MI-LINK

Passenger Experiences Onboard the Mi-Link Autonomous Bus Services

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Executive summary

The MultiCAV research and development project, co-funded by Innovate UK and the Centre for Connected and Autonomous Vehicles, was established 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, first operating on public roads within Milton Park Technology and Science Park, Didcot (Oxfordshire) and later linking to Didcot Parkway railway station. The demonstration services took place in 2023 and were branded to the public as part of the Mi-Link[1] suite of transport services. The project was conducted by a consortium which brought together First Bus as lead, Milton Park, Oxfordshire County Council, Nova Modus, Fusion Processing[2], Zipabout, and the University of the West of England (UWE Bristol).

As part of a wide programme of research, UWE Bristol undertook a questionnaire-based survey (n=119) and post-ride interviews (n=12) with people who had ridden on the electric autonomous bus services to understand their experiences and perceptions of this novel transport technology. The research was designed to address the following questions:

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

Key findings

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

The majority of questionnaire respondents were using the autonomous minibus in place of one of the conventional bus services between Milton Park and Didcot Parkway railway station (84% of respondents, n=119).

There was also a small group of 'autonomous bus enthusiasts' who were travelling solely to experience the novel transport technology (13% of questionnaire respondents, n=119).

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

88% of questionnaire respondents (n=115) agreed that they felt safe on board the electric autonomous minibus because there was a human operator onboard.

The important role of the safety operator in providing passenger confidence in the bus was confirmed in the post-ride interviews. Passengers explained that: (i) the safety operator provided re-assurance, (ii) that passengers felt confident in the safety operator's ability to quickly assume control of the vehicle when required; and (iii) that the apparent need for a safety operator, demonstrated through the frequency with which the safety operator manually intervened, meant that passengers would not have felt comfortable without the safety operator onboard.

Passengers also reported in the interviews (conducted following the initial service) that the low speed of traffic within Milton Park contributed to their feelings of safety. Indeed, a slightly lower

[1] See https://www.mi-link.uk/ for the public-facing website
[2] Initially a subcontractor to the project appointed through a procurement exercise, later a full project partner.

proportion of questionnaire respondents reported feeling safe at high speeds compared to low speeds: 72% of respondents compared to 88% of respondents respectively (n=115).

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

The electric propulsion system was perceptibly quieter than a conventional diesel bus. 72% of questionnaire respondents rated the electric autonomous minibus as being quieter than a normal bus (n=114).

There were divergent views on whether the ride quality was smoother or jerkier than a conventional bus. 28% of respondents reported that they felt the autonomous electric minibus was smoother, and 23% said it was jerkier than a normal bus (n=114).

Indeed, the combination of electric propulsion and automation technology meant that the ride quality could at times be objectively smoother than a conventional diesel bus, while at other times presented sharper and sometimes unexpected deceleration events. For example:

- Smoothness: the minibus was noted by interview participants to be good at vehicle following and speed matching, and could offer a smooth and gentle acceleration or deceleration profile in anticipation of traffic conditions. The absence of a gearing mechanism in an electric drivetrain partly explains the vehicle's smooth acceleration capability.
- Abruptness: abrupt decelerations were noticed at times when the safety operator took over control of the bus and on occasions when the minibus had detected a potential hazard. The autonomous minibus was viewed by passengers as reacting more cautiously (in a sense of lower risk acceptance) in response to potential hazards than a human driver.

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

Questionnaire 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.

- A clear majority in all five cases felt the performance of the autonomous bus was similar to a human-driven bus.
- About 1 in 5 respondents rated the autonomous minibus as performing better than a bus with a human driver across all manoeuvres examined (n=111 to 113).
- Approaching junctions was identified as the most challenging manoeuvre – About 1 in 5 questionnaire respondents rated the minibus as performing worse than a normal bus (n=111) at junctions.

The post-ride interviews confirmed that passengers identified an apparent need for the safety operator to take control at the most complex junctions, for example when there was a need for the human operator to assertively achieve priority over oncoming traffic in heavy or fast traffic conditions.

Overall, the autonomous bus service was viewed positively by passengers. 97 percent of questionnaire respondents confirmed that they would use the service again (n=112) and 98% of questionnaire respondents reported being satisfied with the bus service overall (n=115).

1. Introduction

The Mi-Link research and development project, co-funded by Innovate UK and the Centre for Connected and Autonomous Vehicles, was established 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, first operating on public roads within Milton Park Technology and Science Park, Didcot (Oxfordshire) and later linking to Didcot Parkway railway station. The demonstration services took place in 2023 and were branded to the public as part of the Mi-Link[3] suite of transport services. The project was conducted by a consortium which brought together First Bus as lead, Milton Park, Oxfordshire County Council, Nova Modus, Fusion Processing[4], Zipabout, and the University of the West of England (UWE Bristol).

