The impact of automated transport on disabled people

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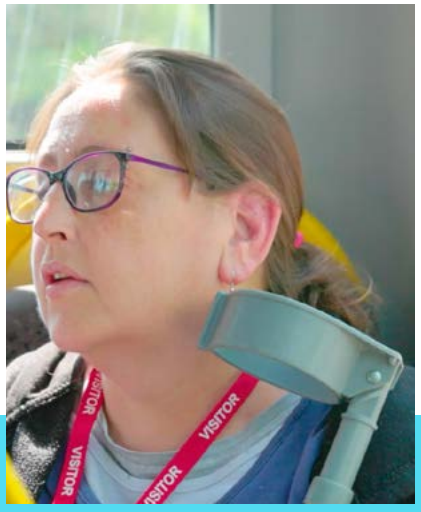
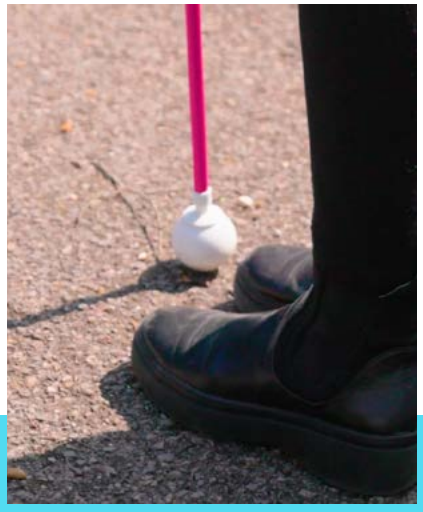
Motability Foundation
Making all journeys accessible





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TRL THE FUTURE OF TRANSPORT
RiDC Research Institute for Disabled Consumers

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Disclaimer

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Executive summary

Background and methods

In the development of automated transport, there is a need to consider accessibility. History shows that accessibility of new technology and services often slips down the agenda in favour of rapid deployment and a need to generate return on investment. To help prevent this scenario, this project had the objective to 'support the development of inclusive automated transport technologies and services by understanding the needs, perceptions, and challenges faced by disabled people'. The following research questions were considered:

- Identify the benefits of automated transport for disabled people
- Identify and prioritise the challenges faced by disabled people with automated transport
- Identify the extent to which accessibility is currently being considered in the design and development of automated transport technologies and services, including any good practice examples
- Identify design principles and recommended solutions to support the design, development and implementation of inclusive automated transport

These research questions were explored through an evidence review, stakeholder engagement with disability organisations, automated technology developers and transport operators, focus groups and a survey with disabled people and usability trials of two existing automated services.

The research was focused on Level 5 automation, with some discussion of Levels 3 and 4 (as set out in the SAE Autonomy scale). We explored both private and shared automated services. The focus was on services which transport people rather than goods.

Key findings

The benefits and challenges that disabled people may experience when using automated vehicles

Disabled participants could see several benefits both in private and shared automated vehicles. Both modes present the potential for numerous safety benefits, providing the automated systems are sophisticated enough to ensure safety. Automated private vehicles would offer users greater independence and a greater range of journeys they could take without the need for additional assistance. Participants felt that shared automated transport would also be able to provide improved staff assistance while the automated system has responsibility for the driving task. In addition, participants thought that the continued development of automated technologies are likely to come hand-in-hand with technologies that can provide improved audio and visual information (e.g. dedicated smartphone apps).

Several potential barriers were foreseen. Key themes were as follows:

- Many of the barriers disabled people experience in relation to non-automated transport will continue to be a barrier in relation to automated transport. These include being able to buy tickets, board and alight the vehicle, navigate to suitable seats, and the use of disabled priority spaces.
- Different people experience different barriers and, to be inclusive, these differences must be acknowledged and catered for.
- The challenges experienced by disabled people can often be barriers, not 'inconveniences' – some barriers can prevent some disabled people from travelling altogether.
- All stages of the journey need to be accessible for disabled people to be able to use automated transport. It's not just about the vehicle itself, but the surrounding infrastructure This includes information provision, digital systems and interfaces, transfer to other transport modes, and the built environment.
- A specific concern around automation was related to the lack of a driver, who would carry out an essential role in providing physical assistance, information, enforcement of rules and assistance in emergencies.
- Additionally, disabled participants were concerned about the licensing requirements needed to operate a private automated vehicle and whether this would exclude them.

The extent to which accessibility is currently being considered in the design and development of automated transport technologies and services

Twenty-eight stakeholders were interviewed. It should be noted that this small sample of representatives from industry and disability organisations may not represent the views and actions of all.

Nonetheless, the following themes were identified:

- Stakeholders expressed support for goal of designing accessible automated vehicles and systems, noting the positive impact that accessible design will have on overall access and service quality for a diverse range of individuals.
- Developer priorities are typically ensuring that the technology functions correctly and safely to establish a solid foundation before focusing on the user experience. This can overshadow the consideration of customer experience and accessibility considerations.
- Automated solutions in the short term may rely on retrofitting existing vehicles with automated technology, which means that existing accessibility issues will not be addressed.
- Stakeholders felt that a one-size-fits-all solution will not be technically or commercially viable, due to differing needs of disabled passengers.

- Stakeholders felt that existing guidance on making automated transport more accessible is limited. Existing regulations, such as PSVAR, were considered useful but may not provide sufficient guidance. The lack of guidance (over and above the regulations) risks creating inconsistent levels of accessibility across different services.
- Stakeholders stressed the importance of inclusivity of customer groups from the outset. There were some examples of this being done in practice, for example through conducting open days, gathering feedback on new vehicle designs and consulting individuals who have lodged accessibility-related complaints. These activities were not consistently reported across the sample.
- Some operators and technology providers have already introduced features to enhance the accessibility of their existing non-automated transport services, which would also be relevant to automated services. Examples include automatic ramp deployment, accessible colour schemes and apps to enable customers to log specific support needs. These were not consistently implemented across all organisations.

Conclusions

Disabled people can see some benefits of automation, but there are many potential barriers to be overcome. These barriers exist across the journey – from booking to boarding to feeling comfortable and informed on board to interchange with other services. Automation is not in itself a solution to current accessibility barriers. Not only this, but automation has potential to create new barriers; for example in situations where new automated services don't adequately consider how to replace the roles that drivers currently play – roles which are crucial to enable accessibility.

There are signs that industry stakeholders are beginning to consider accessibility – however good practice is currently patchy, with some organisations further along in their journey than others. Given the number of types of organisations involved in development of an automated service (e.g. technology developers, manufacturers, operators), there is a risk that consideration of accessibility is falling between the cracks.

A key challenge is that there is a lack of guidance for creating accessible automated services. To aid the development of guidance in this area, we have developed a draft set of principles which we believe all automated services should follow.

First and foremost, is to engage in user-centric participatory design.

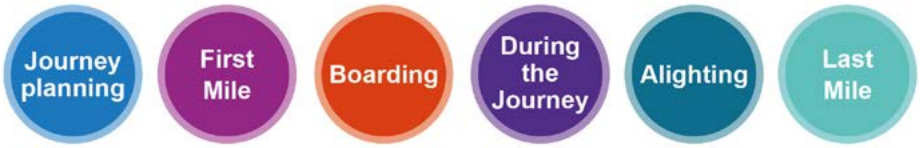
Disabled user groups should be actively included in the development and design of all aspects of a vehicle and service, including ideation, prototyping, beta-testing, and post-production.

Following implementation, efforts should be made to allow continuous monitoring and evaluation of that product or service.

This would involve gathering, tracking, and assessing data on the accessibility and customer experience of the service.

Both of these principles feed into the third overarching design principle, which is to ensure that an inclusive design approach is applied across the end-to-end journey.

This is a matter of ensuring a service is accessible to its users from journey planning to arriving at a destination.



Across the end-to-end journey, the automated service should:

- Be designed to be physically accessible to all
- Be predictable and reliable
- Provide a safe and comfortable experience
- Provide effective assistance, available when needed
- Provide accessible information and communication
- Enforce clear and understood passenger rights

We propose that under each principle, there are a series of outcomes. These outcomes should be met in order to achieve the principle. We suggest defining outcomes, rather than prescribing certain features or actions, to allow manufacturers, technology developers or operators to innovate, rather than being overly restrictive.

