which focused first on assisting elderly people. They also have transfer assistance at major hubs as it can be very busy and difficult for different vulnerable groups to navigate to the next mode of transportation.

With no staff on-board, there will need to be a way to open the door by a passenger and let the vehicle drive after the passenger has entered. This will require some kind of technological solution, such as:

- Pressing a button on the vehicle door (but this might introduce security issues)
- Using an app (not inclusive for all)
- Using a public transport smartcard on a reader (for example, this is a typical approach with car clubs)
- Machine vision or other technology to recognise an individual
- Putting on a seatbelt so the vehicle can start driving
- Having the same outline. It would help many people when there would be one inclusive outline and use, so there is no confusion.

Safety: not only safety in the sense of technology is important for a CCAM service. Safety with regards to emotional aspects are also important. The journey flows show that there is a need to think about a safety button when someone wants to get of due to health or emotional issues or any other reason. Then, there should be considered how these functions in practice with regards to a person pushing a button or using an app (if any). This needs to be feasible for different vulnerable groups as well and should not trigger any incommodities.

To conclude this chapter and research, it is good to know that all nation states are mandatory to implement the EU accessibility law since 2022. The European Commission adopted the Strategy for the rights of persons with disabilities 2021-2030 to improve the lives of said groups in Europe and around the world. Accessibility to the built and virtual environments including information and communication and transport is mentioned as an enabler of rights and prerequisite for the full participation of persons with disabilities on an equal basis with others.[18] In addition to this, there is a revised passenger rights regulation. One section gives special attention to the needs of passengers with disabilities or reduced mobility. There needs to be free assistance available at connecting points by carriers and operators. Furthermore, they are obliged to report on the number of persons with disabilities to whom they deny transport and the number of complaints received plus their outcome.

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Appendix: Questionnaire survey sent to CCAM projects and operators

Public/Shared transport services using CCAM

Survey on services and trials: Typology, inclusion of user needs and user feedback

Thank you for taking part in this survey from the SINFONICA project, which is aimed at CCAM service operators, managers, project coordinators and project pilot site leaders.

Its **purpose** is to collect information on **public and shared passenger transport services by road using CCAM**, which are (or were) available for use by the general public. Information on services due to start in the near future (during 2024) is also welcome.

This information contributes to the SINFONICA task entitled “Definition of limits and possibilities of CCAM solutions in terms of inclusiveness of vulnerable users”. This task looks at what has been deployed recently/currently/in the near future and is building a typology of service types.

More information on SINFONICA is available at **https://sinfonica.eu**

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From question 7 onwards (page 4), the survey relates to your specific operation, service or demonstration. In cases of a project with several demonstration sites, please make copies of this questionnaire and fill in one per demonstration or pilot site/service.

Each form (individual service or demonstration site) should take 15-20 minutes to fill, depending on the maturity of the service and any feedback received to date.

Not all questions are compulsory, and if answers are contained within a report, you can share that with us instead.

Scope of this survey

The purpose of this survey is to collect information on public and shared passenger transport services by road using CCAM, which are (or were or will be) available for use by the general public. These may be:

- Buses, mini/micro-buses, shared taxis or other road vehicles that can carry passengers, which are either fully or partly automated, with or without on-board staff.
- Services open to public use, that have either operated in the past, are currently operating, or will start to operate during 2024.
- They may be permanent operations, or public trials/demonstrations as part of a project.
- Services may be fixed route public transport services, semi-flexible or bookable demand-responsive services.

We do not include:

- Services which are (or were) not open to the public.
- Very short trials (lasting less than a month).
- Rail-based systems or services running on similar dedicated and segregated infrastructure.
- Services which are planned to start after December 2024.

Use of your answers and Data protection

Factual information that you provide that is expected to be public anyway (details of the vehicle, service route, timetable, operation period, fares (if any) and other characteristics) will be used in SINFONICA deliverables, as will information already available in the public domain (online, in public reports, etc.)

Subjective information (such as your views on issues encountered and lessons learnt) and data not in the public domain (such as user feedback or operational costs, which have not been published), will be used in SINFONICA deliverables anonymously, without linking it to any CCAM-based transport service, project, respondent or country. Should we wish to link any such information to a transport service or project, we will seek and obtain your permission first.

Respondent details

7. **Your name** (first + family) Click or tap here to enter text.
8. **Your email address** Click or tap here to enter text.

9. **Your organisation or company** Click or tap here to enter text.
10. **Your role within CCAM service planning and/or operation** Click or tap here to enter text.