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

Project timeline

The autonomous bus service trials took place over three phases, but passenger research was limited to Phases One and Two:

- The first demonstration (Service 001) took place in February and March 2023 and involved an electric autonomous minibus operating on a circuit around Milton Park (see Figure 1**Error! Reference source not found.** for a plan of the route).
- The second demonstration (Service 002) took place during June and July 2023 and involved the same electric autonomous minibus connecting Milton Park to Didcot Parkway railway station (see Figure 2 for a plan of the route).
- The third demonstration (Service 003) took place during September 2023, and involved a full-sized electric autonomous bus operating on a similar circuit to Service 002. However, this service was curtailed after a few days due to a technical problem with the vehicle which was unrelated to the automation technology. It was not possible to conduct passenger surveys during this phase, due to the short operating period.

[3] See https://www.mi-link.uk/ for the public-facing website

[4] Initially a subcontractor to the project appointed through a procurement exercise, later a full project partner.

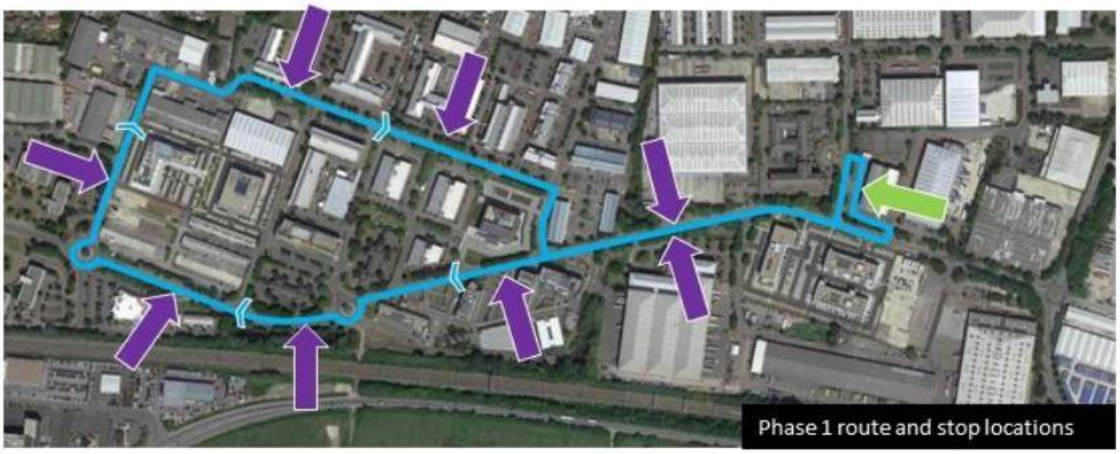

Figure 1: Service 001 route – business park circuit

Figure 2: Service 002 extended route from business park to railway station

The vehicle

The phase one and two bus services employed a type-approved 15-seat electric minibus supplied by Mellor and equipped with Fusion's CAVstar® automated driving system (Figure 3).

Figure 3: Phase One and Two electric, autonomous Mellor Orion minibus

2. Research methods

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

2.1. The questionnaire

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 UWE 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.

2.2 Passenger interviews

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; and
- 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, UWE 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.

3. Questionnaire findings

3.1 Sample size and characteristics

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".

3.2 Reasons for using the autonomous minibus service

The phase two autonomous minibus was providing a service to Didcot Parkway railway station, and so it is not surprising that the majority of respondents had used the bus (which was free) instead of one of the conventional bus services[5] to / from the station - 84% of respondents were traveling to or from Didcot Parkway station (Figure 4). 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.