We propose that the principles and their associated outcomes are applied within a system of regulation and guidance. This system could include:

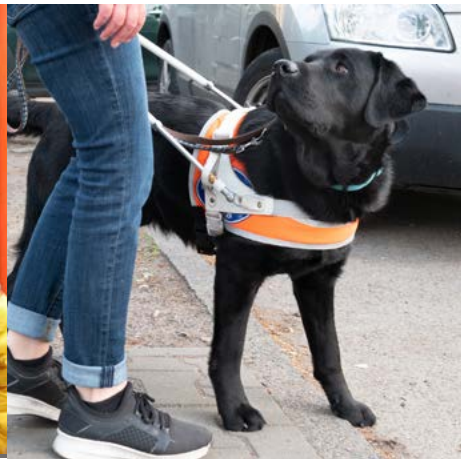
- Regulation – containing minimum outcomes that all services would need to meet
- Guidance – containing additional outcomes which go beyond minimum standards and align with good practice
- Rating system – something for services to be rated against, drawing on the minimum and additional outcomes

Recommendations

Our primary recommendation from this work is to:

Develop a clear and comprehensive framework of regulation and policy to provide market direction, guidance and incentives for delivering accessible automation.





We also recommend that these programmes of work are delivered to address some of the key issues identified:

1. Examine the trade-off between staff presence on public AVs and commercial viability to understand the most viable solutions.
2. Clarify obligations and licensing requirements placed on passengers / owners of private automated vehicles.
3. Define a mechanism for sharing best practice across the industry, nationally and internationally.
4. Explore optimal solutions for ensuring communication between the vehicle and passenger(s).
5. Investigate the impact of automation on accessibility and safety of pedestrians.
6. Explore the role of vehicle connectivity (V2I, V2V, V2X) in improving accessibility and customer experience.
7. Set out a plan and framework for greater data sharing.
8. Examine the role of AI and facilitate its application in an ethical manner.
9. Examine the opportunity for enhanced use of data.

Background to the research

Context

Automation is significantly disrupting the transport sector. Various automated transport technologies are being developed, including:

- Vehicles which move people and are operated by a user (for example private automated cars);
- Vehicles which move people but are not operated by the user (for example automated shuttles or buses); and
- Vehicles which move goods (for example delivery drones or robots).

As well as improving safety and efficiency, a key driver for automation is to enable people (who might previously have been excluded) to travel and to access goods or services. However, history shows that accessibility of new technology and services often slips down the agenda in favour of rapid deployment and a need to generate return on investment. For example, the lack of consideration of accessibility in electric vehicle (EV) charging station design has led to a need for expensive retrofitting which could have been avoided. Considering accessibility when technology is still in its infancy is therefore vital to ensure the same mistakes are not made again; the needs of disabled people must be considered in the development of automated transport.

This research project was developed to address this gap, by producing a robust evidence base for designers, developers, and policy makers working in automated transport, to ensure more inclusive vehicles and services are developed.

Scope and definitions

In this report, the term ‘disabled people’ refers to anyone who has a physical or mental impairment that has a substantial and long-term negative effect on their ability to do normal daily activities (GOV.UK, n.d.).

The focus of this work was automated vehicles which operate at Level 5 as set out in the SAE Autonomy scale. The focus on this level of autonomy was chosen due to it having the greatest potential to prompt changes in vehicle design and business models, given the opportunity to remove (or change) the role of the driver. Insights around privately-owned vehicles with lower levels

of autonomy (such as Advanced Driver Assistance Systems) have also been explored through this research to understand accessibility needs related to the transition between manual to automated driving modes, and vice versa.

We also focussed the research on vehicles designed for transporting people, rather than goods.

Research objectives

The research project was designed to answer a set of research questions, defined to meet the following overarching objective:

> **To support the development of inclusive automated transport technologies and services by understanding the needs, perceptions, and challenges faced by disabled people.**

The following research questions were addressed:

1. Identify the benefits of automated transport for disabled people
2. Identify and prioritise the challenges faced by disabled people with automated transport
3. Identify the extent to which accessibility is currently being considered in the design and development of automated transport technologies and services, including any good practice examples
4. Identify design principles and recommended solutions to support the design, development and implementation of inclusive automated transport

Method

The research involved five distinct tasks to address the research questions. All the tasks were supported by regular consultations with an Advisory Group which included representatives from central and local government. This group was used to gain insight into the wider policy context (e.g., key issues, priorities, blockers to progress) and to discuss ensure findings were shared as the research progressed.

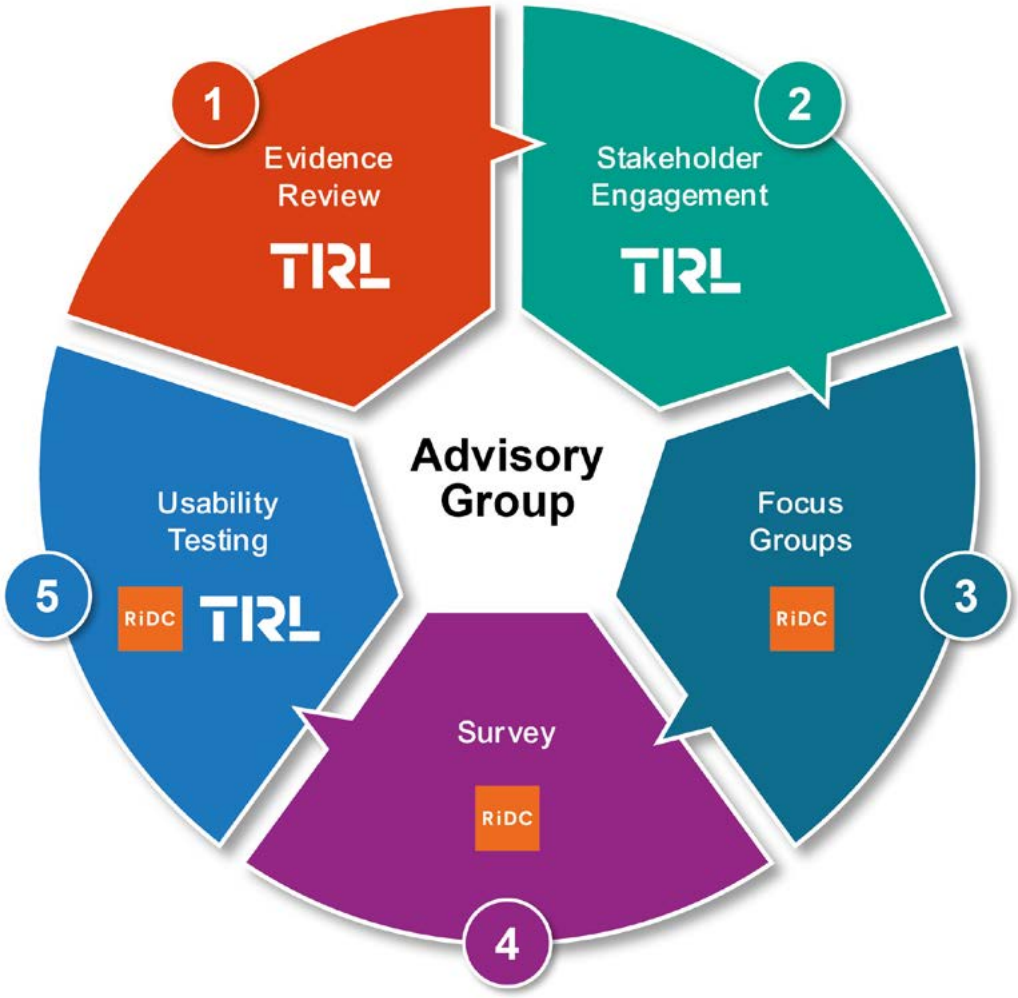


Figure 1: Sequence of tasks in the research project

Evidence review

The evidence review took a systematic approach consisting of three main tasks: literature search, literature assessment, and in-depth review. The research questions were used to determine the terms used for the literature search. We then conducted a thorough evidence review by searching for papers and websites within four databases and performing a critical appraisal on each paper. A total of 122 papers and 15 websites were identified in the initial search; 70 papers passed the in-depth review and were included in this review.

Stakeholder engagement

Interviews were conducted with representatives from three different types of organisations: Disability Organisations who have oversight of key issues for the disabled groups they represent, Technology Providers who were developing automated technology and Transport Operators who were operating automated services (or who may consider doing so in the future). The objective of the interviews was to understand the perspectives of these various stakeholders in terms of the challenges and opportunities automated transport brings for disabled people, how much current focus is being given to accessibility in the development of automated transport, and what can be done to improve accessibility in the future.

A total of 28 stakeholders took part in the interviews, covering six Disability Organisations, 11 Technology Providers and 11 Transport Operators. Whilst we aimed to cover a broad cross-section of organisations, it should be noted that due to the relatively small sample size the findings from these interviews should not be assumed to be representative of the whole sector.

Focus groups

Three focus groups were conducted with a total of 16 disabled people to collect rich qualitative data around the accessibility needs, barriers, and opportunities for users of automated vehicles and services. Participants had a range of different impairments and were from different demographics. Findings contributed to the design of an online survey intended to collect data from a wider sample of disabled people.

