



**Towards  
safe, accessible  
and trustworthy  
self-driving  
services**

Insights into the future of  
self-driving services from **DG Cities**,  
the UK's leading authority on  
public attitudes to Connected and  
Autonomous Vehicles (CAV).



## INTRODUCTION

Self-driving vehicles have the potential to completely reshape our towns and cities. Optimists predict that by 2040, self-driving technology will have reached a standard that is of good enough quality, affordability and reliability to replace human-driven vehicles in many common scenarios. The potential benefits of this transformation are huge. However, there are many good reasons to express caution. As with all transformative innovations, there are still several hurdles to overcome, and barriers that must be understood and reduced.

In this report, we explore public attitudes to and perceptions of self-driving services and highlight how, through a variety of methods, it is possible to better understand, plan for, and overcome even the most challenging barriers facing public acceptance of this technology. We also explore the leading-edge research that is enabling stakeholders across the sector to build their understanding of the technology and its potential, and introduce a practical model for exploring safety and trust through deep public engagement.



## What is a self-driving service?

The *Automated and Electric Vehicles Act 2018* defines a self-driving vehicle as one which is “designed or adapted to be capable, at least in some circumstances or situations, of safely driving themselves”. The Law Commission also outlines that “driving itself” is defined as “operating in a mode in which it is not being controlled, and does not need to be monitored, by an individual”. In this document, we explore the concept of a service model of vehicle use, and not private ownership. This, we believe, is a compelling model of deployment that will maximise the benefits of self-driving technologies for all stakeholders and the environment.

## About the authors

DG Cities works with public and private sector organisations to help cities and communities harness the potential of technology to improve people’s lives. Our work spans net-zero housing, decarbonisation, fleet electrification, electric vehicle infrastructure, connected and autonomous vehicles, public engagement, research and much more. Through the insight we have gained from our role at the heart of the UK’s pioneering self-driving projects, we have become a leading authority on public attitudes to the future of this technology.



# TOWARDS HUMAN-CENTRED SELF-DRIVING SERVICES



## Understanding the human component

Improvements in self-driving vehicle technologies, such as machine learning, radar, GPS and cameras have meant that self-driving services are closer to becoming a reality. Technological advancements mean that much of the hardware needed to run a service is now in place, or under development. However, a critical aspect remains less understood: if and how the public will accept and adopt self-driving technologies.

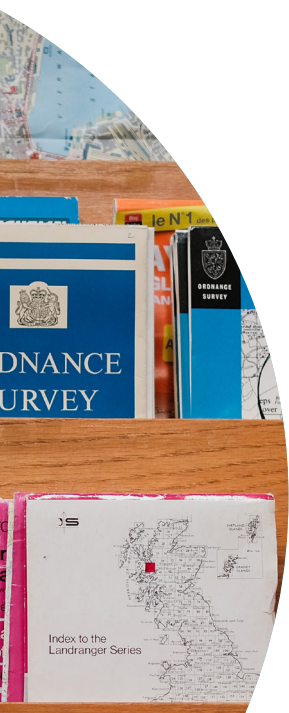
Building trust in self-driving services will be vital if they are to be adopted en-masse by the public. As with all new technologies, the rate of adoption will be reliant on several key factors, including access to the technology, perceptions of safety and reliability, and how individuals view their usefulness.

At DG Cities we understand the importance of engagement in building trust in new innovations. Through our projects in the sector, we have explored perceptions of trust in self-driving services among citizens and communities. We have worked closely with leading organisations through trials and simulations to understand how trust in self-driving technology can be developed, and what our findings could mean for the transition to widely adopted self-driving services.

## Benefits of self-driving services

**Radically improving road safety:** It is estimated that around 85% of road traffic accidents are the result of human error. Self-driving AI has the potential to reduce a significant proportion of that risk. As part of Project Endeavour, DG Cities partnered with BRAKE, the road-safety charity, to develop information and education materials that highlight the current evidence for and against self-driving vehicles. Our work highlighted the significant safety benefits of self-driving vehicles on UK roads. For example, it has been estimated that self-driving vehicles could save over 3,900 lives and prevent more than 47,000 serious crashes per year in the UK.

