
# User needs final report

## WP3 D10

June 2019

## Contributions to this document

This report was authored by Ian Shergold (UWE), although it is draws on material related to user engagement conducted over the three years of the Flourish project. All of those who have contributed in some way to the work discussed in the report are listed below (in alphabetical order):

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# Preface

## The Flourish Project

The FLOURISH project developed in response to Innovate UK's *Connected and Autonomous Vehicles Collaboration Research & Development competition*. It set out to identify innovative solutions that address two distinct but related topics within the connected autonomous vehicle (CAV) market which would help to realise market readiness of CAVs:

- *Customer Interaction focusing on the customers' needs and experience when using the technology; and*
- *Connectivity focusing on effective data analytics and ensuring that the cyber security and wireless connectivity elements of CAVs are safe by design.*

**Box 1 Flourish project themes**

The project had the following principal objectives:

- *To develop an understanding and articulation of user needs and expectations of CAVs in order to maximize the mobility potential they offer.*
- *To develop usable adaptive interfaces, performance certification processes, products and services that enable secure, trustworthy and private technology within CAVs.*
- *To capitalize on the large volume of data created by CAVs to develop innovative new tools and products.*
- *To leverage existing investment in the Bristol City-Region to expand validation and test capabilities in both urban and interurban networked environments and enhance the commercial opportunities this will deliver.*

**Box 2 Flourish project objectives**

Older adults with ageing-related impairments are seen to be particular beneficiaries of CAV technology, allowing them to continue to be active contributors to the economy and society. As a consequence, there has been a focus on exploring the needs of this group within the Flourish project through a series of user engagement activities. The results from this work detailed below will hopefully contribute to their ability to become early adopters of CAVs. It is also expected that by identifying, and addressing the needs of this demographic, the knowledge, services and capabilities that will be developed will also be exploited by a wider range of social groups.

## Levels of autonomy

Whilst many vehicles on the road already offer some element of autonomy, this project has focussed on a future *where an automated driving system will be able to undertake all aspects of the driving task on all types of road, and in all conditions*. This is described as 'Level 5', or 'full automation' in the SAE International standard J3016: Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems. (Copyright © 2014)

The research activities described here were conducted on the basis of vehicles functioning at Level 5, and all information and scenarios used were describing vehicles at this level.

# 1. Understanding User Needs

## Introduction

This report addresses a key objective of the Flourish project, to develop an understanding and articulation of older people's needs and expectations of CAVs in order to maximize the mobility potential they offer for this segment of society. Through a range of user engagement activities, across the UK, and with a range of relevant user groups it has been possible to capture and articulate these needs in two distinct areas. Firstly, addressing the wider mobility needs of older people, and how CAVs might play a role in addressing those needs (see Chapter 2 below). Then secondly, considering the needs expressed by participants for how CAVs should function and how older people would interact with them (see Chapter 3 below).

The remainder of this section provides a brief summary of the user engagement activity in Flourish.

## Flourish user engagement

The engagement with 'users' within the Flourish project has included the following:

- An initial desktop review of literature on older people's mobility needs, as well as existing research involving older people and CAVs.
- Stakeholder and public engagement activities across the UK undertaken by project partners OPM Group / Traverse - focus groups, workshops, interviews.
- Participant engagement alongside simulator and live-vehicle trials[i], activities led by researchers at the University of the West of England (UWE) - workshops, interviews.

The specific groups of interest for Flourish at the outset were:

- ***People aged 70 and above**. It is likely that some members of this group will have age-related physical and/or cognitive impairments that may preclude or inhibit / prevent driving or other forms of mobility / transport*[ii].
- ***People of any age (over 18), who have physical and/or cognitive impairments** that may preclude or inhibit / prevent driving or other forms of mobility / transport.*

**Box 3 Flourish target user groups**

Engagement has though extended to include those aged 50-69, as a group likely be able to experience use of some form of CAV in their later life, and groups of carers, on the basis that they have some responsibilities and an enabling role in mobility for older people they support.

The engagement activities took place across all three years of the project (2016-19), and at a range of locations across the UK. Two main strands of user engagement activities have been

[i] Note: Results from these trials, which focussed on development of vehicle interfaces, and experiments related to participants being in a vehicle are reported on elsewhere. The data collection and analysis related to the trials themselves was undertaken by a team from UWE Psychology.

[ii] Older people who might be experiencing illnesses such as dementia and Alzheimer's disease are not within scope for this work.

undertaken – workshops with participants involved in simulator and live-vehicle trials, and focus group / workshop sessions with specified groups of older people (and related groups) unconnected with the trials.

Those involved in the trials had responded to a call for participants (and were thus self-selecting in their involvement in Flourish), whilst the focus groups recruited a sample to meet specific characteristics and criteria. In the 2019 focus groups, explicit attempts were made to reach out to groups less well represented in the study to date, including older women, those in minority ethnic communities and those living in rural areas. More details of the activities can be found in Appendix A, including the location, and make-up of specific groups. Over two hundred and forty people took part in the engagement activities over the course of the project (see Table 1 below).

**Table 1 Number of participants – across all user engagement activities**

| Location | Date of activity | Age >70 | Age <70 | Other / unclassified | Total |
|---|---|---|---|---|---|
| Bristol | 2016-19 | 43 | 42 | 9 | 94 |
| London | 2017 | 7 | 9 | | 16 |
| Croydon | 2017 | 9 | 10 | | 19 |
| Manchester | 2018 | 20 | 10 | | 30 |
| Ashford | 2018 | 12 | 10 | 8 | 30 |
| London[a] | 2019 | | | 32 | 32 |
| Settle[b] | 2019 | | | 10 | 10 |
| Phone | 2018 | | | 5 | 5 |
| Video diary[c] | 2019 | | | 7 | 7 |
| Total: | | 91 | 81 | 71 | 243 |

[a] *Ages across these three London groups ranged from 50-85*

[b] *Ages in the Settle group ranged from 50-80*

[c] *Participants in the video diary exercise were aged 18-26*

# 2. Older people's mobility needs and the role of CAVs

## The mobility needs of older people

Existing research suggests that out-of-home mobility is a vital element in older people's lives, helping to maintain their independence, their wellbeing and health (see Figure 2 below). It enables social connectedness and social activity, and facilitates involvement in activities such as volunteering, itself an important enabler of community cohesion. The process of ageing will though inevitably present physical or cognitive issues for many people, and reductions in mobility in respect of journeys and distance travelled will be experienced by most people as they age. This at a time when a growing older population means that the number and proportion of such people in most (if not all) developed nations will increase significantly over coming decades.