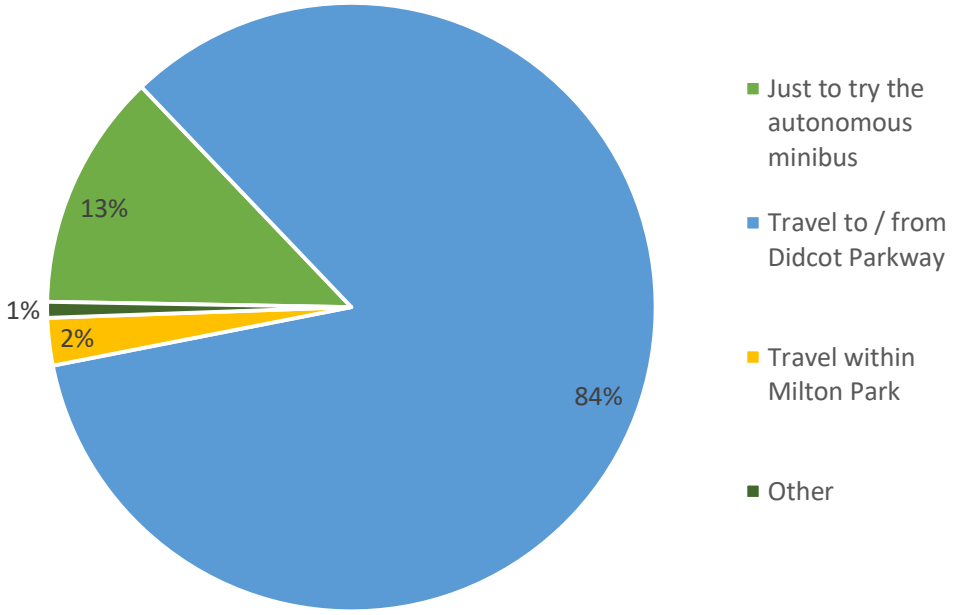

Figure 4 – Reason for using the autonomous minibus service (n=119)

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 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 (Figure 5).

[5] 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.

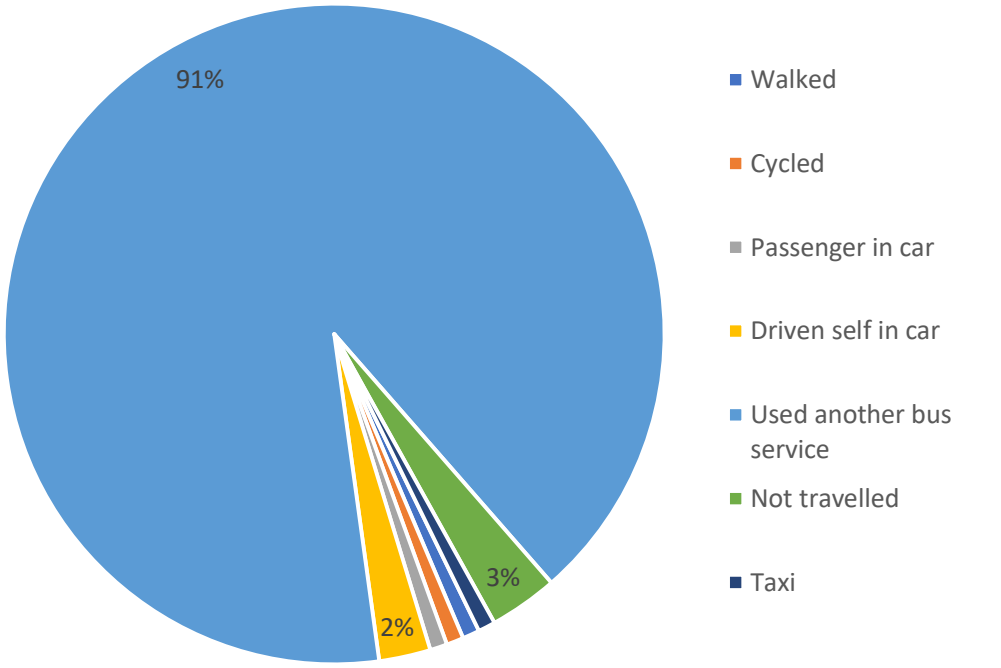

Figure 5: Mode of travel if the autonomous minibus was not available (n=119)

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 (Figure 6).

