Passenger experiences of an Autonomous Bus service: The MultiCAV project

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Abstract

This paper reports on a mixed methods study investigating the on-board passenger experience of one of the world's first autonomous bus trials open to the general public. The MultiCAV project – branded publicly as Mi-Link – was an autonomous bus trial serving the Milton Park business park, Didcot, Oxfordshire (UK), and linking it to Didcot Station, in the town centre. To be of practical benefit, automation must be applicable to standard urban buses and routes. A 3km initial loop service with 9 stops was begun in February 2023, operating at up to 32km/h (the site speed limit). In May 2023 the two autonomous buses began an expanded service, linking the business park with the railway station 3km away in central Didcot. Both services operated in mixed traffic, including pedestrians and cyclists, on public roads with speed limits of up to 65km/h. Our mixed methods study utilised an on-board quantitative survey (n = 119) and post-journey qualitative interviews (n = 12) with passengers of the autonomous buses. Our findings focus on people's experiences of actually using the autonomous buses; we consider several facets of the passenger experience: comfort, safety, ride quality, and comparisons to a non-autonomous bus. We analyse different groups within our sample, with a focus on the effects of participants' technological orientations on their experiences of the automated bus. The paper concludes with a discussion of what wider-scale adoption of the new technologies could mean for passenger experiences and the transport system more generally, and how AV bus services might fit into future public transport operations to assist in reducing carbon emissions.

Keywords

Autonomous Vehicles; AV; SAV; public transport; buses; passenger experience; travel behaviour; technology acceptance

Introduction

This paper focuses on passenger experiences of an Autonomous Bus trial. Driverless, autonomous, self-driving, or robotic vehicles are those which partially or completely operate without direct human assistance. These vehicles are classified into five levels of autonomy, depending on the degree of automation (Faisal et al., 2019). Autonomous vehicles (AVs) are suggested to have the potential to reduce emissions, alleviate traffic congestion, mitigate social exclusion, and liberate individuals from the task of driving (Clark, Parkhurst, and Ricci, 2016). However, there are concerns about potential adverse impacts on transport networks, such as worsening traffic congestion, increased vehicle distance travelled, more trips and new trips, reductions in safety, exacerbating inequalities, and introducing new risks to privacy and security (Anderson et al., 2014; Krueger, Rashidi, and Rose, 2016; Fagnant and Kockelman, 2018; Clayton et al., 2020).

Shared AVs (SAVs) represent the best opportunity for sustainable automation of transport networks. SAVs can improve mobility for underserved groups, such as children, the elderly, women, larger households, rural inhabitants, and low-income individuals, by providing access

where current public transport does not operate (De Paepe et al., 2023). These vehicles may help reduce inequalities and improve social inclusion (Alessandrini et al., 2015). As electric vehicles, SAVs can also enhance environmental and economic sustainability by replacing fossil fuel-powered counterparts.

Examples of shared AVs include public transport systems like trains, metros, buses, and coaches, as well as ridesharing services such as Uber Pool and Lyft Share (Chng et al., 2022; Salonen and Haavisto, 2019; Gao et al., 2014). Although driverless public transport vehicles are not new and have been common in underground rail and metro systems for decades (Carteni, 2020), the automation of road public transport (e.g., buses and coaches) poses a different challenge. These vehicles must operate alongside other road users in often unrestricted public spaces, presenting unique operational difficulties (Chng et al., 2002).

Despite the potential benefits of AVs and SAVs, studies have found widespread public distrust of riding in them. For instance, 78% of US participants feared riding in an AV (Power, 2017), and only 10% believed AVs would make roads safer (Brannon, 2017). Similarly, 80% of people in Germany, Norway, Spain, France, and the UK were less willing to trust AVs to safely carry their loved ones (Penn Schoen Berland, 2016). However, recent autonomous shuttle trials have shown remarkably positive results in terms of passenger perceptions and experiences. Participants in these trials were often surprised by how safe and secure they felt in autonomous shuttles (Salonen and Haavisto, 2019). Positive attitudes towards AVs can be fostered by providing people with opportunities to experience them in a safe, real-life environment (Salonen and Haavisto, 2019).

Therefore, understanding SAVs' social acceptability is crucial. Studies so far have assessed willingness to use SAVs based on availability, accessibility, affordability, and attractiveness (De Paepe et al., 2023). Much research has explored hypothetical scenarios, asking individuals without SAV experience about their perceptions and conditions for use. There have been several trials around the world in the past few years of automated road passenger service vehicles; however, mostly these are small-capacity shuttle vehicles, speed limited to 20-25km/h, and do not meet the crash test performance of current urban buses. No studies to our knowledge have to-date reported on the actual experience of using an autonomous public bus under real road conditions, as a “normal” passenger. This study fills that gap by examining people’s experiences with an Autonomous Bus operating a typical public bus service on roads in Didcot, UK, as part of the MultiCAV project.

The paper begins with a literature review on public perceptions and experiences with AV and SAV technology, followed by a methodology section explaining data collection and analysis methods. The results and discussion present findings on Autonomous Bus user experiences and perceptions. The paper concludes with implications for SAV developers, public transport operators, policymakers, and other stakeholders interested in deploying SAV services in the future.

Literature Review: AV and SAV perceptions and experiences

Psychological factors

Psychological factors play a critical role in consumer willingness to adopt AVs. Key influences include individual attitudes towards technology, perceived ease of use, and usefulness of AVs. Positive attitudes towards innovation and trust in technology enhance AV adoption likelihood (Rahman et al., 2024; Rahman & Thill, 2023). Safety perceptions are crucial, with consumers more inclined to use AVs if considered safer than conventional vehicles (Litman, 2023). Perceived usefulness, particularly reducing manual driving, is a significant factor (Rahman et al., 2024). These findings, relevant to SAVs, are explored further in our results and discussion.

Socioeconomic and demographic factors

Socioeconomic status, age, gender, and education level significantly influence AV adoption. Younger, tech-savvy individuals with higher education and incomes are more likely to use AVs (Kyriakidis et al., 2015; Clayton et al., 2020). Men are generally more willing to adopt AV technology than women, who may be more sceptical (Rahman et al., 2024). Urban residents

show higher inclination towards AV adoption due to better infrastructure and exposure to advanced technologies (Ghasrodashti et al., 2022).