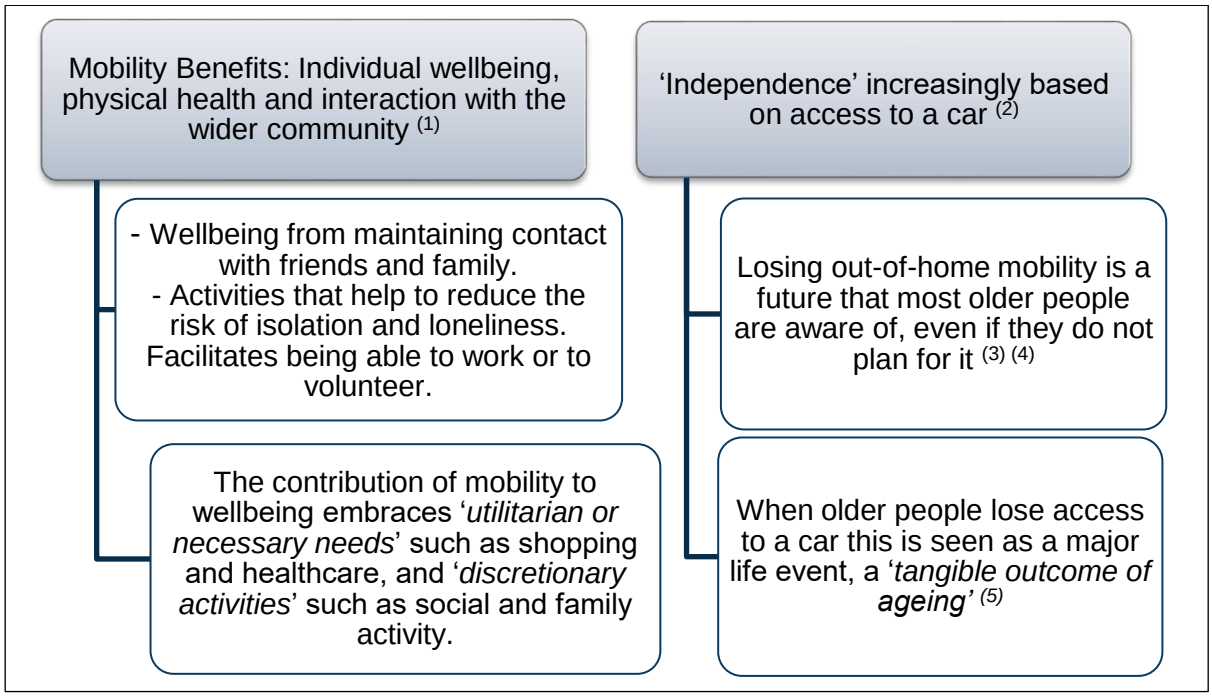


**Figure 1 Mobility and older people**

Mobility can be affected by a range of physical impairments in older age, and although driver aids and assistance technologies may provide some support, such impairment can impact on how often, where and when journeys are made. It may even influence the choice of vehicle owned and driven. Cognitive issues are also relevant, with those experiencing mild cognitive impairment (MCI)[iii] more likely to self-regulate their driving - although actual driving cessation is more likely for women

[iii] A cognitive impairment in at least one aspect of cognitive functioning, but with no sign of dementia and no significant decline in functional activities of daily life. It is suggested that such a condition might affect up to 20% of those aged over 65, and that there is no pharmacological response as such.

than men with the condition. It also appears to be a reasonable predictor of driving problems, reductions in driving and eventually driving cessation. Its more serious form, dementia, can make drivers more dangerous, and be an indicator for higher accident rates. Whilst it is possible to compensate for some physical impairments, there are no aids to help those with serious cognitive issues – such as dementia.

The resultant transport disadvantage may not be evenly felt, with evidence suggesting that the older old, women and those in rural communities are likely to experience more problems. Alternative forms of mobility are not always easily found, and for those who can no longer use a car then a range of negative health outcomes are unfortunately more commonplace. Without adequate planning for some form of alternate mobility beyond the car, many older people will experience problems with access to destinations and activities (unmet needs) that could negatively impact on their quality of life. It is also often the case that insufficient effort is put into planning for such circumstances.

The role that CAV might play in response to some of these issues constituted a key element of the research undertaken during the Flourish project, particularly in the user engagement activities.

## Existing research on the potential for CAV to meet mobility needs

In the preliminary review of literature on user needs for the Flourish project[iv] it was noted that older people seemed to be willing to embrace a range of technological aids and assistance in vehicles (particularly related to safety), but had less appetite to use CAV at present. This finding is though based on relatively limited research to date involving older people and CAV, and on polling that may be biased towards those who are not yet aged seventy (and thus more likely to still be car drivers). It is also likely to be several decades before there is widespread availability of the technology, and thus the opinions of those who will be 'older people' then may change over that time.

The initial review also found a range of technologies being adopted and used by older people to help address mobility needs, and it is possible to gain some insights from these experiences as well. For example, older people make use of a variety of in-vehicle technologies, and gain high satisfaction and benefit from them. Mobility scooters and electric bicycles are also seen to be beneficial.

Other key points to note from existing research are that:

- *There appears to be limited difference between older and younger drivers in most of the research reviewed.*
- *It is seen though that older people use technology differently, in particular how any new technologies is learnt.*

This latter point could be an important factor in terms of take-up of CAV to meet mobility needs.

[iv] Flourish (WP3 D3) – The mobility of older people, and the future role of Connected Autonomous Vehicles. A Literature Review. (Sept 2016)

## Willingness to Use CAVs now

People attending most of the user engagement activities were asked if they would use a CAV now (if deemed safe). Whilst the reaction was broadly positive in the IVPW, initial reactions in the other user engagement activities could be more sceptical, with many participants asking questions or expressing concerns about their safety and viability. Over the course of the sessions though participants would tend to become more positive about use of the vehicles. Around half of those in the IVPW were already accepting of the technology (see Figure 2 below), rising to 75% of the sample after the workshops had provided more information on how they might work, and where you might use one. Less than 10% were unlikely to use a CAV if it was already available.

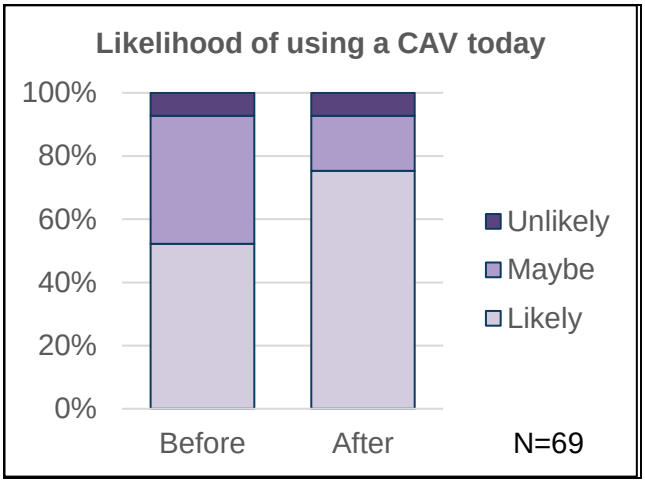


**Figure 2 Likelihood of using a CAV if deemed safe by the Government. (Before and after IVPW)**

The same question was asked in the focus groups (see Figure 3), where there was slightly less enthusiasm for CAV use compared to the IVPW.

