CATAPULT

D4.1 Structured overview on requirements of the user groups

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Introduction

This deliverable presents a Strength, Weakness, Opportunity, and Threat (SWOT) analysis. It is based on the screening of documentation, internal workshops, feedback from interviews within the project consortium CATAPULT, its partners and game sessions. The results obtained from those research activities focused on identifying users' needs were validated with SURAAA[1]. This analysis will include the identification of overarching outcomes and local specifics learnings based on WP2 and WP3. Furthermore, it ensures a successive learning path that improves the research process and supports the development of valuable policy recommendations.

This deliverable 4.1 is divided into five sections. The first section presents in a summarised manner the results obtained from WP2 and WP3. These results are categorised into four key acceptability factors of the autonomous shuttle: safety, ease of use, accessibility, and comfort. The identified needs are divided per target group. First, we present the results of older adults, then persons with physical and mental impairments and finally, children. The second section includes a SWOT analysis following four key aspects of automated shuttle acceptability; safety, ease of use, accessibility and comfort. The third section presents and discusses the overarching outcomes. The fourth section focalises the analysis at the local level and discusses local outcomes in Austria and Sweden. Section five presents our conclusions. The results of these three game sessions will be the base for Deliverable 4.2, which will develop guidelines for public authorities and practitioners, and Deliverable 4.3 that will be a handbook containing the different versions of the serious games played in Belgium, Austria and Sweden.

Connection to other activities in the project

This report is based on WP2 and WP3.

[1] https://www.suraaa.at/

1. Users' needs results of older adults, people with physical and mental impairments and children

This section builds upon the results of Deliverable 2.2 (D2.2) "Catalogue of needs and requirements, report on statistical data analysis results", Deliverable 3.1 (D3.1), "Results of the field studies with children, older adults and persons with disabilities" and the Deliverable 3.2 (D3.2) "Serious Game Report".

D2.2 contains results of interviews and surveys conducted with the three target groups (children, older adults and people with impairments) as well as additional stakeholders, including mobility service providers, providers of autonomous shuttles, researchers, policymakers, and spatial planners. As the final result, D2.2 contains a catalogue of the requirements of the target groups for inclusive, demand-oriented and target-group-specific automated mobility solutions for (semi-)urban areas as well as results of statistical data analysis from the surveys.

The results of the field studies in Pörtschach, Austria and in Linköping, Sweden, are covered in D3.1. In these field studies, the target groups of children, older adults and persons with impairments took a test ride in an autonomous shuttle. They were observed during the ride and interviewed afterwards. The shuttles employed during the field studies were automated and electric. In D3.1. a content analysis was carried out, and common themes were derived too. The results provide insights into what bothers the target groups while taking a ride in an automated shuttle and what needs and requirements they have towards them.

D3.2 presents the results of the Serious Game sessions carried out in Belgium. The Serious Game is called "A shuttle for everyone", and it is a mobility game that aims to identify the needs of specific target groups when using an automated shuttle. The target groups are also considered groups in vulnerable situations, in our case, older adults, people with physical or cognitive impairments, and children. The selected area of the game was the Noordrand region. The non-Belgian partners tailored this game in Austria and Sweden, where they also conducted game sessions.

In Sweden, two different games were played in two different sessions. In the first game, the participants were exposed to vulnerable situations, as developed by the Belgian partner, but with the addition of some situations related to snowy conditions. In the second game, the participants were asked to highlight areas of particular interest for autonomous shuttles on map, either based on where autonomous buses are suitable, or where they should not be used. The participants in the first session came from the regional transport agency Östgötatrafiken, and they played both games. In the second session, the participants came from the target groups, and they only played the second game. In Austria, a routing and an awareness version were played in several sessions. The routing version was played in four sessions with senior citizens, persons with physical and/or mental impairments, their assistants and special needs teachers in the district Waidmannsdorf in the city of Klagenfurt, Austria. The routing version aims at fostering discussion between different stakeholders and end users to find the ideal route for an automated shuttle in a real neighbourhood. The awareness version of the Austrian Serious Game aimed at sensitizing persons in charge of designing mobility services and/or persons who decide about the implementation of mobility services about the importance of designing and implementing mobility services accessible and according to a

design-for-all approach. We played two parallel sessions with policymakers, accessibility commissioners, mobility service providers and transport planners in Klagenfurt, Austria.

The results from D2.2, D3.1 and D3.2 have been classified in safety, ease of use, accessibility and comfort. Understanding that safety is an ambiguous term (Reschka, 2016), it is seen here as reducing potential risks for users. Ease of use is understood as "the degree to which a person believes that using a particular system would be free of effort" (Davis, Bagozzi, & Warshaw, 1989, p. 320). Accessibility involves different design factors in the automated vehicle that aim to make it accessible for all individuals (Riggs & Pande, 2022). Finally, in terms of comfort, acknowledging the controversy around the concept, it is understood as lack of discomfort of passengers during the ride (Wang, Zhao, Fu, & Li, 2020). The physical game sessions aimed to identify the needs of the target groups and the game had two prototype versions. The first prototype version was played with senior citizens and people with physical impairments, while the second was played with children. More details on the Belgian game sessions can be found in D3.2 Serious Game report.

1.1 Older adults' needs identification

The analyses conducted in D2.1 and D3.1, confirmed that there are many needs related with safety factors. Safety is key to increase acceptability of the automated shuttle among older adults. Based on the identification of the needs resulting from D2.2, D3.1 and D3.2, we can determine that the safety aspects do not only concern the automated shuttle, but the infrastructure in which the service is embedded too. Safety is so relevant for older adults, that most of their recommendations were classified under this category.

In terms of safety, a secure ramp that is not slippery even when the temperature is very cold, is important. Inside the shuttle, relevant aspects are: the emergency button, sufficient poles and handles, the possibility to communicate with a person in case of an emergency, video surveillance, and preferably a person inside that is responsible for the shuttle in case of an emergency. Also, older adults mentioned that announcements in different formats are important as some of them can be less responsive to sounds or to images. So having different choices to communicate is key. Older adults would also like that the door and ramp can be operated manually, so for example, the door can be safely opened. Other safety aspects regarding the automated shuttle are the sounds and warnings that can avoid a collision with other road users. Therefore, older adults consider very important that the shuttle displays different sounds and warnings. Finally, the need to adjust behavioural aspects was also identified. On one side training and information for road users to learn how to behave with an automated shuttle and on the other side, to understand better how the automated shuttle will behave with other road users and passengers.

It is important to highlight that many of the safety elements are also related to ease of use. Which can mean that it is important not only necessary to have the element of security but they must be used easily. Among these elements are the contact with the operator, ramps, doors and the emergency button. Other element is information of the route, preferably with a map that can include the surrounding area. The map could be available in digital and analogue formats in order to be easy to access for those not familiar with digital channels of communication. Moreover, clear information about the shuttle, the schedules with large font and consistent and visible design of signs and symbols are also important.

For accessibility, integration of the automated shuttle with the existing transport network is key. Poles, handles and enough time to access and leave the vehicle with a proper ramp were mentioned as a need. Also, accessibility can be supported by giving the possibility to communicate special needs to the vehicle before boarding and by providing information of the service. This includes traditional communication channels and digital channels, such as apps. It was also interesting to identify that some older adults are adopting the use of apps. Although they were a minority in the group, they suggested that information about the service and the route should be there. However, options such as buying the ticket inside the shuttle and the availability of information in different forms and media is seen as important. They also consider necessary a proper space for walking aid. Finally, in the case of the seats, it is relevant to mention that besides being accessible, they need to be comfortable.

Regarding comfort, there are concerns about the seats, there are just a few in the shuttle and they are narrow and hard. Public toilets seem to be an important topic that has been mentioned in the literature (See D2.1) and also came up during the interviews, field studies and game sessions in Austria and Belgium. Furthermore, older adults mentioned that the information about the location of the toilets needs to be displayed on a map. Airconditioning was mentioned as an important need too. Additionally, older adults have a positive perception on the shuttle driving in a low speed and highlight the importance of a smooth acceleration and deacceleration. They also consider that charging stations for phones are important since from these devices it is possible to access comfortably information about the trip, the shuttles and to communicate. Finally, dedicated space for luggage, sufficient poles and handles and cleanness of the shuttle were also mentioned in terms of comfort needs. Table 1 below presents the classification of the results.