Background information

11. **Is this service…?** (select all that apply):

☐ Part of a research, innovation or demonstration project

☐ A commercial operation by the operator

☐ A subsidised/publicly funded service commissioned by a local or regional authority or transport authority

☐ Other (please describe: Click or tap here to enter text.)

12. **If it is part of a research, innovation or demonstration project**:
    - What is the name of project? Click or tap here to enter text.
    - Website of project, if available? Click or tap here to enter text.
    - Start date of the project (month and year)? Click or tap here to enter text.
    - (Expected) End date of the project (month and year)? Click or tap here to enter text.
    - Is it (select all that apply in case of several funding sources):
        - ☐ an EU-funded project
        - ☐ a national publicly funded project
        - ☐ a regional or local publicly funded project?
        - ☐ a commercially funded project?
    - How many different CCAM-based transport service demonstrations are there in this project? Click or tap here to enter text.
    - In which locations/countries are they situated? Click or tap here to enter text.
    - Who is the project coordinator?
        - Name: Click or tap here to enter text.
        - Organisation: Click or tap here to enter text.
        - Country: Click or tap here to enter text.

If there are two or more demonstrations or services in this project (in different locations), please make a copy this form(including the general information above) for each different service.

Then please answer the following questions in a **separate version of the form for each service**.

You may need to forward this form to the local operator or demonstration site manager for this.

CCAM service details (fill in separately for each individual public or shared transport service)

13. **Location of this service**:
- Town or city Click or tap here to enter text.
- Country Click or tap here to enter text.

14. **Responsible person and organisation for this service or demonstration site** (if different from respondent details in (1)):
- **Name** (first + family) Click or tap here to enter text.
- **Email address** Click or tap here to enter text.
- **Organisation or company** Click or tap here to enter text.

15. **Is this CCAM-based transport service…?**
Choose an item.

16. Please give the month and year of the **service start date** (the first time public passengers can use the service, not the project start date) Click or tap here to enter text.

17. Please give the month and year of the **service end date** (if one is foreseen) Click or tap here to enter text.

18. **What is the public name or number of the transport service** (as used in branding / passenger information, such as a bus route number or letter(s), not the name of the project): Click or tap here to enter text.

19. If there is a **public website or web page aimed at passengers** of the service (that is different from the project's website), please give the URL. This might be a page on the website of the operator's or public transport authority, containing passenger information such as route, timetable, fares, how to user, etc. Click or tap here to enter text.

20. Which company **owns the vehicles?** Click or tap here to enter text.

21. Which company **operates the vehicles** (employs staff, whether on board or remote operators)? Click or tap here to enter text.

22. **Does the service have**…?
Choose an item.

23. If "Other" to the above question, please elaborate. Click or tap here to enter text.

24. If it is a fixed route, please give the **start and end locations** (district or street, town or city) and **number of stops**.

- Start location of route Click or tap here to enter text.
- End location of route Click or tap here to enter text.
- Number of bus stops service Click or tap here to enter text.

25. If it is a fixed (or mostly fixed) route, please give the **end-to-end one-way distance** in kilometres (please also mention if it is a circular service) Click or tap here to enter text.

26. If it is a fixed (or mostly fixed) route, what is the typical **end-to-end journey time** (in minutes)? Click or tap here to enter text.

27. If it is a fixed (or mostly fixed) route, what is the **maximum speed** reached by the CCAM vehicles on the route? Click or tap here to enter text.

28. If it is a fixed (or mostly fixed) route, **what is the service frequency?** (state None if no service at this time):

- On weekdays (morning and evening peak periods) Click or tap here to enter text.
- On weekdays (daytime between peaks) Click or tap here to enter text.
- Saturday daytime Click or tap here to enter text.
- Sunday and public holidays daytime Click or tap here to enter text.
- Evenings (also what time is the last service?) Click or tap here to enter text.

29. **What types of roads are used** by the service? (select all that apply)
    ☐ Urban roads (typically 30-50 km/h speed limit)
    ☐ Core city centre urban streets (typically 30-40 km/h speed limit)
    ☐ Suburban roads (typically 50-70 km/h speed limit)
    ☐ Urban expressways (typically 60-90 km/h speed limit)
    ☐ Motorways outside urban areas (typically >100 km/h speed limit)
    ☐ Major roads outside urban areas (typically 70-100 km/h speed limit)
    ☐ Secondary or minor rural roads (typically 60-80 km/h speed limit)

30. **Can you estimate the percentage of the total route which is** … ?