Awareness and education

Increasing awareness and understanding of AV technology is essential for acceptance. Educational campaigns highlighting AV benefits, such as enhanced safety, reduced congestion, and environmental sustainability, positively influence consumer attitudes. Addressing common misconceptions and fears is crucial for building trust (Rahman et al., 2024). This is relevant to our findings on participants' experiences with the Autonomous Bus.

The Shared Autonomous Vehicle context

Pilot programs and early adoption

Early SAV services, such as robotaxis and pod services, have been launched in select markets, primarily in urban centres with favourable weather conditions. These pilot programs are essential for testing SAV technology in real-world conditions and gauging consumer response (Litman, 2023; Ghasrodashti et al., 2022). Studies suggest that the commercial deployment of AVs on a larger scale is expected to begin around 2026, with the U.S. and China at the forefront (McKinsey & Company, 2023).

Perceptions and acceptability of SAVs

Public acceptance of driverless buses depends on perceptions of safety, comfort, operator presence, and concerns about riding in automated vehicles (Dong et al., 2019). Factors like journey and waiting times, fares, and bus occupancy also significantly influence acceptance (Wicki et al., 2019).

Echoing the more general discussion above about AV acceptance, demographics are suggested to play an important role in the acceptability of SAVs, and similar factors are suggested to be important here. De Paepe *et al.*, (2023) provide an overview of studies in this area, noting four demographic dimensions of relevance to SAV acceptability:

1. **Age:** In general, evidence suggests that young people are more accepting of SAVs than older people (Bansal et al., 2016; Cartenì, 2020; Fafoutellis et al., 2021; Guo et al., 2020; Haboucha et al., 2017; Clayton et al., 2020; König & Grippenkoven, 2020; Polydoropoulou et al., 2021; Sener & Zmud, 2019; Wang et al., 2020; Wicki et al., 2019).
2. **Gender:** Men report more positive views of SAVs than women (Alfonsi et al., 2018; Bansal et al., 2016; Cartenì, 2020; Fafoutellis et al., 2021; Haboucha et al., 2017; König & Grippenkoven, 2020; Lavieri & Bhat, 2019; Nathanail et al., 2020; Rosell & Allen, 2020; Sener & Zmud, 2019; Wang et al., 2020).
3. **Education:** People with higher reported levels of education are more accepting of SAVs (Alfonsi et al., 2018; Feys et al., 2020; Haboucha et al., 2017; Rosell & Allen, 2020; Wang et al., 2021).
4. **Residential context:** urban residents show higher acceptability towards SAVs (Bansal et al., 2016; Sener & Zmud, 2019).

Focusing specifically on Autonomous Buses, studies show mixed reactions to the absence of a driver. Some research indicates a preference for automated buses over conventional ones, especially for longer trips or when service frequency is high (Piao et al., 2016; Alessandrini et al., 2016; Winter et al., 2018; Chee et al., 2020). On the other hand, Clayton et al. (2020) explored people's willingness to share an AV (in the form of both an AV taxi and an AV bus) in comparison to a traditional car and a personal AV, and found that the shared AV options were the least popular of the choices, compared to the non-shared (private) options.

Passenger experiences of SAV

Several studies on SAVs, primarily small AV shuttles, indicate that firsthand experience improves perceptions and increases future use likelihood. Experiencing the technology mitigates concerns and fosters positive attitudes toward autonomous transport (Bernhard et

al., 2020; Feys et al., 2020; Hilgarter & Granig, 2020; Andersson et al., 2021), underscoring the importance of awareness and understanding for SAV uptake (Rahman et al., 2024).

General perceptions and acceptance

Existing research suggests that autonomous shuttles are generally well-received. In Finland, passengers trusted driverless shuttles, comparing them to trams and metros (Salonen & Haavisto, 2019). In a Brussels (Belgium) trial, 70% of passengers reported positive experiences, with enjoyment influencing their use intention (Feys et al., 2020). Trial respondents in Berlin (Germany) saw automated shuttles as useful feeders to public transport (Nordhoff et al., 2018). Comparisons between experiences in different countries found high safety and personal security ratings (Bellone et al., 2021). Mainz's AV shuttle trial (Germany) received positive feedback, with performance expectancy being a key acceptance predictor (Bernhard et al., 2020). Curiosity and novelty were major factors in positive perceptions across demographics in a study across trials reported by Andersson et al. (2021).

Key determinants of acceptance

Performance expectancy, effort expectancy, and hedonic motivation significantly influenced usage intention in the Brussels trial (Feys et al., 2020). Safety and personal security were highly rated, with variations due to route design and environment (Bellone et al., 2021). In Austria, perceived safety, enjoyment, and novelty were critical, though some scepticism remained (Hilgarter & Granig, 2020). Pleasant ride experiences in Mainz significantly influenced willingness to use the shuttle (Bernhard et al., 2020).

Demographic influences

Younger passengers generally rated the experience more favourably. In Finland, younger individuals showed higher acceptance levels, especially regarding safety (Salonen & Haavisto, 2019). Berlin's older respondents had a higher intention to use shuttles but rated effectiveness lower compared to existing transport options (Nordhoff et al., 2018). Across locations, younger demographics consistently reported higher acceptance, while older participants were more sceptical (Andersson et al., 2021).

Safety and operational concerns

Safety is a key theme in autonomous shuttle acceptance, as it is with AV acceptance more generally. In Finland, passengers felt safe due to slow speeds and controlled environments (Salonen & Haavisto, 2019). Berlin trial passengers preferred supervision from an external control room (Nordhoff et al., 2018). Brussels participants highlighted concerns about handling emergencies despite positive safety perceptions (Feys et al., 2020). Whilst the trial in Mainz emphasized perceived safety and pleasant experiences in user acceptance (Bernhard et al., 2020).

Considering ride quality, common issues include shuttle speed, route flexibility, and luggage space. The Berlin trial passengers were dissatisfied with shuttle speed and luggage space compared to existing modes (Nordhoff et al., 2018). Suggestions include increasing speed, expanding routes, and better integration with public transport (Bellone et al., 2021; Feys et al., 2020). Respondents in Mainz stressed improving route designs and communication about stops and unexpected situations (Bernhard et al., 2020).