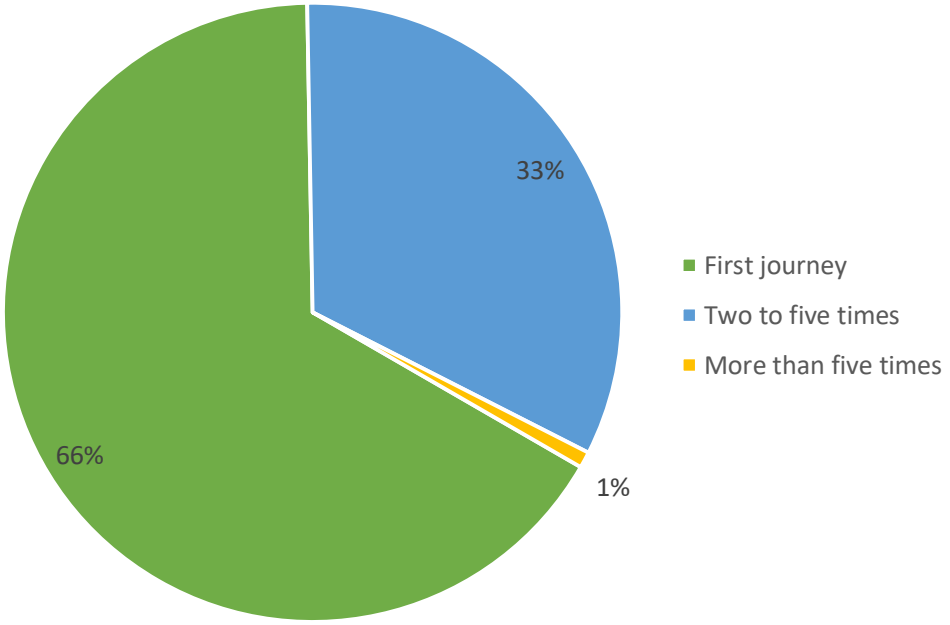

Figure 6: Number of journeys on the autonomous minibus (n=119)

3.3 Autonomous bus ride quality

Passengers 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 (Figure 7).

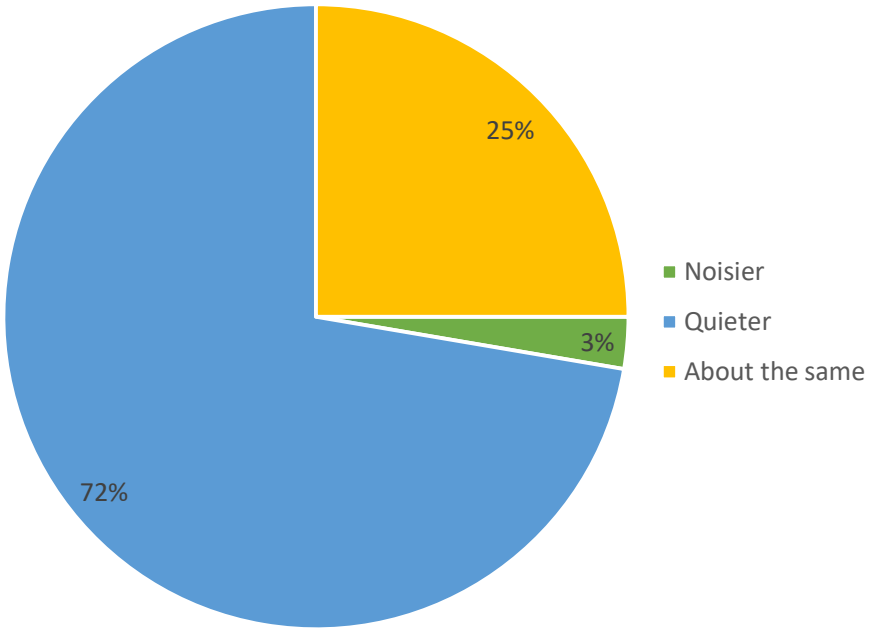

Figure 7: Do you think the electric autonomous minibus is noisier or quieter than a normal bus? (n=114)

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 (Figure 8). 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”.

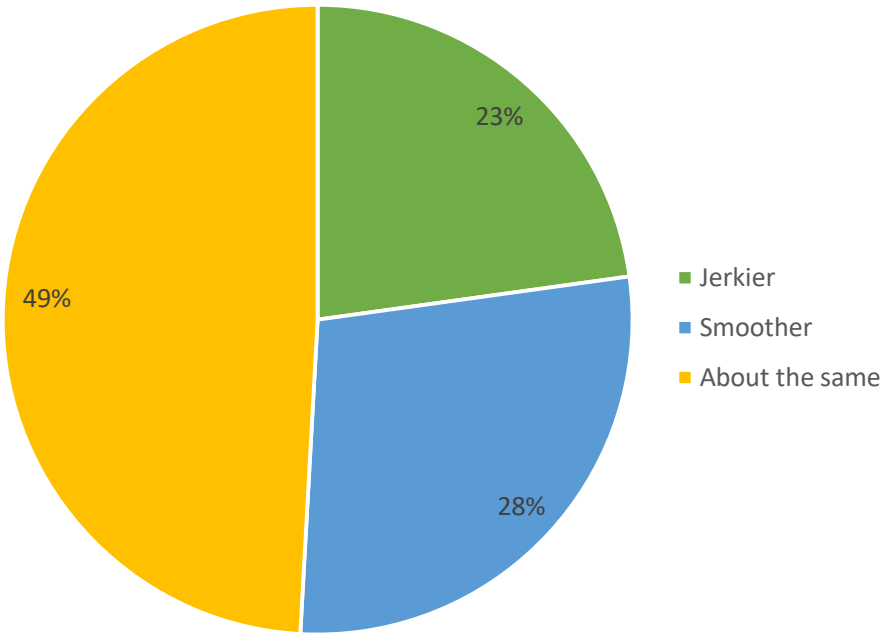

Figure 8: Do you think the ride on the autonomous minibus was jerkier or smoother than a normal bus*? (n=114)*

It seems 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.