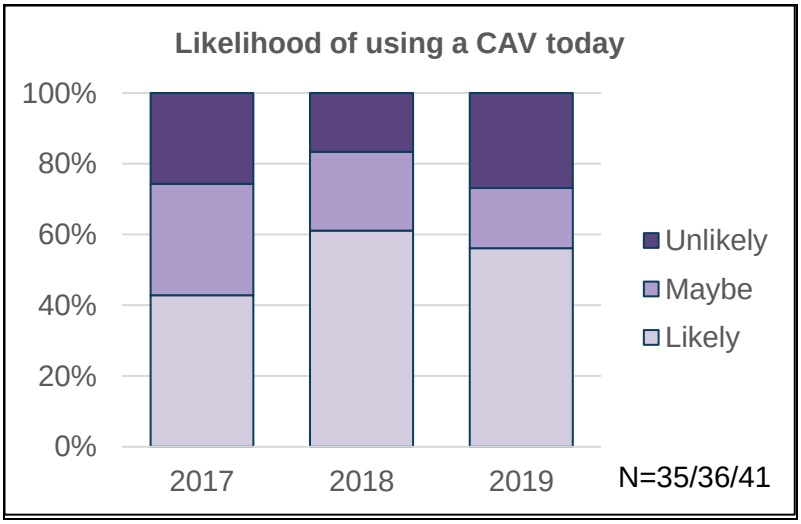


**Figure 3 Likelihood of using CAV if deemed safe - Focus groups 2017 and 2018**

Around 40% in the 2017 groups claimed they would be likely to use one today (if available and safe), with just over 60% in 2018 and slightly fewer (56%) in 2019. Other points of interest emerging from this question in the focus groups included:

- In 2017, younger participants in the groups were slightly more comfortable with using a CAV today than the older old – contrary to feedback in the IVPW sessions.
- In 2018, non-drivers were less likely to be happy to use CAV today, again at odds to some at the IVPW. This perhaps a reflection of the self-selected nature of those engaged in the IVPW sessions.
- The 2019 groups continued the high-level of interest in driverless vehicles, with participants thinking it would feel more normal to use such vehicles in the future. There was though a degree of concern around safety and reliability, related in part to the fatality in the Uber AV trials in the US in 2018. This had been a very high-profile incident, and had received much media coverage – in fact reporting of issues like this was often where people first heard about CAV. Some participants were more wary of the safety of autonomous vehicle technology as a consequence.

## How might older people use CAV to meet their mobility needs?

Focus group activities provided an opportunity to conduct a more detailed examination of issues related to how older people might use CAV if they were available.

### Mobility benefits of CAV for older people

Participants provided a sense of how CAVs might meet their mobility needs by discussing the benefits they could see from their use (see Figure 4 below). Perhaps unsurprisingly, the notion of 'convenience' from using a CAV emerged as a particular benefit. But other potential mobility-related benefits emerged in respect of independence, the ability to socialise, and perhaps less obviously in connection with older people's health and wellbeing. In addition, there were some clear messages about how CAV could replace, and enhance the current model (and understanding) of public transport to better support older people in delivering out-of-home mobility. These four areas of benefit are discussed further below.

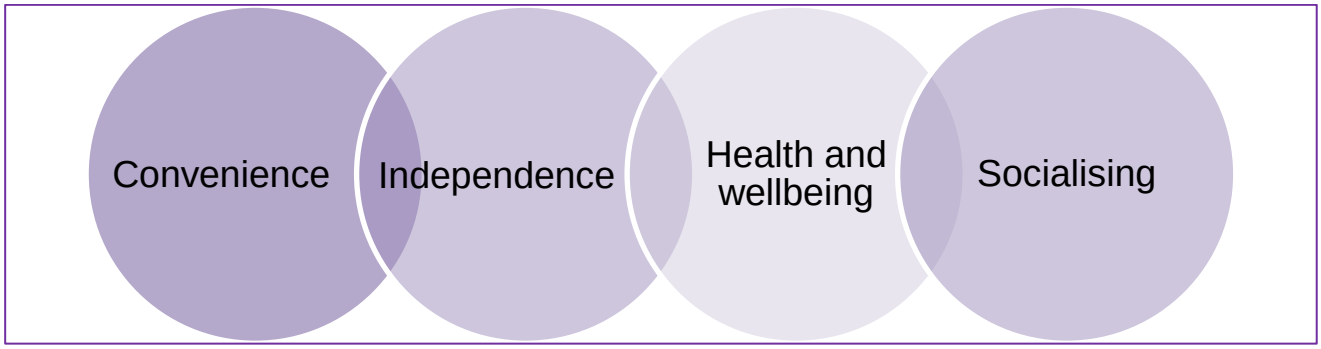


**Figure 4 Benefits of CAV for older people**

#### Convenience

- Driverless vehicles would provide a more convenient means of mobility when making a range of journeys, and would help older people to '*get around*'. For example: to visit friends and family, going shopping, getting to and from the airport or to a hospital. These sort of journeys are perhaps the ones that are starting to become problematic for some older people. Many

participants noted the advantage of a CAV of being able to be taken right to the entrance of a building, seen to be particularly beneficial for those with mobility issues.

- Parking was another area where clear benefit were seen with CAV use, with participants enthusiastic about not having to think about it. Many also assumed that they would no longer have to pay for parking as the vehicle would possibly go somewhere else. This potentially illustrating an underlying issue in current mobility, as parking becomes increasingly difficult as a result of physiological decline in older age.
- Interestingly, a few participants (all drivers) identified that driverless vehicles could free them up from giving lifts to others that cannot drive - including children and those with mobility issues. Lifts are an important form of transport for some older people, but giving them can sometimes be perceived as an imposition, and perhaps something to be avoided.
- Another element of convenience emerging from the user engagement activities was the ability to undertake activities in time that previously might be wasted – especially if driving. Instead people would now be able to eat, drink or perhaps watch TV. This was seen as a particular benefit for longer journeys, helping to remove barriers to making such journeys, and would provide time for other activities, which for some older people meant sleeping!

### Independence

- Perhaps a more obvious mobility-need is that for non-drivers and those with mobility issues which might preclude them from using existing forms of travel. In these circumstances, driverless vehicles were seen as an opportunity for greater independence – directly meeting such needs. In addition, for those with a carer such vehicles promised the ability to be mobile without having to rely on someone for assistance (a driver). Access to a driverless vehicle could facilitate activities such as days out or visits to friends for example, which might now be undertaken independently.
- Reliance on others was identified as a particular constraint on mobility for some. A CAV would remove the need to take lifts for example, a practice seen to be problematic in respect of imposing a burden on family and friends,
- People also identified other circumstances where a driverless vehicle might provide independence. For example, it would facilitate longer journeys – as it would make the journey less tiring than in a current vehicle, thus allowing them to travel further afield.
- It could also allow people to better support others, such as providing company for ill friends who needed to make trips to healthcare.
- It was notable, that the benefit of independence foreseen for non-drivers and the less-able was identified not only by individuals in that situation, but also by those who were currently able to drive. Perhaps in some instances people were looking to their own future, and thinking how their mobility might be constrained in later life.
- Some older people suggested that driverless vehicles would be an appealing alternative to the public transport options that were currently available to them – again helping them to be independent. This might be for journeys to get to work or further afield, for example for holidays, and would address restrictions on routes and times of services.

### Health and wellbeing

- Many participants in later focus groups envisioned how driverless vehicles might relieve the stress and anxiety of making journeys seen to be difficult now, which would have positive benefits in respect of mental health.
- Some participants liked the idea that the vehicle could monitor their 'vital signs', and directly raise the alarm when there were health emergencies. This potentially meaning that people were more likely to make journeys (again supporting the 'independence' discussed above).
- This interaction with support and health services was seen positively by participants, and extended to the sharing of data with emergency services. Examples put forward in the groups included a car registering raised blood pressure, temperature and heart rate, and then alerting emergency services as a safety feature. Others suggested that occupant's health profile might be carried by the vehicle whilst they were travelling, and again available to emergency services if needed. The generally positive attitude towards sharing data with emergency services in times of an incident is consistent with participants' overall concern with their safety and wellbeing throughout the different sessions.
- Another aspect of wellbeing related to being in contact with friends or relatives, especially when it came to the most vulnerable passengers, such as children or older people with dementia. They felt reassured that they would be able to keep track of their loved ones during journeys.
- Some people also saw driverless vehicles as a preferable, and safer alternative to a taxi. The driverless car would address safety issues (particularly when travelling alone), as well as a perception that sometimes drivers took longer routes than necessary.