Survey

A survey, informed by the preceding focus group work, was developed to explore travel habits, attitudes toward automated transport and people's predicted needs at different stages of a typical journey using automated transport. Both private and shared automated services were explored. The survey received 808 complete responses which were used in the analysis.

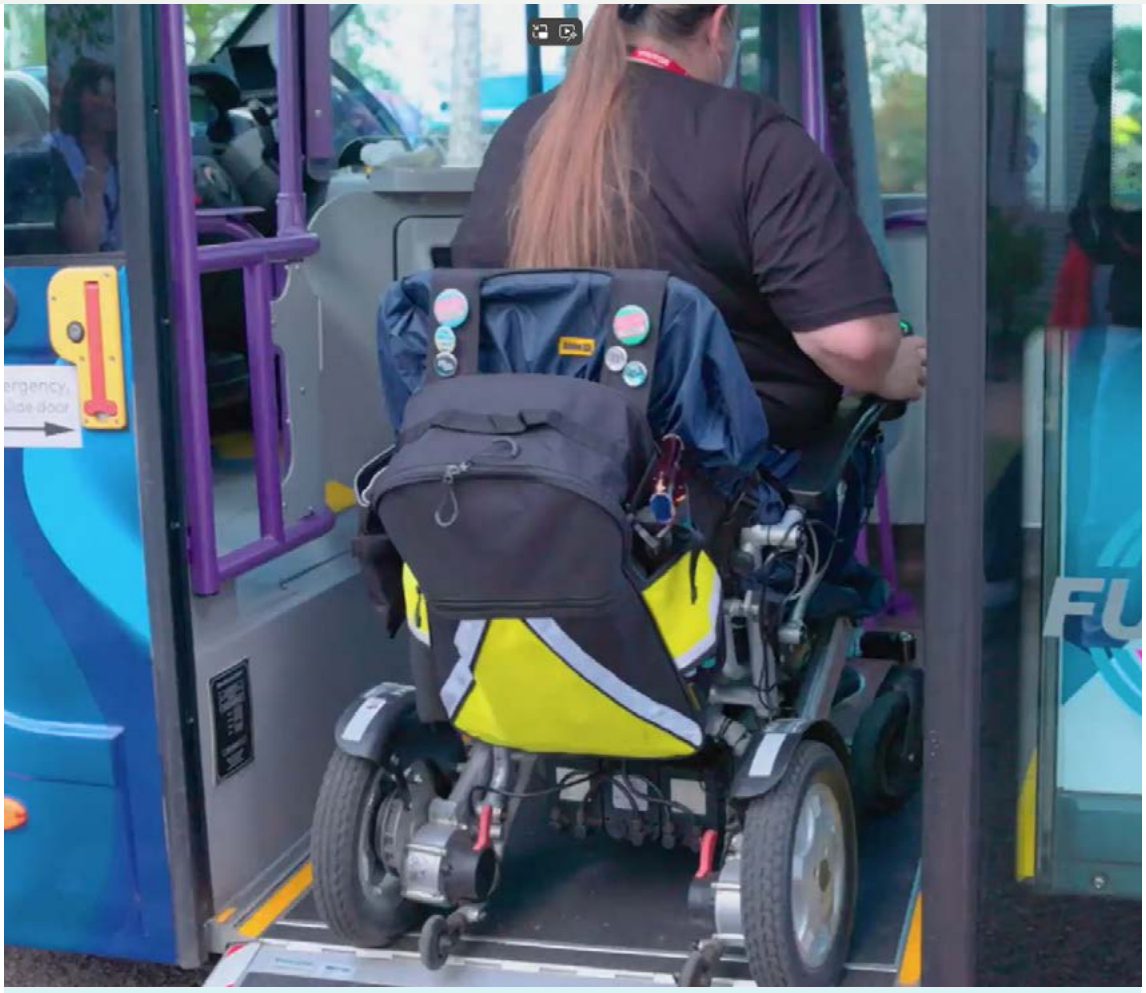
Usability and accessibility trials

Two usability and accessibility trials were conducted with disabled people to evaluate the design efficacy of vehicles, services, and service interfaces. The first trial was conducted in Edinburgh, Scotland using the 'CAVForth' service operated by Stagecoach. During the trial, ten participants rode the CAVForth AB1 autonomous bus as part of its usual commuter service. Three researchers accompanied the participants throughout the journey, discussing their experiences of the bus with them in real time. Participants were also invited to complete a paper survey whilst on-board, and take part in an in-person debrief session to discuss the accessibility of the bus journey and their perspectives on autonomous vehicles.

The second trial involved a minibus with automated capabilities, provided by the company Fusion. The vehicle remained static and participants were asked to examine it and think about whether it was accessible for them. Eleven participants with a range of sensory, cognitive and mobility impairments took part. Once participants had explored the minibus, they took part in a 45-minute debrief session to talk about their experience of the vehicle, whether they thought it was accessible for them and their needs, and what they would need to feel comfortable travelling on automated transport.

Further detail on each of the research tasks, including detailed findings, can be found in an accompanying report: 'The impact of automated transport on disabled people: Detailed methodology and findings' (RPN2050).

The benefits and challenges for disabled people



Key benefits

The evidence review, focus groups, survey and usability trials revealed several benefits that automated transport might bring for disabled people.

Private automated transport

One key benefit of private automated transport is that it has potential to give disabled users a greater amount of freedom when travelling. The evidence review findings showed that automation can provide increased independence for disabled people due to reduced reliance on others to meet their needs (Bennett et al., 2020), and fewer time restrictions on when disabled people can travel if using a private automated vehicle. This sentiment was supported by findings from the focus groups and the survey, though participants also reported they were wary of the accessibility requirements that would be required to support independent journeys: “Freedom to get out! But only if fully accessible and affordable”. Participants in the usability trials also supported this: “It could give so much freedom and independence to people”.

Private automated transport was suggested to be able to support independent journeys by providing door-to-door travel. This was shown in the evidence review, with one source, for example, predicting it will remove first and last mile challenges currently faced by disabled users (Department for Transport, 2023). It was also supported by findings from the stakeholder engagement, with a common view being that an automated vehicle could provide true door-to-door transport which is, typically, not possible with existing public transport. It was also raised that private automated vehicles have potential to be set up to the bespoke needs of each individual traveller, including space for mobility aids and the best channels for communication. Perceptions of using a private automated vehicle were that it was expected to reduce feelings of judgement or burden on disabled users, compared with using public transport. Such feelings are currently experienced by disabled people when using non-automated shared transport modes, particularly when asking for individual needs to be met.

As well as greater independence and improved door-to-door travel, the survey illustrated the increased range of travel that could be provided by private automated vehicles, leading to improved access to work, education and social opportunities for disabled users. Another perceived benefit of using private automated vehicles was decreased travel time; the evidence review found that

people may expect travel time to reduce in private automated transport through more optimised and direct routing compared with public transport (Brinkley et al., 2020b).

When discussing the benefits of private automated transport, excitement about the technology emerged during the focus groups:

> *I would find it fascinating and I love the idea of it*

This was supported by stakeholders such as technology developers and operators that were excited by the opportunity to explore new form factors of vehicles which could overcome some of the current barriers around accessibility. At least for some potential future users and members of the industry, there are positive feelings of excitement about the technology that is being developed.

Shared automated transport

A key benefit of shared automated transport is the potential for more cost-efficient journeys. The evidence review suggested that this may take a while to be realised as a benefit for customers in practice (Hwang et al., 2020), however, stakeholder engagement findings suggested that with an efficiently running service and the potential for lower running costs (if no staff on board), customers may feel the benefits of a cheaper service. Stakeholders suggested that disabled users already perceive costs as a barrier to travelling, so a cheaper service would be of benefit. Stakeholders also raised that if automation can enable more shared vehicles in shared transport lanes, this could help to improve the commercial viability of some bus routes, again bringing benefits to customers.

Conversely, stakeholders suggested that if there is a ‘customer service assistant’ (or similar) on board a shared automated vehicle, this could enable a better level of service to be delivered for customers than is currently provided by drivers who need to be focused on the driving task. This may include providing physical assistance to passengers, being a source of information or providing other general support throughout the journey. This level of assistance was highlighted as a priority in the user survey.

It is apparent that there may be a trade-off between improving cost-efficiencies through removal of the driver, and thus passing those efficiencies onto the customer (as discussed above), and replacing the role of the driver with that of an on-board customer service assistant, thus losing the opportunity to make cost reductions, but gaining an opportunity to deliver a better (and perhaps more commercially successful) service. Further research is needed to examine this trade-off more closely to understand the most viable solutions.

Overall, greater benefits were perceived for private automated vehicles than shared AVs. Additionally, participants in the focus groups and survey stated that they were more likely to be willing to use a private automated vehicle (37%), compared to a shared automated vehicle (20%).