3.4 Safety perceptions

Passengers were asked to rate their level of agreement with three statements on safety:

- I felt safe on the autonomous minibus because there was a human operator onboard
- I felt safe when the autonomous minibus was travelling at low speed
- I felt safe when the autonomous minibus was travelling at high speed.

The results are summarised in Figure 9. Presence of the human operator is 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 ($z = -3.059$, $p = 0.0017$).

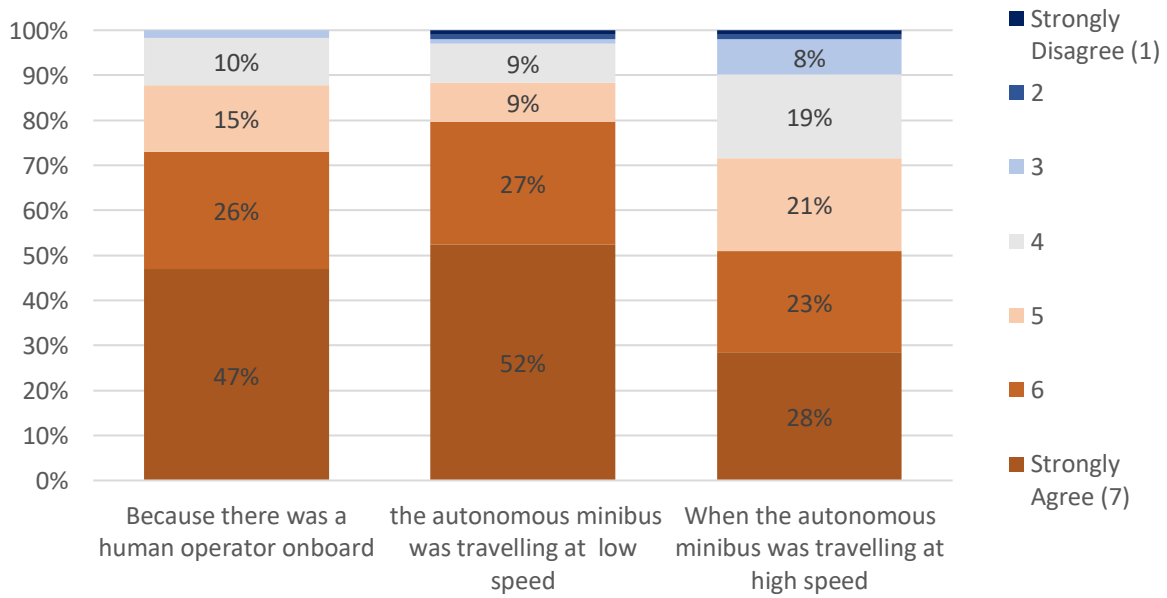

Figure 9: Feelings of safety on the electric autonomous minibus (n=115)

3.5 Ability to handle 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 Figure 10, 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.

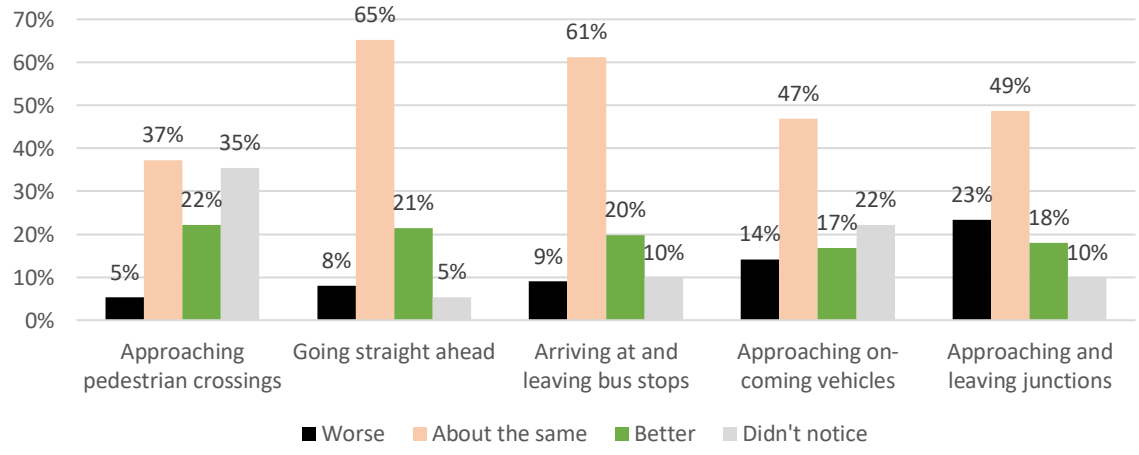

Figure 10: How the autonomous minibus was perceived to be 'driving' compared to a human

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 002 following feedback from Service 001.

