Highly automated public transport for everybody: Insights from Focus Groups

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ABSTRACT

Over one billion individuals globally live with some form of disability, and the implementation of highly automated public transport vehicles (APTVs) holds significant promise for enhancing their quality of life. The purpose of this qualitative study is to identify specific requirements by passengers with special needs (PwSNs) towards APTVs, identifying concerns and gathering solutions from PwSNs, their representatives, and public transport providers. Forty participants from Finland, Germany and Spain, including mobility-impaired and visually impaired users, elderly, tourists, and public transport stakeholders, engaged in 8 focus group discussions. Key findings highlight the importance of safety, accessibility, comfort, and responsiveness in APTVs. Safety concerns include the need for emergency systems and human assistance to handle emergencies and technical malfunctions. Specific requirements regarding e.g., abnormal situations detection, accessibility aids in snow and icy conditions, solutions for clearing occupied spaces, as well as the necessity of humans in selected cases were outlined. The study emphasizes the need for co-creating solutions to boost acceptance and reduce barriers to APTV adoption, ensuring inclusivity and accessibility for all passengers.

Keywords: Automated Public Transport, Special Needs, Acceptance, Focus Groups, Design Recommendations, Accessibility.

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1 INTRODUCTION

Over one billion individuals (16% of the global population) live with some form of disability (World Health Organization, 2023). The implementation of highly automated public transport vehicles (APTVs) holds significant promise for enhancing the quality of life for individuals with special needs (e.g., Golbabaei et al., 2024). Developments in automation have led to numerous highly automated shuttles, including Baidu Apollo, EasyMile EZ10, Navya Arma, and Local Motors Olli (Iclodean, Cordos, & Varga, 2020). Research on the acceptance of APTV by passengers with special needs (PwSNs) has increased recently. Kassens-Noor et al. (2021) distinguished between five communities: Intellectual and Developmental Disability, Deaf/Hard of Hearing, Blind and Low-vision, Mobility Impaired, and Older People/Aging Population. The “OptiPEx” project focused on the last three groups, each of which has unique requirements from a transport perspective and would benefit from different communication and engagement strategies (Bayless & Davidson, 2019). Most respondents with special needs viewed

This project has received funding from the European Union’s Horizon Europe research and innovation programme under Grant Agreement No. 101146513.

APTVs negatively (Kassens-Noor et al. 2021) due to concerns about safety, security, technical feasibility, and lack of assistance. Further research (Dicianno et al., 2021; Golbabaei et al., 2024) has identified barriers regarding accessibility such as inadequate space for wheeled mobility devices, crowd-induced inaccessibility, non-standardised seating configurations, confusing seating locations for visually impaired individuals, inoperable or overly steep lifts and ramps. Visually impaired users encounter challenges with navigating to bus stops, understanding timetables, and boarding buses due to the lack of tactile and auditory aids (Mathé et al., 2024). Adding modern technologies like GPS localization, online timetables, audio signals, and braille on buttons can improve AV accessibility. Furthermore, Golbabaei et al. (2024) gave some design recommendations, including *doorways, ramps*, *seating*, *securement system*, *interior layout*, and *interfaces*. Many recommendations appear to be quite general, and the entire passenger journey is rarely thoroughly investigated, as suggested by Dicianno et al. (2021). Therefore, focus of the present research lies on details and more concrete cases that development should address to increase safety, comfort and acceptance of APTV. Beyond disabilities or reduced mobility, other groups with special needs include the elderly, passengers with large objects, and tourists. Asha et al. (2021) stress the importance of co-creating solutions to boost acceptance and reduce barriers to APTV adoption. This study aims to identify concerns regarding APTVs and gather solutions from special needs passengers, their representatives, and public transport providers.

2 METHOD

A qualitative approach was selected to gain insights into the requirements for APTVs. Focus groups were conducted by project partners VTT (Finland), UZ (Spain), and IAV (Germany), representing the southern, central, and northern regions of Europe, along with diverse cultural spheres within the EU.