Table 1. Needs of older adults for autonomous shuttles

Safety	Ease of use	Accessibility	Comfort
Emergency button (3.2)	Easy contact with the operator (3.2)	Reachable poles and handles (3.2)	Enough and comfortable seats (3.1, 3.2)
Seatbelts (3.1)	Emergency button easy to use (3.2)	Accessible seats (3.2)	Public toilets in some stops (3.1, 3.2) Insufficiently equipped stops, including lack of toilets (2.2) Include in the map of the app the stops that have toilets (3.2)
Secure access to the vehicle with a rough surface or a heating up area that melts snow (3.2)	Easy access to information of the route via analogue and digital channels (3.2)	Sufficient time to access and leave the vehicle (3.1, 3.2)	Airconditioning (3.2)
A responsible person inside the shuttle, mainly	Include comprehensive passenger	Accessibility also to information of the service (3.2)	Low speed and relax driving (2.2, 3.1)

for emergencies but also for information (2.2, 3.1)	information to be used without help. This includes information of the route and about what do in specific situation. This information must be in digital and analogue formats (2.2)		
Direct connection to a person for emergencies and an additional emergency number (2.2, 3.1)	The screen should include the map with streets and not only the stops (Adults) (3.2)	App with information of the route (3.2)	Charging stations for phones inside the vehicle (3.2)
In case of emergency doors needs to be open immediately. Yet there is concern that if there is no person, they can be trapped (2.2)	Consistent and visible design of signs and symbols (3.1)	Space for walk aid (adults) (3.2)	Dedicated space for luggage (2.2)
Video surveillance (2.2)	Schedules in large Fonts (3.1)	Ticketing within the bus – no need to install an app to be able to use the bus (3.1)	Sufficient poles and handles (3.1, 3.2)
Announcements in different formats to know where they are. It includes screens and voiceover (3.2)	Unambiguous information (3.1)	Integration of the bus in existing transport networks (3.1)	Cleanness (3.1)
Sounds and warns when bikes or cars are getting close to the vehicle (3.2)	Ramps and doors that are easy to operate and can be controlled manually (3.1, 3.2)	Possibility to communicate special needs to the vehicle before boarding (3.1)	Smooth acceleration (3.1)
Communication with operator via the app (3.2)			
Guidance during all the trip (adults) (3.2)			
External cameras to take pics of vehicles disrupting the route and			

send it to the police (3.2)			
Being able to open the door manually (3.2)			
Training for road users to learn how to behave towards an automated shuttle (3.1)			
Information about the current behaviour of the bus (3.1)			
Ensure that the doors are safely opened in case of an emergency (3.1)			

1.2 Persons with mental and physical impairments' needs identification

For people with impairments, in terms of safety, we identified that the emergency button is important. When considering mental impairments, a colourful design can help to identify objects when being in a stressful situation. Also, sounds or flashlights are considered important to avoid accidents, as the shuttle can be salient and this can be an issue for people with hearing or other impairments.

In terms of ease of use, to guarantee easy access to information is very relevant. Such access can help users to feel more familiar with the automated shuttle. This can be made via an app that contains all the relevant information for the user or a user guide, but also personal training is important for all those who cannot use an app. Finally, the emergency button is also classified within this category as it needs to be easily used and accessible.

For persons with physical impairments, an accessible design is key (D2.2, D3.1). The design needs to be adapted to all kind of impairments. Information and interaction need to be multi-sensorial: visual, acoustic and tactile. Visual information must be written in large letters and presented with high contrast, there must be enough acoustic information when approaching buses, the route, the doors, the next stops, etc. Information and buttons with braille and tactile guidance systems at the stops are also key. In terms of accessibility, signs at the bus stop and inside the shuttle are important facilitators of accessibility. Also, it is necessary to consider different sizes of wheelchairs, for example, chairs with electric batteries might be very difficult to fit. Sensors that can help to keep doors open longer in case that the wheelchair user needs to do extra movement is important too.

Finally in terms of comfort there were three needs remarks, the creation of an app that helps to inform about issues during the trip. Knowing possible situations in advance can decrease mental discomfort. In the same app, users would value the possibility of being informed in

different languages and finally comfortable seats are important. Table 2 below presents the classification of the results.

Table 2. Needs of persons with impairments for autonomous shuttles

Safety	Ease of use	Accessibility	Comfort
Emergency button (3.1, 3.2)	Easy access to information about the shuttle (route tables, apps, websites etc) (3.1, 3.2)	Very clear signs at the bus stop and inside the bus (3.2)	App that shows the route as well as issues that can be encountered (3.2)
Colourful or bright colour of the shuttle (3.2)	Emergency button easy to use and accessible (3.2)	Consider different sizes of wheelchairs (3.2) Ample spots, space, and easy means of securing/fastening wheelchairs, walkers, strollers and cargo (3.1)	App in multiple languages (3.2)
Use sounds or flashlights to maintain the distance of the autonomous shuttles with other road users (3.2) Busses are too quiet to locate and hear (3.1)	An app that can guide the user (3.2)	Sensors to keep the doors open longer if needed (3.1, 3.2)	Comfortable seats (3.1)
	Passengers should be able to say where they are going, no need to press STOP	Large Fonts with high contrasts (3.1)	
		Tactile guidance systems and braille (3.1)	
		Ramps that are easy to operate (3.1)	
		Acoustic information (3.1)	
		Consider placement of buttons and handrails (3.1)	

1.3 Children's needs identification

In terms of safety, children mentioned the need of an emergency button, with its capacity for an emergency brake. Also, they think that seatbelts, airbags, a weather proof ramp, more handle accessories and a fire alarm are needed. One particular concern is the possibility to operate the door manually and they would like that the automated shuttle had two doors. While these elements are directly related to physical aspects inside the shuttle, there are also aspects related to the capability of the vehicle such as its capacity to be connected to emergency services, sensors that can help by keeping the door open for a longer time if needed, and announcements in different formats. The latter is important as children can get distracted or feel sleepy. Actually, they think that they would feel safer if they know and see what the shuttle is doing during the trip. Finally, they also consider necessary video surveillance inside the automated shuttle in case of any incident and to interact with the operator.

Regarding ease of use, the emergency button was categorised here too as children mentioned that it is necessary to use it easily. They also think that to have a payment system inside the bus would be very practical. Finally, they consider that the screens inside the shuttle need to be easy to understand and with a simple design, this also applies to the schedules' layouts. Consistent symbols and signs are also necessary for them. The clear signalisation should permit to find the bus stop easily within the surrounding area. Finally, the shuttle itself needs to be self-explanatory with clear and multi-lingual communication.

Accessibility is also important for the buttons and the payment system inside the shuttle. They would also like that through the payment system the shuttle could identify if the user needs some special attention. Otherwise, they would like to have a button that can provide additional time to leave the shuttle. The displays need to include information about the timetables and the route. The bus stops need to be in a reasonable distance from each other so they do not have to walk long distances to reach the stops. Moreover, the shuttle should be integrated with the current transport network. Finally, information about the shuttle in an app is also considered important to increase accessibility.

About comfort, children would like that if they need additional assistance, they could request it one day before. This type of service currently exists for other means of transportation such as trains. In terms of the shuttle, they consider necessary large windows to have a wider perspective of the surroundings, the air-conditioning in case the day is hot, and leather-type material for the seats. This material would keep the shuttle looking cleaner according to them. Also, for the seats, they think that the current autonomous shuttle design has very few seats, so they think more are needed. They also believe that entertainment systems and Wi-Fi inside the shuttle would increase their comfort. For comfort toilets are needed. Also, bus stops with greenery that allow children to play were mentioned. Children also find comfort opportunities with the apps. They can be used to create a service on-demand. Moreover, such app could make their phone or watch vibrate when they have to get off the shuttle. Additionally, apps can be a comfortable channel of communication. Children also mentioned possibilities that can allow to speed up the trip. For example, if the autonomous shuttle has sensors to know if it needs to make the stop, or it can skip such stop if there is no one waiting for the service. Finally, more spacious shuttles and a colourful design that can be pleasant to look are considered needed by the children. Table 3 below presents the classification of the aforementioned results.

Table 3. Needs of children for autonomous shuttles

Safety	Ease of use	Accessibility	Comfort
Emergency button (3.2) and emergency brake (3.2)	Emergency button easy to use and accessible (3.2)	Buttons easy to reach (2.2, 3.1)	You can ask for assistance up front (a real-life person). At least the day before (3.2)
Airbags (3.2)	Payment system inside the bus (3.2)	Plenty of places to scan tickets, such as in the seats (3.2)	Automatic aircon (3.2) (2.2)
Weather proof ramp (3.2)	Large display that is easy to use and understandable with a simple design (2.2, 3.1)	Display accessible to children. It should include timetables and routes (2.2, 3.1)	Leather or similar material that helps to keep it clean (3.2)
Fire alarm (3.2)	Consistent and visible design of signs and symbols (3.1)	When you scan your card, the system knows whether you are a person that needs special attention (that needs more time for example) (3.2)	App that vibrates or sounds when you must get off the shuttle (3.2)
Autonomous shuttle connected to emergency services (3.2)	Understandable and simple design of schedules (3.1)	Press a button to have more time for leaving the shuttle (3.2).	Toilets (2.2)
A responsible person on board (2.2, 3.1)	Signs that help to find the stop and to identify the surroundings (3.1)	Bus stops must be distributed frequently – no long walks (3.1)	Comfortable bus stops: display with information, flowers, trees, bins, possibilities to play (e.g. slides) (2.2)
More hand rails and poles (2.2, 3.1)	Bus must be self-explanatory, clear communication and multilingual (3.1)	Ticketing options on the bus (3.1)	Entrainment inside the shuttle (e.g. movies, possibility to play games) (2.2)
Announcements in different formats to know where they are. It includes screens and voiceover (3.2)		Autonomous shuttle should be integrated in existing transport network (3.1)	Colourful and more variety in the design of the shuttle (2.2?)
The shuttle should have two doors (3.2)		All information in an app (3.1)	Sufficient amount of comfortable seats (2.2, 3.1)

Possibility to open the door manually (3.2)			Larger windows to look better their surroundings (2.2)
Cameras that support the interaction between users and operator (3.2)			On demand service, using an app (2.2, 3.1)
Seatbelts (3.1)			Less stops than current buses' routes (2.2)
Information about the current behaviour (what is the bus doing, what is it seeing, why is it behaving in a certain way) of the bus (3.1)			Too slow, to be practical (3.1)
			Sensors that can allow the shuttle to know if it needs to make the stop, or it can skip such stop if there is no one coming in or out (3.2)
			Wifi in the shuttle (3.2)
			More spacious shuttles (3.1)

2. SWOT field studies and serious game

The SWOT analysis was based on the needs findings presented in the previous section and have been categorised into: safety, ease of use, accessibility and comfort. In our SWOT analysis, strengths and weaknesses are aspects directly related to the automated shuttle while opportunities and threats are related to factors outside the automated shuttle itself. The final results of these section were validated with SURAAA experts via an online meeting where we presented to them a preliminary version of the SWOT analysis.