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).

Overall, the autonomous bus service was viewed positively by passengers. 97 percent of questionnaire respondents confirmed that they would use the service again (n=112) and 98% of questionnaire respondents reported being satisfied with the service (n=115).

4. Passenger interview findings

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 interview guide is included as Appendix B. The interviewee characteristics are summarised in Table 1.

Table 1: Interviewee Characteristics

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

Passenger reflections on the journey experience from the interviews are now considered in relation to:

- Safety perceptions
- Feelings of excitement
- Feelings of disappointment
- The autonomous bus ride quality
- Interactions with general traffic
- The role of automation in the bus sector
- The role of a 'within Milton Park' shuttle bus service

4.1 Safety perceptions

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 (20 mph[6] 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

[6] 32 km/h

"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

4.2 Feelings of excitement

Many of the interviewees expressed feelings of excitement prior to travelling on the autonomous minibus:

"Excited because it's a new technology."

Participant 6

"I was just intrigued to see how it operated".

Participant 9

Another participant, who showed a clear interest in technology described the bus as "fascinating", and expressed his curiosity and excitement about how the bus operated:

"it's interesting, because (…) you can see that it's learning."

Participant 5

4.3 Feelings of disappointment

Other participants acknowledged feelings of disappointment with the experience on the autonomous minibus, because the bus was not fully autonomous. Whilst the safety operators instilled confidence in the technology, seeing a *driver* behind the steering wheel - as in any normal bus – detracted from the excitement and novelty of the autonomous bus experience.

"I was disappointed. You know, whenever I looked at the driver, he was driving. (…) To me... It looked like the driver was driving. It was just an ordinary bus."

Participant 8

"I guess it was less exciting to see a driver there. So you didn't have that... Feeling of it wasn't immediately obvious that you're driving this bus... Yeah, I guess I was hoping to take a video and say: 'hey, yeah, this is me on the bus'. It was a lot more boring than that."

Participant 6

"I was quite surprised by the fact that the driver was or maybe its assisting person was... was present in the bus, so... so I think that's why I didn't see any difference between a standard service and this experience."

Participant 7

4.4 Autonomous bus ride quality

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[7]. 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 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

[7] 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.

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

4.1 Interactions with general traffic

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*

4.2 The role of automation in the bus sector

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

4.3 The role of a 'within Milton Park' shuttle bus service

The phase one trial route was designed to connect-up destinations within Milton Park, but the Phase One trial indicated that there was a low demand for this service (potentially linked also to inclement weather conditions in February and March 2023) as the passenger numbers were not high.

One interviewee reflected on the idea that there is not necessarily high demand for motorised journeys around the business park as the distances are quite short:

"if I'm going down there [to the shops and cafés]… to sort of go and buy something from, you know, the restaurant or whatever down there, I'd walk."

Participant 8

By contrast, another participant suggested that an internal business park shuttle service could be useful when it is raining:

"I guess that's useful if the weather's bad or just don't feel like walking or cycling."

Participant 6

One interviewee highlighted that the 'wait time' penalty associated with low frequency public transport services meant that bus journeys are not competitive with private car for short journeys:

"But, you know, even a 15-minute wait, well, for going around Milton Park is a 15-minute wait, would it be 15 minutes to the station? I don't know. I probably wouldn't want to plan to

sort of meet a bus that only ran once an hour, you know? Because then you just miss it. It's an hour. So, I'd probably drive."

Participant 8

5. Summary of findings in relation to research questions

The report now concludes by returning to the questions that the survey and post-ride interviews were designed to address:

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

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

The majority of questionnaire respondents were using the autonomous minibus in place of one of the conventional bus services between Milton Park and Didcot Parkway train station (84% of respondents, n=119).

There was also a small group of 'autonomous bus enthusiasts' who were travelling solely to experience the novel transport technology (13% of questionnaire respondents, n=119).

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

88% of questionnaire respondents (n=115) agreed that they felt safe on board the electric autonomous minibus because there was a human operator onboard.

The important role of the safety operator in providing passenger confidence in the bus was confirmed in the post-ride interviews. Passengers explained that: (i) the safety operator provided re-assurance, (ii) that passengers felt confident in the safety operator's ability to quickly assume control of the vehicle when required; and (iii) that the apparent need for a safety operator, demonstrated through the frequency with which the safety operator manually intervened, meant that passengers would not have felt comfortable without the safety operator onboard.