2.1 Participants

Across all countries, study participants were recruited with the assistance of local associations for disabled and older individuals, as well as through OptiPEx partner networks, which include project partner personnel and representatives from Public Transport Providers. In Finland, the Nysse lab, focused on customer-centric service development in Tampere public transport, facilitated recruitment efforts. In Chemnitz, Germany, additional contacts were made with regional projects such as ‘ÖPNV für alle’ and the Commissioner for the Disabled. Personal social media channels and notices on bulletin boards at TU Chemnitz were also utilized during the recruitment process. In Spain, participants were recruited through municipal associations (Oficina del Mayor), NGO (DFA, Discapacitados Físicos de Aragón) and a private organization of social nature (ONCE, Organización Nacional de Ciegos Españoles. The recruitment strategy aimed to ensure gender balance, public transport usage and encompass a wide range of ages and special needs, including mobility or visual impairments, elderly participants, tourists, and individuals requiring extra space do to e.g., stroller or wheelchair use.

Three focus groups in Finland were held in Tampere. These had 14 participants (8 male, 6 female), aged 30 to 83, and included mobility impaired users (2 wheelchair, 2 walker/rollator), users traveling with large objects (2 traveling with a pram/baby stroller), tourists (3) and stakeholders (3 providers, 2

research & development, from 2 different organizations). In Germany, four focus groups were conducted: three at IAV GmbH in Chemnitz, and one online by request. The 15 participants (8 male, 7 female), aged 24 to 75, included three blind individuals (two representing local blind associations), one wheelchair user, three public transport operators, one representative for disabled/senior citizens, three senior citizens, and four tourists. In Spain, a focus group in Zaragoza with 11 participants (6 female, 5 male), aged 45 to 75 was conducted. It included 2 wheelchair users, 1 with balance difficulties, 3 pensioners and 5 visually impaired participants as well as a representative from “Tram of Zaragoza”.

2.2 Procedure

All sessions included a moderator and an observer, were recorded and transcribed. In the beginning, participants signed consent forms, completed a demographic questionnaire, and were introduced to the "OptiPEx" project. Across all countries, the sessions lasted 2 to 2.5 hours. At first, participants were asked about challenges when boarding. Afterwards, solutions to overcome the collected challenges were gathered and the question “what if the vehicle is autonomous, i.e. there is no driver” was raised. Second, exceptional situations (“What makes/ Which situations make you feel uncomfortable while using PT?”) and third, passenger distribution issues (i.e. finding free spaces) were discussed, again, followed by identifying APTV-specific issues and gathering potential solutions and design recommendations. Written notes from observers supported the inductive thematic analyses for the different questions. For the present paper, results regarding the “What if there was no driver” sections of the focus groups are reported.

3 RESULTS

3.1 Safety

Safety was the most prominent topic. The *need for an emergency system* was emphasized, which should be able to automatically detect and report emergencies or accidents to a center control. Participants expected a *loss in feeling safe* as the absence of a driver could lead to more conflicts and inappropriate behavior. The presence of staff is seen as a deterrent that regulates passenger behavior. The vehicle or remote control (operator) may also be unable to quickly identify the problem and remotely handle the situation. The former depends on situational awareness capabilities (chiefly sensors and AI), the latter depends on the nature of the problem. It was suggested that there should be *emergency buttons and other mechanisms* to call for help - not only for emergencies, but also for abnormal situations such as medical issues, harassment, or vandalism. Concrete design recommendations were clear labeling, tactile markings, bell sign on the button and connecting directly to a person/central control using video transmission for additional reassurance. It was suggested that concrete action protocols e.g., for accidents, harassment, or malfunctions should be developed. Additionally, an emergency function within a mobile application was brought up by stakeholders. For cases in which all else fails, a phone number to call for help could improve safety. It also was proposed to *analyse passenger behaviour* inside the vehicle using AI and video to detect medical emergencies, like an unconscious or fallen passenger, or unsafe behaviour, such as standing without support. Such

instances should trigger a call for help, alert, or reminder.

Malfunctions or insufficient sensitivity in door sensors could close doors on passengers or fail to detect white canes, potentially causing more harm in APTV than in conventional public transport due to the lack of a driver. The missing human driver also led to worries that assistance in case of emergencies or safety threats might be delayed. Thus, participants recommended having human assistance onboard.

3.2 Accessibility

Visually impaired participants stated they needed *reassurance* if multiple lines would stop at the station. In general, until now, bus drivers have often helped, and APTVs would need other solutions. When entering a bus or tram, it is often relatively noisy, so acoustic information will be hard to understand. Drivers often help when infrastructure is not inclusive, adapt to current circumstances and support PwSNs in *orientation*. Part of it might be addressed by longer dwell times, but other devices or solutions are needed such as activatable audio at the station, in the vehicle or an app. Uniform regulations and clear communication channels including multimodality are recommended to prevent misunderstandings or missing information. However, visually impaired passengers may delay others while waiting for auditory cues and impatient co-passengers might push and reduce safety and comfort. Apart from that, visually impaired passengers are used to entering the first door using a tactile field at a station to guide them; APTV should be capable of stopping there. Moreover, APTV as a technical system might consistently stop at the very same location, which would also aid in navigation.