2.1 Strength, Weakness, Opportunity, and Threat (SWOT) analysis for safety

In terms of **strengths**, the shuttle in Pörtschach, Austria has an emergency button, which is big and red. It is very visible and easy to push. The shuttle is prepared in case of a fire and has a mechanism that aims to extinguish it. Additionally, the automated shuttle has extinguishers too. There is also video surveillance, which is above the door and can see inside the shuttle. It is possible to operate the door manually. The seatbelts are similar to the ones in the airplanes. The current ramp has a rough area and while it does not have a heating system, the way in which is constructed avoids that it can freeze. Moreover, no trips of the shuttle in Austria take place in winter or in bad weather conditions. Regarding the **weaknesses**, the ramp of the shuttle cannot be controlled manually so in case of an energy problem, it would not work. The ramp is also very steep, if the stop is on not elevated. For persons in wheelchairs it is hardly possible to get on and off the bus without help from others. Currently, the shuttle only can provide announcements with the voiceover, as the screen has information about the shuttle. The screen has different tabs and one of them includes a map but it cannot show different information simultaneously. The shuttle does not have flashlights or sounds that can help to keep other road users away from it. However, there are possibilities to add in the near future sounds similar to the one used by vehicles when parking, which frequency and sound increases as another road user gets closer. While the shuttle does not have emergency brakes, it stops if a user or object is closer than 20 centimetres. Due to the small design, there are not two doors, but each part of the one door operates individually. There are insufficient poles and handles if people are standing. Yet in the current pilots, this is not allowed, every passenger has to be seated. The present model does not have airbags neither. Currently, there is no information that is being shared with the passengers about the behaviour of the shuttle. There is a connection button that is only to ask for help, but in the current trips is not working. The sound of the vehicle is low which makes difficult for people with hearing problems. With respect to **opportunities**, the automated shuttle could be connected to emergency services. Also, the users of the shuttle should be able to communicate with the operator via the app or the shuttle cameras. Additionally, it would be very positive if cameras of the shuttle could take pictures of the vehicles disrupting the route and send it to the police. However, this level of surveillance needs to be agreed with society as there are some countries where this is not fully accepted by society. Finally, the training for road users on how to behave towards an automated shuttle could take place in driving schools. Regarding **threats**, there are concerns about the lack of driver and guidance during the trip. Nowadays there is an operator inside the shuttle in Austria pilots.

Strengths	Weaknesses
Emergency button (3.1, 3.2) Current appearance of the emergency button and the shuttle. Make it colourful or bright colour of the shuttle (3.2) Fire alarm and fire-extinguisher inside the vehicle (3.2) Video Surveillance (2.2) Door can be controlled manually, which ensure that the door can be safely opened in case of an emergency (3.1, 3.2) Seatbelts (3.1) The ramp of to the vehicle has a rough surface or a heating up area that melts snow in the ramp (3.2)	Ramp cannot be controlled manually, very steep (3.1, 3.2) Lack of announcements in different formats to know where they are, consider the inclusion of both screens and voiceovers (3.2) Lack of sounds or flashlights to maintain the distance of the autonomous shuttles with other road users. Sounds and warns when bikes or cars are getting close to the vehicle (3.2) Lack of emergency brakes (3.2) Lack of two doors (they work independently) Insufficient poles and handles (2.2, 3.1, 3.2) Airbags (3.2) No information about the current behaviour of the bus or why it is doing what it is doing (3.1) Direct connection to a person for emergencies and an additional emergency number (2.2, 3.1) The noise of the vehicle is difficult to hear (3.1)
Opportunities	**Threats**
Autonomous shuttle connected to emergency services (3.2) Communication with the operator via the app / via the cameras to support interaction between users and operators (3.2) External cameras to take pics of the vehicles disrupting the route and send it to the police (3.2) Training for road users how to behave towards an automated shuttle (3.1)	Lack of a responsible person inside the shuttle, mainly for emergencies and help (2.2, 3.1) Lack of guidance during the trip (3.2)

2.2 Strength, Weakness, Opportunity, and Threat (SWOT) Analysis for ease of use

In terms of **strengths**, we confirmed through the validation process that the emergency button is easy to use and the ramps and doors are easy to operate. In case of the doors, it is even possible to operate them manually. The current automated shuttle provides information as a regular bus and it provides information in English and German; so it is also possible to have different languages. Regarding the **weaknesses** of the automated shuttle, the display is not very easy to use and people who are not familiar with the technology might find it difficult to understand. Currently the shuttle does not have additional information with large fonts with high contrast, or visible design of signs and symbols. All these aspects need to be considered if the automated shuttle is implemented. Current communication about the route is ambiguous and it is not easy to access it with the current screen. This could be improved with a secondary screen that provides information for the passengers. The vehicle is slow and sometimes people

have rejected to participate in the pilots as they consider the shuttle too slow. So, it is important to reassess the speed. About **opportunities,** it is important to make sure that schedules are easy to understand. Include comprehensive passenger information to be used without help. This includes information on the route and about what to do in specific situations. This information must be provided in digital and analogue formats. Also the contact with the operator should be easy. An app that can guide the user needs to be taken into account. In this regard, the development of an app is something that is already being considered as part of the future implementation. However, alternative choices need to be taken into account for people who do not use apps. Payment system inside the bus needs to be considered too. In this regard, an important reflection has to take place to harmonise the payment system considering the different means of transportation in the urban area. Signs that help to find the shuttle stops and to identify the surroundings are also important. Finally, in terms of **threats,** lack of easy access to information about the shuttle (route tables, apps, websites etc.) could really affect the implementation of the automated shuttle. This also includes schedules with large fonts and easy to read. It is important to mention that it is not only about the existence of the information, it needs to be easy to find and to be available via analogue and digital channels of communication. If possible, a guidance systems around the stops should be included.

Strengths	**Weaknesses**
Emergency button easy to use (3.2) Ramps (is not) and doors that are easy to operate (3.1, 3.2) Bus must be self-explanatory and multilingual (3.1)	Lack of a large display that is ease of use and understandable with a simple design (2.2, 3.1) Lack of large fonts with high contrasts in the design (3.1). Consistent and visible design of signs and symbols (3.1) Ambiguous communication (3.1) Lack of screen with the map containing the streets and not only the stops (3.2). Too slow, to be practical (3.1)
Opportunities	**Threats**
Schedules easy to understand (3.1) Include comprehensive passenger information to be used without help. This includes information of the route and about what do in specific situation. This information must be in digital and analogue formats (2.2) Easy contact with the operator (3.2) An app that can guide the user (3.2) Signs that help to find the stop and to identify the surroundings (3.1) Payment system inside the bus (3.2)	Lack of easy access to information about the shuttle (route tables, apps, websites etc) (3.1, 3.2). This also includes schedules with large fonts, easy to read (3.1) Lack of easy access to information of the route via analogue and digital channels (3.2) No guidance systems around the stops (3.1)

2.3 Strength, Weakness, Opportunity, and Threat (SWOT) Analysis for accessibility

In terms of accessibility **strengths**, we validated that the poles and handles are reachable, the seats are accessible, there is good acoustic for the information and the operation of the ramps is accessible. Buttons are easy to reach as their height is approximately 1 meter. Regarding **weaknesses**, we found that there are plans to add screens that can make information more accessible. Yet the idea is to avoid that children can manipulate them. It is also important to provide additional time to access and leave the vehicle. The current time is 45 seconds. Furthermore, there are no sensors to keep the door open longer if needed or an additional button to have more time to leave the shuttle. Due to the size of the shuttle, there is not enough space if people with wheelchairs, strollers and cargo come inside at the same time. The number of buttons and handrails could be increased too. There is also a lack of large fonts with high contrasts that can make information more accessible, especially for people with impairments. Lack of tactile guidance systems and information in braille; and space to consider different sizes of wheelchairs and walking aid are current weaknesses of the automated shuttle. Moreover, it is not possible to communicate special needs to the vehicle before boarding. About **opportunities**, we identified that accessibility to information of the service is important. This includes clear signs at the bus stop and inside the bus. An app with information of the route can also be very useful. Another way to improve accessibility could be that when you scan your transport card, the system recognises whether you are a person that needs special attention. Yet, for the implementation of the shuttle in Austria, a way to obtain information regarding special needs of users is being planned within an app. In this sense, it is expected that all information about the shuttle service should be included in an automated shuttle app. The bus stops could be distributed frequently to avoid long walks. Plenty of places to scan tickets, such as in the seats is another recommendation. Finally, the automated shuttle should be integrated in the existing transport network. Among the **threats** we identified are not to include ticketing options inside the shuttle and/or force the user to install apps.