### Socialising

It was perhaps surprising that socialising did not feature more strongly in the benefits that participants saw from the use of driverless cars. Perhaps this element is though also evident in the 'independence' issue described above, and in some aspects of the view that driverless cars would provide an alternative to public transport, addressing some of the perceived shortfalls in mobility caused by constraints and limitations in current services.

- Some of the younger participants thought that a driverless car would help people to socialise, although they specifically identified the ability to be able to use a driverless vehicle after having a drink – thus avoiding drink driving problems.

## Journeys likely to be made by older people in a CAV

Another reflection on how CAV might address existing mobility needs (met or unmet) can be seen in responses to questions that asked people about the sort of journeys they might like to make in a CAV. With responses perhaps revealing journeys that might be problematic now (or expected to become so) in three areas. These related to a) self-imposed driving regulation, b) journeys not possible for those without access to a car and c) journeys perhaps seen to be too difficult at present and thus not currently undertaken (see Figure 5 below). These three categories of response can be seen to be a measure of 'suppressed demand' within the Flourish user engagement participants.

Self-regulation of travel to avoid busy roads, and difficult conditions (light, weather etc.), or to avoid issues of parking were all highlighted as factors that might curtail travel at present, and

which a CAV might overcome. For those that no longer had the ability to drive (or had access to a car in their household) then there were a range of journeys that people would like to make that they currently were prevented from doing. For example, journeys that couldn't be made by bicycle or by bus. The third category of suppressed mobility need encompasses practicality (access to the GP for example), but equally importantly several types of mobility for aesthetic purposes, more likely to address quality of life and wellbeing goals for older people.

| Addressing current restrictions on driving | Journeys for those who don't drive | New or additional journeys not currently made |
|---|---|---|
| Travelling at night and/or in the dark, or in unfamiliar areas | Going to places that buses don't go | Trips to the countryside – seen as inaccessible for some now |
| Travelling on Motorways, or in heavy traffic | To collect things, and journeys you can't do by bicycle, bus or walking | Providing a link with other transport (first and last mile) |
| Being on the road at times when they are busy – e.g. school times | All journeys for those who don't have a licence – or for health reasons don't have access to a vehicle | New services: For example, a rural GP could send cars to get patients! |
| Longer journeys which are becoming harder to do for some (e.g. tiredness) | | CAV could provide a 'magical mystery tour' – to just go somewhere |
| Where and when parking is a problem | | |

**Figure 5 Journeys likely to be made by CAV (by Flourish IVPW participants)**

IVPW participants also described a CAV journey of their choice (destination, distance, etc.). Over a third of journeys were over fifty miles, and a quarter over one hundred miles (see Figure 6).

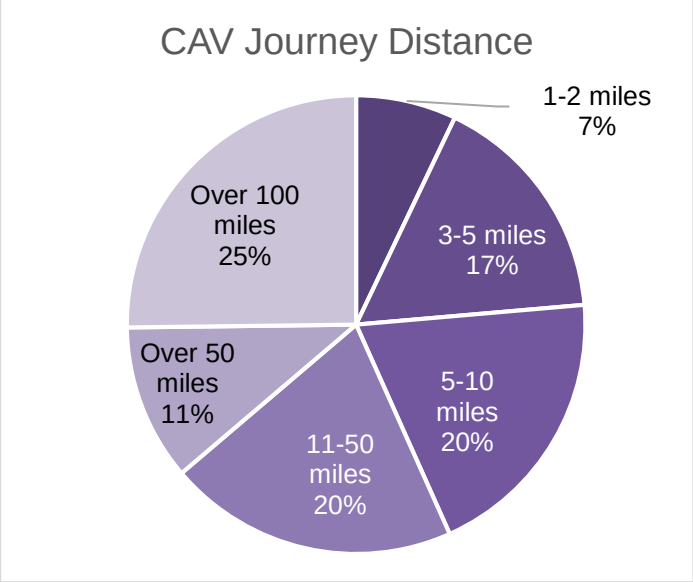


**Figure 6 Journey lengths proposed in CAV journey exercise**

Often these longer journeys were visits to family who lived a long way away, or a holiday of some description (in the UK). The smaller proportion of short trips is perhaps an indication that to some extent these journeys might be easier to resolve through other means at present.

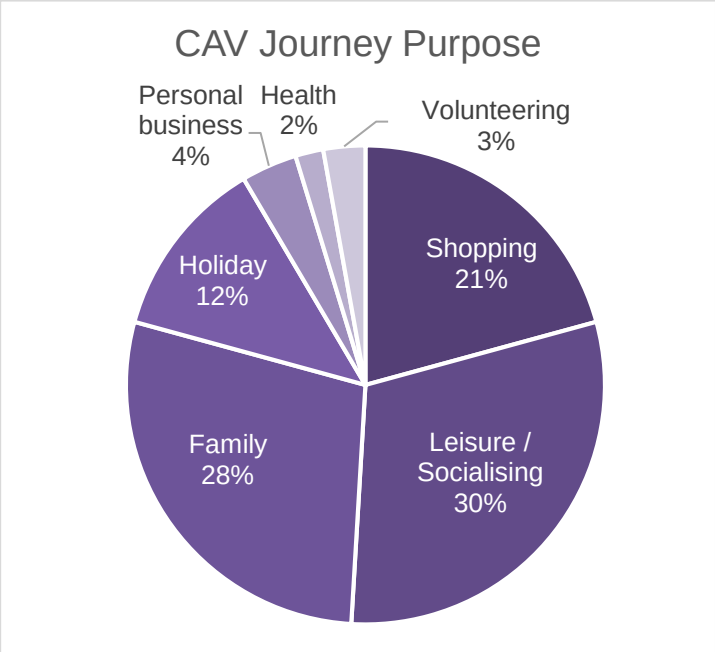


Figure 7 Destination / purpose for CAV journey exercise

When describing the purpose of an imaginary CAV trip in the IVPW[v] (see Figure 7), around a quarter of those who gave specific destinations mentioned what might be seen as a necessary trip (to shop or to access healthcare for example). Shopping was the common response, consistent with wider understanding (and statistics) on older people's travel in the UK which shows a greater distance being travelled for shopping on average for those over 70 [(6)] (either by car or by public transport).

The majority of the imagined trips were though more discretionary, to socialise, see family or to go on holiday. This broader focus on social and family trips may indicate an area of concern in respect of future mobility, with CAVs seen to offer a potential solution for meeting needs in this context. This was also a theme picked up in some focus groups, with London participants for example highlighting a need for journeys to visit the seaside and national parks, as well as to visit family and friends. Trips to cultural activity such as the theatre, cinema, and museums also featured. For some older people, mobility for these purposes is seen as problematic [(7)], and the ability to undertake them is often foregone as mobility becomes more difficult.

There may be particular problems for destinations that might be less well served by public transport, where journeys might need to be undertaken at times of the day when older people are less likely to drive (i.e. after dark), or when they feel less safe using other modes of transport.

[v] Note: Around a quarter of the participants did not specifically identify the destination, or purpose of the journey they described.

