D-RISK: DEFINING SAFETY FOR SELF-DRIVING VEHICLES
INTRODUCTION

OVERVIEW OF D-RISK

CREATING THE WORLD’S LARGEST LIBRARY OF SELF-DRIVING VEHICLE EDGE-CASES

Self-driving vehicles have the potential to transform the way we move in our towns and cities. As well as improving road-safety, self-driving vehicles provide a unique opportunity to improve service quality and accessibility for citizens, including those with disabilities, and those unable to drive.

In order to develop safe self-driving vehicle technology, we need to develop a deeper understanding of safety: how we define, measure, and experience safety on the roads. We can think of safety as being both objective and subjective. By ‘objective dimension of safety’ we are referring to a self-driving vehicle’s technical performance in different simulated environments, quantifiable and with clear measurable boundaries, while the ‘subjective dimension’ relates to the public’s perception of safety. As well as passing technical safety tests, self-driving vehicles must be trusted by the public in order to get buy-in from potential users and deliver a positive user experience.

For D-RISK, we have been collecting insights from the public to generate a common understanding of safety that includes both subjective and objective approaches, and to understand the minimum safety requirements and assurances needed to build public trust in self-driving technology. This will allow us to calibrate objective safety measurements based on the public’s insights.

This report explores our findings, and describes a path forward for those developing, regulating and ultimately using self-driving vehicles.

WHY COMMUNITY RESEARCH?

Community research is a vital element of the process for developing safe self-driving services. Through community research, it is possible to explore, understand and make use of ideas and opinions that are valuable to developing services that meet the needs of different users.

The D-RISK research programme has put public attitudes and perceptions central to its approach. We have developed a programme of engagement which explores, through a variety of methods, public attitudes to and perceptions and experiences of road safety, and the self-driving vehicle concept.

This study follows on from the first D-RISK report What does the public think of self-driving vehicles? by focusing specifically on perceptions of safety to
better support the development of self-driving vehicles and technologies. It is through this research that we hope to stimulate interest, discussion and debate as to the value and importance of public participation in the design of self-driving technologies.

METHODOLOGY
This study deploys a mixed-methods approach to gain a more rounded picture of the public’s perception of self-driving vehicle safety.

We conducted a quantitative online survey across the UK to collect data from a broad demographic to identify trends, patterns and common themes.

For richer insights into perceptions of safety, we complemented the survey element with a qualitative methodology utilising in-person deliberative workshops. Deliberative workshops are suitable for building consensus on a divisive topic like self-driving vehicle safety. The workshops involve sharing information in phases and giving participants the opportunity to learn more about a topic, consider relevant evidence and discuss this evidence before presenting their view.

ONLINE SURVEY
A survey was distributed online between May and July 2022. After data cleaning, we analysed 651 good quality responses. The survey explored:

- Safety requirements for different scenarios: e.g., urban and rural settings, service-owned vehicles and privately-owned vehicles
- Potential self-driving vehicle driving tests
- Safety assurance and trust
- Safety maintenance.

Deliberative workshops
Six deliberative workshops were conducted between June and July 2022, engaging 43 participants. The workshops explored:

- Perceptions of road safety
- Perceptions of self-driving technology – including potential safety benefits and challenges
- Desired safety features for self-driving vehicles
- Safety assurance and trust.
FINDINGS

Key findings

Willingness to ride differs across urban and rural use-cases, but less so by time of day: less than a fifth (17.6%) believe travelling in a self-driving vehicle in an urban environment, or in a rural environment (15.5%), at night would be safe, whilst daytime travel was rated slightly safer (urban: 24.7%, rural: 22.1%).

ALKS (Automated Lane Keeping Systems) are viewed with some scepticism by the public, with only a quarter (25.2%) looking to use them in the future. Almost three fifths (59.3%) of those we surveyed would not use ALKS technologies if they were made available to them. Less than half (48.7%) do not believe that ALKS will improve road safety, whilst almost a quarter (24.6%) are yet to be convinced. ALKS are within a group of technologies commonly defined as ADAS (advanced driver-assistance system), technologies that serve as a stepping stone to self-driving systems.