Literature summary

The most applicable form of public transport to the SAV context is the bus. SAVs have significant potential to improve bus services in terms of fares, network coverage, and more. In SAV research there remains a substantial research gap concerning public reaction to Autonomous Buses in operation, and people's experiences of being actual passengers on these new types of bus. This study presents a first look at these "real life" experiences, in its exploration of the experiences of passengers using one of the first publicly accessible Autonomous Bus services, running on public roads to normal speeds. The next section sets out the methodology employed to explore these experiences.

Methodology

Study context

The Mi-Link project, co-funded by Innovate UK and the Centre for Connected and Autonomous Vehicles, aimed to deliver sustainable transport services in a 'Mobility as a Service' environment. The centrepiece of the project was a series of three phases of electric autonomous bus service trials (in the end, only two of these phases would run due to technical issues with Phase 3), first operating on public roads within Milton Park Technology and Science Park, Didcot (Oxfordshire) (Phase 1) and later linking to Didcot Parkway railway station (Phase 2).

The vehicle

The Phase 1 and 2 bus services employed a type-approved 15-seat electric minibus equipped with Fusion's CAVstar® automated driving system (Figure 1).

Figure 1 - Phase One and Two electric, autonomous Mellor Orion minibus

The demonstration services took place in 2023 and were branded as part of the Mi-Link transport services. Conducted by a consortium led by First Bus, the project included Milton Park, Oxfordshire County Council, Nova Modus, Fusion Processing, Zipabout, and UWE Bristol.

- **Phase 1 route:** Milton Park circuit (<3km round-trip – within yellow perimeter top left of Figure 2 below)
    - Ten autonomous bus stops around the circuit (purple arrows)
- **Phase 2 route:** Milton Park and Didcot Parkway (10km round-trip – extends original Phase 1 circuit out to Didcot Parkway station (bottom right of Figure 2)
    - Twenty autonomous bus stops along the route (purple arrows)

Researchers carried out a questionnaire survey (n=119) and post-ride interviews (n=12) to understand passengers' experiences with the electric autonomous bus services. The research aimed to answer the following Research Questions:

1. Why did passengers choose to use the electric autonomous minibus services?
2. To what extent did passengers feel safe on board and why?
3. What did passengers think about the ride quality compared to a conventional bus?
4. What were passenger views on how well the autonomous minibus handled different manoeuvres compared to a conventional bus?

The research questions were addressed through a mixed-methods approach which combined an onboard questionnaire-based passenger survey, with passenger interviews.

Figure 2 - Map of the route taken by the Mi-Link autonomous bus service

Passenger survey	Passenger interviews
Key information	
• Took place during Phase 2 • Conducted from 12 June - 21 July, 2023 • Offered in both paper and digital formats • Administered on-board AV bus during normal operations • Took around 5 minutes to complete	• Took place during Phase 1 and Phase 2 • Conducted off-bus either in person or on MS Teams • Lasted 15-30mins
Sample	
• Total = 126, Completed = 119, Full completion rate = 94% • QR responses = 23%, Completion time = ~ 5 minutes • 60% men, 39% women, 1% nonbinary / other • Average age = 37 years, range = 18 – 77 • 63% were daily users, 27% used a few times a week, 10% used once or twice a month, 1% less than once or never	• 9 participants: 5 female, 4 male • Employees of organisations on Milton Park • Age range spread from 25 - 65+

Questionnaire survey detail

A questionnaire-based survey was identified as the most appropriate method to capture responses from a reasonably large number of passengers. The questionnaire (included as Appendix A) was designed to capture passenger responses about:

- Why passengers had chosen to travel on the autonomous minibus;
- Perspectives on the bus's ride quality and ability to undertake manoeuvres, compared to a conventional bus;
- Feelings of safety when onboard the autonomous minibus;
- Overall satisfaction with the autonomous minibus service; and

- Some indicators of respondent demographic characteristics, general travel behaviour and attitudes towards technology.

The questionnaire was administered during the Phase Two service only (having been piloted in Phase One). It was designed to be completable while passengers were onboard the bus, and so was necessarily short. Passengers could complete the questionnaire either online (by scanning a QR code on a card handed to them as they joined the bus and then completing on a smartphone), or they could complete a hard-copy handed out by a surveyor situated on the bus. Few passengers opted to use the QR code, and it was found that response rates were much better following an active personal introduction from an on-board surveyor and when paper questionnaires were personally handed to passengers to fill-in. Hence the paper questionnaire became the main mode of survey administration. Passengers were asked to spend some time experiencing the bus before responding to the questions.

Passenger interview detail

A small number of short (approximately 15 minute) post-ride interviews were also conducted to generate deeper insights into passenger experiences and perspectives. The interview guide is included as Appendix B and was designed to explore similar themes to the questionnaire, including:

- Reasons for using the autonomous bus services
- Feelings of trust in the autonomous bus before, during and after the journey
- Observations on how the bus behaved
- Future intention to use autonomous bus services

Compared to the quantitative survey method, the qualitative method allowed participant experiences to emerge naturally through discussion, rather than being guided by the pre-defined categories required by the questionnaire format, and allowed participants to explain and reflect on their experiences in much greater detail.

During the Phase One service, researchers were stationed at the Milton Park Bee House café and co-working space. Passengers alighting at the Bee House were asked if they were willing to undertake a short interview immediately following their journey on the autonomous minibus. Nine Phase One participants took part in these interviews.

During the Phase Two service, questionnaire respondents were invited to provide contact details if they were willing to take part in a short online interview. Three Phase Two participants took part in these interviews.

The performance of the bus in automated mode was enhanced during and between the two periods of operation. Given that the interviews were mainly conducted during the first phase of operation, around Milton Park, they mostly refer to the inaugural service. Had it been possible to conduct more interviews during the second period of operation there may have been fewer accounts of operator intervention being needed and a clearer understanding of when the bus was in automated mode.

Findings from the questionnaire are now considered (in Section 3), before moving on to consider insights from the passenger interviews in Section 4. Finally, Section 5 summarises the findings by each of the research questions in turn.