Such shortfalls in these discretionary journeys can impact on older people's social participation and their wellbeing[8], and reductions in 'social' leisure activities away from home are seen to lead to a lower level of life satisfaction[9]. Whilst alternatives may be found for the journeys to shop, or access healthcare, the social and leisure trips that also contribute to quality of life and offer the psychological benefits of '*getting out and about'*, may be lost with reduced mobility[10], and again may have negative effects on wellbeing[11]. It is clear that CAV could potential play an important role in reducing such mobility shortfalls, and it is very interesting to see these sorts of journey purposes being identified by the participants in the workshops.

## Groups of participants most likely to meet their mobility needs with CAV

Those with moderate health conditions and impairments which affected their ability to travel independently, and younger disabled people who were very reliant on others to get around, tended to be the most positive about the potential of driverless vehicles to improve the quality of their lives. Those with mobility issues identified the opportunities for freedom that it could potentially offer them.

Others saw CAV as less relevant in meeting their mobility needs. For example, those who currently drove were less likely to say they would use driverless vehicles, as driving was something they enjoyed doing and because they valued the sense of control and independence which driving gave them.

Others outside of the groups here might have complex health needs and/or cognitive challenges, resulting in unmet mobility needs, but may struggle to appreciate the potential benefits of CAV or be able to use a CAV without help.

## Barriers to CAVs meeting mobility needs

CAV would not necessarily resolve all the mobility needs implicit in the results above, as participants also identified a series of barriers to use of the vehicles. For example, a CAV would need to meet safety standards and the technology would need to have been proven to be reliable. This was seemingly more important for focus group participants than those in the IVPW sessions. This especially important if the CAV were to share the roads with non-driverless vehicles. For some participants, sharing the road with non-driverless vehicles was a 'red line' they would be unwilling to cross in terms of their acceptability.

Alongside these issues, there was also a widespread concern about the cost of such vehicles, and whether older people would be able to afford to either buy or use them – particularly when they were initially launched. It was thought that hire schemes and government subsidies might help to make the vehicles affordable, and there was interest in whether concessionary passes might operate on public-transport CAVs.

Another potential barrier to use was the availability of training and support to use CAV. It was often suggested that people in the oldest age groups, who were not confident technology users, would need a greater level of reassurance, training and support before they could appreciate the benefits of CAV, and be able to use them.

Whilst CAV seemingly offer clear benefits in respect of independence for older and less-able people, there were concerns that for some the lack of human support (in the form of a driver for example) would be problematic. It would make access to a vehicle more difficult perhaps, and remove support during the journey.

Others expressed additional barriers to use. For example, CAVs might make it too easy to avoid walking with implications for health, or that the surge in demand created by those currently unable to drive would lead to increased congestion. This might then imply some degree of rationing, again perhaps by price, to manage such situations. This might curtail access, and thus the ability to meet mobility needs.

## Planning to meet the mobility needs of future generations of older people

There are seen to be existing shortfalls in planning for mobility for older people, and if this deficit continues into future networks built on CAVs then this could have both social and economic consequences. Ensuring that future mobility services best meet the needs of an older population will be important, helping those who currently struggle to get around due to declining health, or living in areas that are not well served by public transport. If systems develop purely through a market-led approach this could mean unequal access to the technology (perhaps because of cost) and continuation of existing travel inequalities, for example, between the affluent and less affluent and the rural and urban. In such a scenario the mobility potential described above may not be met.

There will also be a balance to be struck in respect of CAV use, as the potential such vehicles have to help alleviate mobility problems will not be without issue. For example, facilitating full mobility for those whose mobility is impaired could lead to a significant increase in vehicle miles travelled, and whilst addressing a social sustainability issue this may then have negative environmental effects.

One way in which CAV could themselves help alleviate some of these planning issues is through the delivery of far more accurate and comprehensive data about patterns of travel, which could be used by transport planners and service commissioners alike to plan and commission services more effectively and efficiently. Having this information will help those planning the transport system of the future to adequately address the mobility needs of older people.

## CAV and younger disabled participants

Whilst the focus of activity across the Flourish user engagement has been with older people, there has also been some interaction with groups of younger, less-able participants. Thus, visits have been facilitated to the Flourish trials for some with disabilities, whilst project partners Traverse have explored the potential of CAV with a small group via a video-diary exercise. This latter activity produced some interesting findings which also have relevance for other groups.

- CAV could remove reliance on others (perhaps strangers) to facilitate travel or to complete journeys successfully.

- CAV would help resolve access issues – the vehicle coming to you, and being purposed for your journey. Avoiding having to wait for a bus with space for a wheelchair for example, or having to ‘prove’ that you had a disability to access services or even particular seats.
- Use of such vehicles could also help address broader accessibility issues – in terms of transport infrastructure (buildings, vehicles) or the wider built environment (parking availability near to a destination for an example).

What was also interesting in this specific piece of work was the expression of the sentiment that CAV would make travel less of a struggle both physically and emotionally, both of which could be seen to be barriers to meeting mobility needs currently. The latter unlikely to be a factor considered in traditional mobility planning or fulfilment.

# 3. Needs related to use of CAVs

As discussed above, the advent of CAV at some point in the future will potentially allow older people to meet a range of their mobility needs. However, older people will also have 'needs' in respect of how such vehicles might operate, and how they might be designed.

The first part of this section will consider broader issues to do with using a CAV, and how the vehicle might look and function. The second element of this section will consider the needs expressed by participants in respect of the interface to the vehicle. This human-machine interface, or HMI, was another key research area for Flourish, and was more deeply explored in the trials themselves.

## Older people's needs in respect of how the CAV functions

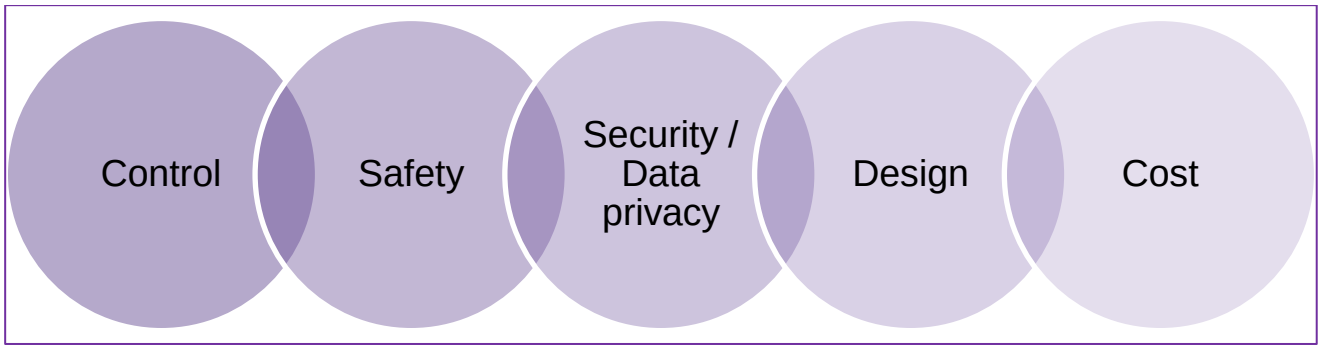


**Figure 8 CAV functionality needs for older people**

In the main, participants in the user engagement activities undertaken for the Flourish project see the idea of a driverless vehicle as a positive possibility. They do though have some concerns and thus needs and expectations of vehicles, in particular around control, but also in respect of factors such as safety, security and cost.