**Greater accessibility:** self-driving services offer significant benefits to those who are unable to drive, including those with mobility needs, and people without a driving licence. Self-driving cars could offer major benefits to elderly people concerned about losing their freedom as they age, and to younger people with mobility-limiting disabilities.





**Decreased congestion and energy use:** the shift from individual ownership toward new models of mobility services, such as car-sharing or an on-demand service operated by self-driving vehicles, has been predicted to reduce energy demand, and in some scenarios, reduce congestion on roads. The extent to which this is realised depends significantly on the model of deployment and usership rates.

## Challenges to address

**Significant testing required before widespread adoption:** evidence shows that demonstrations and trials are an effective way to both test technologies and encourage engagement and learning among communities. However, the scale of trialling required to achieve this is a limiting factor. Therefore, we must develop new ways to engage en-masse to be able to support learning across large populations.

**Affordability and attractiveness to consumers:** highly complex new technologies demand high price-tags, meaning that many of the new products or services that come to market are unavailable to the vast majority of consumers. Affordability is therefore a key constraint to adoption, and new ownership and service models will be needed.

**Pace of change in public policy and regulation:** given the pace of change, it can be hard for policymakers to keep up. Regulation and public policy needs to keep pace with innovation, setting the environment for adoption, whilst acknowledging and managing the risk that the transition could bring to society. Therefore innovators will need to understand how to work with policymakers to share knowledge and foster innovations in policy that can encourage adoption and mitigate risk.

**Trust in 'big tech' at an all time low:** perceptions of surveillance, over-reach of data capture and data use, and lack of personal privacy are key concerns for the public. Trust will limit adoption if consumers do not feel their data is being used appropriately and that their rights are protected.

In this document, we outline how the public perceives these challenges and barriers, and their views and opinions on the potential role of self-driving technologies in their lives. We explore innovative approaches to engagement, and highlight the key steps needed to move the innovation forward towards acceptance and adoption.

# INNOVATING THROUGH PUBLIC ENGAGEMENT: IS THE PUBLIC READY FOR SELF-DRIVING SERVICES?



## Project Endeavour

Project Endeavour was a pioneering mobility initiative designed to accelerate and scale the adoption of self-driving services across the UK. It set out to test the building blocks of self-driving services in the real world and ran from March 2019 to autumn 2021. The project was led by Oxbotica, working alongside DG Cities and Immense. In autumn 2020, three further partners joined the project: TRL, BSI, and Oxfordshire County Council. The project delivered four trials at locations across the UK to build the technology capability, test and validate technology in live urban environments, and engage with the public to understand their attitudes and perceptions towards self-driving vehicles.

Over the course of three weeks, Project Endeavour invited over 120 members of the public to ride in a self-driving vehicle around a planned route in the London borough of Greenwich. Members of the public learned about the latest technology, spoke with experts about their ideas, views and concerns, and experienced a ten minute journey to see the technology for themselves.

Alongside this, DG Cities also delivered a national engagement programme to explore attitudes towards self-driving technology safety and trustworthiness. A national survey of over 2000 members of the public was distributed online, and 25 took part in online workshops and focus groups to share their views in greater depth and learn from experts.



Our work with the public during Project Endeavour showed:

- **The majority are either undecided or are not yet comfortable using self-driving vehicles:** findings from our national survey show 26.8% would feel confident using an AV tomorrow if it were possible to do so. Over half would not (55.1%). The remainder are undecided (18.1%).
- **The safety case for self-driving vehicles has yet to fully convince the public:** findings from our national survey show that three in 10 (29.9%) believe that self-driving vehicles will be safer than traditional vehicles, whilst 44.2% disagree. A quarter (25.9%) are undecided.
- **Live trials improved perceptions of safety by 15 percentage points:** before the trial, 68.3% agreed that AVs would be safer than human driven vehicles, whilst after the trial 83.6% agreed, an improvement of 15 points.
- **Trust in self-driving vehicles is low, but a large minority is yet to be persuaded:** findings from our national survey show almost a third (32.5%) think self-driving vehicles will be trustworthy, whilst two in five (43.8%) do not. Almost a quarter (23.6%) are undecided.