Strengths	**Weaknesses**
Reachable poles and handles (3.2) Accessible seats (3.2) Good acoustic information (3.1) Ramps that are accessible to be operated (3.1) Buttons easy to reach (3.1, 3.2)	Displays to access information, but to avoid that children can manipulate them (interview with SURAAA). Sufficient time to access and leave the vehicle (3.2) Lack of sensors to keep the door open longer if needed (3.1, 3.2) Not enough ample spots, space, or easy means of securing/fastening wheelchairs, walkers, strollers and cargo (3.1) Few buttons and handrails (3.1) Lack of large fonts with high contrasts (3.1) Lack of a button to have more time to leave the shuttle (3.2) No tactile guidance systems and braille (3.1)

	Lack of space to consider different sizes of wheelchairs and walking aid (3.2) Lack of possibility to communicate special needs to the vehicle before boarding (3.1)
Opportunities Accessibility also to information of the service (3.2) Very clear signs at the bus stop and inside the bus (3.2) App with information of the route (3.2) When you scan your card, the system knows whether you are a person that needs special attention (3.2) All information should be in an app (3.1) Bus stops distributed frequently – no long walks (3.1) Plenty of places to scan tickets, such as in the seats (3.2) Autonomous shuttle is integrated in existing transport network (3.1)	**Threats** No ticketing options inside the bus. There should be no need to install an app to be able to use the bus (3.1)

2.4 Strength, Weakness, Opportunity, and Threat (SWOT) analysis for comfort

Regarding the comfort **strengths**, older adults find the low speed and relaxed driving of the automated shuttle comfortable. Another positive factor is the air conditioning inside the shuttle. However, it is noisy in the current model. Also, ample windows with clear outside view are seen as positive together with the smooth acceleration the vehicle. There are also inside the shuttle USB chargers ports where people can connect their phone. In terms of **weakness**, the seats are few and not comfortable. A leather or similar material could help even to keep the seats clean. The stopping of the vehicle can be abrupt. Lack of entrainment inside the shuttle is also perceived as a downside. This is especially important for children as they would like to be able to access videos or games. There is no dedicated space for luggage. Not enough poles and handles that can make the trip comfortable if people are standing inside the shuttle. It can also be too slow, to be practical for some users and the way it stops can be abrupt. In general, there is a perception that the shuttle lacks room as they are small. There is no WIFI service, which is considered important. But based on the validation process we learned that it could be easily implemented. Also, a more colourful design with variety of colours could make the shuttle more pleasant for users. In order to make the trip faster it could be helpful to include sensors that can allow the shuttle to know if it needs to make the stop, or skip it if there is no one inside or leaving the automated shuttle. Regarding this last capability, during the validation of the results, we were informed this is actually something the shuttle company is working on. About **opportunities**, we found that the development of an app that can show the route as well as issues that can be encountered and in multiple languages could improve comfort for the users. Also, the app could send signals to the phone or to the smart watch to vibrate or sound when

the passenger must get off the shuttle. Development of comfortable bus stops, including display with information, flowers, trees, bins, possibilities to play (e.g. slides) can also provide the opportunity to make the passengers' journeys more comfortable. An on-demand service using an app could also be considered. Keeping the shuttle clean is important to make it comfortable. Some users, also consider that less stops than current buses' routes, could make the route faster and then more convenient for some users. Moreover, considering the inclusion of additional assistance that can be requested upfront, as it is done currently for services like in trains. Finally, regarding **threats**, we identified that not well equipped shuttle stops and a lack of toilets could affect the user experience negatively. In the same line, non-inclusion of public toilets in some stops and their addition on a map (also in the app) are also considered factors that can threat the inclusive implementation of automated shuttles. It is important to highlight that these are issues commonly referred in the public mobility literature (Casiano Flores, Vanongeval, & Steenberghen, 2023).

Strengths	**Weaknesses**
Low speed and relax driving (2.2) Aircon (3.2) Large windows to look the surroundings (2.2) Charging stations for phones inside the vehicle (3.2) The acceleration is smooth (3.1)	Lack of sufficient number and comfortable seats (2.2, 3.1, 3.2) Leather or similar material that helps to keep it clean (3.2) Lack of Entrainment inside the shuttle (e.g. movies, possibility to play games) (2.2) Lack of colourful and more variety in the design of the shuttle (2.2) No dedicated space for luggage (3.1) Not enough poles and handles (3.1, 3.2) Too slow, to be practical (3.1) Lack of more room in the busses (3.1) Buses are too small (3.1) Lack of Wifi in the shuttle (3.2) Lack of sensors that can allow the shuttle to know if it needs to make the stop, or it can skip such stop if there is no one coming in or out (3.2) Stopping can be abrupt (3.1)
Opportunities	**Threats**
App that shows the route as well as issues that can be encountered (3.2) App in multiple languages (3.2) App that vibrates or sounds when you must get off the shuttle (3.2)	Insufficiently equipped stops, including lack of toilets (2.2) Public toilets in some stops and add them in a map (also in the app) (3.2)

Comfortable bus stops: display with information, flowers, trees, bins, possibilities to play (e.g. slides) (2.2) On demand service, using an app (2.2, 3.1) No cleanliness (3.1) Less stops than current buses' routes, could make faster the route (2.2) Provide assistance up front (a real-life person). At least the day before (3.2)	

3. Overarching outcomes from the SWOT analysis

Based on Deliverable 2.1 we categorised the needs' results of the research conducted in D3.1 and D3.2 in safety, ease of use, comfort and accessibility. Based on the previous results, we can state that while different studies have identified different purposes for the automated shuttles, the majority sees them as a complement of existing public transport services by adding feeding routes to and from train stations, airports, or parks. Yet, based on the initial findings and our co-creation approach with service providers in Brussels and Flanders, we set as a scenario for the game, the development of a route that connects different areas of the Noordrand region[2].

Through our research we could corroborate that safety is a key aspect to take into consideration if automated vehicles are implemented. Stop buttons and various means of communication (Pigeon, Alauzet, & Paire-Ficout, 2021) were confirmed as relevant. In this regard, it is important that all passengers and road users can communicate to the automated vehicle and vice versa. This should include people with speech, language, hearing impediments or other disabilities (Bigby et al., 2019; Hwang, Li, Stough, Lee, & Turnbull, 2021). Moreover, communication using lights and sounds to interact with other road users are also considered relevant in terms of safety. However, it is important to mention that previous studies have found that while contributing to safety, lights and sounds can lead to lowered passengers' comfort (Pigeon et al., 2021). Additionally, our target groups mentioned video surveillance as important, despite privacy concerns (Acheampong, Marten, Beyazıt, Cugurullo, & Dusparic, 2018). Stop buttons and various means of communication (Pigeon et al., 2021) were confirmed with our research.

Previous studies have identified that careful public information campaigns about automated vehicles explaining their benefits can help to decrease safety concerns (Chikaraishi, Khan, Yasuda, & Fujiwara, 2020; Chng, Anowar, & Cheah, 2021; Golbabaei, Yigitcanlar, Paz, & Bunker, 2020; Hussain et al., 2021; Roche-Cerasi, 2019). However, if not done properly, it can lead to more safety concerns (Hussain et al., 2021). Through our research, we found that campaigns need to be informative on how the automated vehicle works in order to increase familiarity of the potential user with the vehicle. Moreover, we confirmed that information on the multi-modal route and bus stop should be readily and clearly available in smartphone apps (Piatkowski, 2021; Pigeon et al., 2021) as well as in traditional channels.

[2] https://topnoordrand.be/en

Although the current autonomous shuttle contains important strengths in terms of safety, there are still several weaknesses that need to be overcome when considering an inclusive approach. Aspects such as the lack of a ramp that can be controlled manually, insufficient poles and handles, and direct connection to communicate emergencies to have an immediate response were reported by different groups in different research settings. Therefore, it is important to pay special attention to them. In terms of opportunities and despite their feasibility, we think, that one of the most important is to consider trainings in driving schools to teach other road users about how to interact with automated vehicles. Finally, a very important threat that we identified from an inclusive perspective, it is related to one of the main characteristics of an automated vehicle, the lack of a responsible person inside the shuttle, that can help in cases of emergencies or when help is needed. While, previous research suggests positive attitudes toward automated vehicles (Azad, Hoseinzadeh, Brakewood, Cherry, & Han, 2019; Chen, 2019; Guo, Susilo, Antoniou, & Pernestål Brenden, 2020; Herrenkind, Brendel, Nastjuk, Greve, & Kolbe, 2019), when taking into account older adults and people with impairments, we noticed that they had a less positive attitude. The main concerns came from the older adults who consider it very important to have the support of a person inside the vehicle. Hence, our target groups consider it key having a person in charge inside the shuttle. In this regard, it can be interesting to consider hiring a responsible person inside the bus. This could be done, for example, via social programs by offering job opportunities to unemployed people.