Passengers also reported in the interviews that the low speed, often low traffic environment at Milton Park contributed to their feelings of safety. Indeed, a slightly lower proportion of questionnaire respondents reported feeling safe at high speeds compared to low speeds: 72% of respondents compared to 88% of respondents respectively (n=115).

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

The electric propulsion system was perceptibly quieter than a conventional diesel bus. 72% of questionnaire respondents rated the electric autonomous minibus as being quieter than a normal bus (n=114).

There were divergent views on whether the ride quality was smoother or jerkier than a conventional bus. 28% of respondents reported that they felt the autonomous electric minibus was smoother, and 23% said it was jerkier than a normal bus (n=114).

Indeed, the combination of electric propulsion and automation technology meant that the ride quality could at times be objectively 'smoother' than a conventional diesel bus, while at other times presented sharper and sometimes unexpected deceleration events. For example:

- Smoothness: The minibus was noted, by interview participants, to be good at vehicle following and speed matching, and could offer smooth and a gentle acceleration or deceleration profile in anticipation of traffic conditions. The absence of a gearing mechanism in an electric drivetrain partly explains the vehicle's smooth acceleration capability.
- Abruptness: Abrupt decelerations were noticed at times when the safety operator took over control of the bus and on occasions when the minibus had detected a potential hazard. The autonomous minibus was viewed by passengers as reacting more cautiously in response to potential hazards than a human driver.

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

Questionnaire 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.

- About 1 in 5 respondents rated the autonomous minibus as performing better than a normal bus across all manoeuvres examined (n=111 to 113).
- Approaching junctions was identified as the most challenging manoeuvre – About 1 in 5 questionnaire respondents rated the minibus as performing worse than a normal bus (n=111) at junctions.

The post-ride interviews confirmed that passengers identified an apparent need for the safety operator to take control at the most complex junctions, for example when there was a need for the human operator to assertively achieve priority over oncoming traffic at heavily trafficked junctions.

Overall, the autonomous bus service was viewed positively by passengers. 97 percent of questionnaire respondents confirmed that they would use the service again (n=112) and 98% of questionnaire respondents reported being satisfied with the bus service overall (n=115).

Appendix A – Passenger Questionnaire

UWE Bristol University of the West of England

Mi-Link Autonomous Bus Survey

Centre for Transport & Society

The University of the West of England (UWE) is doing a survey to understand people's experiences of using the Mi-Link autonomous buses.

Participation in this survey is voluntary and your responses to the questionnaire cannot be used to identify you. For more information about the research, please contact graham.parkhurst@uwe.ac.uk.

Consent: I am 18 years old or over. I consent to the processing of my response, as described in the privacy notice, for the purpose of the Mi-Link autonomous bus study. All personal data is processed in accordance with the applicable UK data protection legislation. The Data Controller is UWE.

☐ ***Please tick this box to provide consent for your survey answers to be used in this research***

Thank you!

Question 1 *(please circle one)*

Please tell us how many times you have travelled on the autonomous minibus

This was my first journey on the autonomous minibus	Two to five times	More than five times

Question 2 *(please circle one)*

Please tell us the reason for your **current journey** on the autonomous minibus

Just to try the autonomous bus	Travel to or from Didcot Parkway station	Travel within Milton Park	Other

Question 3 *(please tick one)*

How would you have travelled if the autonomous minibus had not been available?

Used another bus service	☐	Driven self in car	☐
Taxi	☐	Passenger in car	☐
Walked	☐	Not travelled	☐
Cycled/e-cycled	☐	Other	☐
Scooted/e-scooted	☐		

Question 4 *(please tick one)*

Your most recent journey on the autonomous minibus

Before getting on the bus, did you know that you were about to get on an autonomous minibus?

☐ No ☐ Yes

Question 5

Your thoughts on the quality of the autonomous minibus ride

Please circle the responses below to indicate your thoughts on the quality of the autonomous minibus ride:

Do you think the ride on the autonomous minibus was jerkier or smoother than a ride on a normal bus?	Jerkier	About the same	Smoother
Do you think the autonomous minibus was noisier, quieter or about the same as a normal bus?	Noisier	About the same	Quieter

Question 6

How well does the autonomous minibus drive compared to a human bus driver?