“If there was someone that can operate it in there, to take control, I would trust it. If it was just me and this car, then maybe not.”

“I felt safer than I feel when I drive. I felt it’s probably the safest drive I have had.”





## D-RISK

If self-driving services are to operate safely, they will need to go through extensive testing and validation. A key part of this process will be ensuring that they can routinely manage complexity and uncertainty. This is the challenge that project D-RISK is tackling.

D-RISK is a £3million Innovate UK-funded project. It is a collaboration between dRisk.ai, Claytex, Imperial College London and DG Cities that focuses on the development of software for safe self-driving vehicles. The project has been developed to help self-driving AI developers take account of the complexity of modern roads, supporting them to build systems that can handle even the most unique and challenging of live road scenarios. Key to this is ensuring that the public is engaged in the development of training systems and processes.

### Mapping 'edge cases'

D-RISK is building the world's largest library of driving 'edge cases'. These are unusual or unexpected situations which AVs need to be able to handle safely. By gathering data from multiple sources, including stories from the public, D-RISK is training autonomous vehicle artificial intelligence (AI) through a process of machine learning and simulation. Edge cases are being gathered from traffic cameras, road accident reports and through a crowdsourcing initiative with the UK public.

### Exploring safe and trustworthy self-driving AI

Over the course of D-RISK DG Cities has investigated perceptions of safety, trust and reliability of self-driving services, and through engagement with the public. Through our work we've been able to draw together insights and intelligence from across the UK to support D-RISK and enable the development of an effective driving test that builds public trust and acceptance. We delivered two waves of online surveys to over 1700 members of the public in total, exploring safety, trust, and accessibility, five online focus groups engaged 46 members of the public, and a series of deliberative face to face workshops with over 50 participants in London, Southampton and Nottingham.

Our data shows that:

- **Over a third (36.4%) are happy to ride in a self-driving vehicle tomorrow.** Almost 3 in 10 (28.5%) are undecided so could be persuaded.
- **Age is a key factor:** there were significant differences in perceptions of self-driving vehicles between younger and older groups with regards to safety and trust. In general, young people were more positive than their older counterparts.
- **Safety is a major concern:** less than a quarter (24.7%) would feel safe using a self-driving service during the daytime in a city centre, compared to less than a fifth (17.6%) who would feel safe using the same service at 10pm. The key concern was sharing with strangers.



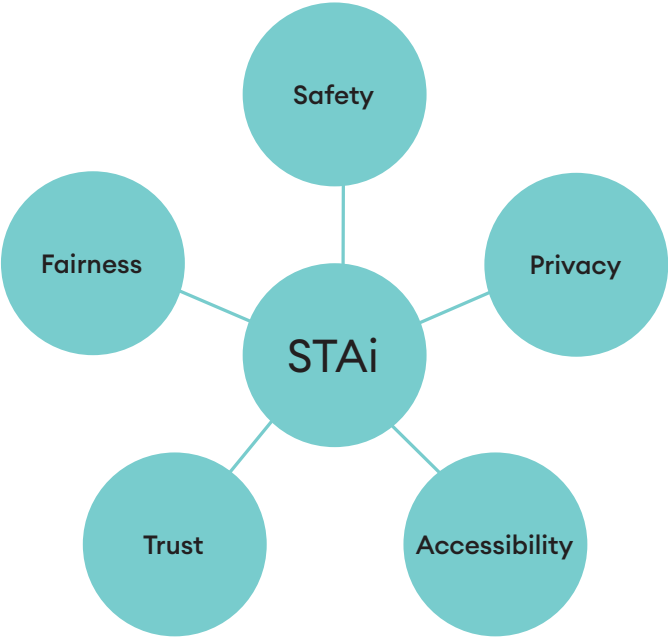
**“There is potential for [self-driving cars] to be safer than many drivers. The safety standard they are aiming for is zero collisions, and zero deaths.”**

# SAFE AND TRUSTWORTHY SELF-DRIVING: THE STAi MODEL

Our work with the public has enabled us to capture evidence of the opportunities and risks facing developers of services looking to deploy self-driving technologies. Through our engagement, we have focused on drawing out insights which allow us to better understand the methods and approaches that can help to foster public trust and acceptance.