Regarding ease-of-use factors, it is important to mention that many of the safety factors have a close relation with ease of use. For example, the emergency button, the ramps and doors are expected to be easy to operate. In terms of weaknesses the lack of displays that can be easily used by the users is an important issue. In case of an emergency, easy contact with the operator is important. A screen that includes a map with the stops and the surroundings was mentioned too. Ease of use can also be related to the existence of digital and analogue channels of communication that can help the user with the journey. In this vein, we confirmed that information on the multi-modal route and bus stop should be available in smartphone apps (Piatkowski, 2021; Pigeon et al., 2021) as well as on traditional channels. Among the threats that could affect the automated shuttle negatively and which we identified through different research methods was the lack of easy access to information about the shuttle, including route tables, apps, websites etc.

In terms of accessibility, the automated shuttles already cover some important needs such as the accessibility to important buttons. Previous research also identified the need of sufficient space to provide ample maneuvering and storage space (Eden, Nanchen, Ramseyer, & Evéquoz, 2017; Feeley, Lubin, Kornhauser, Tobin, & Hwang, 2020; Hwang et al., 2021; Pigeon et al., 2021; Tabattanon, Sandhu, & D'Souza, 2019). We could confirm that this is important, especially in terms of mobility aids. There is a need of space, equipment and seating configurations for people in wheelchairs (Tabattanon, Schuler, & D'Souza, 2020) and other users with similar needs. This is an important weakness along with the lack of sensors or buttons that could keep the door open longer if needed. Additionally, we identified the lack of a tactile guidance systems that take into account the needs of different users and the lack of adequate space for different sizes of wheelchairs and walking aid.

When looking at accessibility, previous studies have identified the need for compatibility between automated vehicles and the surrounding infrastructure such as bus stops. This means that accessibility infrastructure should be useable (Feys, Rombaut, & Vanhaverbeke, 2020; Hwang et al., 2021). In this regard, we would like to mention that our target groups perceived

as natural the use of existing infrastructure. Yet, they consider that some adequation might be needed and these could be applied to different types of transportation. An important opportunity to address this situation is providing information and developing apps that facilitate accessibility to users with different needs. In this regard, throughout the game sessions we confirmed that people with mental impairments, including autism, prefer entering their destinations in smartphone apps rather than doing so using on-board interfaces (Feeley et al., 2020; Risser, Iwarsson, & Ståhl, 2012). Meanwhile the main threat that was identified was not to consider ticketing options inside the automated shuttle.

Comfort has been identified as a factor that impacts the acceptability of automated vehicles (Chen, 2019; Eden et al., 2017) and our research allowed us to confirm that passengers can enjoy smooth rides (Feeley et al., 2020; Feys et al., 2020; Portouli et al., 2017). Yet we found some important differences in this regard between the groups. While children find the speed slow, older adults are fine with it. This was actually not a new finding, previous studies identified that younger passengers unapproved automated vehicles traveling slow, whereas older passengers often do not have an issue with it (Chen, 2019). Other strengths identified and confirmed were the large windows as they provide natural lighting and excellent visibility inside the shuttle (Eden et al., 2017; Feeley et al., 2020; Pigeon et al., 2021) and air conditioning (Pigeon et al., 2021). When looking at the weaknesses, among those that were more frequently mentioned were the lack of sufficient and comfortable seats, and the reduced number of poles and handles, which can be a problem if many people are using the shuttle. Another factor that was commonly mentioned was the development of an app that could help to increase comfort by providing information about the shuttle in multiple languages and formats and even considering the provision of an on-demand service. Other factor in which we found contradiction in terms of comfort was regarding the distance between the stops. While some potential users would like stops that are not far from each other, others would like not many stops in order to provide a faster service. Finally, an important treat identified was the inclusion of toilets and maps that can facilitate their location and access. Public toilets availability has been discussed as an important issue in the public transport literature in the last decades (Greed, 2004; Shrestha, Millonig, Hounsell, & McDonald, 2017).

In general, we could identify that many of the needs tend to be similar among the three target groups. Yet we found that children, people with impairments and older adults differ in some of their needs and requirements. For example, older adults mainly require non-digital and offline types of information and ticketing. For this group safety tended to be among the qualities over which they made most of their comments. Also, older adults expect a more personal contact in every stage of public transport usage. Children tend to prefer the use of apps and focused most of their input on factors related to comfort. Meanwhile, people with impairments primarily mentioned factors related to accessibility and they value both analogue and technological aspects.

4. Local lessons (results from game sessions in Austria and Sweden and Austria)

The experience and knowledge gained in WP2 and WP3 and reported in Deliverable 2.2 “Catalogue of needs and requirements, report on statistical data analysis results”, Deliverable 3.1 (“Results of the field studies with children, older adults and persons with disabilities” and the Deliverable 3.2 “Serious Game Report” worked as a base to tailor and develop game sessions in Austria and Sweden that were adapted to the research needs of their context. These experiences are presented below. More information about the design of the game can be found in Deliverable 2.4, Conceptual design of serious game.

4.1 The results of the game session in Sweden

In Sweden, 2 game sessions took place. For the first game session, one player started by throwing the dice and moving the player’s bus accordingly. If the bus landed on a red dot, a card was drawn, and solutions to the challenge presented was discussed with all participants. The discussion usually lasted around a minute, which proved to be enough time to find a decent solution, and not too long to become very detailed. The players were keen to move on with the game, making their own driving force to proceed with the game to limit the time spent on each question. After the question was answered, it was the next player’s turn. The game finished after the time limit was reached (approx. 1 hour).

The comments of the participants were divided into the three different category descriptions. Category descriptions System 1 are: the bus, the infrastructure and the passenger. Category descriptions System 2: new solutions and already implemented. Finally, Category descriptions System 3: safety, perceived safety and confidence, simplicity and comfortability.

Category descriptions System 1

Bus

Vehicle

- Bus acceleration/deceleration must be smooth and slow to reduce the risk of falling
- Softer floors that reduce damage in the event of a fall
- The bus signs full if the capacity is reached

Automation

- Speakers on board announcing the next stop
- The seat can detect if a passenger is falling asleep (for example, by using smart textiles) and can wake it up
- The doors sense if someone is in the opening and wait until they have passed completely to close themselves
- Passenger counting systems can see if someone has gone off and keep the doors open until the person is off
- The doors of the bus stay open for a certain time
- A sensor in the bus can detect if someone is moving and keep the doors open until they are off
- Camera technology can act as a passenger counting system and determine how many people are on the way off the bus
- A loudspeaker tells the bus to start moving to prepare the passengers
- Passenger bill that can determine if it is full in the bus
- If the bus is full, it stops only for disembarkation
- If the bus there are too many on the bus, it talks about it, and does not depart until someone gets off

- The bus does not depart until everyone has scanned their tickets
- A sensor in the bus can determine if a passenger has a ticket on their mobile phone when it gets on
- Camera technology in the bus that can read a ticket if it is displayed in the "air", no scanner needed
- The bus does not depart if it feels that passengers are still scanning their tickets
- The bus itself can tell when a fault occurs and inform passengers
- If a fault occurs that causes the bus to stop, the doors can be opened automatically
- If a fault occurs that causes the bus to stop, the bus knows whether it is safe to open the doors or not, and can act accordingly
- If smoke develops in the bus, an alarm goes off and the bus can be evacuated
- The bus can diagnose itself to more quickly find sources of error
- Forecast in real time, the bus can find out and tells you how many people are on the bus right now

Interactions

- Travel search on board in a tablet on the wall
- Travelers tell you where they're going when they get on, and don't have to click stop
- Travelers can tell you they need a wake-up call when they get on the bus
- An alternative stop button that gives a passenger extra time to get off the bus
- Everyone in the bus pushes stop if they want to get off. The system detects how many people are getting off and keeps the doors open. Regret button if pressed incorrectly.
- Buttons in the bus to open and close the doors, like an elevator.
- Passengers who need more time to get to their seat can click a button in the bus that makes the bus wait to start
- Alarm buttons in the bus, which also sit low down
- Voice-controlled alarm, you can contact the control tower by calling for help
- Camera technology and AI that can determine if someone has fallen and call for help
- Passengers can scan their tickets on the outside of the bus before entering
- If a fault occurs that causes the bus to stop, passengers can decide for themselves whether it is safe to get out or not and open the door themselves
- Passengers tell us when they get to which stop they are going to to improve occupancy forecast
- The passenger can (voluntarily) talk about their needs before boarding, and the bus can take these needs into account

Infrastructure

Control Tower

- The control tower can monitor the bus and keep the doors open until everyone is off
- If a fault occurs in the bus, the Control Tower is connected, which can inform passengers about what is happening and make decisions on how to solve the problem
- The control tower resembles an air traffic control tower, where each person is responsible for a certain number of buses

Planning

- Demand-controlled buses, if a bus is full then an extra bus can be called on to the stop
- Demand-controlled bus where you can choose to talk about your needs before getting on, and the bus can act accordingly
- Special times when more buses staff the line to reduce congestion in the buses
- If you notice that people with a need for more space in the bus travel at certain times, then more buses can be put in to those stops during those times

Online

- Journey planner in an app

Passenger

- The passenger is solely responsible for waking up before their stop
- A new type of ticket carrier that the passenger can wear, facilitates ticket scanning
- Function that knows when you arrive at your stop and wake the person up