### Control

The issue of remaining in control is a constant theme throughout the various user engagement activities. Participants expressing a desire to have:

- A high degree of choice and control over the speed and route of the journey and the operation of the vehicle (and the choice as to whether they exercise this).
- The ability to drive the vehicle if for whatever reason you felt like it.
- Control over the amount of information and interaction associated with a journey, depending on personal preferences and the type of journey taking place.
- Clear systems and procedures in place for when a problem emerges, e.g. the technology malfunctions, or the user has a health-related emergency.
- For some, an active interest in their journey and in decisions being made by the vehicle, while others would be happy to sit back and let the CAV take over.

### Safety

Concerns about overall safety and reliability were discussed widely in the engagement activity. In general, safety was an important concern for older people, with some participants noting that they were 'nervous drivers' and thus likely to be nervous passengers. More broadly there was an expectation of the following:

- The need to feel safe and secure while travelling, with access to a 'panic button' and lines of communication with carers, relatives and emergency services.
- The need for the vehicle to operate at safe speeds, (which might vary depending on driving conditions).
- Where operational issues were discussed, the idea of using CAV as a shared, taxi-style service often exposed concerns around sharing with strangers.

### Security / Data privacy

Participants across the engagement activities tended to be comfortable with anonymous non-personalised data being shared beyond the CAV, but were more cautious when it came to sharing personal data such as contact details, locations data and health records (unless in emergencies as discussed above)[vi] . There were though some specific concerns about:

- The risk of important personal data falling into the wrong hands, putting them at risk of fraud or personal harm from criminals.
- The potential for a user's personal data, including their movements in the vehicle, to be misused or intercepted.
- For some people there were also concerns around risks from hacking, or malicious interference with software in the CAV. Some degree of certification of security measures might be needed by some participants to allay their fears.

### Design

Comfortable and accessible vehicle design was also seen to be very important.

- There were mixed views about what connected driverless vehicle should look like, including the interior. Most participants said that the vehicle needs to have comfortable and adjustable seating, the vehicle should also have plenty of leg room and height.
- A few suggested that the vehicle did not need to look anything like a conventional car. By contrast, others suggested that mimicking a conventional car might be reassuring for some users.

### Cost (of CAV)

As discussed earlier, cost (of vehicles or their use) was a potential issue for some older participants, although less important than some other factors it seems.

[vi] Note: Data on data privacy and sharing was also collected during some of the trials and via the 'standardized assessment framework' (SAF) developed within Flourish.

- For many there was also an expectation that CAV would be more like a taxi service, and thus they wouldn't have to buy one themselves – this too an extent was suggested in material presented / provided to participants in some of the activities.

## Older people's needs in respect of the HMI

During the user engagement activities, participants were asked to think about the HMI in respect of four aspects[vii] (see Figure 8).

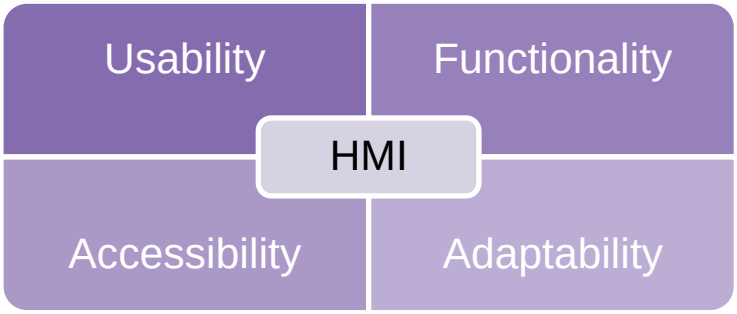


**Figure 9 HMI Characteristics discussed in the user engagement activity**

For older people to effectively be able to use CAV the HMI will need to reflect these needs, and the following categorisations were provided to participants when thinking about responses.

**Table 2 Definition of HMI characteristics discussed in the user engagement activity**

| | |
|---|---|
| **Usability** | *How the interface to the vehicle will behave and what features it should have that would help people to understand what it is doing* |
| **Accessibility** | *Elements that might increase people's ability to interact with and use a CAV in-vehicle interface.* |
| **Functionality** | *Functions and features that would be desirable in an interface to the vehicle.* |
| **Adaptability** | *Aspects of the interface (and how it works) that would support those who might be less able to use it equally well, or to just make it easier for all to use.* |

### Usability / Design of the interface

Key messages emerging under this theme were the need for simplicity, and the desire to use voice control to communicate with the vehicle.

- There was widespread agreement that whatever form the HMI took, that it must be as simple and user friendly as possible. It was also thought that there would need to be alternate interfaces available, so that people with different communication needs were catered for.
- Most participants were of the view that voice control should be the primary form of HMI because it had the potential to be intuitive and accessible to the broadest range of users.

[vii] Determining the needs of older people in respect of the HMI has been a key research element for the wider Flourish study, and a range of project outputs based on simulator and live trials directly address this in greater detail.

Notably, this approach was also supported by older participants who were not confident technology users as well as those who did not currently use a voice control interface in their everyday lives. Often this might be a combination of voice and touch-control screens.

- There were many pleas to avoid an over-complicated dashboard – like that in a plane, or interfaces which required people to be 'tech-savvy'. People also wanted to avoid jargon, make things context-sensitive, and not offer too many controls, or multiple ways of doing things. Too much information about what was happening with the vehicle might also be a problem for some people – reminding them that there were things that could go wrong.

### Accessibility

Needs related to this category often reflected accessibility features that were desired in a conventional vehicle now – and thus were not unique to using a CAV in the future.

- The CAV HMI would need to cope with the commonplace and predictable physical and cognitive issues of ageing, such as poorer eyesight. Voice-based interaction was seen as a good alternative in many cases – although a counter view was expressed by some deaf participants (underlining perhaps the need for flexibility in control mechanisms).
- Almost as important it seems for the effectiveness of the HMI is the physical design of any interface (or controls) in the vehicle. Some participants thought that having a removable device (either part of the vehicle or their own) as a way of controlling things from anywhere in the vehicle would help interaction.
- Any screens in the vehicle would need to present a clearly laid out interface, big enough, but not too big, close enough to passengers, but not too close to accidently touch.
- Several of the participants expressed the view that using their own phone or tablet as a control interface would be beneficial, as they could program the journey, or have personal preferences already loaded on such devices and just plug them into the vehicle.

### Functionality

Control was the important message in this category of responses. The desire to know what is happening (inside and outside the vehicle) and to retain some degree of control (including mental model(s)) over where it is going – and to be able to stop it or change something if it is deemed necessary.

- The vehicle (and HMI) should inform the passenger(s) as to where they were, when they would reach their destination, and the state of the vehicle (e.g. fuel reserves).
- The vehicle should always 'confirm' what it was doing and what it had been asked (or told) to do.
- Participants were keen that driverless vehicles should make the most of being connected, e.g. providing updates about the vehicles progress to whoever you were meeting, and sharing information in the event of an emergency, as well as negotiating traffic and road incidents.
- Many participants were looking for a continuation of the functionality they already knew, or had in vehicles, such as the features and functions of 'Sat-Nav' systems.
- The ability for the vehicle to call for help – perhaps automatically.
- Programming of the vehicle should be kept simple, and the vehicle should be able to understand commands such as 'go to the Doctor'.