Key challenges

The evidence review, focus groups, survey and usability trials revealed several barriers that will need to be considered in the development and deployment of automated transport. The overarching themes were as follows:

- Many of the barriers disabled people experience in relation to non-automated transport will continue to be a barrier in relation to automated transport.
- People have different needs. There were not any ‘stand out’ barriers - different people experience different barriers and, to be inclusive, these differences must be acknowledged and catered for.
- The challenges experienced by disabled people can often be barriers, not ‘inconveniences’ – some barriers can prevent some disabled people from travelling altogether.
- All stages of the journey need to be accessible for disabled people to be able to use automated transport. It’s not just about the vehicle itself, but the surrounding system.
- Safety concerns should not be underestimated – these can include fundamental concerns regarding the automated driving technology itself, as well as the implications of having a lack of human support on-board services, and what to do in an emergency.

Different types of barriers are described below in further detail, mapped against the different stages of the journey (pre- and post-boarding a vehicle).

Pre-journey / post-journey

In the focus groups, participants indicated greater reluctance to use shared automated vehicles compared with private ones. This was supported by the evidence review, which suggested there are more barriers to use of shared automated transport than private.

A key barrier 'pre-journey' is the need for reliable, accessible and up-to-date information regarding the service. This was noted in many studies identified in the evidence review. Poor quality or inaccessible information is a key barrier for disabled users today when trying to plan journeys on current (non-automated) transport modes. When designing future services for disabled users, being able to access information is vital to support their travel on both private and shared transport modes. Through our engagement with stakeholders, including representatives of disability groups and disabled users, it was made clear that disabled people rely on various sources of information (including tactile, audible, and visual messages) to orientate themselves and navigate to and through public transport stops, hubs, and interchanges.

As part of the journey planning process, the potential lack of staff on an automated service may create a barrier, in particular when purchasing tickets. In the evidence review we found that users can feel restricted with reduced staff availability on public transport (Low et al., 2020). While some users are able to book journeys online, others require the use of ticket offices, or assistance using machines. Survey responses also emphasised the importance of having a staff member who can provide assistance during the booking process:

> *Having staff to speak to who actually understand that all disabled people are different, and we might all have different needs…*

Through the stakeholder engagement process, engagement with disabled users and the usability trials, we also identified further barriers to shared automated transport. For example, being able to ensure that there are enough accessible seats and spaces available before starting the journey and challenges of needing to use traditional transport modes to access a service stop for an automated service, if a service is unable to provide a door-to-door journey. This includes the accessibility of current transport services and interchanges (discussed further in boarding and alighting).

Boarding and alighting

Challenges with boarding or alighting are key barriers relevant to both shared and private automated vehicles; physical access needs must be fully considered. While public transport vehicles are required to have boarding ramps (Department for Transport, 2000), stakeholders highlighted that there are still issues with ramps failing, preventing disabled users from boarding which could be an issue for automated transport too. Stakeholder engagement highlighted the need for automatic ramps to be deployed if there are no staff members on-board. This, however, raised concerns regarding safe deployment in different environments, and focus group participants suggested that they would prefer a human to be present to help with access to the vehicle:

> *...if, for instance, you're in a wheelchair or mobility scooter or anything like that and the ramp stops working, then you need help to get off...*

Additionally, survey respondents expressed concerns with having sufficient time to alight a vehicle, and how this would be managed with on an automated service:

> *When you are getting on, the vehicle waits for you to board. Getting off (specifically getting up from the seat) can be slow/difficult. There needs to be sufficient time at the stop without having to think you need to start getting up when the vehicle is moving.*

Insufficient availability of accessible seats, or concerns about lack of availability, is another key theme which emerged. Disabled people in the usability trial suggested that they would like to have had information about the busyness of a service and how many accessible seats and wheelchair spaces there are. Additionally they voiced frustration in there often being competition for limited accessible space with other disabled users, and those using prams on current transport modes. The survey with disabled users also highlighted the need for space for guide dogs, as well as the space for wheelchair users to enter and

manoeuvre in both shared and private vehicles. Having to wait for a service that has an accessible space, and being sure that one is available, are major barriers to current public transport use, extending journey time, increasing risks of delay and creating uncertainty for disabled passengers.

The importance of the external environment and how disabled users can transfer between different modes was also highlighted. Needs include step-free access at stations, drop kerb and a lack of obstructions on footways when boarding and alighting. Stakeholders raised these items as issues which currently affect transport today and considered them to remain issues for shared automated transport services in future unless specifically addressed. Indeed, some of these issues may be exacerbated in the absence of assistance being available from a driver. This was supported by a qualitative response in the survey:

> *But step free or automatic ramps would help. Knowing the drop off/pick areas are safe and not overcrowded so that disabled can take our time getting in/out.*

The importance of the design of a service stop, in particular, was highlighted during the CAVForth usability trial, as the bus stop pole was positioned directly in the middle of footway, making it difficult for some participants to board the vehicle. The design of stops and whether the automated technology can detect obstructions are important to consider during future development to ensure service stops are accessible.

During the journey

Safety concerns related to the absence of a driver was a prominent barrier for both private and shared automated transport, with evidence emerging at all stages of the research. Concerns included uncertainty about what happens in emergency situations. It was stated that immediate and effective assistance needs be provided when something goes wrong with the technology, and a particular concern was the risk of being stranded with no support. The usability trials gave disabled users the opportunity to test a shared automated service, which had a staff member working as a customer service assistance on board, rather than controlling the vehicle. Participants in the usability trials found the staff member to be reassuring and was actually considered an enabler for them using the service. Alternatives were discussed, for the options that could be available in the event of an emergency and if there was no staff member working aboard an automated service. When discussing a calling service, or 'panic button' for help, it was not deemed satisfactory by participants; human (in-person) support was preferred.

Some participants felt that drivers also play an important role in providing social connection. This matches up with findings from Motability Foundation's research on community transport.

As stated in the discussion of pre-journey barriers, information during the journey needs to be accessible, clear and timely. Stakeholder engagement stated that this is essential for users to understand cues such as changes to their journey and upcoming stops. This information enables disabled users to travel independently and without confusion. This is likely to be a concern for shared automated vehicles in future as well. Stakeholders emphasised that there is the need for all information to be accessible and for this to be considered in the design of future services.

Stakeholders stated the need for users to feel safe and comfortable to use any automated service. Focus group participants supported this, stating the need to establish trust in these transport services, as some would not use them at all or not until they had been proved to be safe. Similar concerns were also raised by participants in the usability trials:

> *But when I see this vehicle with nobody controlling it, yes, it does worry me.*

Another barrier identified from the evidence review was concerns about how users will interact with the human machine interface of a private automated vehicle. There was discussion around the different types of inputs that will be required to make this interface accessible to all users (Riggs and Pande, 2022), to allow users to know where they are, when to get on and off and to confirm their destination, amongst other functions.

Focus group participants raised whether there will be a need for a driving licence to own and 'operate' a private automated vehicle in future. This was raised as potential barrier in the evidence review (Emory et al, 2022), as some disabilities such as physical or visual impairments prevent people from obtaining a licence. If this remains the case in future, then the benefit of autonomy for disabled users will be diminished. In the UK, current regulations require a 'safety driver' to be on-board any automated vehicle (Level 4 and 5) during testing and trials. As this development work continues and the industry works towards full automation without a safety driver, the obligations and licensing requirements placed on passengers / owners of private automated vehicles will need to be clarified. Further research is needed to ensure the implications for accessibility are considered in full.

Stakeholders also emphasised the need for affordable services for all, to ensure that people are able to own private automated vehicles or use shared services.

Current consideration of accessibility in the design and development of automated transport technologies and services

The challenges for designers

The stakeholders expressed support for the goal of designing accessible vehicles and systems. They emphasised the positive impact that accessible design will have on overall access and service quality for a diverse range of individuals. Some technology developers observed that there is an opportunity to change the public transport system as the current system prioritises the movement of people over the quality of their experience.

Despite showing support for the goal of developing accessible automated transport systems, developers appear to be prioritising the development of the automated technology. Priorities are typically ensuring that the technology functions correctly and safely. This is currently overshadowing customer experience and accessibility considerations.

Given that automated transport is still in early stages of development, it is likely that many iterations of automated services will emerge during the transition to more advanced and fully automated transport services. One stakeholder felt that the current, shorter-term focus is likely to be on retrofitting existing vehicles with automated technology as this would be more practical and cost effective than manufacturing entirely new automated vehicle form factors from scratch. However, this could limit the potential opportunity to implement more fundamental improvements to the design of vehicles in to make them more accessible. With a retrofitting approach, the layouts and design of the vehicles is unlikely to change from the existing design; which may have negative consequences for accessibility.