We’ve captured the key concepts below in the Safe and Trustworthy Artificial Intelligence (STAi) Model, which draws together the key components gathered from our research to date. The STAi model is designed to provide a framework for research with the public to build safe and trustworthy self-driving services. We focus on Ai as this is a key component of the self-driving service for which the public has limited knowledge and understanding.

*STAi Model*



We believe that through the application of the STAi model as part of engagement with the public, developers and researchers will be able to better understand how to build safe and trustworthy AI systems that foster acceptance of self-driving services for the future.



## DESIGNING PEOPLE-CENTRED SELF-DRIVING SERVICES

User-centred service design will be critical to ensuring that self-driving vehicles are developed and deployed for all to use.

Self-driving technologies will touch the lives of many, whether as service users or as other road users. Engaging communities in their development can help to support the evolution of people-centric services, which in turn, can make acceptance and adoption more likely. We know that technology developers, policymakers, academics and others designing new services will achieve better results when communities and service users are engaged and empowered.

As part of Project Endeavour and D-Risk, we focused on developing new service models with communities. Our approach is grounded in the principle of deep and purposeful engagement with all society, taking into account the perspectives of different groups on self-driving technologies and their use in our towns and cities. We took this approach because we see the value in accessing and harnessing the collective intelligence of communities.

### Mapping new services: the Project Endeavour engagement programme

As part of the Project Endeavour trial we hosted five online workshops throughout the COVID-19 pandemic in which we explored the opportunities and challenges related to the development and deployment of safe self-driving services. Using online workshop tools, we drew together evidence and examples from the project and supported participants to road-test operating models. We provided an example of a shared self-driving service and explored perceptions of safety, trust and additional risks through exploratory workshop activities.

The Project Endeavour online engagement work highlighted that:

- **Personal safety was an issue for those sharing services**, particularly those sharing vehicles at night or in urban environments. For many, access to safety devices like alarms and emergency stop buttons was important.
- **Trusted service providers are needed to drive up acceptance:** when asked to design services, participants highlighted the importance of a transparent and regulated operator who is able to manage and maintain the service to a high quality. Participants felt that open models of reporting would promote accountability in service providers.
- **Accessible options and services for older people:** many noted the need for a safety driver or vehicle manager to be present to support onboarding and off-boarding. Without this, there was a concern that many would be prevented from using the service.

## Exploring safety through deliberative workshops

For the D-Risk project, we took simulations and examples of self-driving AI out on the road to the UK public in a series of deliberative exercises. At key locations across the country we facilitated half-day workshops in which we introduced and explored the concept of safe self-driving vehicles, and the services they might provide in the future. This work enabled us to further define the needs of different communities, and map out user requirements for future services. Across the UK, over 50 participants signed up and attended our engagement workshops.



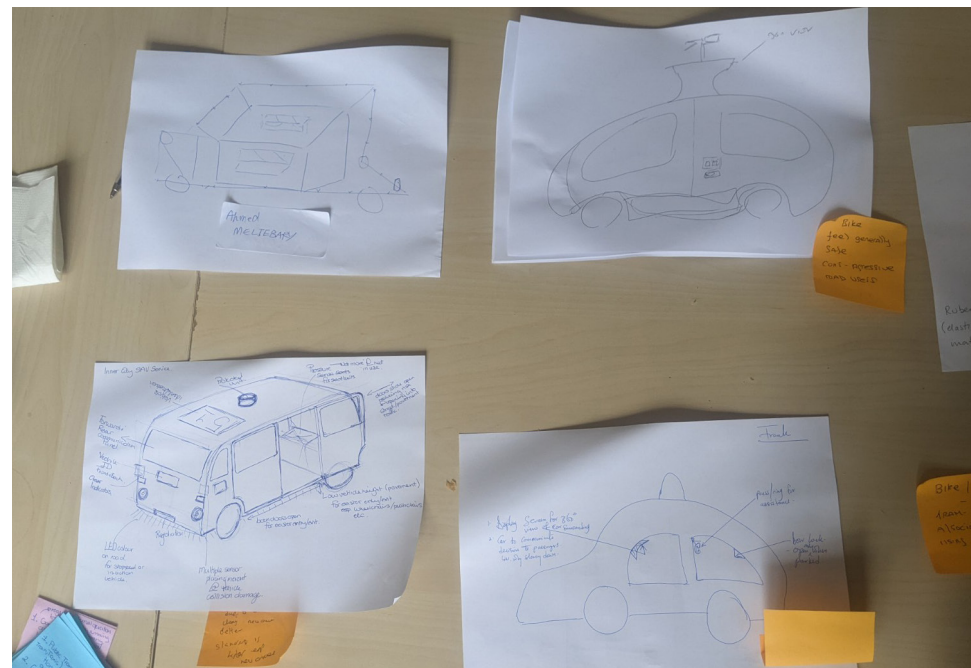
*Deliberative service-design workshop at Imperial College.*