Assurance processes such as annual software MOTs and independent software audits were considered to have the potential to significantly enhance trust by respondents: there was broad agreement that assurance processes which were outlined to participants would have positive impacts on perceptions of trust. The highest rated impacts were annual software MOTs (49.8% believed it would have a positive impact) and independent software audits (48.4%), illustrating the importance of assurance processes to the public.

Access to a trained driver and/or safety personnel was the key safety feature for survey respondents and deliberative workshop participants. Our design workshop highlighted the value that participants place on access to a trained individual to be able to provide support in the event of an emergency, and to maintain a comfortable riding environment.

ANALYSIS

In total, the survey received 651 viable responses. A weight variable was calculated and applied to the data set to improve equivalence with the UK population by gender and age.¹ More information about the diversity of respondents can be found in the appendix.

Automated Lane Keeping System

Automated lane keeping systems (ALKS) are one of the major automated systems that is likely to gain wide attention and use in the near future. ALKS technologies have gained considerable attention from regulators and the press in the recent past, and as such are a useful topic through which to

¹ A weighting variable was calculated through a process of raking (or proportional fitting) using the American National Election Study weighting algorithm ANESRAKE. The weights are calculated so that the survey marginals closely match UK population marginals for Gender and Age. More information can be found here: https://web.stanford.edu/group/iriss/cgi-bin/anesrake/resources/RakingDescription.pdf
gauge public interest and attitudes towards autonomous technologies. We explored attitudes and perceptions towards ALKS in our national survey.

**Figure 1: ALKS safety opinion**

Our survey highlighted a generally mixed view of ALKS. Just over a quarter (26.6%) were positive towards ALKS and its role in improving safety, but a majority (48.7%) disagreed and do not see its safety value. Respondents noted concerns about the quality of the computer technology, and perceived risks of failure, for example:

“Computers can fail and the result of this could be fatal. Without multiple backup systems the system is an accident waiting to happen.” Survey respondent.

*And;*

“The computer programmer is the weak link! Would need a failsafe backup.” Survey respondent.

Whilst another highlighted that it will affect the ability of current drivers, making them less aware of what is happening on the road:

“It will just make inattentive drivers even more so.” Survey respondent.

We also gauged trust in ALKS to make safe decisions when in operation (Fig 2).
Finally, we tested attitudes towards using ALKS in the future. Almost three-fifths (59.3%) of respondents would not use ALKS if it were made available to them, whilst a quarter (25.2%) said that they would (Fig 3).

Our data highlighted that, as with other technologies, interest in using ALKS is greater for young people (18-24 year olds, 57.1%; 25-34 year olds, 58.3%).
Differences in ALKS adoption differed across age. Younger groups (18-34) were statistically significantly more likely than older groups (35-75) to adopt ALKS.²

² One way ANOVA was conducted for age groups: F(6, 550) = 10.095, p < 0.01, 18-24 (M = 0.57 SD = 0.502) and 25-34 (M = 0.58 SD = 0.497) compared to older ages, 35-44 (M = 0.27 SD = 0.448), 45-54 (M = 0.32 SD = 0.470), 55-64 (M = 0.26 SD = 0.439), 65-74 (M = 0.18 SD = 0.388), 75+ (M = 0.1 SD = 0.299)
Use-cases for self-driving vehicles vary across contexts and environments. In this study we tested how perceptions of safety differed across rural and urban environments.

We presented participants with a scenario of self-driving vehicle use in which they were driving through a busy urban environment (e.g. town centre) and a second rural environment, including a country road. We then explored interest and perceptions of safety for each environment.

**Figure 5: Interest in using self-driving vehicles, urban versus rural**

<table>
<thead>
<tr>
<th></th>
<th>Rural scenario</th>
<th>Urban scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>11.3%</td>
<td>9.6%</td>
</tr>
<tr>
<td>Unsure</td>
<td>20.30%</td>
<td>25.3%</td>
</tr>
<tr>
<td>Yes</td>
<td>68.4%</td>
<td>65.1%</td>
</tr>
</tbody>
</table>

Base: n(weighted) = 651

Participants in the deliberative workshops highlighted some of the challenges of using a self-driving vehicle in a rural setting:

“It won’t be economical to provide self-driving cars in rural areas. So, this new technology will not be distributed equally” Workshop participant.