Category systems 2

New ideas

Autonomous buses

- Bus acceleration/deceleration must be smooth and slow to reduce falls
- The seat can detect if a passenger is falling asleep (for example, by using smart textiles) and can wake it up
- Passenger counting systems can see if someone has gone off and keep the doors open until the person is off
- The doors of the bus stay open for a certain time
- A sensor in the bus can detect if someone is moving and keep the doors open until they are off
- Camera technology can act as a passenger counting system and determine how many people are on the way off the bus
- A loudspeaker tells the bus to start moving to prepare the passengers
- If the bus there are too many on the bus, it talks about it, and does not depart until someone gets off
- The bus does not depart until everyone has scanned their tickets
- A sensor in the bus can determine if a passenger has a ticket on their mobile phone when it gets on
- Camera technology in the bus that can read a ticket if it is displayed in the "air", no scanner needed
- The bus does not depart if it feels that passengers are still scanning their tickets
- The bus itself can tell when a fault occurs and inform passengers
- If a fault occurs that causes the bus to stop, the doors can be opened automatically
- If a fault occurs that causes the bus to stop, the bus knows whether it is safe to open the doors or not, and can act accordingly
- Travel search on board in a tablet on the wall
- Travelers tell you where they're going when they get on, and don't have to click stop
- Travelers can tell you they need a wake-up call when they get on the bus
- An alternative stop button that gives a passenger extra time to get off the bus
- Everyone in the bus pushes stop if they want to get off. The system detects how many people are getting off and keeps the doors open. Regret button if pressed incorrectly.
- Buttons in the bus to open and close the doors, like an elevator.
- Passengers who need more time to get to their seat can click a button in the bus that makes the bus wait to start
- Alarm buttons in the bus, which also sit low down
- Voice-controlled alarm, you can contact the control tower by calling for help
- Camera technology and AI that can determine if someone has fallen and call for help
- Passengers can scan their tickets on the outside of the bus before entering
- If a fault occurs that causes the bus to stop, passengers can decide for themselves whether it is safe to get out or not and open the door themselves
- The passenger can (voluntarily) talk about their needs before boarding, and the bus can take these needs into account
- The control tower can monitor the bus and keep the doors open until everyone is off
- If a fault occurs in the bus, the Control Tower is connected, which can inform passengers about what is happening and make decisions on how to solve the problem
- Demand-controlled buses, if a bus is full then an extra bus can be called on to the stop
- Demand-controlled bus where you can choose to talk about your needs before getting on, and the bus can act accordingly
- The control tower resembles an air traffic control tower, where each person is responsible for

a certain number of buses

All buses

- Softer floors that reduce damage in the event of a fall
- Passenger bill that can determine if it is full in the bus
- The bus can diagnose itself to more quickly find sources of error
- Forecast in real time, the bus can find out and tells you how many people are on the bus right now
- Passengers tell us when they get to which stop they are going to to improve occupancy forecast
- If you notice that people with a need for more space in the bus travel at certain times, then more buses can be put in to those stops during those times
- A new type of ticket carrier that the passenger can wear, facilitates ticket scanning
- Function that knows when you arrive at your stop and wake the person up

Already implemented in manned buses

- The bus signs full if the capacity is reached
- Speakers on board announcing the next stop
- The doors sense if someone is in the opening and wait until they have passed completely to close themselves
- If smoke develops in the bus, an alarm goes off and the bus can be evacuated
- Special times when more buses staff the line to reduce congestion in the buses
- Journey planner in an app
- The passenger is solely responsible for waking up before their stop
- If the bus is full, it stops only for disembarkation
- A forecast can tell you how many people are likely to be on the bus before getting on, based on normal occupancy rates

Category descriptions System 3:

Safety

- Bus acceleration/deceleration must be smooth and slow to reduce the risk of falling
- Softer floors that reduce damage in the event of a fall
- The doors sense if someone is in the opening and wait until they have passed completely to close themselves
- A loudspeaker tells the bus to start moving to prepare the passengers
- Passenger bill that can determine if it is full in the bus
- If the bus is full, it stops only for disembarkation
- If the bus there are too many on the bus, it talks about it, and does not depart until someone gets off
- The bus does not depart until everyone has scanned their tickets
- The bus does not depart if it feels that passengers are still scanning their tickets
- If a fault occurs that causes the bus to stop, the bus knows whether it is safe to open the doors or not, and can act accordingly
- If smoke develops in the bus, an alarm goes off and the bus can be evacuated
- The bus can diagnose itself to more quickly find sources of error
- Passengers who need more time to get to their seat can click a button in the bus that makes the bus wait to start
- Alarm buttons in the bus, which also sit low down
- Voice-controlled alarm, you can contact the control tower by calling for help
- Camera technology and AI that can determine if someone has fallen and call for help
- The control tower resembles an air traffic control tower, where each person is responsible for a certain number of buses

Security

- Passenger counting systems can see if someone has gone off and keep the doors open until the person is off
- A sensor in the bus can detect if someone is moving and keep the doors open until they are off
- Camera technology can act as a passenger counting system and determine how many people are on the way off the bus
- The bus itself can tell when a fault occurs and inform passengers
- If a fault occurs that causes the bus to stop, the doors can be opened automatically
- An alternative stop button that gives a passenger extra time to get off the bus
- Everyone in the bus pushes stop if they want to get off. The system detects how many people are getting off and keeps the doors open. Regret button if pressed incorrectly.
- Buttons in the bus to open and close the doors, like an elevator.
- If a fault occurs that causes the bus to stop, passengers can decide for themselves whether it is safe to get out or not and open the door themselves
- The passenger can (voluntarily) talk about their needs before boarding, and the bus can take these needs into account
- The control tower can monitor the bus and keep the doors open until everyone is off
- If a fault occurs in the bus, the Control Tower is connected, which can inform passengers about what is happening and make decisions on how to solve the problem
- Demand-controlled bus where you can choose to talk about your needs before getting on, and the bus can act accordingly
- A new type of ticket carrier that the passenger can wear, facilitates ticket scanning

Simplicity

- Speakers on board announcing the next stop
- The doors of the bus stay open for a certain time
- A sensor in the bus can determine if a passenger has a ticket on their mobile phone when it gets on
- Camera technology in the bus that can read a ticket if it is displayed in the "air", no scanner needed
- The bus signs full if the capacity is reached
- Passengers can scan their tickets on the outside of the bus before entering
- Journey planner in an app

Convenience

- The seat can detect if a passenger is falling asleep (for example, by using smart textiles) and can wake it up
- Passengers tell us when they get to which stop they are going to to improve occupancy forecast
- Forecast in real time, the bus can find out and tells you how many people are on the bus right now
- Demand-controlled buses, if a bus is full then an extra bus can be called on to the stop
- Special times when more buses staff the line to reduce congestion in the buses
- If you notice that people with a need for more space in the bus travel at certain times, then more buses can be put in to those stops during those times
- The passenger is solely responsible for waking up before their stop
- Function that knows when you arrive at your stop and wake the person up

In the second game session, a more detailed map with labels was used, as it was important for the purpose of the game that the players understood what was in the area, even if they had little real-life experience there. The map was sourced from Lantmäteriet (The Swedish Mapping, Cadastral and Land Registration Authority). While the map originally contained some labels, including street and area names, some labels were added. For example, schools, stores, authorities and hospitals, as these could be relevant for certain stakeholders in the area

when planning routes. A vectorised map could not be sourced, and so a raster image with a large resolution was used instead.

Between 3 and 4 players participated, four stakeholder groups in the area were identified via discussion and subsequent research. These were given randomly to the players.

- The University Hospital, including patients, employees, visitors and students
- The Criminal Justice System, including the police, security service, and courts
- Inhabitants of all ages
- Businesses of all sizes

The players were given about 15 minutes to assess the needs of their stakeholder and were asked to write ideas on three differently coloured post-it notes. Green for areas where they would like to see an autonomous bus, red for areas where they would not like to see an autonomous bus, and yellow for areas where they had other opinions on the implementation of autonomous buses. These were then placed on their corresponding areas of the map. The participants then gathered to discuss their opinions. Each player was instructed to present their ideas, and a brief discussion took place after each presentation.

In the Session 2 of the Game 2, the same map was used, with the difference that the bus stops and parking spots had been marked, following the feedback from the first session. This was added to increase the participants' understanding of the area and the transport options that are already in place in the area. In session 1, participants mentioned having a difficult time getting into character, as they had little prior knowledge of the interests of the stakeholder they had been assigned. To avoid this issue in session 2, players were instead instructed to represent themselves and to base the opinions on their own needs. The players were given three missions in the area, and were told to choose how many, and which ones, they wanted to do. Players where then asked to either work alone, or in groups of two, to determine how they would like the autonomous bus network to look to solve their mission in the best way possible.

The following three missions were available:

- Imagine that you are an inhabitant in the area
- Imagine that you are traveling in from outside to run an errand in the area.
- Imagine that you are visiting the hospital. You might have to visit multiple wards

The players were given a paper with further instructions for each of the missions, to aid in their discussions. These questions and instructions included:

- Where would you like to see the implementation of autonomous buses?
- Where would you not like to see the implementation of autonomous buses?
- Do you have any other opinions on the implementation of autonomous buses?
- The opinions do not have to be tied to a specific area, but can be general as well
- Consider times where you are not traveling by bus, but by other means. Where would you want the autonomous buses to be implemented in those cases?