Most of the organisations within our sample were responsible for one part of the process, i.e. the development of the automated technology, the vehicle design or service operation. Therefore, there is a risk that no-one is taking overall responsibility for considering accessibility – it may be falling between organisations.

Some of the industry stakeholders interviewed expressed excitement about exploring new form factors of vehicles to overcome current accessibility barriers, although many had not yet initiated the development of such innovations. They raised some challenges and complexities in designing accessible transport services:

- Difficulty in developing a universal solution that addresses all needs.
- Existing guidance on making automated transport more accessible is limited.
- Inconsistency in the external environment poses a challenge to the initial deployment of automated vehicles.

These are discussed further below.

Difficulty in developing a universal solution that addresses all needs

While industry stakeholders recognised the need to address all accessibility needs, it was perceived to be impracticable to develop a vehicle that fits all needs due to:

- There being a wide variety of accessibility needs, with different (and sometimes conflicting) requirements;
- The higher cost of incorporating all accessibility features in a single vehicle;
- The financial implications, with increased manufacturing costs likely to increase the cost of services for passengers, and;
- Tthe low likelihood that an individual will require all accessibility features – that is fitting a vehicle with more features than is ever likely to be needed for a single person's journey.

For example, a commonly used information and communication technology in public transport is the use of touchscreen technology. It offers the advantage of an intuitive interface that is overall easy to use. However, not everyone can use these interfaces. For instance, visually impaired users require tactile information, such as braille, or audio instructions to operate touchscreens. As

Case study

Nissan is conducting research on advanced facial and voice recognition technologies to simplify vehicle operations. Their efforts include reducing the number of functions required to start the vehicle and using facial recognition to assess stress and wellness levels, thereby managing speed and ride comfort. These innovations are intended to benefit all users, extending beyond those with disabilities. The integration of these technologies aims to enhance overall user experience and safety.

such, this could potentially increase costs on manufacturers to include all accessible features in all vehicles. This could have implications for adoption of privately-owned automated vehicles as well, where individuals who might not require all accessibility features are reluctant to pay a higher price for features that are not essential to them.

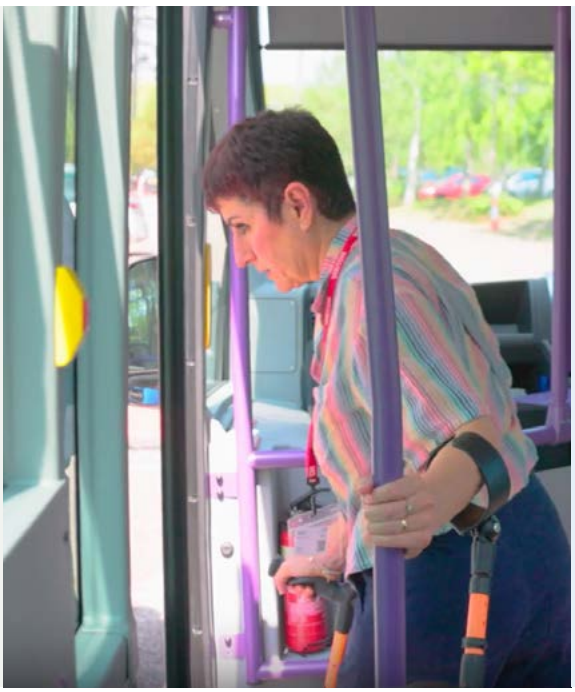
The interviews also found that conversion companies, responsible for installing adapted systems to make vehicles accessible on behalf of OEMs, often keep their methods of vehicle alteration confidential due to commercial sensitivity. As a result, OEMs face challenges in being able to create accessible vehicles 'at source'.

According to one stakeholder, a more practical goal would be to create vehicles that cater to the majority of users' needs, while allowing the option to adapt the vehicle for other purposes. This suggestion raised concerns around the difficulty of meeting all needs, but also highlighted the risks of relying on different vehicles to meet different needs. This solution raises the risk that access to more accessible/ modified vehicles would be limited and at a premium price. For example, wheelchair accessible taxis currently exist but require customers to book in advance to ensure availability. If vehicles are made specific to certain

needs, it is essential that customers can easily make their selection and access the vehicle that best suits their needs. It is clear that there are some trade-offs to manage, but it is important that the challenges posed by a more universal design for vehicles do not diminish the ambition to create a comprehensive solution.

Existing guidance on making automated transport more accessible is limited

The accessibility regulations for current non-automated vehicles were considered a useful minimum standard for accessibility by several stakeholders; namely, the National Technical Specification Notices - Persons with Reduced Mobility (NTSN-PRM) and PSVAR regulations, which cover requirements for non-automated trains and buses, respectively. However, it was felt that these regulations do not provide sufficient guidance on making automated vehicles accessible. The lack of guidance (over and above the regulations) also risks creating inconsistent levels of accessibility across different vehicle models.



Case study

One organisation is developing a new vehicle designed with several key accessibility features. Anti-slip flooring has been incorporated to reduce the risk of injuries and enhance stability. Emergency buttons are positioned at lower heights to ensure accessibility for individuals sitting or using wheelchairs. These considerations are aimed at improving safety and convenience for all passengers.

Inconsistency in the external environment poses a challenge to the initial deployment of automated vehicles

While vehicle design is crucial for ensuring accessibility, as we highlighted in the previous section of this report, it is not the only factor. Many interviewees suggested that automated vehicles will need a highly standardised environment to operate safely. This would, ideally, include having fewer non-automated vehicles on the road and more consistent road layouts, bus stops, and kerb heights. However, achieving this would require a comprehensive overhaul of the transport system and its infrastructure, which would be costly and time-consuming—a barrier many interviewees felt hindered the rollout of automated vehicles in the first place.

Technology Developers felt that establishing a minimum design standard that considers the needs of all disabled users would be valuable. Some interviewees suggested implementing a rating system similar to the New Car Assessment Programme (NCAP), a voluntary but standardised car safety performance assessment through which OEMs can obtain an independent assessment of vehicle safety. Stakeholders felt that a similar voluntary, consumer rating programme could encourage manufacturers to prioritise accessibility. Achieving a high rating could bring many benefits for technology developers / vehicle OEMs, such as differentiation from competitors, increased consumer appeal, and enhanced chances of securing public procurement contracts.

Good practice

Based on the findings drawn from the interviews, it was concluded that there were currently few examples of good practices regarding the design of automated vehicles. This is likely because the technology is still in its early stages of development.

Prioritising inclusivity in the design process

The stakeholders stressed the importance of not treating disabled individuals as an afterthought in the design and implementation of automated transport services, highlighting the need for inclusivity from the outset to consider the fundamental needs of all passengers. Some of the transport operators that we engaged with explained that they are already engaging with disabled people through various activities such as:

- Conducting formal research initiatives to understand disabled people's needs,
- Consulting individuals who have lodged accessibility-related complaints,
- Conducting open days to encourage two-way communication with drivers and passengers on accessibility needs, and
- Gathering feedback on new vehicle designs to improve accessibility.

Potential solutions to challenges in automated bus operations

Some suggestions were raised by the interviewed stakeholders as ideas that could be considered and explored in the future. This included the following solutions to certain challenges that come with removing the driver from a bus service:

- In non-automated buses, a driver can identify when a passenger requires a ramp and deploy it. In an automated bus, an automated ramp could be deployed at each stop to ensure that passengers who require a ramp can board or alight the bus.
- In the event of an emergency, a driver has authority to direct passengers and provide guidance. In an automated bus, an intercom system should be available to enable passengers to communicate with a supervisor to provide guidance.
- CCTV cameras could be used to monitor passengers on-board and discourage anti-social behaviour.
- There needs to be greater enforcement around bus stops to prevent other vehicles from causing obstructions. When faced with abnormal conditions (e.g. an obstruction at a stop), a driver is able to make a situational decision as to how to best overcome this challenge. As automated systems will be inherently reliant on recognising infrastructure markers (e.g. kerbs) to conduct their manoeuvres, they will likely be less capable of handling such obstructions and other unexpected occurrences. Consequently, this may impact the ability to deliver an accessible service.
- An information system on-board will be necessary to answer passenger queries. For example, this could be done via a human machine interface such as a digital concierge or an avatar.

Measures to improve accessibility

Some operators and technology providers have already introduced features to enhance the accessibility of their existing non-automated transport services. These innovations can potentially be adapted for use in automated vehicles as well. Examples included:

- Automatic ramp deployment
- Considering colour schemes with brand materials that are more accessible to those with vision impairments
- Audio announcements that increase in volume when there are more passengers on the vehicle, to adjust for background noise
- Adding a second wheelchair space onto the bus
- Display screens positioned to be viewable from the wheelchair-priority bay on vehicles
- Research on wireless charging of electric vehicles to remove the need to lift and plug in a cable
- Anti-slip flooring to reduce injuries and improve stability
- Emergency buttons placed at lower heights to be accessible to those sitting or in wheelchairs
- Systems to allow passengers to flag that they have specific needs in advance of travel

These features did not seem to be consistently implemented across vehicles and operators among those that we engaged with.