Results

Sample characteristics - Survey

The questionnaire-based survey received 119 complete responses. 60% of respondents were men, 39% women and 1% indicated nonbinary or other. The average age of respondents was 37 years, with a minimum age of 18 and a maximum age of 77. The majority of the respondents were frequent public transport users - 63% used public transport every day, 27% used public transport a few times a week, while 10% used public transport once or twice a month. The

majority of the respondents also self-identified as early adopters of new technologies. 63% of respondents agreed with the statement "I am often one of the first to try out a new technology".

Sample characteristics – Interviews

Twelve passengers agreed to take part in post-ride interviews: nine from the Phase One service and three from the Phase Two service. All took part in one-to-one interviews, except in Phase 1 a group of three (Participants 1-3) that preferred to be interviewed together. The interviewee characteristics are summarised in Table 1 below.

ID	Age group	Gender	Worked at Milton Park	Trial Phase
Participant 1	25-34	Female	Y	1
Participant 2	45-54	Female	Y	1
Participant 3	25-34	Female	Y	1
Participant 4	35-44	Female	Y	1
Participant 5	45-54	Male	Y	1
Participant 6	55-64	Male	Y	1
Participant 7	35-44	Female	Y	1
Participant 8	55-64	Male	Y	1
Participant 9	65+	Male	N	1
Participant 10	35-44	Male	Y	2
Participant 11	45-54	Male	Y	2
Participant 12	45-54	Male	N	2

Table 1 - Interviewee characteristics

Reasons for using the Autonomous Bus service

The phase two autonomous minibus was providing a service to Didcot Parkway railway station, and so it is not surprising that most survey respondents had used the bus (which was free) instead of one of the conventional bus services[1] to/from the station - 84% of respondents were traveling to or from Didcot Parkway station (Table 2). There were also a small group of 'autonomous bus enthusiasts' that had made the journey specifically to experience the autonomous bus technology - 13% travelled just to try the autonomous minibus. The remaining 2% were using it to reach other places in Milton Park and 1% were travelling for other purposes.

Please tell us the reason for your current journey on the autonomous minibus	N	%
Just to try the autonomous minibus	15	12.6%
Travel to / from Didcot Parkway	100	84.0%
Travel within Milton Park	3	2.5%
Other	1	0.8%
Total	**119**	**100.0%**

Table 2 - Reason for using the autonomous minibus service

When asked how respondents would have travelled if the autonomous bus had not been available (n=119), 91% stated they would have used another bus service (consistent with the

[1] As the majority of the users were regular travellers on this route the opportunity to travel free-of-charge would not have been a significant factor in choosing the bus as employees based at Milton Park can purchase a very low-cost (£20) annual bus pass.

majority travelling to/from Didcot Parkway railway station), 3.4% said they would not have travelled at all, 2.5% said they would have driven themselves in a private car and the remaining 3% would have either walked, cycled, taken a taxi, or travelled as a passenger in a car (Table 3).

How would you have travelled if the autonomous minibus had not been available?	N	%
Walked	1	0.8%
Cycled	1	0.8%
Passenger in car	1	0.8%
Driven self in car	3	2.5%
Used another bus service	108	90.8%
Not travelled	4	3.4%
Taxi	1	0.8%
Total	**119**	**100.0%**

Table 3 - Mode of travel if the autonomous minibus was not available

When asked about the frequency of autonomous vehicle use before the survey (n=119), 66% said that it was their first journey, 33% had previously travelled on it two to five times and 1% had travelled more than five times on an autonomous vehicle (Table 4).

Please tell us how many times you have travelled on the autonomous minibus:	N	%
First journey	79	66.4%
Two to five times	39	32.8%
More than five times	1	0.8%
Total	**119**	**100.0%**

Table 4 - Number of journeys on the autonomous minibus

In interview, participants reported diverse motivations for using the autonomous bus. Some were regular public transport users leveraging the service for their commutes, while others were technology enthusiasts eager to experience autonomous transportation firsthand. The interviews revealed that most participants viewed the autonomous minibus as a convenient alternative to traditional buses. Enthusiasts appreciated the innovative experience, indicating that the service attracts a diverse user group motivated by both utility and curiosity. As two participants noted:

> *"Excited because it's a new technology." (Participant 6)*

> *"I was just intrigued to see how it operated" (Participant 9)*

Safety Perceptions

The quantitative results are presented in Chart 1. Presence of the human operator was found to provide passenger confidence in the vehicle – 88% of respondents agreed that they "felt safe on the autonomous minibus because there was a human operator onboard". Indeed, one respondent used the open response part of the questionnaire to note that: "*I am glad there was a human driver there too*".

With respect to the relationship between speed and feelings of safety, the majority of respondents reported feeling safe at both high and low speeds. But a slightly lower proportion of respondents reported feeling safe at high speeds:

- 88% of respondents reported feeling safe at low speeds compared to 72% of respondents reporting feeling safe at high speeds.

- A Wilcoxon Signed Rank Test determined that there was a statistically significant difference in the mean score of feeling safe when the minibus was travelling at high speed and low speed across survey respondents (z = -3.059, p = 0.0017).

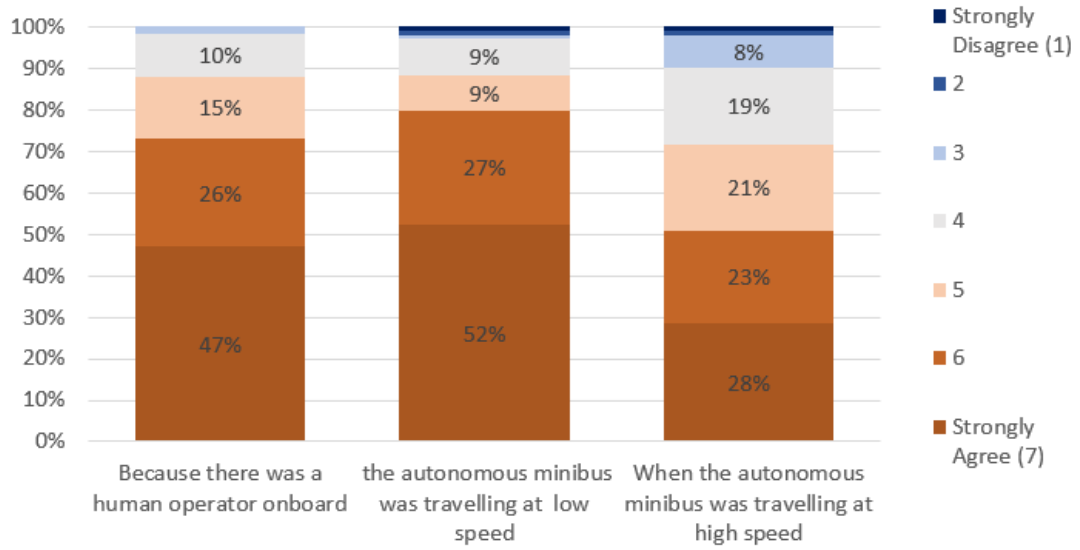

Chart 1 - Feelings of safety on the autonomous bus (n=115)