Lack of Assistance. For boarding passengers with limited mobility without human assistance, different means to trigger automatic ramps doors, e.g., by AI-based identification of the wheelchair or by pressing a special button were discussed. Assistive technology (e.g. automated ramps) should be capable to handle the variation in elevation of bus stops and varying weather conditions (in Finland, snow and ice are a major challenge). Additionally, participants pointed out that drivers often help to clear the designated space and ask other passengers to make room. In Finland, the weather conditions further increase the need for assistance. If there is no driver, it is unclear for PwSNs how to get skilled assistance. Instructions given by the APTV may not be sufficient and fellow passengers may not know how to help, how to do it safely without causing risk or damage to either helped or themselves. It is also unclear who would then be responsible in case of damages. Still, social engagement campaigns and simplifying technical aids, to motivate other passengers to help would be especially helpful in emergencies. On-call assistance (call via app) at stations could help boarding or getting off. Implementing a communication system with a central control staffed by a real person was discussed in all groups, ensuring passengers can ask questions and receive support. Participants proposed an app that would allow users to check if has room for a wheelchair or buggy and reserve a place in an APTV at a specific time and location. It could also notify visually impaired passengers if they enter the wrong APTV and include features like an emergency button or service call. Participants emphasized that this should be an additional option, as emergency calls need to be independent on personal devices.

A *unified and clear ticketing system* was proposed to simplify ticket machine operation and facilitate

public transport use for all passengers. Uniform regulations and standardized procedures at stops and on vehicles are crucial, for instance, to substitute the driver's task of checking validity of tickets.

Clear orientation aids are vital such as loud and clear acoustic announcements, color-coded doors, clear, highly visible line markings, and directions in local language and a generally spoken language such as English. Information should be in large, easily readable text and/or pictorial communication. Audio information could be automatically transferred to monitors and translated. A potential guidance system via an app can further ease navigation for visually impaired passengers.

3.3 Comfort

Practical experience and *smooth transformation including human assistance* in the beginning of APTV operation will reduce uncertainty and increase comfort according to participants. *Communication* in crowded APTV should include automated announcements to inform passengers when it's too crowded or if they should make space for PwSNs. Providing reassurance options about e.g., the current line, upcoming stations, and connections are needed to enhance comfort. Innovative in-vehicle communication methods can assist those unfamiliar with mobile apps or when route changes due to construction are not updated in apps. Participants also suggested an AI-based robot for interaction but noted the lack of warmth compared to human communication. *Privacy challenges* were a topic seldomly recognized by participants but was a concern with Finnish stakeholders. APTV vehicles require increased number of sensors (e.g., cameras) for situational awareness, in-cabin or crowd behaviour recognition. In Finland, the challenge was seen in addressing regulations in service development by the stakeholders.

PwSNs expect a *loss of potential extra services*. Though, many systems lack accessibility, drivers try to accommodate needs. If someone has only five minutes to transfer, they can ask the driver to stop a bit closer to their connection. PwSNs would also experience *additional stress* when they look for a seat as the APTV might not wait until they are seated. Again, prolonged, adaptive dwell times appeared as one solution, but other solutions are needed to overcome this barrier. The *Loss of social contact* was also discussed. Drivers frequent on same routes and can become familiar faces, forming a social touchpoint. This is especially important to people who lack of other social contacts e.g., elderly people.

3.4 Responsiveness

There was doubt that the APTV should be operated without any human on board who would support in emergency or malfunction cases. In cases where no human is on board, passengers should be informed that the APTV operates autonomously. This will prevent them from waiting for others to join or expecting a driver and avoid mistaking the absence of drivers as an indication that the vehicle is malfunctioning. The APTV or central control should automatically track the vehicle's location and detect various situations, such as accidents, malfunctions, emergencies, harassment, and passengers searching for space. It should respond by contacting central control, adjusting vehicle behaviour, making automatic announcements, or providing human assistance/security at the next station.