Please circle one option for each manoeuvre:

	How well does the autonomous minibus drive <u>compared to a human driver</u>?			
Arriving at and leaving bus stops	worse	about the same	better	didn't notice
Going straight ahead	worse	about the same	better	didn't notice
Approaching pedestrian crossings	worse	about the same	better	didn't notice
Approaching on-coming vehicles	worse	about the same	better	didn't notice
Approaching and leaving junctions	worse	about the same	better	didn't notice

Question 7

How you felt on the autonomous minibus

Please indicate the extent to which you agree or disagree with the following statements about your experience of using the autonomous minibus:

	Strongly agree						Strongly disagree
I felt **safe** on the autonomous minibus **because there was a human operator onboard**	7	6	5	4	3	2	1
I would **not feel safe** on the autonomous minibus **if there was no human operator onboard**	7	6	5	4	3	2	1
I felt **safe** when the autonomous minibus was travelling at **low speed**	7	6	5	4	3	2	1
I felt **safe** when the autonomous minibus was travelling at **high speed**	7	6	5	4	3	2	1

Question 8

Your satisfaction with the autonomous minibus service

	Completely satisfied						Not at all satisfied
Please indicate **how satisfied** you were with your ride on the autonomous minibus	7	6	5	4	3	2	1

Question 9 *(please tick one)*

Would you use the autonomous minibus again?

☐ No ☐ Yes

Question 10

About your regular travel

In your day-to-day life, please indicate how frequently you use public transport:

Every day	A few times a week	Once or twice a month	Less often/never

Question 11

Your views on technology

Please indicate the extent to which you agree or disagree with these statements about new technology in general:

	Strongly agree						Strongly disagree
I am often **one of the first to try** out a new technology	7	6	5	4	3	2	1
I usually **wait a while before** trying out new technology	7	6	5	4	3	2	1

Question 12

About you

Are you: ☐ Male ☐ Female ☐ Non-binary/third gender ☐ Prefer not to say

Please tell us your age in years: ☐

If you have anything additional to say about your experience, please write your comments in this box:

Are willing to have a short (15 minute) online discussion with us about your experience?

If so, please leave your email address and/or phone number below. This information will be held securely and only used to contact you about participating in the study.

Email address:	
Phone number:	

That's the end of the survey. Thank you for your time.

Please hand this questionnaire back to the researcher on the bus as you alight.

Appendix B – Post-ride Passenger Interviews

Researcher introduction

Researcher introduces him/herself and their role in the MultiCAV project

My name is []. I am a researcher working for the University of the West of England.

The purpose of our discussion today is to briefly explore your experience of riding on the autonomous minibus around Milton Park.

The discussion should take no more than 10-15 minutes. It will be audio recorded and transcribed and the discussion will be used as a basis for a report and paper about people's experiences of travelling on autonomous buses.

No information will be collected that can be used to identify you.

Short quotes from the interview may be used in the dissemination materials, but you will not be identifiable.

Before we start, we need to confirm that you understand what taking part in the interview involves and that you have provided consent for us to use the interview in the study. Please could you read and sign this consent form? Do you have any questions about the study?

[Start recording]

Reason for using the bus and usefulness of the service

Do you regularly work at MP?

Why did you travel on the autonomous minibus?

- *Was this your first trip on the autonomous minibus?*
- *Would you say that you tend to try out new technologies when they become available?*

Is a bus service from Milton Park to Didcot Parkway generally useful to you? Why?

Is a bus service about around Milton Park generally useful to you? Why?

Feelings of trust and anxiety before, during and after the journey

How did you feel on the bus?

Was there any part of the journey where you felt uncomfortable or anxious at all? Please explain.

[We want to understand why someone either felt 'comfortable' or 'uncomfortable' in the sense of feeling safe and at ease or not].

Prompt for what was making people feel uncomfortable

If participant says they did not feel uncomfortable, ask

Can you explain why you felt at ease on the journey? *like presence of the operators, their use of explanation, cautious behaviour of the bus.*

How would you feel if there were no bus staff on board the bus?

Observations on how the bus behaved

What did you notice about how the autonomous minibus was driving, compared to being on a normal bus? did you notice anything different or unusual?

[Leave open and then prompt as below]

Thinking about some specific parts of the journey around the park, what did you notice about:

- How the minibus negotiated:
    - junctions
    - pedestrian crossings?
- How the minibus accelerated or decelerated when travelling along a road e.g. was this similar or different to a normal bus?
- How the minibus behaved around bus stops?
- How the minibus behaved when approaching oncoming vehicles?
- How the minibus travelled along the long straight where there is the higher 40 mph speed limit?

Was there any part of the journey that you felt the minibus handled particularly well? Please explain.

Was there any part of the journey where you felt the minibus seemed to have difficulty? Please explain.

Do you have any reflections on whether the autonomous minibus was in any way better or worse than a normal bus?

Future intention and wrap-up

And finally, do you think you will use the bus again? For what purpose? [If relevant - Do you think you would still feel nervous if you used the bus again?]

Thank you very much for your time. Do you have any final questions or comments about your experience of using the autonomous minibus?

[Stop recording]