In the interviews, passengers emphasized the reassurance provided by the human operator, particularly during complex manoeuvres and unexpected events. Interviews confirmed that the low-speed environment of Milton Park contributed significantly to the feeling of safety. Participants expressed reluctance to ride without a human operator until more confidence in the system's reliability is established. For example, one participant explained:

Consistent with the questionnaire responses, none of the participants reported feeling unsafe on the bus as the presence of the safety operator instilled confidence in the technology:

> *"I probably felt safe, because I knew that there was a driver there as well. I think I would feel a bit nervous if there wasn't anyone there." (Participant 1)*

> *"[the safety driver] did make it feel more comfortable." (Participant 6)*

Participants also expressed confidence in the safety operator's ability to immediately take control over the vehicle:

> *"There was only one moment when the bus was on auto and it basically stopped on a roundabout. And before the driver took over, another motorist overtook the bus on the roundabout, which was kind of an interesting move. I wouldn't say it made me feel uncomfortable, but that… felt unusual certainly." (Participant 10)*

> *"I think when I was on it, there was some bad weather and the driver did take over… so that was interesting. But yeah, I didn't feel anxious or whatever because of the autonomous part of it, no." (Participant 12)*

> *"The fact that I know that there's a driver there when he's… actually driving all the complicated bits means I'm not even slightly worried". (Participant 11)*

The low-speed (20mph / 32kph speed limit) and relatively low traffic levels within Milton Park was also a factor that promoted confidence in the autonomous bus:

> *"I think the speed limit as well; that it's not going really fast…" (Participant 3)*

> *"Milton Park is a private estate and there isn't that much traffic, and there is a 20 mile [speed limit] … so you'd be less anxious anyway. Yeah. So, I'd be very keen to try it again on one journey to Didcot station." (Participant 9)*

One participant considered that the electric propulsion made the bus easier to control and hence safer:

> *"(…) the fact that it's an electric bus; so that probably means there's more control over it. If it had been a petrol bus, I would have been more nervous... or a diesel bus because it'd be more difficult to control the motor." (Participant 6)*

Another interviewee had a perception that the automation technology was 'learning' and hence improving over time. (The technology 'learnt' in the sense that technicians manually improved how the sensor responded to the park environment over the period of the trials):

> *"The fact that we know that it's learning as it goes as well, because we'll probably be using it to go from one type of path to the next." (Participant 2)*

In Phase 2, interviewees were specifically asked if they would feel anxious with no safety driver on board. Responses indicated that people would feel less safe if there was no safety operator, partly based on the observation that the safety operator was quite regularly intervening:

> "*I don't know how I would feel if there would be nobody in the bus." (Participant 7)*
>
> *"If I had never travelled on the bus and it was just presented with no driver, then I wouldn't be too bothered (…). But having got on the bus and having had that journey and having realised that the driver does take over 60% of the time (…) then I would be slightly more nervous". (Participant 10)*
>
> *"Prefer to see a few more runs with a lot more 'blue light' saying it's autonomous on it before I would be totally confident [to be on the minibus without a driver]." (Participant 11)*
>
> *"Not sure if I feel comfortable with that to be honest." (Participant 12)*

Ride Quality

Survey participants were asked to rate the quality of the electric autonomous minibus in relation to noise and journey smoothness compared to a 'normal bus'. There is clear evidence that electric buses are perceptibly quieter than conventional diesel buses – 72% of respondents rated the electric autonomous minibus as being quieter than a normal bus (

Do you think the ride on the autonomous minibus was jerkier or smoother than a ride on a normal bus?	**N**	**%**
Jerkier	26	22.8%
Smoother	32	28.1%
About the same	56	49.1%
Total	**114**	**100.0%**

).

There were divergent views on the smoothness of the ride. 28% of respondents reported that they felt the autonomous electric minibus was smoother, and 23% said it was jerkier than a normal bus (

Do you think the autonomous minibus was noisier, quieter or about the same as a normal bus?	**N**	**%**
Noisier	3	2.7%
Quieter	81	72.3%
About the same	28	25.0%
Total	**112**	**100.0%**

). Such divergent views were also reflected in the questionnaire open response comments where one respondent noted: *"smooth ride. no complaints. arrived on-time"*; while another

suggested there were *"quite hard stops"*.

Do you think the ride on the autonomous minibus was jerkier or smoother than a ride on a normal bus?	N	%
Jerkier	26	22.8%
Smoother	32	28.1%
About the same	56	49.1%
Total	**114**	**100.0%**

Table 5 - Autonomous bus smoothness

It appears likely that the ride quality was objectively variable given that the minibus brought together electric propulsion and automation technology. Electric propulsion has smoother (but also higher) acceleration than internal combustion engines due to the absence of gearing, while automation technology occasionally introduced hesitation or abrupt stops as the bus responded to potential hazards and/or slight jerkiness in transitioning between human and automated operation. These facets of the ride quality were also highlighted in the post-ride interviews and are explained in further detail in Section 4.

Do you think the autonomous minibus was noisier, quieter or about the same as a normal bus?	N	%
Noisier	3	2.7%
Quieter	81	72.3%
About the same	28	25.0%
Total	**112**	**100.0%**

Table 6 - Autonomous bus noise levels

In interviews, the quieter operation of the electric minibus was generally appreciated, however, opinions on ride smoothness were mixed. Interviewees noted the smooth acceleration and deceleration linked to electric propulsion but also mentioned occasional abrupt stops due to the autonomous system's cautious responses to perceived hazards. This divergent feedback indicates a difference of opinion and focus for participants between technological benefits and areas needing improvement.