- There was seen to be a need amongst some participants to be able to slow down or stop the vehicle if needed, and to alter course, or to explore other options before selecting them without interfering with a current journey.
- Personalisation of functionality, and the HMI was also identified as being helpful. This might be achieved through physical means (smart card or fob for example), or by having a PIN number to key into the vehicle. This could provide a personal profile (entertainment, climate control, driving mode etc.), as well as access to information on regular journeys made for instance. For some people the idea of facial-recognition was a possible way of accessing a vehicle, and another way of configuring the vehicle to individual needs.

### Adaptability

The needs articulated here[viii] reflected not only those of groups who might be seen to be less-able, but also a range of physiological and cognitive change that might be expected as people age – declining eyesight for example.

- The HMI should cope with capabilities by offering a range of interaction approaches, or through changes in the HMI (e.g. changes in text size, contrast, volume etc.).
- The HMI should be flexible enough to cope with different circumstances (even different states of ability in the same person from day to day).
- By bringing your own capabilities to the HMI via a device, or perhaps via information stored on the cloud could also be a mechanism to 'customise' or prepare the vehicle for different users (and abilities).

### HMI conclusions

Whilst the four categories have proved to be useful in helping participants to think about aspects of the HMI, there was overlap in the interpretation and in their responses. Thus the needs expressed above do not always neatly fit into one category or another, or will embrace more than one category perhaps. Notwithstanding this, these responses provide some useful insights into how older people currently perceive their future interaction with a level 5 CAV. It is notable that in some areas, this perception is very much based on existing knowledge and expectation related to current vehicles and technologies. This perhaps further reinforces the benefits of projects such as Flourish, which are exposing 'users' to elements of the future to help them to think more about how new forms of mobility could be developed and enabled for their benefit.

[viii] Note: It is acknowledged that it is difficult for participants to envisage what can be made adaptable without having an example of an existing product. No example or mock-up was provided in the workshop sessions so as not to confound responses.

# 4. Conclusions

Both explicitly, and revealed through answers provided in user engagement activity it is possible to see that older people can see how CAV might address their mobility needs. In some instances this is to perhaps replace shortfalls being experienced as a result of ageing, and in others to provide additional journeys not currently being made – but seen as important. Using CAV to meet these mobility needs, and to address deficiencies identified in alternatives such as public transport, taxis and lift-giving, provides important clues as to how effective CAV may be for this group in the future. It also highlights where potentially there are shortfalls in older people's mobility now.

There are important caveats to use of CAV by older people though. Although the general view of the vehicles is broadly positive, there are issues in respect of control, safety, security, and to a lesser extent cost of ownership and use.

What is also evident in the user engagement activity undertaken for the Flourish project, is that there are a series of specific needs for this group in respect of the vehicle and its operation. Whilst more broadly there are growing aspirations for adopting a 'universal design' approach that takes all needs into account, there may be questions as to how effective this might be in respect of the particular requirements for older occupants of CAV.

There was a desire for the HMI to remain simple, clear and easy to operate, and for voice interaction to play an important role (either alone or in conjunction with other means such as touch screens for example). The interface should carry forward and adopt the best functionality and accessibility features of current vehicles. Importantly, it should be able to cope with the predictable physiological and cognitive issues of older age. There was also a need for clarity over what the CAV was doing (or going to do), and the capacity to adjust a journey, or to stop it if an occupant of the vehicle requested that. Across all the data collected here there is a desire for a flexible HMI, capable of coping with a range of capabilities likely to be present in a growing older population. This information is helpful and important, and offers a rich source of data for designers of HMI for future vehicles.

Future generations of older people will be more technology aware, cogniscent for example of the development of CAV, and this may make them more likely to accept these vehicles as a way of meeting their mobility needs. The coming generation of those about to reach their 70s and 80s, expect to continue be mobile, and to be consumers of mobility in later life. At present, they believe they will continue to drive (although women are more likely to think that they will stop driving by the age of 80). However there is little evidence currently that they plan for this eventuality – consistent with current cohorts of older people. The advent of CAV, providing they are equipped to meet the needs of older people, could offer better and more effective mobility for this group, and allow them to continue to fully participate in society. This notwithstanding some of the predictable changes experienced in later life. The advent of fully-autonomous vehicles may also help to address the mobility issues experienced by those most at risk of isolation and exclusion, older women, the older old, and those in areas poorly served by alternatives to the car.

The Flourish 'user-engagement' activity has then provided useful insights into the potential for CAV to meet the mobility needs of an ageing population, as well as a focus on how such vehicles

might interact with their passengers. The latter providing some key pointers as to how CAV will need to develop in order to be fit for purpose for what will be a growing segment of society, and a group seemingly accepting and supportive of their use.

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# Appendix A. User engagement activity

This appendix details the various user engagement activities undertaken during the Flourish project from 2016-19.

### *1. In vehicle participant workshop (IVPW) and interviews*

Six IVPW sessions were held over the course of the Flourish project. These events had two purposes, firstly to brief and prepare those involved in simulator and live-vehicle trials, and secondly to collect some data on initial views on CAVs. In total, almost one hundred participants took part, spending around two hours each in the IVPW sessions. Data collection involved responding to a series of questions around potential use of a CAV and how people would like to interact with such vehicles. The latter also provided an opportunity to begin to collect high-level data on how people envisaged a CAV HMI might be tailored to the needs of an older population.

The workshops were complemented by almost twenty short interviews with participants after they had taken part in either a simulator or live-trial. These interviews again asked people to think about the potential uses of a CAV, and what benefits such a means of mobility might bring.

**Table 3 Participant profiles (IVPW – All Bristol)**

| Workshop No | Date | Participants | Workshop No | Date | Participants |
|---|---|---|---|---|---|
| 1 | 20th Mar 2017 | 14 | 2 | 20th Mar 2017 | 5 |
| 3 | 24th Apr 2017 | 29 | 4 | 15th Nov 2017 | 28 |
| 5 | 8th Oct 2018 | 7 | 6 | 28th Jan 2019 | 11 |
| Gender: | Male | Female | Not classified | | |
| | 52 | 38 | 4 | | |
| Age: | Aged 50 - 69 | Aged 70 and above | Not classified | | |
| | 43 | 42 | 9 | | |

More details of this research can be found in project deliverable: WP3 D3: *Findings from Workshops held with Older People considering participating in Connected Autonomous Vehicle trials. April 2019*

### *2. OPM – Focus groups (1)*

OPM Group ran a series of focus groups with members of the public and telephone interviews with carers in February 2017 to understand needs and expectations relating to CAV including views about the human machine interface. Target groups included:

a. people who are 70-years and above at the time of taking part;
b. people in their 50s and 60s at the time of taking part;
c. people who currently rely on some form of assistive mobility technology; and
d. people who are relatives and/or carers of those who are 70+ or who rely on a form of assistive mobility technology.