Key challenges highlighted by participants in the sessions included:

- *“There is a need to be able to retain certain data and information so it doesn’t go into the cloud. I want to be able to control what data I share with the car... the data that the car shares with the many stakeholders it’s involved with.”*
- *“I would like to be able to track the vehicle or have some connection to be able to monitor them.”*

Participants in the workshop were asked to design features for a self-driving service that would help them to feel safe and trusting towards it. Through facilitated discussion, participants worked in groups to come up with new features.



Safety feature exercise

Common features highlighted included:

- Personal alarm / emergency buttons
- Physical safety personnel in the shared vehicle
- Monitors to view cameras and data.

We also explored safety features through our national survey, asking respondents to rate features they most wanted to see in a future service.

# ENABLING THE SELF-DRIVING CITY: THE ROLE OF LOCAL AUTHORITIES

## How will self-driving services influence our towns and cities?

The adoption of self-driving vehicles on our roads will not happen overnight. The rate of adoption will likely be slow, increasing as the market builds and various factors, including cost and perceptions, drive up adoption rates. A key question, however, is will our towns and cities be ready for the technology as it matures?

A range of socio-economic, environmental, political and technological drivers shape our towns and cities, and over time, our urban spaces have adapted to new forms of mobility. From stagecoaches through to the automobile, how we move through our towns and cities has been transformed by technological advances. The same will be true for the adoption of self-driving vehicles.

## How ready are local authorities for the transition?

At DG Cities, we have been exploring the readiness of local authorities to adopt new self-driving services. Local authorities play a crucial role as an enabling force in supporting the transition. However as with all new technologies, there can be significant challenges that limit uptake and long-term adoption.

As part of Project Endeavour, DG Cities undertook an engagement exercise with several local authorities to gain an understanding of the current levels of awareness and acceptance of self-driving technologies within a range of different authority types. Through this, we developed materials to support local authorities to understand how to maximise the value of self-driving testing on their highways. Our research shows that there are ways in which local authorities can prepare for self-driving trials, and set up their environments to be ready to accept self-driving vehicles in the future. These include:

- **Assess readiness:** It is recommended that LAs looking to accept CAV trials ensure that their region or jurisdiction is ready. Accessible frameworks like the Automation-Ready Framework are useful tools for assessing local authority readiness and mapping improvement opportunities.

- **Review safety assurance documentation:** Local authorities should engage on safety-related measures to (1) understand whether best practice is being applied to the trial (2) provide input and local knowledge; and (3) better understand safety issues prior to widescale adoption.
- **Be open to learning and developing capabilities through trials and exposure to new technologies and services:** self-driving services offer a significant opportunity for local authorities to build their skills and capabilities, and prepare for self-driving technologies. Leaders in local authorities should look to trialling opportunities to build their capability and capacity, and explore how services may reshape their environments.

The outputs of this engagement helped DG Cities produce two guides:

- *CAV Trialling on Public Highways*, which supports councils to help them understand the information organisations trialling in their area could be expected to provide.
- *The CAV Trial Guide for Trialling Organisations*, which is targeted towards organisations undertaking self-driving trials to help build understanding of what would be useful to provide when approaching the local highways authority.





# INNOVATIVE PUBLIC ENGAGEMENT METHODS

Demonstrations and live trials play a valuable role in building awareness and understanding of self-driving technology, but are expensive to administer for large numbers of people. At DG Cities, we have utilised several methods of engagement with the community, and have captured useful lessons for those developing, trialing and testing self-driving technologies that will support future engagement and outreach.