With respect to the autonomous bus ride quality, in Phase one interviewees noted that they found it hard to distinguish between when the bus was operating in autonomous mode and when the safety operator was driving. This was partly because some passengers were not aware of the beep when the bus changed from autonomous to manual – and vice versa[2]. This suggests that the experience of autonomous driving was often very similar to human operation:

> *"I could only tell by looking at the driver. Otherwise, I couldn't really tell when it was"*. (*Participant 4)*

> *"You knew because the driver was keeping up the commentary at times when I think that was happening [switching between autonomous and human driven modes], which was really, really interesting. Um, if he hadn't, it would have been hard to tell when it's driving." (Participant 5)*

Having said that, participants did identify certain driving events that were obviously different and related to autonomous operation. These included (i) transitioning between autonomous

[2] This problem was solved in phase 2, when an electronic screen was installed in the bus to let the passengers know when the bus was running in autonomous mode.

and human driven mode; and (ii) sharp deceleration in response to potential hazards that were not easily perceived by the passenger:

> *"When it slips from autonomous to non-autonomous. It's quite sudden braking."* (*Participant 5)*

> *"It is that jarring…of stopping. (…) it doesn't feel natural. (…) It's quite a dramatic braking. Feels like… you know, when you're in a drive on a bus with like, a driver hasn't been driving that long."* (*Participant 5)*

Indeed, it was noticed by some other interviewees that the minibus was more cautious in response to potential hazards and hence slowed down more frequently than a conventional bus:

> *"But it certainly felt even when there weren't people [pedestrians] there it slowed down a little bit, like it was observing it and then went off". (Participant 2)*

> *"There was a pedestrian that walked past the zebra crossing, so the bus stopped but the pedestrian doesn't cross".* (*Participant 4)*

Some of those stops felt a bit uncomfortable for some participants:

> *"I think it felt maybe slowing at a bus stop felt a bit more abrupt than normal." (Participant 4*)

> *"There is quite a lot of automatic stopping."* (*Participant 5)*

Interviewees highlighted a mix of experiences in relation to the overall ride quality. Some commented on smoothness and powerful acceleration, linked to the electric propulsion:

> *"A bit more powerful." (Participant 1)*

> *"I was quite surprised how smooth the whole thing was. So even when he had to slow down, it took its time to slow down. Where there were speed bumps, it anticipated them. So, they were not sharp. I didn't have any other anxieties. I'm fine with it." (Participant 9)*

> *"I think it was very gentle, in comparison with a bus with a driver." (Participant 7)*

> *"About acceleration and deceleration, I reckon that was probably better than the [mentions another conventional local bus service]" (Participant 10)*

> *"It was generally smoother than the normal. So, I thought that was good" (Participant 10)*

> *"It might be a bit smoother, I suppose on the longer straights … it's an electric bus, that's a bit quieter in that sense … but difficult to compare, really" (Participant 12)*

Others identified that acceleration and deceleration could be more pronounced than a conventional diesel bus, again linked to the difference between electric and internal combustion engine propulsion:

> *"It felt lashing. It felt a bit like, you know, the acceleration of electric car (…); it feels very sudden power." (Participant 5)*

Handling of manoeuvres

Respondents were asked to rate how well the autonomous bus handled five manoeuvres compared to a normal bus: (i) arriving and leaving bus stops; (ii) going straight ahead; (iii) approaching pedestrian crossings; (iv) approaching on-coming vehicles; and (v) approaching and leaving junctions. The responses are summarised in Chart 1, revealing differences in ratings across the five manoeuvres and also divergent views between passengers:

About 1 in 5 respondents rated the autonomous minibus as performing better than a human-driven bus across all manoeuvres, but another group of respondents (in most cases a lower proportion) rated the autonomous minibus as performing worse than a normal bus.

Approaching junctions received the 'worst' ratings, with about 1 in 5 respondents rating the minibus as performing worse than a normal bus.

Approaching pedestrian crossings and approaching oncoming vehicles were the hardest manoeuvres for passengers to judge– 35% and 22% of respondents respectively reported not noticing these manoeuvres. This is possibly linked to the low number of pedestrian crossings encountered on the route and the need for passengers to have more forward visibility to detect these manoeuvres.

An important caveat here is that the validity of the responses relies on the respondent having awareness of when the system was in autonomous and human driven mode, and it was precisely to promote this validity that a visible 'auto' indicator was provided inside the bus for Service 2 following feedback from Service 1.

On the fifth case of 'approaching and leaving junctions' it is to be noted that the number of people rating the autonomous driving as 'worse' than a human exceeded those rating it as 'better' than a human (which was the reverse situation to the other four cases). It is likely that the autonomous system was less willing to accept gaps than a human driver, so was perceived as hesitant or incapable, and it was noted in the post-ride interviews that passengers observed that the operator often took control at the most complex junctions.

A Fisher's exact test was used to determine if user experiences varied across three personal characteristics that could be expected to be associated with differences in views: (i) prior experience of an autonomous minibus, (ii) gender, and (iii) age (above and below 30). In most cases, differences were not statistically significant, except for the following three cases:

- Men were more likely than women to rate 'arriving and leaving at bus stops' as worse than a normal bus (p=0.026)
- Adults aged below 30 were more likely to agree that they felt safe at high speeds than adults aged over 30 (p=.007), suggesting that younger adults either perceive the risk of higher speed lower than older adults do, or are more accepting of it.
- There was a weaker relationship showing first-time users being more likely to rate 'approaching and leaving junctions' as worse than a human-driven bus than repeat users (p=0.061)