“It will only be fine in the Australian outback on straight roads, not in towns in the UK.” Workshop participant

As well as setting, we also explored how time of day affected perceptions of safety. In the online survey we tested whether the respondent would use a self-driving vehicle at 9am or 10pm in either an urban or rural environment (Fig 6).
SAFE SELF-DRIVING: DEFINING SAFETY

There is no single definition of safety in relation to self-driving technology. Previous research by D-Risk highlighted the importance of safety to consumers, and as such we investigated definitions of safety as part of this research.

Through the online survey and deliberative workshop methods we conducted a word-associate task with participants to explore their views of the term “safe self-driving”. The figure below highlights the most frequently cited terms when asked about the definition of safe self-driving:

Figure 7: Safe self-driving word cloud

SAFETY FEATURES AND FUTURE VEHICLE DESIGN

We conducted an exercise with participants in the deliberative workshop to develop safety features that they believed would help them feel safer and more trusting of self-driving technology. Participants sketched and
described key features they would expect to see in a self-driving vehicle. These are outlined below in Figure 8:

Figure 8: User-developed design features

We also asked survey participants to rank potential safety features on a scale of 1 to 10, where 10 was safest, and 1 was least safe (Table 1). The following list shows features ranked from most to least safe.

Table 1: Safety features

<table>
<thead>
<tr>
<th>Rank</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Safety driver (i.e., a human in the driver’s seat who is ready to intervene any time there is a situation that the vehicle is uncomfortable or unfamiliar with).</td>
</tr>
<tr>
<td>2</td>
<td>An emergency button which when pressed causes the vehicle to stop in a safe place for you to exit the vehicle.</td>
</tr>
<tr>
<td>3</td>
<td>A digital screen showing the information the vehicle is processing through cameras and sensors.</td>
</tr>
<tr>
<td>4</td>
<td>A digital screen showing the decisions the vehicle is making (e.g. deciding to slow down if it detects a cyclist passing by).</td>
</tr>
<tr>
<td>5</td>
<td>A digital screen showing the communication between the vehicle and other AVs on the road.</td>
</tr>
<tr>
<td>6</td>
<td>Visible information on the safety of the vehicle - including when software was last tested and updated, and compliance with regulations.</td>
</tr>
</tbody>
</table>
Similar to the survey results, the safety features described in the workshops were split between digital additions to the car and physical attributes within the vehicle. Participants could see the benefit of utilising technology to improve safety in the vehicle. This theme emerged in a number of ways.

**Monitoring and privacy**

Workshop participants felt that using monitoring tools inside the vehicle could prevent theft or misuse. Some wanted their vehicle to open using a fingerprint scanner or facial recognition software, similar to smartphones:

“*I want the vehicle to recognise different passengers that get into the car.*”

Workshop participant.

Other participants went further to suggest they wanted the vehicle to only operate for registered users, so that it could not be used by unauthorised individuals. Finally, one participant suggested self-driving cars could reduce alcohol misuse. They suggested that cars could include AI that monitored users and could prevent illegal vehicle use.

As we explored this topic, we found that participants had mixed views about how their personal data was captured and shared. For example, some recognised the benefit to sharing their personal health information in case of an emergency via an integration with phone-based health applications; or saving video footage of close calls or crash incidents. One participant noted the value of sharing safety profiles of different drivers with insurers.

However, several participants were concerned about the privacy implications of the self-driving car having access to their personal data.

“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.”

Workshop participant.

So, while participants could see the benefits of having monitoring systems and data retained in the car, there are clearly limits to how much they are willing to share and with whom.

**Physical safety features**

In the workshops, participants mentioned physical features they would want to improve the safety of the vehicles. Some mentioned features that are in current cars like “seatbelts” and “airbags”. Others proposed improvements to the vehicle, like self-cleaning properties:

“*Windows that de-ice and self-clean for the user.*”  Workshop participant.

External safety features included airless tyres that adapt to different pressures on the road and integral road cages. Most participants were concerned about the car’s ability to see blind spots, so wanted there to be a 360-degree camera which the user could monitor.

**Child-friendly provisions**
When thinking about road safety, it was evident in the workshops that child safety was a priority for many participants. Some participants felt that one should only be able to use the car if they had a certain type of licence, whereas others were happy to leave their child in the car if they could monitor them somehow, using an onboard camera or a GPS.

“I would like to be able to track the vehicle or have some connection to be able to monitor them.” Workshop participant.