## Virtual reality bringing self-driving services to life

Virtual reality offers an exciting channel for bringing self-driving services to life for as many people as possible. DG Cities produced two virtual reality films as part of Project Endeavour to engage communities and ensure that even during the COVID-19 pandemic, people could still participate in trials and learn about self-driving technology. People across the UK were able to experience autonomous vehicles from home through two videos that were designed to bring self-driving services to life. A simple virtual reality (VR) headset was developed, which could be used with a smartphone. This was distributed to over 2,500 members of the public who applied via Facebook from across the UK.

The two videos that were made accessible to the public were:

- **Self-driving cars today:** To showcase current self-driving technology, we developed a 3D film of a ride through Oxford in the Endeavour vehicle. The video included the car overtaking cyclists, driving around a roundabout and emerging from a T-junction. The video utilised visual aids to point out key technologies and was designed to be immersive and replicate what it would be like to travel in an AV in real life.
- **Self-driving cars tomorrow:** A second VR video was developed to explore the future potential of self-driving technology. The animation showcased designs of future autonomous vehicle-based mobility services, and included a self-driving vehicle, as well as a Connected and Autonomous Mobility stop.

Our engagement research highlighted the value of VR based methods.  
For example:

- 73.9% of VR participants believed that self-driving technology in the future will be reliable, compared to 94.6% of those who participated in the physical trial.
- 61.7% of VR participants believed that self-driving technology will be safer than human driven vehicles, compared to 83.6% of those who participated in the physical trial.

Virtual reality provided a unique opportunity to showcase innovative local trials to a wide audience of people, and enabled deep outreach into local schools and communities, bringing to life a technology that for many still feels distant.





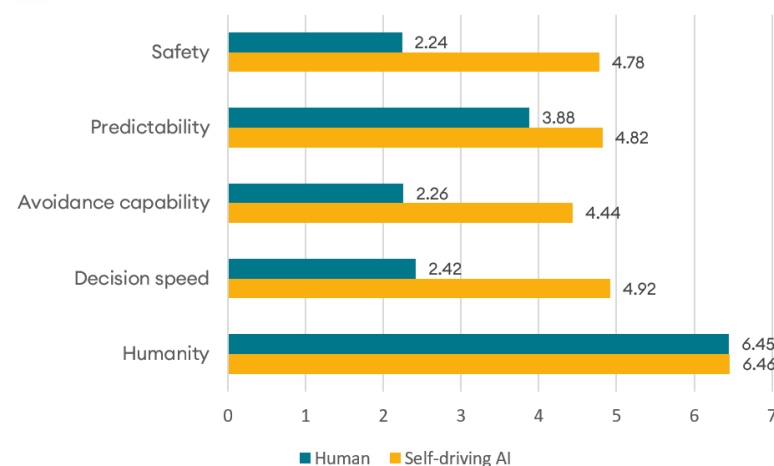
## Showcasing the value of safe self-driving AI through simulation and experimentation

The safety case for self-driving vehicles is one of the most compelling arguments for supporting the transition. However, demonstrating how self-driving AI works in different scenarios is challenging without ready access to the technology in a multitude of different on road scenarios.

Therefore for D-Risk we developed an online safety-perceptions experiment to test views on safety in different on-road scenarios. We tested three pairs of simulation videos, each pair representing a common road scenario. Each pair included one video in which the participant observed a simulation based on a human response to a real-world scenario (e.g. reconstructed from UK traffic camera data). In the second video of each pair the participant watched an AI response to the same issues unfolding. The participant was blind to which response they were observing. Participants then rated the vehicle's behaviour on five scales: safety, predictability, avoidance capability, decision speed and humanity between zero and ten.

The results from our study showed that in most scenarios the self-driving vehicle outperformed the human driven vehicle in the simulation environment. For safety, predictability, avoidance capability and decision speed the self-driving simulation was rated highest.