The participants were given about 45 minutes to discuss in their smaller groups. This amount of time was not selected beforehand and was only based on whether the participants were still actively discussing their missions or not. During the discussions, the game leaders checked in with the different groups to make sure they understood the task, and to aid them in their discussions. The different colour post-it notes were once again given to the different groups. After a short break, the participants gathered for a group discussion, where they were urged to present their findings, and to find similarities and differences between opinions. Some

questions were asked by the game leaders, to clarify results and to encourage the players to develop their answers.

In the second game session, there were 6 participants from different interest groups (elderly and relatives to users with cognitive limitations). Only Game 2 was played since the first game was expected to give similar results as the experiment when travelling with the buses, which they had already participated in. The participants were given the following instructions:

“Now that we have found out some of the actual problems that can occur on a bus, and started looking at different solutions to these problems, we want to start looking at what the route network might look like. Where will the buses go, and what needs should they meet? Where do we not want buses?

To look into this, we need your help, the player was assigned missions in the garrison area. The player then has to think and with the help of the facilitator, - how would they like the buses to go, so the user can best cope with the mission? After this, the player has to work with other players, and look at how the bus routes could actually be designed.

There are three missions, and the player gets to choose to watch only one, or to do all three. Think about the situation and think, how would you like the buses to travel in order to be able to fulfil the mission? Are there areas or occasions where the participant does not want buses?

- The first assignment is to imagine that the player lives in the area. What day-to-day errands can she/he possibly have, and how can the bus routes be designed accordingly?
- The second assignment is that the player comes from outside and has one, or more, activities in the area. There can be several different types of activities, the player may want to shop, or visit the police.
- The third assignment is that the player come from outside and has a to go to the hospital. So the player may need to visit multiple units, or maybe even the unit “Movement and health”, which is located in the Garrison area.

The solutions did not have to be specific to areas of the Garrison, could be independent of the location.

Also players were asked to think about the different ways to get to and from the garrison and how it would have affected how they would have liked to ride the bus.

Larger parking lots and bus stops were marked on the map. As residents may have to get into town, and how do they actually get to the area if you have an errand? Hence, they had to think about how the buses can help to get to and from the area.

The general results are presented below and the meaning of each colour in the categorisation of the results is as follows:

Specific: Solutions or opinions that specifically concern the chosen area

General: Solutions or opinions that are not location-bound, but that are applied to the entire system, regardless of location

Green: Areas where players are positive about implementation, or ideas they'd love to see implemented

Yellow: General opinions on what implementation should look like

Red: Areas where players are negative about implementation

System 1 - Green/Yellow/Red

Green
Buses are needed to/from shops, as there are few in the area and the distances are long
Buses between parking lots and the hospital area
Buses in the hospital area, between clinics and buildings
Buses that connect short-term accommodation with the rest of the area and the hospital
Steep slopes in the hospital area and in the Garrison make it difficult to get around as a disabled person. Buses can facilitate.
Buses between parking lots and the Garrison area
Buses connecting hospital units with those in the Garrison
Bus routes should pass through the police and the district court
The bus routes should pass restaurants, etc. in the area
The bus is welcome to pass through the emergency room to make it easier for people to get there / home
The bus needs to pass all the different devices in the hospital
The bus is welcome to go between parking lots and the emergency department
Buses between residential areas and supermarkets
The buses must be routed
Buses in the Garrison are suitable because the area is hilly
Ring line that goes both ways to all care units in the area
Connect the buses to stops from regular public transport

System 2 - Specific/General

Specific
Buses are needed to/from shops, as there are few in the area and the distances are long
Buses between parking lots and the hospital area
Buses in the hospital area, between clinics and buildings
Buses that connect short-term accommodation with the rest of the area and the hospital
Steep slopes in the hospital area and in the Garrison make it difficult to get around as a disabled person. Buses can facilitate.
Buses between parking lots and the Garrison area
Buses connecting hospital units with those in the Garrison
Bus routes should pass through the police and the district court
The bus routes should pass restaurants, etc. in the area
Summonses to hospital/police etc should include a map of the bus routes
The bus needs to pass all the different devices in the hospital
The bus is welcome to pass through the emergency room to make it easier for people to get there / home
The bus is welcome to go between parking lots and the emergency department
Buses in the Garrison are suitable because the area is hilly
Ring line that goes both ways to all care units in the area
Different lines in the Garrison area and in the hospital so you don't have to go to both

There must be several buses that come with high frequency

Yellow
Demand-controlled buses that can be used instead of transportation service
100-metre rule: bus stops are welcome to be within 100 metres
Stops must be designed so that wheelchair-bound passengers can board the bus
Autonomous buses are best suited in smaller areas, and should not be mixed with regular public transport
Summonses to hospital/police etc should include a map of the bus routes
Stops must be adapted to the visually impaired, with high contrast
No problem if the line needs to be redirected as long as information comes out
Different lines in the Garrison area and in the hospital so you don't have to go to both
Demand-controlled within residential areas, with bus stops

Red
No buses near large playgrounds
No buses near schools
No buses on major roads
No buses on bicycles and walkways

General
Demand-controlled buses that can be used instead of transportation service
100-metre rule: bus stops are welcome to be within 100 metres
No buses near large playgrounds
No buses near schools
The buses must be routed
There must be several buses that come with high frequency
Autonomous buses are best suited in smaller areas, and should not be mixed with regular public transport
Stops must be designed so that wheelchair-bound passengers can board the bus
No buses on major roads
No buses on bicycle roads and walkways
Request-driven within residential areas
Stops must be designed so that wheelchair-bound passengers can board the bus
Stops must be adapted to the visually impaired, with high contrast
No problem if the line needs to be redirected as long as information comes out
Connect the buses to stops from regular public transport

4.2 The results of the game sessions in Austria

In Austria, a routing and an awareness version were played in several sessions.

Serious Game Routing Version

The routing version was played in four sessions with senior citizens, persons with physical and/or mental impairments, their assistants, special needs teachers and persons from SURAAA in the district Waidmannsdorf in the city of Klagenfurt, Austria. The map of the game showed this district. The routing version aims at fostering discussion between different stakeholders and end users to find the ideal route for an automated shuttle in a real neighbourhood. When setting the route, the players should take the interests and needs of each other into account. The number of shuttle stops, the length of the route, the size of the neighbourhood and, if wished for, the maximum amount of costs can be determined beforehand. These criteria provide a framework for the discussion. During the game session, the players first introduce themselves and their relation to the neighbourhood (inhabitant, working in the area, visiting regularly etc.). Next, all of the players can mark the most important points of interests in the neighbourhood – already at this stage discussion starts as individual players often choose the same points of interest such as a train station, supermarket, doctor etc. In the end, all players should be satisfied and in favour of the fixed route.

The results presented here are the aspects mentioned in the Game Session related to a future mobility system / automated mobility services.

Current Mobility Behavior

- Car as a predominant mean of transport
- Hospital, Cemetery, Pharmacy, Doctor's office, Cinema and the Inner City as main destinations when travelling
- Further points of interest mentioned (in regards to other people's needs): Supermarket, Train station, bank, work place, schools, car repair shop, hairdresser, bakery, restaurants, university sport classes, gas stations

<u>Needs and wishes regarding Shuttle bus</u>

- On-Board explanation on how the technology works / information campaign beforehand that addresses potential fears
- It has to be possible to fasten the seatbelt with one hand
- Emergency brake should be available inside
- Needs to be more spacious than it is at the moment
- Needs to be easier to get in as it is at the moment
- Buttons need to be labeled

<u>Needs and wishes regarding surrounding infrastructure / Bus stop</u>

- Bus stop needs to be reachable by foot
- Tactile guidance system has to be available
- Level entry to the bus (currently, the entry to the shuttle is too high to get in)
- Bus stop should have:
    - A roof that protects from wind
    - Seating
    - Vending machines
    - Displays and information of the shuttle route

<u>Needs and wishes regarding Information</u>

- Communication channel to speak with a remote operator
- Real-time information via display
- Multi-Channel information (acoustic, visual, haptic information)
- Easily understandable orientation signs

Needs and wishes regarding Routing/Timetable

- User groups preferred routes with fixed bus stops
- Every 15 minutes
- On-Demand only outside rush hours

Needs and wishes regarding Ticketing

- More than one option to buy tickets (App, Ticket machine at the stop or in the shuttle, News shop), at least one option "offline" (e.g. ticket machine at the station)
- Different pay models (rides for free, integrated into the Klimaticket, daytrips, monthly/yearly subscription)

Serious Game Awareness Version

The awareness version of the Austrian serious game aims at sensitizing persons in charge of designing mobility services and/or persons who decide about the implementation of mobility services about the importance of designing and implementing mobility services accessible and according to a design-for-all approach. At the beginning of the game session a persona role is allocated to each player, e.g. someone plays the role of a 7-year-old child with minor skills in using the public transport or a blind middle-aged male person with advanced use in technologies. The players then face several possible challenges, which can occur on a trip with an automated shuttle, including pre- and post-trip processes. The players have to solve the challenges from the point of view of their persona role to move forward on the game board. With some challenges, the players have to pick an additional "action card" which may restricts the proposed solution or demands cooperation between two players. The game ends when the first player reaches the finishing line. In this serious game version, the players are persuaded to take the needs and requirements of persons with mobility restrictions into account in their daily work by offering them an interactive experience from the perspective of a (fictional) person with mobility restrictions. The evaluation of our two parallel awareness game sessions with policymakers, accessibility commissioners, mobility service providers, mobility researchers and transport planners in Klagenfurt, Austria showed that the participants were more aware of issues of accessibility after playing the serious game and wanted to consider the needs and requirements of persons with reduced mobility in their (future) work (even more).In general, the participants involved mentioned a lot of barriers and challenges they are already facing in the current public transport system.