In addition to having a connection to the child, participants wanted a vehicle to have specific safety features that would cater to children. For example, sensors that detect whether there are children in the car.

“Height and airbag that can be adjusted for children.” Workshop participant.

Accessibility needs

Participants at the deliberative workshops could see the accessibility benefits of self-driving cars, for example, they expected larger entrances and ramps for wheelchairs.

“Side opening doors and sliding doors for people with accessibility needs, plus ramps.” Workshop participant.

Some also mentioned the need for a just transition: to make sure that people of all needs could benefit from the new technology. Participants wanted those with accessibility needs to gain privileged access to the self-driving cars either before other people, or for the vehicles to completely cater to them.

Safety of others

While most of the safety features described create benefits for the vehicle’s passengers, some also considered safety for pedestrians and other road users. Participants felt that a benefit of having connected vehicles was that they could share data:

“The ability to communicate with other vehicles and warn them of hazards” Workshop participant.

Sound and visual signals were also important to participants – some wanted electric self-driving vehicles to make a similar sound to petrol vehicles, so that pedestrians would be able to hear them coming, and also highlighted the value of a signal to alert other road users of their presence.

One question raised by workshop participants is how we can emulate driving culture to keep pedestrians safe. For example, one participant noted that road users often use hand gestures or facial expressions to indicate when a pedestrian should pass in front of the vehicle. Participants discussed various solutions to this issue, such as projecting a zebra crossing in front of the car when it is safe to cross, or the potential for a hologram or projection of a driver in the vehicle to make the gestures pedestrians would be used to.

Building trust in self-driving vehicles

Trust is vital, if the public are to both accept and safely use self-driving vehicles. We explored attitudes to trust through the deliberative workshops by first considering trust and safety in the present-day context. A key
emergent theme was the notion of ‘control’, this could be divided through an understanding of transport culture and human decision-making processes.

**Transport culture**

The general consensus from workshop participants was that present-day drivers are impatient and selfish. Generally, participants felt that they feel safe, but they see other people as the problem.

“It’s a bit lawless out there” Workshop participant.

Some mentioned that emotions run high while driving and shared their own experiences of “road rage”:

“People take it personally if you make an error when you’re driving, there is a bad culture where everybody looks after themselves only.” Workshop participant.

One solution raised by participants was to change people’s mindsets so that they are less individualistic and instead see road use as a collective endeavour, e.g. to keep one another safe. However, it was acknowledged that UK roads were quite hard to drive on: while other countries like the USA typically have long straight highways, participants felt that driving in the UK required more concentration and “active driving” because there are fewer warning signs and:

“Big changes occur in a short time period, so it’s split-second decision making.” Workshop participant.

**Human decision-making processes**

Human error was a common issue cited in the deliberative workshops. Many participants noted the issues presented by other drivers, and the ease by which drivers can be distracted:

“Phones, other passengers in the car, eating or drink, even reading road signs.” Workshop participant.

The deliberative workshop process introduced data and information describing the significant proportion of road traffic incidents caused by human error. However, participants showed some reluctance to give up control despite acknowledging that human error contributes to a large proportion of road accidents. Many respondents stated they did not want the car to have ultimate control. Some participants suggested that having some degree of control helps them to feel safe:

“I feel safe when driving as I’m in charge.” Workshop participant.

One participant even recognised that:

“You’re not eliminating human error; you’re just shifting it to other humans like the software developer.” Workshop participant.

**Trust**

In the deliberative workshops, trust was an overarching theme common across location and participant demographics. This emerged in two ways:
*trust in the technology* and *trust in the system*. We explored trust in detail due to its important relationship with perceptions of safety.

**Trust in technology**

The general public feel that they need to have full trust in self-driving technologies before they choose to use them. Several participants brought up the notion of ‘tech maturity’, and suggested that time was needed for the technology to mature to a level where it was safe.

Many questioned whether we could rely on the technology, as in their experience, “computers always break”. Some gave specific examples that highlighted their fears about trusting the technology, for example, the ability of the technology to deal with external issues with the road such as black ice or surface water. Others questioned issues related to software, for example cybersecurity and the risk of hacking, or the ethical implications of AI-based decision making.