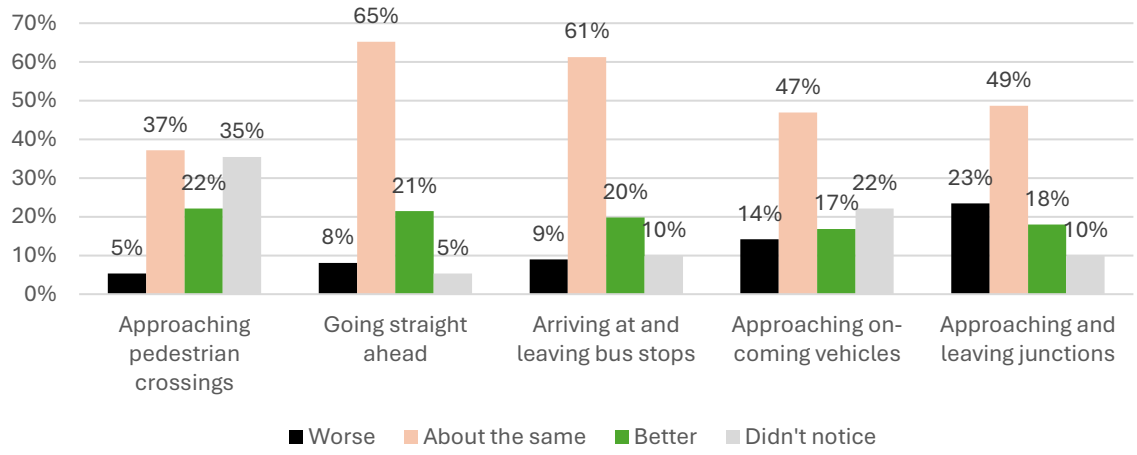

Chart 2 - How the autonomous minibus was perceived to be 'driving' compared to a human

Interview participants highlighted the cautious nature of the autonomous bus, especially at junctions and in heavy traffic, where human operators often had to intervene. Some passengers appreciated the consistent following distance maintained by the bus, while others felt the system was overly cautious, leading to unnecessary stops.

Some participants observed that the behaviour of the autonomous minibus was of course impacted by the surrounding traffic conditions:

"I reckon is also about how other motorists react to the vehicle". (*Participant 10)*

At junctions, where there were complex interactions between vehicles and occasionally a need to assertively take priority over on-coming vehicles, passengers noticed that the human operator would often need to take control as the autonomous system was hesitant:

> *"Whenever you get up to a one of the more major junctions, it's almost always the driver taking you through that route, and I suspect that's more to do with oncoming traffic and difficulty." (Participant 11)*
>
> *"I think compared to a bus driver who drives out route regularly and has that kind of confidence and understands the route, maybe the autonomous bus was just marginally more hesitant." (Participant 10)*
>
> *"I do notice a lot of the more complicated manoeuvres do tend to be the driver rather than the autonomous. It's very much sort of a driver assist rather than autonomous from what I can make out. Let's say I'm quite curious, so I'm happy watching (…) it does tend to be a bit of a 'swervy'." (Participant 11)*
>
> *"I think it was OK if the junction wasn't so busy, I think it might have done one of them. And then … one of the roundabouts is very busy and the bus driver had to take over because I don't think it recognised the need to go out and get through the traffic when it was very busy" (Participant 12)*
>
> *"I think the transitions [from auto to manual] are noticeable. There are certainly points, particularly when we are taking junctions that it seems very cautious. A driver would have taken the junctions a little bit more aggressively. I don't see that a particular problem, but it's noticeable." (Participant 11)*

One participant identified that the autonomous minibus was better at vehicle following, speed matching and keeping a consistent distance to the lead vehicle compared to a human driven bus:

> *"I have noticed that the bus is actually quite or seemingly quite good at following traffic along the road as well….in the big stretch that runs between [x and y]. It's quite frequent for me to see the bus go on autonomous and essentially sort of matching speeds with the vehicle in front quite nicely. That's actually slightly more reassuring than having a driver doing it." (Participant 11)*

Overall satisfaction and thoughts

Overall, the autonomous bus service was viewed positively by survey participants, with 92% of participants reporting themselves as satisfied (Table 7). In total, 97% of questionnaire respondents confirmed that they would use the service again, and 98% reported being satisfied with the service (Table 8).

Please indicate how satisfied you were with your ride on the autonomous minibus	N	%
Completely Satisfied (7)	46	40.0%
6	44	38.3%
5	16	13.9%
4	7	6.1%
3	1	0.9%
2	1	0.9%
Not satisfied at all (1)	0	0.0%
Total	**115**	**100.0%**

Table 7 - Overall participant satisfaction

Would you use the autonomous minibus again?	N	%
Yes	109	97.3%
No	3	2.7%
Total	112	100.0%

Table 8 - Willingness to use Autonomous Bus again

Participants in interview gave some interesting insights into the potential role of autonomation in bus service operations more generally. Participants expressed a range of views in relation to the role of automation technology in the bus sector.

Those who described themselves as early adopters of technology expressed positive views about the potential of the technology:

> *"I don't think it's any worse than a normal bus... definitely not... it definitely feels more technological and environmentally friendly."* (*Participant 4)*
>
> *"I think this is new technology, new exciting technology, so… so if we could travel without drivers, that would be fantastic. And it's electric as well, so…." (Participant 7)*
>
> *"Financially, it makes sense because the cost of the driver is such a high proportion of the cost of a commercial bus. So, I'm hopeful that it is… that is the future and I would like to be alive to see it if I could" (Participant 9)*

By contrast, another interviewee raised concerns about the social impacts of autonomous buses in relation to job losses:

> *"What's the advantage of an autonomous bus? I'm not sure. And I sometimes wonder whether technology is used in this way (…). We could make it work…but…ultimately…bus drivers will lose their jobs. And is that a good use of the technology? (…) I love technology, and I love everything it can do. But do we think about how it's actually going to be used in practical terms?... So… there's a technological debate, which is astonishing and amazing...But think about the social cultural aspects, how does it change society?" (Participant 5)*

This is an important point, an links into wider debates about the role of automation in society, and the tension between promised benefits of the technology and the consequences for society, both known and unintended.

Overall though, interview participants generally had a similarly positive outlook to the survey participants on the autonomous bus service. Enthusiasts were excited by the new technology, while utility users appreciated the convenience and quiet operation. Concerns were mainly centred on the need for further technological refinement and increased confidence in fully autonomous operations.

Discussion

This discussion section responds to the research questions set out earlier, incorporating insights from our findings and the existing literature presented in the review.

Why did passengers choose to use the electric autonomous mini-bus service?

The majority of questionnaire respondents (84%) used the autonomous minibus as a replacement for conventional bus services between Milton Park and Didcot Parkway train station. This confirms previous findings indicating that the availability and convenience of SAVs can significantly influence usage (De Paepe et al., 2023). Additionally, 13% of respondents were motivated by a desire to experience the novel technology, linking to findings from Salonen and Haavisto (2019) that curiosity and the novelty of autonomous vehicles could attract future users.