The participants of group 1 of the awareness version were: 1 person from the Transport Planning department of the municipality, 3 persons from mobility research and 1 person from the mobility service provider. The five participants were males.

The participants in group 2 were: 1 from Transport Planning at the county level and 1 at the municipal level. Plus 2 researchers and 1 disability officer. It was a total of 5 participants, 4 males and 1 female.

The results presented here are the ideas/themes for solutions that the participants came up with when being confronted with a challenge:

Shuttle bus

- On-Board Motion detection to recognize if somebody wants to get off the shuttle
- Communication channel to remote operator
- Emergency Button

Surrounding infrastructure / Bus stop

- Information like timetable, telephone number for emergencies, etc. should be available
- Display of information: as easy to read and “clean” as possible

Information

- Information is considered key à information needs to be available fast and communicated in in a proper way
- Information campaign before shuttle deployment starts
- On-Board announcements
- Personalized push-notifications via Smart Phone that can be adjusted to personal needs
    - When something is wrong with the shuttle
    - Reminder to get off (could be important when you fall asleep or)
    - Beforehand to communicate that the shuttle is full
- Multi-channel information:
    - Acoustic/visual/haptic
- Real time information on shuttle behavior and unplanned actions
- Information on automation level of the shuttle
- Announcements also at the shuttle stops

Ticketing

- Public transport should be for free in the future
- Who checks the ticket? (Pay-per-Use model via wearable?)

Others

- Police, Ambulance and Fire fighters need to be trained to better respond to incidents happening with the shuttle

5. Conclusion and discussion of results

This deliverable 4.1 contains five sections. The first section presented the results obtained from WP2 and WP3 and the results were categorised into four key acceptability factors of the autonomous shuttle: safety, ease of use, accessibility, and comfort. Afterwards, the identified needs were presented per target group 1) older adults, 2) persons with physical and mental impairments and 3) children. The second section of this document included a SWOT analysis of the automated shuttle from a safety, ease of use, accessibility and comfort perspective. Meanwhile, the third section presented and discussed the overarching outcomes and the fourth section presented the local outcomes from the game sessions in Austria and Sweden.

From the first section, we can conclude that the research conducted in D3.1 and D3.2 found that automated shuttles could be used as a complement to existing public transport services. The results show that safety, ease of use, accessibility and comfort are key to increase user acceptability when designing automated shuttles for the three target groups. Safety elements such as emergency buttons, various communication methods, surveillance, lights and sounds are key as there is a serious concern from the three target groups about the absence of the driver. The driver is the first person our target groups have in mind in case of a problem. Ease of use and accessibility also need to be taken into consideration in order to provide a user-friendly experience. Ease of use was highly associated to safety elements and it was also related to information inside the vehicle and the access to general information of the service via digital and traditional channels. In terms of accessibility, compatible infrastructure, enough space for mobility aids and tactile guidance systems were mentioned. Finally, considering comfort needs is important to provide a pleasant experience for the user. In this regard, sufficient and comfortable seats, enough poles and handles, smooth rides and air conditioning are some of the elements that should be taken into account.

The second section presented the SWOT analysis, from it we can conclude that various aspects related to safety, ease of use, accessibility and comfort still need to be considered in order to achieve an inclusive implementation of the automated shuttle. While the shuttle already has positive characteristics, there are issues that need to be addressed. The identified strengths of the shuttle included an emergency button, video surveillance, the extinguishing system, and the seatbelts. The weaknesses include the lack of emergency brakes, the lack of communication between passenger and controller, and the lack of sound systems to keep other road users away, just to mention few. The opportunities include the possibility of connecting the shuttle to emergency services, providing more information to the passengers, developing an app with route information, providing additional time to access and leave the shuttle, and integrating the shuttle into the existing transport network. The threats include the lack of easy access to information about the shuttle, not equipping the shuttle stops, and a lack of toilets.

Based on the second section, the third section discussed a general understanding on the needs of each group. In this sense, the SWOT analysis helped to understand the potential of the automated shuttle when considering an inclusive implementation. All this acquired knowledge provided the consortium partners with the required experience to adapt the serious game in the Austrian and Swedish context to identified specific needs. In other words, this experience permitted the development of adapted versions of the serious games initially created for the Belgian context.

Section four, presented the results of the game sessions in Austria and Sweden. The serious games in Austria provided us with important inputs not only on needs and wishes for automated mobility services, but also on struggles that our target groups are facing within the Austrian mobility system. Unfortunately, these current issues will not be resolved by introducing automated mobility services, on the contrary, they might even be reinforced if human drivers are eliminated. The response to our serious games as a tool for participation was overall very good. Both games proved to be very well suited to involve stakeholders by guiding and stimulating the discussion, focusing on the development of solutions in a playful way, which otherwise would be perceived as unpleasant or taboos. We were able to identify needs, wishes and concerns regarding the introduction of a automated mobility service. This showed us, that it is crucial to include user groups at an early stage of the planning process.

The Austrian awareness game version raised awareness of the challenges faced by vulnerable groups and generated an understanding of potential problems associated with the use of driverless buses. The decision makers who participated were aware of many of the problems mentioned, the perspective of our target groups on the challenges was a valuable asset and urged to offering inclusive solutions. The use of the challenge cards together with the event cards has proven methodologically successful, as this can also be used as a method to check how inclusive (technical) solutions actually are and which shortcomings still exist. The serious game was seen as particularly recommended for training public transport staff or students, as it puts them in the shoes of passengers and self-experience has proven to be a sustainable awareness-raising method. Moreover, the game also proved to be particularly suitable for the development and evaluation of existing guidelines for public transport. A particular advantage of the game was that it also had a positive effect on group dynamics, as all players were involved and solving a situation became a joint action.

For the routing game, it also showed that its use in practice would be considered desirable and that the game could be a simple but effective tool in citizen participation. The game is suitable for all user groups, can be implemented with simple means and also allows people with sensory impairments to participate in planning processes. It has been shown that the game is very suitable as a start of a planning process, because it can be agreed with the users, in which area a public transport offer is missed or where it is only due to the organization of the existing offer and no additional offer is necessary. It was often mentioned here that there are sufficient bus connections, but the transfer times are not long enough, resulting in long waiting times. With the help of the game, is possible to identify what people's actual needs are and thus also to set targeted and needs-based measures. This can help to ensure that financial resources are used more efficiently. It is particularly interesting to mention that the game not only reveals the needs of the users, but also raises awareness among the users for the complexity of the planning of public transport services. The specifications we gave to the players (e.g. route has to be of certain length) proved to be necessary, to start the discussion about the stops, the route and finding an agreement between the needs of the players. Otherwise, it would have been a “walk in the park”. The most important success factor that was identified for the serious game in Austria was the familiarity with the area in question. Furthermore, the heterogeneity of the group proved to be really useful, to identify as many needs and wishes as possible.

In the Swedish game, the awareness game version was very useful to raise challenges associated with creating an inclusive autonomous transportation system. The participants found interesting and relevant to discuss the different situations. However, in some case the conversation ended with discussing technical solutions even though that was not part of the

task. In this regard, it was helpful that the game forced the participants to be brief and to the point. Moreover, many of the issues raised were related not only to automated buses, but are also relevant for “normal” buses, so some results can be useful also in other contexts.

The routing game was more difficult for the decision maker participants since they thought it was difficult to understand the transportation needs of users with special needs. The participants found easier to identify points of interest regarding where the buses route should run and where buses should be avoided (e.g. near emergency intake at the hospital). The participants from Funktionsrätt, who are the ones with special needs, found with the serious game, a much easier way to discuss how the routes should be designed to address their needs. Therefore, we believe, it is important that this type of game are played with a wide variety of potential users in order to accommodate as many different needs as possible.

Regarding concrete results from the Swedish games, there are a number of issues related to comfort/safety of the automated buses and the bus stops, that are similar to buses with drivers. Yet, the most important points that are specific for automated shuttles are:

- Proper choice of routes with high frequency, short distances as complement to ordinary public transport.
- Monitoring of passengers to ensure that no one falls, that the bus does not start or stop when passengers are still standing, etc.
- Easy communication with a remote human being in case of need (emergency, information etc).

As we can conclude, from the research conducted in Austria, Belgium and Sweden, there are many important factors in terms of safety, ease of use, accessibility and comfort that need to be addressed to achieve an inclusive mobility. Furthermore, many of the above mentioned challenges that have arisen during CATAPULT project do not belong only to automated vehicles but they apply to the current mobility system. Therefore, we hope that the recommendations that we will present in Deliverable 4.2 and which build upon these results, are taken in this way. While the main focused of our project is in automated vehicles, we think that several of our recommendations can already be considered to improve inclusiveness in public transportation systems.

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