*Sudden stop scenario (mean rating scores, e.g., 0 = Unsafe, 10 = Safe)*



*Base: Safety n = 299\*\*, Predictability n = 293\*\*, Avoidance capability = 289\*\*, Decision speed = 284\*\*, Humanity = 273. \*\* = <0.001 significance.*



## BARRIERS: WHERE NEXT FOR RESEARCH INTO SELF-DRIVING SERVICES?

For safe self-driving services to become a reality, policymakers, researchers and technology providers should look to invest in building capacity and knowledge in a number of key areas:

- **Deeper public engagement into service design:** a recurring theme across our research is that of emerging understanding and expectation amongst the public of how future services may be operated using self-driving technologies. There is little evidence of extensive and lasting engagement with the public on the design of a self-driving service, from ideation through to piloting and towards implementation. Service user voice on the design and development of new models will benefit not only the service delivery organisation, but can also surface and validate assumptions and barriers. We believe application of the STAI model will help achieve this.
- **Investment in behaviour change intervention design to tackle limited acceptance of and interest in self-driving technology:** both Project Endeavour and D-RISK highlight a significant number of “undecided” participants who have yet to be convinced by self-driving technology. Our work also highlighted the low level of basic knowledge as to how self-driving technologies work, and their potential benefits to individuals and wider society. It is our view that there are significant embedded attitudes and behaviours related to traditional vehicle use which require transformation through extensive behaviour change intervention. Our evidence shows the important role that public trials play in building public knowledge and informing attitudes, but it is not economically feasible to fund extensive trials for the large number of people who are yet to be convinced. Instead, funding should go towards exploring how to create large-scale change through simple and effective behavioural interventions, e.g. knowledge sharing, information distribution, access to VR solutions, and access to simulated experiments and videos. A combination of methods and channels will be needed to meet the learning needs of different groups.

- **Increased engagement with excluded and vulnerable groups:** interest and engagement in public trials and survey methods is often amongst those with access to resources, and with interest in the topic. Future service models must be developed with accessibility for excluded and vulnerable groups in mind. As such, it's critical that future research initiatives - funded research programmes, as well as private sector R&D - focus on including vulnerable groups, particularly the elderly, those with disabilities, and those on low incomes in the design of future technologies and services.
- **Support for additional research on capability and capacity building in local authorities around self-driving technologies and their potential impacts:** local authorities need support to better understand the opportunities autonomous vehicles can offer, and the influence deeper consideration of self-driving can have on wider highways matters. Local authorities should invest in the capabilities and skills to support the transition. This will include understanding how to accommodate superficially simple changes, such as managing kerbside space and design for accessible self-driving rideshare pick-ups/drop-offs, understanding the the needs for V2I and V2X and what this could mean for their street furniture, and better mapping the changes required to the street environment, including 'lining and signing'. More evidence is needed to understand the steps local authorities should go through to accommodate new self-driving technologies.



## BRINGING PEOPLE ON BOARD WITH THE SELF-DRIVING REVOLUTION

Self-driving services have the potential to radically change how we move through our towns and cities. As well as changing our travel habits, they could also significantly shift safety standards, accessibility and even the nature of our relationship with privately-owned vehicles. However, for much of the public, many of the concepts related to self-driving still feel far in the future, and not a technology that could change our travel habits today.

Nevertheless, there are real present day opportunities to shape attitudes and behaviour, and to encourage greater participation in the design and development of self-driving technologies. Projects like Endeavour illustrate the value of real-world trials that enable people to engage with technologies, speak to experts, and learn from seeing and understanding. And when coupled with traditional research methods like surveys and workshops, it is possible to gain a deeper understanding of people's perceptions of self-driving technologies and how individuals appreciate their potential. In the future, the STAi model will provide a useful tool for exploring the key concepts related to safe and trustworthy self-driving technology.

There is a risk of stopping there, at passive research, avoiding deeper engagement with the public with regards to the design and development of new services. However, there is a real need for technology developers, policymakers and academics to encourage participation and engage people from diverse communities to shape the opportunities for use when it comes to technological innovation. To be fit for the 21st Century, services must be designed by and for their users, and have accessibility and inclusion at their core. Only by doing this will we be able to realise the true value and potential of safe, accessible, and trustworthy self-driving services as part of the UK's transport network.



## Contact



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