To what extent did passengers feel safe on board the electric autonomous minibus and why?

Safety perceptions are suggested to be crucial for the adoption of autonomous vehicles (Litman, 2023). In our study, 88% of questionnaire respondents felt safe on board due to the presence of a human operator. This finding is consistent with earlier research suggesting that operator presence can enhance passenger confidence in autonomous shuttles (Salonen & Haavisto, 2019). A question remains about how passengers might experience safety aboard an autonomous bus without a driver present, but the gathering evidence in this area suggests that passengers prefer to have a human presence on board in the form of an operator in some form, and that this may be essential to encouraging SAV and Autonomous Bus use, particularly in the early stages of a wider rollout.

Interview participants highlighted that the low-speed, low-traffic environment of Milton Park contributed significantly to their feelings of safety, reflecting the potential of controlled environments in creating trust in early AV adoption (Salonen & Haavisto, 2019). However, a slightly lower proportion of respondents felt safe at high speeds (72%) compared to low speeds (88%). This variation underscores the need for further trials into on-road experiences of Autonomous Bus services to further understand people's perceptions of safety at typical speeds on public roads.

Interestingly, it was in this area that we found a significant relationship with demographics. Younger passengers felt safer than older passengers at higher speeds, which aligns with several previous studies that have found younger people more accepting of autonomous technology that older people (e.g. Bansal et al., 2016; Haboucha et al., 2017; Nordhoff et al., 2018; Salonen & Haavisto, 2019; Sener & Zmud, 2019; Wicki et al., 2019; Cartenì, 2020; Clayton et al., 2020; Guo et al., 2020; König & Grippenkoven, 2020; Wang et al., 2020; Andersson et al., 2021; Fafoutellis et al., 2021; Polydoropoulou et al., 2021). It is interesting to see this demographic difference in AV perception carried through into the real-world context of experiences a public autonomous bus service.

What did passengers think about the ride quality onboard the electric autonomous minibus compared to a conventional bus?

The electric propulsion system was perceived as quieter than a conventional diesel bus by 72% of respondents, supporting findings that electric vehicles typically offer a quieter ride, which links to discussions in existing literature about the pleasant experience offered by SAV shuttle services (Bernhard et al., 2020). However, opinions on ride smoothness were mixed. While 28% felt the ride was smoother, 23% found it jerkier, reflecting the challenges associated with integrating automation technology, which can sometimes lead to abrupt stops in response to perceived hazards. This links to the finding from Feys et al. (2020) that participants had concerns over the handling of emergency incidents, within overall positive perceptions.

Interview feedback highlighted both smooth acceleration due to electric propulsion and occasional abrupt stops caused by the cautious nature of the autonomous system. These findings suggest that while there are clear benefits to ride quality from electric propulsion, further refinement of the autonomous control systems is necessary to achieve a consistently smooth ride (see: Berhnard et al., 2020).

What were passenger views on how well the autonomous minibus handled different manoeuvres compared to a conventional bus?

Questionnaire respondents provided varied ratings for the autonomous bus's performance across different manoeuvres. About 20% rated it as better than a normal bus, while a similar proportion rated it worse, particularly for complex manoeuvres such as approaching and leaving junctions. These findings indicate that passengers may perceive autonomous vehicles as *overly* cautious or hesitant in complex traffic situations.

Interviewees noted frequent operator interventions at complex junctions, emphasizing the need for further advancements in AV technology to handle such scenarios more confidently. This aligns with the broader literature, which highlights that human intervention remains a

crucial component in ensuring the safety and reliability of autonomous vehicles in mixed traffic environments.

Overall satisfaction and future intentions

Overall, the autonomous bus service was well-received, with 97% of questionnaire respondents indicating they would use the service again and 98% expressing overall satisfaction. These high satisfaction rates are encouraging and suggest that with continued technological improvements and effective communication about the benefits and safety of AVs, public acceptance and usage are likely to increase (Bernhard et al., 2020; Feys et al., 2020; Hilgarter & Granig, 2020; Andersson et al., 2021; Rahman et al., 2024).

Conclusion

Our paper reports on a novel investigation into passenger experiences of the Mi-Link autonomous bus service within a real-world, on road, public bus service context. We found that passengers predominantly used the autonomous minibus as a convenient alternative to conventional bus services, with many attracted on board by the novelty of the technology. Safety perceptions were generally positive, largely due to the presence of a human operator and the controlled, low-speed environment of Milton Parkin Phase 1. Whilst still remaining relatively high, safety confidence did decrease noticeably at higher speed operation, indicating a need for further research into real world trials such as this one, to explore people's experiences travelling at normal road speeds, and how these develop over time and with additional exposure. We suggest that peoples' confidence in riding an Autonomous Bus at higher speeds will improve as their experience expands, but this needs further research.

Ride quality showed some mixed opinions, with the electric propulsion system praised for its quietness and smooth acceleration, while the automation technology occasionally resulted in abrupt stops. This suggests that while there are clear benefits to electric propulsion, further refinement of the autonomous systems is needed to ensure a consistently smooth ride. It should be noted that the majority of participants were very positive, and rated the Autonomous Bus as equivalent in ride quality to a human-driven bus. Passenger feedback highlighted the bus's cautious nature in complex manoeuvres, often requiring human intervention, underscoring the need for ongoing technological improvements to handle such situations more confidently.

Overall, the Mi-Link autonomous bus service was well-received, with high satisfaction and a willingness among passengers to use the service again. This positive reception suggests that Autonomous Bus services might be well received by the public in future, provided that technological developments and refinements, and effective communication about safety and benefits are maintained.

The study emphasises the importance of real-world trials in understanding and improving passenger experiences with autonomous public transport vehicles. Future research should focus on broadening our understanding of the "real-world" experience of these services, including longitudinal studies to track changes in passenger attitudes over time, as they gain more exposure to and experience with AVs. Future studies might also explore the broader implications of AV adoption on urban planning, public transport systems, and social inclusion, particularly for underserved populations. Insights in these areas will be crucial for guiding the development and implementation of sustainable, efficient, and socially equitable public SAV systems

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