**Trust in the system**

A second strand of trust we noted was more macro, and can be described as ‘trust in the system’: the system in which driving a car exists. This includes indemnity, insurance, legalities and assurances. Before participants use a self-driving car, they wanted to know who is responsible should anything go wrong.

“Who takes responsibility if my car crashes? I don’t fancy suing Elon Musk!” Workshop participant.

Some participants stated that they trusted “household names” and brands that they were familiar with, like current car manufacturers such as Ford and Mercedes. While others felt that they could not trust ‘big business’ to be responsible for self-driving cars. One participant used the Volkswagen emissions tests scandal as an example of why large car manufacturers could not be trusted to self-regulate, and another participant described that they would trust a technology manufacturer more than a car brand when it comes to self-driving cars.

“Technology is more important than the car, so I’m more likely to trust a tech brand than a car brand.” Workshop participant.

Deliberative workshop participants stated that they would want Government and industry bodies to provide verification that self-driving services were safe to use and to assign blame or responsibility when something went wrong. Survey respondents were in favour of government agency oversight, with few suggesting insurance companies have a central role (figure 9). One participant at the deliberative workshops highlighted that the motor insurance industry would become obsolete because there will be fewer accidents and responsibility will not rest with the drivers.
Finally, workshop participants built on this general idea of governance and assurance to suggest that a national standard does not go far enough. Instead, a global authority and universal standards were proposed such that self-driving cars can remain functional. Participants discussed how driving cultures differ between countries and that there would need to be consistency so that self-driving cars behave consistently across countries.

“Different regulations in different countries will be difficult. There needs to be a universal standard.” Workshop participant.

**Assurance approaches**

The survey and workshop programme also explored approaches to providing assurance to the public. A third of survey participants stated that a self-driving vehicle test and licence from the DVLA would have no impact on self-driving car safety (Figure 10). Workshop participants had mixed opinions on this. Some felt that a person should only be allowed to access a self-driving car if they have a licence, because it adds an additional degree of safety.

“There needs to be a minimum understanding of what to do if the base infrastructure fails” Workshop participant.

While others felt that a license was unnecessary for the drivers as they do not have any responsibility anymore.
A third of survey participants stated an annual MOT would have a positive impact on self-driving car safety, while a further third stated it would have ‘no impact’. In the workshops, participants felt MOTs should be more regular, either every three or six months. They also suggested that while a MOT checks the mechanical features of a car, more frequent software checks and updates would be needed too, to ensure the onboard computer in the self-driving car is working properly.

**Experience of Safety**

We asked workshop participants how they would like to ‘experience’ assurances such as MOTs and licenses. Some wanted information prior to car purchase, for example, via a link to the website and a handbook. Multiple participants wanted signs inside the car to show that all safety tests had been passed and what date the test had taken place. One participant stated they wanted daily testing and validation of the car to show that it had the latest software update.

“Signs in the car to flag that all the tests have been passed” Workshop participant.

When problems arose, participants wanted to be alerted to the specific problem inside the car, an explanation of the decisions that the car was making to reduce the issue, as well as instructions on how to alleviate these problems manually.

“I want to know if there is sensor damage or issues with the computing system” Workshop participant.
Using virtual reality to test assurance

A theme consistent across workshops was a lack of trust in simulations or virtual reality. Participants felt that the virtual environments would not provide them with the feeling of safety they would need to get into a self-driving car.

At the Imperial College London workshops, our session included time using a virtual reality headset to experience what it was like to be a pedestrian in an area of self-driving cars. The general feedback was that the experience felt too much like a videogame and was not close enough to the real world to make participants feel safe.

Instead, multiple participants felt that a live demonstration would be more compelling. People felt that being able to engage with the new technology and experiencing the physical feeling of being in the vehicle would provide them with reassurance that the self-driving car was safe and trustworthy.

“I want to have that sensory experience, little factors like breaking and feeling a jerk will impact how safe I feel.” Workshop participant.
DEFINING TECHNICAL SAFETY: THE WORK OF CLAYTEX AND DRISK.AI

The D-RISK safety research brings together two important elements of safety: public perceptions and technical definition. In this section, experts from Claytex and d-risk.ai share insights from new research exploring the technical definition of safety, and its importance for developing safe self-driving systems.