- Segregated from other traffic (dedicated CCAM bus/vehicle lane) Click or tap here to enter text.
- Shared with other buses (busways/bus lanes) but not general traffic Click or tap here to enter text.
- In city or town centre traffic restricted zones (e.g. pedestrians and cyclists only, or possibly buses and authorised delivery vehicles) Click or tap here to enter text.

31. **Can you estimate the percentage of the route over which the vehicle operates fully automatically?** (This can be from 0% if driver has a constant driving task to do, up to 100% for driverless vehicles, or an intermediate figure for services where the driver needs to drive at certain times or on certain sections of the route) Click or tap here to enter text.

32. **If there is a "safety driver", under what circumstances does this driver take over driving?** (select all that apply)
    - ☐ On certain sections of the route, depending on road type
    - ☐ To access bus stops to pick up or drop off passengers on request
    - ☐ In poor weather conditions
    - ☐ If there is a diversion due to roadworks or other type of blockage
    - ☐ In case of emergency or technical failure
    - ☐ In other situations (please describe: Click or tap here to enter text.)

33. In case of a non-fixed route service, such as **demand-responsive**, what is the defined **area of operation**? Click or tap here to enter text.

34. What were the **main reasons** for choosing the particular route (origin and destination, or operating zone) to run this service? Click or tap here to enter text.

35. Do passengers have to **book their journey**, or can they just turn up and go?

    Choose an item.

36. **If booking is possible, can this be done… ?** (select all that apply)
    - ☐ Online (website)
    - ☐ Online (Smartphone app)
    - ☐ By telephone
    - ☐ At an office or information centre

37. If booking is required, **what is the minimum advance notice that the user has to book?** (for example at least 1 hour before the trip) Click or tap here to enter text.

38. **What happens in case the user wishes to change their booking last minute, if they are late, or in case of a no-show?** Click or tap here to enter text.

Vehicle(s) used

39. **Number of vehicles operating** at this site or on this route: Click or tap here to enter text.

40. **Vehicle type(s)**:

- Make and model Click or tap here to enter text.
- Number of spaces for passengers:
  - Seated: Click or tap here to enter text.
  - Standing: Click or tap here to enter text.
  - Wheelchair: Click or tap here to enter text.
- Maximum legal permitted speed of the vehicle (km/h): Click or tap here to enter text.

- SAE automation level(s) (if known[19]) Click or tap here to enter text.
- Is there a driving cab position?

  Choose an item.

- Are standing passengers allowed?

  Choose an item.

41. **Vehicle choice and design**:

- Were the vehicles…? Choose an item.
- What were the reasons for choosing the vehicle type? Did inclusivity play a role in the design or selection of the vehicle or service? Click or tap here to enter text.

42. Were any **specific modifications made to the vehicle** to make it more inclusive or accessible (e.g., boarding aid, voice assistant, ...)? If so, what? Click or tap here to enter text.

43. **How are the doors operated?**
    Choose an item.

44. **In case of fully unmanned vehicles, what happens if a passenger blocks the doors or other controls?** Click or tap here to enter text.

Staffing

45. **Is there a**…?

☐ Driver or safety driver

☐ Host/steward/assistant on board

☐ Host/steward/assistant at stops or stations

☐ Operations centre where staff can be reached by voice or video link

☐ Remote operator with a voice link or video link

46. Can you elaborate a little on the **role of each staff member** involved?

    Click or tap here to enter text.

47. What were the **reasons** for choosing the staffing configuration (driver, assistant/steward, fully unstaffed, etc.)

[19] see https://www.sae.org/blog/sae-j3016-update for explanation of automation levels

Click or tap here to enter text.

Fares and payment

48. **Is the service**..?

    Choose an item.

49. **If a fare is payable (for some or all users), how can people pay?** (select all that apply)

    ☐ Ticket machine at stops (accepts cash and/or card)

    ☐ Ticket machine on board (accepts cash and/or card)

    ☐ Smartcard required in advance, validated on board

    ☐ Contactless bank card reader on board

    ☐ Agent who sells physical tickets on board (accepts cash and/or card)

    ☐ Payment by Smartphone (including by app)

    ☐ Other (please specify: Click or tap here to enter text.)

50. Is there a payment option for **people without a bank card** (credit/debit card)?

    Choose an item.

51. Is there a payment option for **people unable to use self-service machines**?

    Choose an item.

52. Is there a payment option for **people without a Smartphone**?

    Choose an item.