There was also some evidence of research taking place which may lead to advancements in accessibility in both non-automated and automated transport:

- Research into boarding/alighting a vehicle with elderly participants
- Research into facial and voice recognition technologies to reduce the number of functions required to start a private vehicle, and to interpret the stress/ wellness levels of passengers
- Early stage research into the potential for direct 'brain-to-vehicle communication'

In summary, the organisations we consulted recognised the value of enhancing accessibility in automated transport. While some have initiated efforts in this direction, a consistent and comprehensive approach remains elusive across different stakeholder groups. To address this, further work is necessary to establish appropriate guidelines, standards, and regulations for improved accessibility moving forward.

Case study

First Bus has implemented a programme called "Extra Help to Travel" cards for passengers with disabilities, particularly hidden disabilities. These cards, approximately the size of a credit card, allow passengers to discreetly communicate their need for additional assistance to drivers. For example, a passenger might require the driver to spend more time communicating or need help paying the fare. The cards cover a wide range of disabilities and enable discreet communication between the passenger and the driver. All drivers undergo comprehensive training that focuses on recognising and assisting with hidden disabilities.

Improving the design of automated transport technologies and services to better meet the needs of disabled people

What have we learned?

Through an evidence review, stakeholder engagement, and engagement with disabled end-users, this research has revealed the following key findings.

Disabled people can see some benefits of automation

The disabled groups that were engaged with could see several benefits both in private and shared automated vehicles. Both modes present the potential for numerous safety benefits, providing the automated systems are sophisticated enough to ensure safety. Automated private vehicles would offer users greater independence and a greater range of journeys they could take without the need for additional assistance. There is also the opportunity for improved staff assistance on shared transport, if a staff member took on a customer service role while the automated system has responsibility for the driving task. In addition, the continued development of automated technologies are likely to come hand-in-hand with technologies that can provide improved audio and visual information (e.g. dedicated smartphone apps).

Despite these benefits, disabled people still had many questions about how automation would impact them in practice. In general there was a lack of trust that automation can remove the barriers they currently face relating to transport.

Automation is not in itself a solution to current accessibility barriers – and may even create new barriers

The barriers that disabled people predicted they would encounter with automated transport are similar to the barriers experienced with current transport modes. This includes difficulty boarding if ramps aren't aligned properly with the footway, conflicts arising in the priority wheelchair spaces, negative attitudes of other passengers, and lack of availability of accessible information. These difficulties can often be barriers to travelling, not only inconveniences.

Automation in itself is not a solution to these existing barriers. There is a risk that automation capability is something that is an 'add-on' to existing vehicles and services – but this approach will not remove the barriers that disabled people currently face. This is especially true considering that not all current

public service vehicles are compliant with existing regulation (for example, some vehicles are exempt from the PSVAR (2000) regulations). The PSVAR (2000) states that all regulated public service vehicles (for example, buses) should be fitted with at least one boarding lift or ramp, with the ramp slope not greater than seven degrees. However, this applies to all new public service vehicles (buses and coaches) introduced since 31 December 2000, suggesting that older buses still in service may not meet this requirement.

Not only might automation not solve current accessibility barriers, but it has the potential to create new ones. For example, drivers currently carry out specific tasks which promote accessibility. If drivers are no longer present, there's a risk that these tasks won't be fulfilled, and this may prevent many disabled people from travelling altogether. This could result in deeper inequalities.

In the long-term, automation potentially opens up the opportunity for significant vehicle re-design. For example, removing the driver's cab in Level 5 automated services could result in new interior design configurations which could improve physical access and comfort for disabled people. This is assuming that the needs of disabled people are considered in this vehicle redesign process.

However, we should not ignore accessibility of automated and semi-automated transport in the shorter term. Some automated services may necessarily involve a level of retrofitting of existing vehicles, and there is no reason why this could not also be an opportunity to improve the accessibility of these vehicles – whether it be via physical design adjustments, through improved information and communication systems, or other elements that relate to the pre-boarding or post-ride stages.

Currently, developers seem to be focusing on making the automated technology functional. While important, this approach ignores customer experience factors, which will ultimately make or break the success of automated transport services in the longer-term.

There is also a risk that the consideration of accessibility is falling between organisations. It appears that most organisations are focused on one element of automated transport development (i.e. technology development, vehicle design, operation) and this could result in a lack of joined-up thinking on what may be required for accessibility within each of these elements. Consideration should be given to how requirements for accessibility could be defined and 'trickled down' to each of these parties, for example through procurement specifications which have specific requirements that each party would need to meet.

Specific concerns around automated services related to licensing requirements for private automated vehicles and lack of human support on shared automated vehicles.

As well as the barriers faced on existing transport services, disabled people had specific concerns about potential barriers related to automated services.

Whilst it was felt that private automated services could bring a greater level of independence, disabled people worried about whether they would be legally allowed to operate these vehicles if they do not have a traditional driving licence. Some were concerned that, unfairly, expectations could be raised for disabled people before legislative frameworks were understood. As the industry works towards full automation without a safety driver, the obligations and licensing requirements placed on passengers / owners of private automated vehicles will need to be clarified.

There were also concerns raised around the accessibility of semi- automated vehicles (i.e. Level 3 and 4) being problematic for many disabled people, due to the possible need to monitor the vehicle or take over the driving task.

Regarding shared automated services, many concerns related to a lack of an on-board customer service assistant. The driver currently performs many roles. As noted earlier, this includes providing additional assistance to passengers where needed, monitoring passenger behaviour, and responding to emergency and abnormal scenarios. Some of these responsibilities are done on an informal basis, and are important to ensuring accessibility. Disabled people had concerns around how an automated service would detect them and understand their needs, help them to board, answer their questions and be able to support them in an emergency or unforeseen circumstance.

The desire for human support presents a challenge but also an opportunity. Having a human on board may counteract any economic benefits of removing a driver. But we suggest that having a human involved could also be an opportunity to provide much better customer service than is currently possible to deliver, which could potentially result in a more commercially successful service. A conductor could focus on passenger assistance and experience without being distracted by the driving task. There is an opportunity to innovate around how human involvement could work within a service – for example via an on-board conductor, a person stationed at boarding points, on selected services or remotely. Further research is needed to examine this trade-off more

closely to understand the most viable solutions. What is clear from this work though, is that, in the absence of a human member of staff on-board shared automated transport services, adequate provision of information and assistance to customers by other means will be critical.

Barriers exist across the journey – the end-to-end journey, and not just the vehicle design, needs to be considered

The potential barriers reported by disabled people do not fall only at one stage of the journey. Although the disabled people that we engaged with gave slight emphasis on barriers related to boarding and alighting, it's clear that removing barriers at just one stage will not make a service accessible. The whole journey and whole system need to be considered. This includes the vehicle design itself, the surrounding infrastructure that the vehicle interacts with and the digital system.

A 'one-size-fits-all' automated service is not practically or commercially viable – there is a need to consider how to balance different accessibility needs across the service

Given that disabilities are unique to each person, barriers are also personal to each person. This presents a few considerations. Firstly, addressing only select barriers will not solve the accessibility challenge for all. Secondly, a one-size-fits-all solution is not feasible. People have different, and sometimes conflicting, needs. Certain vehicle design may suit some but not others, and so, practically, it is challenging to design something that meets everyone's needs. Also, commercially, it may not be viable to operate a system which requires expensive features or technology.

This points towards a need to define what the minimum requirements are for an automated service – to ensure that services are designed to be accessible to most. But there is also a need to go beyond this. Developers and operators should consider how to balance different accessibility needs across a fleet of vehicles or across the service as a whole. Customisation of services may also present a solution here – whether that be in enabling a passenger to select/book a vehicle that meets their needs, or enabling a vehicle/service to be configured differently to meet different needs.

There is currently a lack of guidance for creating accessible automated services

Technology developers and operators noted that there is a lack of specific guidance for creating accessible automated services. It's possible to draw on existing regulation and guidance in relation to public transport (e.g. PSVAR, Inclusive Mobility Guidance) – but there is also the opportunity to go further. The Law Commission (2020) have suggested that codes of practice could be used alongside regulation to suggest good practice, given that these may be more flexible to change or adjust as knowledge and technology evolves.

Stakeholders consulted also suggested that a system similar to the New Car Assessment Programme (NCAP) might be useful. Such a scheme could provide different levels of service accessibility to aim for – prompting industry to aspire to higher levels and giving consumers knowledge and choice over which services they choose to use.

There was variation in how much interviewees were involving disabled audiences in the development of transport services – engagement with disabled people is essential in designing what an accessible service might look like.