Limited response if the vehicle is crowded. The decision of whether a vehicle is crowded and requires a

wheelchair user to wait is currently made by the driver. Additionally, to efficiently load the vehicle, passengers are often instructed to “move further back in.” Information systems indicating less occupied parts of the vehicle were considered, but there were concerns about information overload. A space display system like those in parking lots, providing visual cues about available spaces, or a color-coded display system at doors or on station floors, akin to traffic lights, was recommended to guide passengers to less crowded areas. Occupancy displays are particularly useful for large vehicles like trains, where effective space management is critical. Automated announcements to direct passengers and indicate free spaces can also improve distribution. Visually impaired passengers tend to use always the same door to avoid loss of orientation and would not follow such instructions. A unified app showing vehicle occupancy before trips helps passengers plan, though actual occupancy may change.

Interaction requires optimization. All announcements and displayed information within the vehicle must be clear, understandable, and loud/readable enough for all passengers, including those with hearing/visual impairments, to receive necessary information. Responsiveness could improve if a (friendly) human contact was available, including video interaction, which is particularly important in emergencies. Information regarding route changes should be timed to give passengers adequate time to react. Display locations should be selected carefully to ensure visibility and reduce obstructions.

Systems are designed to follow strict programming rather than being adaptive. Human drivers can adjust services and prioritize customers. Examples such as waiting for a missing family member or for grabbing the second suitcase. There are concerns that autonomous vehicles would adhere strictly to fixed timetables instead of allowing for such flexibility.

3.5 Convenience

Decreased quality of help and proactive behaviour gets lost. A user with mobility issues benefited from driver's proactive, physical demonstration on using a walker to get in and out of a bus. An APTV might not identify the need for help and can only show a video, which might not be visible until the user is already inside. To address uncertainties, easy support methods are needed to give passengers similar confidence as with drivers present. Design can't foresee every situation, and technology can't always handle unexpected issues. When human action is needed, the absence of staff or incorrect actions can cause inconvenience or harm. One case raised concerns about how wheelchair users would exit during an emergency stop. It was also noted that automated buses may result in a greater reduction of interactions compared to automated trams, due to the already limited interaction with drivers in trams.

4 DISCUSSION

The findings of the present qualitative study give more detailed insights in the importance of optimizing interaction with APTV, central controls and additional devices to overcome potential barriers of PwSNs. In line with Golbabaei et al. (2024), design recommendations for *doorways, ramps*, *seating, interior layout*, and *interfaces* were given, although additional fine-grained requirements could be retrieved from the focus groups. For instance, addressing Finnish winters, provide solution for clearing occupied spaced, lack of proactive behaviour of drivers and the importance of humans for communication and

special assistance. The latter aligns with the review findings of Golbabaei et al. (2024) who highlighted the importance of human attendants for PwSNs in APTVs. In emergency situations, having access to a friendly human contact can improve responsiveness and provide reassurance to passengers. Solutions should fulfil those specific requirements. Furthermore, the rigidity of APTVs poses significant challenges. Unlike human drivers who can adapt to changing circumstances and prioritize passenger needs, APTVs often adhere strictly to pre-programmed rules and schedules. This inflexibility can lead to dissatisfaction among users, AI-based solutions are promising means to provide at least part of the flexibility of humans (e.g., additional time at stops) and reduce some uncertainties of PwSNs.

Especially interesting was the potential loss of social contact; what is like what Dicianno et al. (2021) in their review found; that mental health and social isolation for older people should be considered. Additionally, the lack of a human element onboard APTV raises concerns about handling unanticipated situations and the need of reassurance. Smart ways to aid orientation are more important for APTV than for conventional public transport. AI-based solutions to detect abnormal situations and react to them seem a fundamental basis for further developments. Orientation-giving application such as WonderVision (IAV GmbH, 2023), to aid visually impaired passengers in navigating to the correct line, might be one part of the future system needed.

As first input, the present research gave various, detailed requirements for future APTV systems within the co-creation process. Throughout the process, further user studies will be needed to quantify identified issues and clarify additional needs of PwSNs. In conclusion, while APTVs offer significant potential for enhancing mobility, addressing the identified challenges is crucial for ensuring inclusivity and accessibility. The integration of human contact, flexibility in operations, and proactive support measures are essential for meeting user expectations and providing a satisfactory travel experience. Future research should focus on developing adaptive systems and incorporating human elements to bridge the gap between technology and user needs.

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This project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101146513.