53. **Is there any enforcement of payment, and how?** (barriers /doors activated by ticket or pass, vehicle only moves when payment is made or validated, manual spot ticket checks by staff, etc.) Click or tap here to enter text.

User feedback

54. **What was the usage of the service?** (Approx number of users per day / week / month / year) Click or tap here to enter text.

55. **What was the user profile of people using the service?** (by gender, age, etc. where available) Click or tap here to enter text.

56. **What were the main travel purposes, if available?** (percentage travelling for work, education, shopping, medical, social, personal business, etc.) Click or tap here to enter text.

57. **What consideration (if any) was given to different user groups when planning the service?** In particular:
    - Gender Click or tap here to enter text.
    - Age (young users, elderly users) Click or tap here to enter text.
    - Disability (physical, mental, visible or invisible disabilities) Click or tap here to enter text.
    - Non-digitally connected users Click or tap here to enter text.
    - Low-income users Click or tap here to enter text.
    - Any other groups considered? Click or tap here to enter text.

58. **Any other user profile data collected?** Click or tap here to enter text.

59. **What feedback was collected from users of the service?** (satisfaction, suggestions, complaints)? Click or tap here to enter text.

60. **What aspects of the vehicle were most valuable or appreciated by the passengers?** Click or tap here to enter text.

61. **Were there any aspects of the vehicle that caused any of the following, and if so, what?**
    - A technical / operational problem? Click or tap here to enter text.
    - A problem for users (accessibility, ease of use)? Click or tap here to enter text.
    - A safety issue? Click or tap here to enter text.

62. **How was feedback collected?**

☐ Self-completion online surveys (e.g. sent by email to registered users or via websites or social media)

☐ Self-completion paper surveys (e.g. handed out by staff on vehicle or at stops)

☐ Telephone surveys

☐ Interviews of users while on board

☐ Interviews of users at stops/stations

☐ Interviews of users elsewhere (physical presence)

☐ Interviews of users online (video call)

☐ Focus groups / Group discussions / meetings

☐ Other (please specify: Click or tap here to enter text.)

63. **Approximately how many users responded to surveys?** Click or tap here to enter text.

64. **Did the user response broadly match the profile of actual users?** (for example were the percentage of older users, disabled people or women responding to surveys similar to the proportion of these groups using the service? If not, can you highlight and explain any differences or under-represented populations?) Click or tap here to enter text.

65. **Is there a report available where this information can be found?** If so, please give the link if it is online, or expected date if not yet ready. Click or tap here to enter text.

Outcomes: Success and lessons learnt

66. **Were any Key Performance Indicators (KPIs) set for measuring the success of this service? If so, what were they? Were they achieved?**

If a public report is available, please share this with us; you can skip the following questions if they are covered in a report:

Click or tap here to enter text.

KPI-1 – Name of Indicator Click or tap here to enter text.

- How it was measured Click or tap here to enter text.
- What was the target? Click or tap here to enter text.
- What was the actual achievement (if available)? Click or tap here to enter text.
- Any other comments/observations? Click or tap here to enter text.

KPI-2 – Name of Indicator Click or tap here to enter text.

- How it was measured Click or tap here to enter text.
- What was the target? Click or tap here to enter text.
- What was the actual achievement (if available)? Click or tap here to enter text.
- Any other comments/observations? Click or tap here to enter text.

KPI-3 – Name of Indicator Click or tap here to enter text.

- How it was measured Click or tap here to enter text.
- What was the target? Click or tap here to enter text.
- What was the actual achievement (if available)? Click or tap here to enter text.
- Any other comments/observations? Click or tap here to enter text.

KPI-4 – Name of Indicator Click or tap here to enter text.

- How it was measured Click or tap here to enter text.

- What was the target? Click or tap here to enter text.
- What was the actual achievement (if available)? Click or tap here to enter text.
- Any other comments/observations? Click or tap here to enter text.

KPI-5 – Name of Indicator Click or tap here to enter text.

- How it was measured Click or tap here to enter text.
- What was the target? Click or tap here to enter text.
- What was the actual achievement (if available)? Click or tap here to enter text.
- Any other comments/observations? Click or tap here to enter text.

67. What do you see as the **main barrier(s)** that need to be overcome in order to make the service or demonstration work in the longer term? Click or tap here to enter text.

68. Do you have any view, from your experiences with this service or project demonstration, on **what is (or will be) the biggest challenge in deploying large-scale CCAM services in the future?** Click or tap here to enter text.

Thank you very much for your assistance!

Information on this questionnaire and task:

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