Disabled people reported that they want to be involved in the design of new services. There is also a clear argument for involving disabled people in the design process, for example to avoid expensive retrofitting, and open up services to a wider group of people who in turn may make it more profitable.

Only a small sample of industry stakeholders were involved in this research, but there was evidence of some technology developers and operators engaging with disabled audiences when developing their service. This did not seem to be consistent across the organisations we interviewed however, and the quality of any engagement is currently unknown.

There is a need for a mechanism to promote engagement with disabled people, which could include requirements for engagement in innovation funding or in the provision of permits for automated services.

Relevance of findings to type of service and automation level

Many of the findings above are relevant to all types of automated transport service. However, some have more relevance to either private or shared transport, and to particular levels of automation, as set out in the table below.

Automation	Private automated transport	Shared automated transport
Level 3 & 4	If existing vehicles are retrofitted with automated capability (rather than new form factors being designed without a drivers' cab), existing accessibility barriers will remain. The obligations and licensing requirements placed on disabled passengers / owners of private automated vehicles are unclear. The process of taking over the driving task from the automated system will need consideration, taking into account the needs of people with different disabilities.	If existing vehicles are retrofitted with automated capability (rather than new form factors being designed without a drivers' cab), existing accessibility barriers will remain. Disabled people were concerned about a lack of on-board driver or attendant. Further research is needed to examine the trade-off between the desire for human support and commercial considerations.
Level 5	The obligations and licensing requirements placed on disabled passengers / owners of private automated vehicles are unclear.	Disabled people were concerned about a lack of on-board driver or attendant. Further research is needed to examine the trade-off between the desire for human support and commercial considerations.

The principles of an accessible automated service

In line with the finding that additional guidance would be useful, we have identified some key principles to support the design and development of inclusive automated transport, presented in the diagram below.

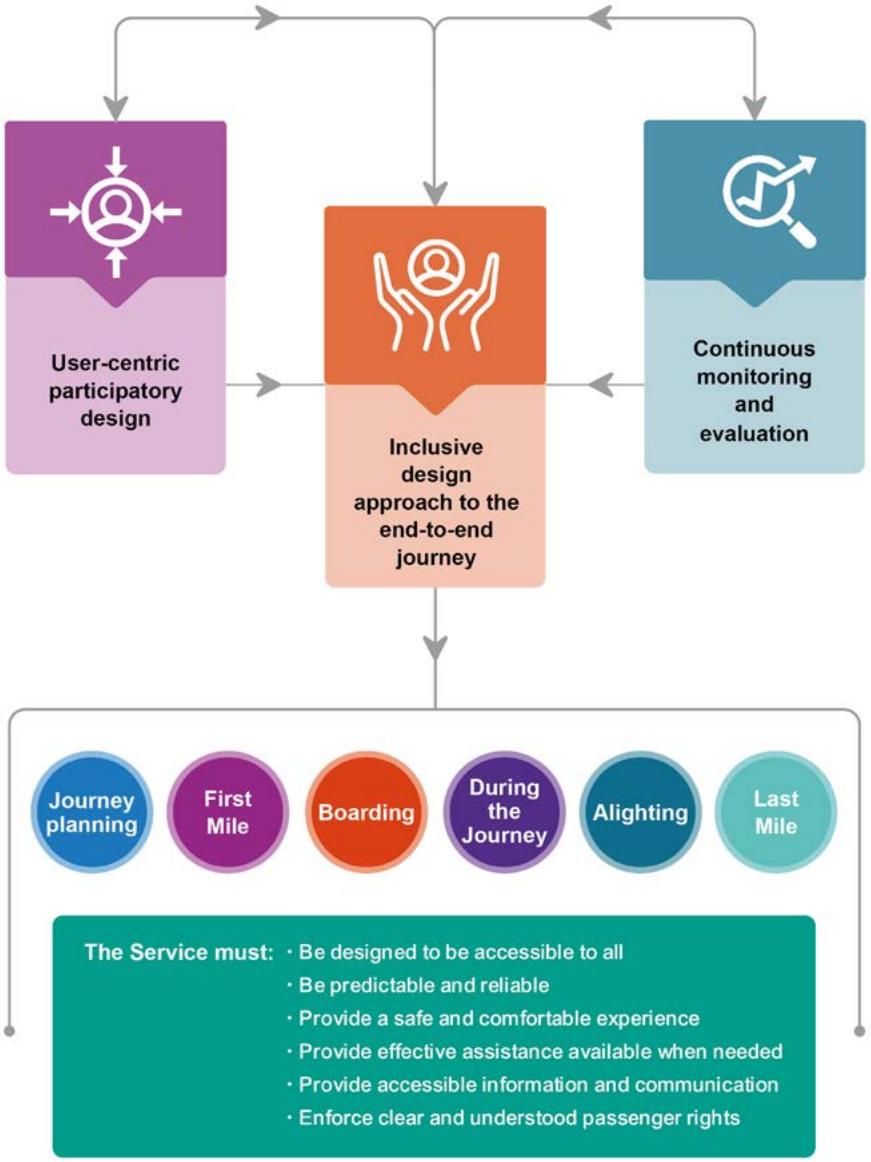


Figure 2. Principles to support the design and development of inclusive automated transport

As shown, there are three overarching principles. First and foremost, is to engage in **user-centric participatory design.** Disabled user groups should be actively included in the development and design of all aspects of a service, including ideation, prototyping, beta-testing, and post-production. Furthermore, involving disabled users (or representatives from disability groups) in the training of staff in how to best support disabled people should also be considered.

Following the implementation of a service, efforts should be made to allow **continuous monitoring and evaluation** of that service. This would involve gathering, tracking, and assessing data on the accessibility and customer experience of the service. Ideally, a heuristic approach would be taken to evaluation where a set of key criteria are established to assess whether a service meets the principles of accessible design. Critically, this process would involve actioning any instances where developments could still be made to further improve accessibility.

Both of these principles feed into the third overarching design principle to ensure that **an inclusive design approach is applied across the end-to-end journey.** This point is multifaceted as there are many elements to each stage of a journey. In practice, this is a matter of ensuring a service meets a minimum level of accessibility to its users from journey planning to arriving at a destination. In particular, it is about identifying and building upon best practice of accessible and inclusive design.

Across the journey, the service must:

- **Be designed to be physically accessible to all** – by providing facilities that allow all user groups to use a service equally, such as a boarding ramp to allow safer boarding and alighting or a suitably designed user interface on ticket booking websites.
- **Be predictable and reliable** – by applying appropriate universal design standards that work consistently.
- **Provide a safe and comfortable experience** – to ensure all users do not feel at risk at any stage of their journey, both in terms of physical and digital security.
- **Provide effective assistance, available when needed** – in the event of an issue or emergency, means must be in place to support and protect users.
- **Provide accessible information and communication** – through the use of visual and audible signals that conform to existing accessibility standards, users should be able to access the information they require and, where necessary, allow for a two-way conversation.
- **Enforce clear and understood passenger rights** – staff and public should have an understanding of people's rights on a public transport service, with an ability to action or feedback where these rights are not being met.

The above list of principles would appear to be key to delivering an accessible public transport service, automated or otherwise.

Applying these principles to an accessible automated service

We propose that under each principle, there are a series of outcomes. These outcomes should be met to achieve the principle. We suggest defining outcomes, rather than prescribing certain features or actions, to allow manufacturers, technology developers or operators to innovate – rather than being overly restricted to specific designs or solutions.

We propose that the principles and their associated outcomes are applied within a system of regulation and guidance (see Figure 3). This system could include:

- **Regulation** – mandating the minimum outcomes that all services would need to meet. This could be tied in with type approval of vehicles, PSVAR regulations and permits for public passenger services. These outcomes would need to be met for the vehicles and services to operate.
- **Guidance** – providing additional outcomes which go beyond minimum standards and align with good practice. This would serve as guidance to encourage operators and manufacturers to go above and beyond the minimum service requirements to offer the best service possible to customers.
- **Rating system** – an independent, consumer-focussed rating system to incentivise adoption of best practice. This could function similarly to the New Car Assessment Programme (NCAP or Euro NCAP) which is a voluntary scheme which provides an independent 'star rating' of the safety performance of different models of car. NCAP has led to considerable improvements in road safety and so could offer a good precedent for a similar scheme which is focused on driving improvements in accessibility. We acknowledge that there is significant complexity in designing such a system focused on accessibility, however the benefits could be significant.