**Table 4 Participant profiles (OPM engagement activity 2017)**

| Group 1: London (9 participants) | Group 2: Croydon (10 participants) | Group 3; Croydon (9 participants) | Group 4: London (7 participants) | One-to-one interviews (5) |
|---|---|---|---|---|
| • Urban<br>• Mix of 70+ and 80+<br>• Current drivers<br>• Gender split, educational attainment and ethnicity broadly in line with age group in recruitment area London<br>• Mix of attitudes towards/use of technology e.g. the internet | • Suburban<br>• Mix of 70+ and 80+<br>• Mix of those who have given up driving, those driven by someone else, those who have never driven<br>• Gender split, educational attainment and ethnicity broadly in line with age group in recruitment area Croydon<br>• Mix of attitudes towards/use of technology e.g. the internet | • Suburban<br>• Mix of 50+ and 60+<br>• Mix of current drivers, those who have given up driving, those who have never driven<br>• Gender split, educational attainment and ethnicity broadly in line with UK<br>• Croydon<br>• Mix of attitudes towards/use of technology e.g. the internet | • Urban<br>• At least half the group aged 55 or under<br>• People who rely on some form of assistive mobility technology (e.g. wheelchair, mobility scooter, community transport)<br>• Gender split, educational attainment and ethnicity broadly in line with UK<br>• London<br>• Mix of attitudes towards/use of technology e.g. the internet | • Carers and relatives of people who have the profile of Group 2 and 4 participants<br>• Mix of attitudes towards/use of technology e.g. the internet |

More details relating to (2) and (3) can be found in project deliverable WP3 D14: *Public Engagement Report 1. March 2017*

### *3. OPM Stakeholder workshops / interviews (1)*

OPM Group organised a workshop and small number of telephone interviews with key stakeholders to understand older people's current use of and attitudes towards technology and who and how CAVs might be used by target groups.

### *4. OPM Focus Groups (Year 2)*

OPM Group ran a second wave of fieldwork during December 2017 and January 2018 in Manchester and Ashford (Kent). Six focus groups (three in each location) were held with members of the public. Group participants had a mix of driving status, age, gender, geography and socioeconomic background. The sample also sought the views of those with mobility needs and carers.

**Table 5 Participant profiles (OPM engagement activity 2017-18)**

| Group 1: Manchester | Group 2: Ashford (Kent) | Group 3: Manchester |
|---|---|---|

| (10 participants) | (10 participants) | (10 participants) |
|---|---|---|
| • Mix of suburban and rural participants<br>• Mix of 70+ and 80+<br>• Current drivers<br>• Gender split, educational attainment and ethnicity broadly in line with age group in the recruitment area<br>• Mix of attitudes towards/use of technology e.g. the internet | • Mix of suburban and rural participants<br>• Mix of 70+ and 80+<br>• Mix of those who have given up driving, those driven by someone else, those who have never driven<br>• Gender split, educational attainment and ethnicity broadly in line with age group in the recruitment area<br>• Mix of attitudes towards/use of technology e.g. the internet | • Mix of urban and suburban participants<br>• 50-75 year olds<br>• Mix of current drivers, those who have given up driving, those who have never driven<br>• Gender split, educational attainment and ethnicity broadly in line with age group in the recruitment area<br>• Mix of attitudes towards/use of technology e.g. the internet |
| **Group 4: Manchester (10 participants)** | **Group 5: Ashford (12 participants)** | **Group 6: Ashford (8 participants)** |
| • Mix of urban and suburban participants<br>• 18-35 year olds<br>• Mix of current drivers, those who have given up driving, those who have never driven<br>• Gender split, educational attainment and ethnicity broadly in line with age group in the recruitment area<br>• Mix of attitudes towards/use of technology e.g. the internet | • Mix of urban and suburban participants<br>• At least half of this group aged under 55<br>• People who rely on some form of assistive mobility technology (e.g. wheelchair, mobility scooter, community transport), at least half of this group aged 55 or under<br>• Gender split, educational attainment and ethnicity broadly in line with the recruitment area<br>• Mix of attitudes towards/use of technology e.g. the internet | • Carers of someone who relies on some form of assistive mobility technology |

More details of this research can be found in project deliverable WP3 DNN*: Public and stakeholder research: Interim Report. May 2018*

### *5. OPM Stakeholder interviews (Year 2)*

Stakeholder interviews were conducted by telephone and face-to-face and lasted 30-60 minutes. Interviewees had backgrounds/expertise in community transport, transporting planning, and road safety. The following topics were explored:

- How driverless vehicles could be successfully rolled out in specific areas
- How different population groups (e.g. older people, those with mobility needs) might respond to the development of CAVs

- Data sharing and the connected vehicle
- Accessibility, ownership and insurance

### *6. Traverse[ix] Focus Groups (Year 3)*

Traverse ran its final round of fieldwork for the Flourish project during February and March 2019. The activity comprised of:

- Four focus groups with 42 older members of the public.
- A video diary project with younger people with mobility issues: 7 young people (18 – 26 year olds) with different mobility issues participated in a video diary project, recording their reflections on four different journeys.

As before, the purpose of the user engagement was to explore the development of driverless vehicle technology for older people and those with mobility issues. Groups 1-3 ran for 90 minutes, whilst group 4 was 60 minutes in duration.

**Table 6 Participant profiles (Traverse engagement activity 2019)**

| **Group1. London (10 participants)** | **Group2. Settle (10 participants)** | **Group3. London (7 participants)** | **Group4. London (15 participants)** |
|---|---|---|---|
| • Urban residents<br>• 8 female/2 male<br>• 60 – 85 year olds<br>• 1 visually impaired participant<br>• Recruited with support from Ageing Better Camden | • Rural residents<br>• 7 female/3 male<br>• 50 – 80 year olds<br>• Recruited with support from Settle Community and Business Hub | • Urban residents<br>• 5 female/2 male<br>• 2 visually impaired<br>• 1 hour 30 mins<br>• Recruited with support from Kilburn Older Voices Exchange | • Urban residents<br>• 15 female, all BAME<br>• 50 – 80 year olds<br>• Recruited with support from Hopscotch Asian Women's Centre |

The final engagement activity involved a group of young people with different mobility issues, who participated in a video diary project. Each participants was asked to take four different journeys and reflect on current travel difficulties and how a driverless vehicle could ease their mobility needs.

**Table 7 Video diary participants (2019)**

| **Group. Video diary (7 participants)** |
|---|
| • Mix of urban/suburban/rural participants<br>• 4 male / 3 female<br>• 18 – 26 year olds<br>• Recruited from within and outside London<br>• All participants have long-term mobility issues that impact on their ability to get around (e.g. use of crutches or limited walking capacity). Of these, 4 participants rely on assistive mobility technology (wheelchair and mobility scooter). |

[ix] Note, OPM renamed as Traverse during the project.

## Note: Some limitations of the sample

There is no claim made for the sample being fully representative of the older population in the UK, although it did represent the groups targeted by the Flourish project. Activity in 2019 looked to carry out research activities with groups less well represented in the IVPW and 2017/18 focus groups, with a focus on engagement with older women, BAME, rural and the younger disabled.

The sample sizes for individual activities are relatively small, although across all the Flourish user engagement over two hundred and forty people have been involved in research activity.

In the IVPW, and in some of the focus groups (2019), the participants were self-selected. Thus they were likely to have some interest (and possibly knowledge) in the topic, and in being involved in research activity. Thus most people attending user engagement activities (particularly in respect of the IVPW), had an understanding of what CAV and driverless vehicles were, and potentially what the claimed benefits of such vehicles might be. IVPW participants also received explanatory material (e.g., an information sheet) from the project in advance of the workshop sessions. Hence they were intentionally more informed about the research topic than the typical citizen. Conversely, the majority of participants in the 2019 focus group with members of the Black, Asian and Minority Ethnic (BAME) community were unaware of CAV and the developments happening around these technologies – so provided a useful counterpoint to the other more knowledgeable and technology-aware participants.

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