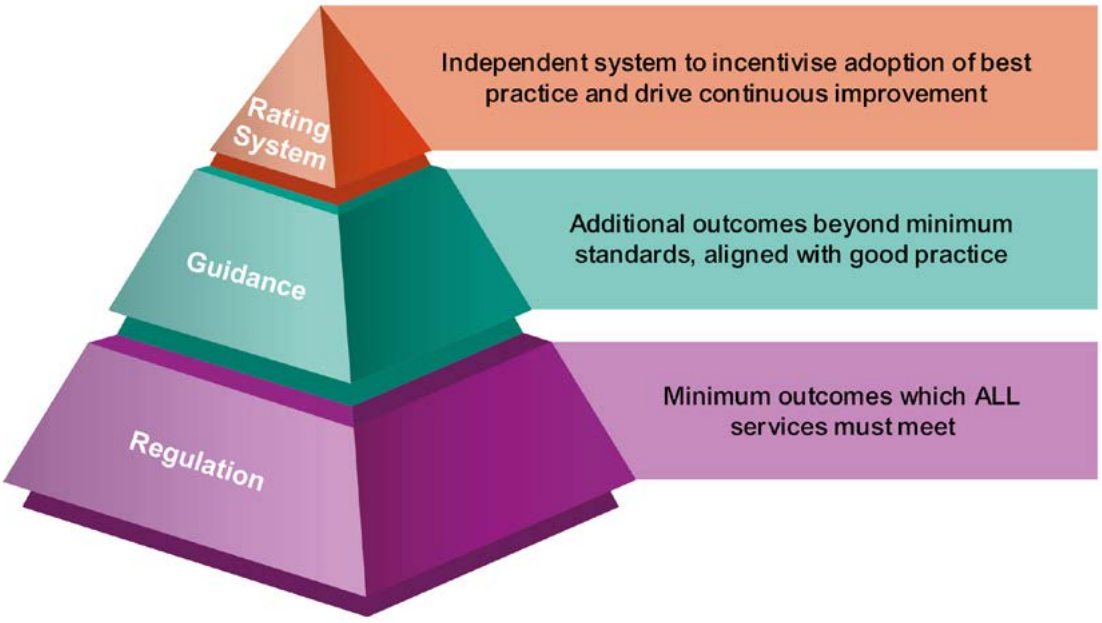


Figure 3. Diagram illustrating proposed high-level system of regulation and guidance to drive improvements in accessibility

The development of the principles, outcomes and the system of regulation and guidance require further development and funding.

Consideration would also need to be given to how to assist the market to navigate the regulations, i.e. not only requiring the market to adhere to regulation, but also supporting the market to do so.

It's also important to note that, to create an accessible service, all parties involved in developing and delivering automated transport services would need to be bought into the principles and align to good practice. For example, in the case of ensuring accessible boarding and alighting of an automated bus service which operates without a driver or on-board member of staff, a robust system would be needed to a) detect the presence of a wheelchair user wishing to board or alight the bus, b) deploy the ramp, c) detect the infrastructure surrounding the vehicle to enable successful and safe deployment of the ramp, d) detect and understand the accessibility of the bus stop, e) provide clear and appropriate communication with the passenger, and f) ensure adequate support in the event of issues, unexpected events or emergencies. Potentially, such a system might involve separate technologies developed and implemented by different parties, therefore, to achieve the required outcomes there is a need for collaboration across the supply chain. This is just one example to illustrate the complexity of the challenge – there are clearly many other aspects to providing an accessible automated transport service, as evidenced in this report.

Recommendations

This work has revealed a number of areas that must be considered to ensure the development of automated transport vehicles and services which are accessible to all in future.

Our primary recommendation from this work is to:

> **Develop a clear and comprehensive framework of regulation and policy to provide market direction, guidance, and incentives for delivering accessible automation.**

In this report we have made some initial suggestions for this framework in terms of the overarching principles which should be embedded and the potential levers that can be pulled.

For the principles to have an impact, there is a need to define how to practically implement them. As a first step, we suggest the development of outcomes which sit below each principle. Further work is needed to develop these and this should be done in collaboration with disabled people.

We recommend a review of existing regulation and guidance, such as PSVAR, and DfT's Inclusive Mobility Guidance to assess whether updates are necessary. Feasibility, structure and governance of an Accessibility 'Star Rating' system, or similar, should also be examined.

The principle of participatory design should be built into future regulation and guidance. Further work is required to determine the most effective mechanisms for doing this, but one option is to incorporate accessibility requirements into existing regulatory levers. For example, the Automated Vehicles Bill 2023-24 describes how a permit should be granted before automated transport services can operate – there is potential for requirements around accessibility and participatory design to be built into the permit approval process.

The Automated Vehicles (AV) Act became law on 20 May 2024, after receiving Royal Assent, leading to suggestions that automated vehicles could be on UK roads by 2026. Therefore, we suggest that such an accessibility framework is also defined by 2026.

Future programmes of work

We recommend that the following programmes of work are delivered to address some of the key issues identified in this report:

1. Examine the trade-off between staff presence on public AVs and commercial viability to understand the most viable solutions

The presence of in-person staff support is a particularly important factor for enabling travel for many disabled people; this should therefore be a key consideration in building an accessible service. However it is recognised that there may be a trade-off here between increased commercial viability of operating a certain route without a driver, and offering a better (and more accessible) service to customers through employment of an on-board 'customer service assistant' or similar. Further work is needed to understand this potential trade-off and how to optimise the operation of automated transport services in future.

More widely, we suggest conducting a more holistic cost-benefit analysis for the implementation of certain accessibility features and solutions in automated transport. Such an analysis could examine potential savings in healthcare and social care costs, as well as economic benefits of increased mobility for disabled people. This could provide compelling evidence for investment in this area, motivating the industry to put more emphasis on accessibility.

2. Clarify obligations and licensing requirements placed on passengers / owners of private automated vehicles

The licensing requirements related to operation of private automated vehicles is not clear – and disabled people were concerned about how this will affect them. Clarification of the legal obligations and licensing requirements is critical here. To inform this process, further research is needed with disabled people to better understand the requirements needed for transition between autonomous and semi-autonomous modes.

3. Define a mechanism for sharing best practice across the industry, nationally and internationally

This work highlighted some areas of current good practice in terms of accessibility in automation, but there are likely to be other examples we were not able to identify. To prompt widespread innovation, good practice should be shared on an ongoing basis within industry. There is a need for a mechanism to do so to be defined. For example, there could be a role for existing trade bodies or an international forum focussed on dissemination and adoption of best practice. Further work is needed to understand the best mechanism and who should drive this initiative forward.

4. Explore optimal solutions for ensuring communication between the vehicle and passenger(s)

This work documented some concerns from disabled people about a lack of adequate communication between the vehicle and passengers in the absence of a driver. This issue should be explored further, with consideration of communication both outside and inside the vehicle, before, during and after the journey.

5. Investigate the impact of automation on accessibility and safety of pedestrians

In the current work, accessibility and safety of pedestrians not using automated services was out of scope. But there are important questions to consider in this topic area, including understanding how pedestrians (including disabled people) safely understand the intentions/ movements of automated vehicles when crossing the road, and understanding the accessibility implications of more automated vehicles on the roads for pedestrians and other vulnerable road users.

6. Explore the role of vehicle connectivity (V2I, V2V, V2X) in improving accessibility and customer experience

The current work focused on automation and de-prioritised vehicle connectivity. But connectivity could play an important role in improving accessibility and customer experience, particularly with regards to multi-modal journeys (e.g. making the interchange experience between modes smoother, easier, etc).

7. Set out a plan and framework for greater data sharing

Transport operators currently have an abundance of data. This includes data on live situations such as whether a service is running on time or whether a lift is broken. It also includes feedback from service users about what is working well and what is not. However, this data is not always viewable or analysable on a greater scale – which means it is not being used to its full potential to increase the accessibility of services. This is an issue which relates to all current transport services and is likely to continue to be an issue with automated transport in future.

We suggest that this issue should be examined more closely to understand how data could be shared effectively, perhaps through a government-led programme of work. This programme should consider interoperability of data and whether there may be a need for data standards to define the format of data.

8. Examine the role of AI and facilitate its application in an ethical manner

All passengers, but especially disabled passengers, experience barriers related to route planning and changes in routes and facilities. Tools incorporating Artificial Intelligence (AI) could help to mitigate these barriers to some degree, for example by enabling personalised journey planning and real-time adaptations. Natural language processing might help to improve information accessibility, and machine learning could optimise vehicle routing.

But we must ensure that systems using AI do not inadvertently discriminate against certain groups, including disabled people. In particular, there is an underlying risk of algorithmic bias in AI systems – both in terms of the bias in data that is fed in, and bias in interpretation of that data.

9. Examine the opportunity for enhanced use of data

Explore the potential role of automated vehicles as medical devices (e.g. monitoring of passenger health and well-being) and the associated benefits and challenges – including customer acceptance and trust in technology, willingness to share personal data/ give permission to be under surveillance, and the legal implications of these sorts of technologies.

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