To understand the technical definition, it is first important to understand how to measure public road safety. The key measure is \( \frac{\text{fatalities}}{\text{mile} \times \text{year}} \), with the UK experiencing approximately 1700 road deaths per year, corresponding to over 200 million miles per fatality. Globally this is an extremely low result, making UK one of the safest countries in the world to drive in. It is also important to recognize secondary and tertiary metrics: injuries and damage to property, to help understand the severity of disruptions better. Government statistics go as far as considering the accident numbers across hours of the week. By correlating traffic incidents to traffic intensity, the outliers: the Monday morning commute rush, and the Friday night home return are respectively the safest, and the most dangerous times of the week.

There are, however, limitations to how we view road safety – the measures outlined are ‘posterior’ in nature: providing metrics of things that have happened nationwide, which is an uncontrollable environment. This has real consequences in practice – for example, let us imagine we are testing a self-driving vehicle. As that vehicle moves towards an intersection, the level of precision in our understanding of ‘what is safe’ gets diluted, just as with zooming in on a picture. We describe this in statistics as ‘low confidence’.

Eventually, as we run the tests to see if the vehicle is safe enough for public roads, we consider a multitude of parameters, such as specificity of traffic, illumination conditions (brightness, glare), precipitation (intensity, rain/snow), road spray, dust, and many others, to identify specific risk factors. Still, we would have to run thousands of tests for the metrics to be satisfyingly precise. Our analysis deploys a chi-square distribution for estimating probability. The result of this is a safety estimate presented as a statistic:

“We are 90%, sure that under given conditions, the failure frequency is less than 1 in 100,000 occurrences per year”.

1. Defining Prior Metrics

The above metrics are posterior, meaning they describe the traffic system that presently exists. They cannot, however, provide input for the design of Automated Driving Systems (ADS) – detecting them there means it is already too late to achieve safety. For this reason, new, advance, or prior, metrics need to be designed to guide the ADS safety design. Figure 11, overleaf, outlines the architecture in which these metrics can help support the development and deployment of safe systems.
2. Towards a Testing Architecture

The self-driving system safety metrics, however excellent, will not mean much without a structured testing architecture.

Figure 12 illustrates a model of an ADS system of steps and its key components and measurable parameters. In this model the Sensing and Perception layers can be developed through deep industry collaboration, using established mathematical tools. The Actuation layer is more straightforward, as the innovation here is least challenging. The Planning layer, however, is most challenging as advanced statistical methods are required to provide reasonably accurate risk estimates.

Figure 1: An ADS model, related components and measurable parameters.

3. Technical summary

This brief summary highlights the key opportunities and challenges to testing and validating safe self-driving systems. While aviation, nuclear, and maritime industries all demonstrate safe operation is possible in complex systems, the application of automation to the complexity of traffic poses some unique challenges, which require novel solutions. Developing these solutions requires visionary leadership, industry-wide commitment to collaboration and consensus building, cutting-edge mathematical tools, and most importantly, robust approaches to verification & validation.
D-Risk provides a powerful virtual testing platform. In the process, the vast complexity of the self-driving safety domain has been uncovered, enabling us to identify valuable insights, and challenging gaps. The work towards safe self-driving vehicles has only just begun.

4. COMBINING THE TWO STRANDS OF SAFETY: TECHNICAL DEFINITION AND PUBLIC PERCEPTIONS

A novel element of our work is that we are considering the public’s perception of safety when creating the metrics. Perception within this system is key as people will have much more direct interaction with self-driving vehicles than they have with other complex systems and individual perception is not homogeneous across the population.

We will need to define safety which is the absence of unacceptable risks, injury or harm to the health of humans, whether direct or indirect, resulting from damage to equipment or the environment. Specifically, we will calibrate our research findings on which risks the public deems unacceptable with technical data to outline minimum safety requirements for a self-driving vehicle. We will also continue to test the validity of an AV license, answering the questions: If a vehicle has gone through a D-Risk test, is that enough? and: What does assurance for an AV look like?

It is interesting to note that it is impossible to say that AVs will need to be designed to a standard that is safe for all, as individual perceptions don't all match at one end of the spectrum. As an example, there is a too fast and a too slow way of approaching an intersection, we cannot say that the intersection will be approached at 1 km/h. AVs might need to calibrate their behavior depending on who is travelling in them, or what other road users are around them.
DISCUSSION

Our data provides some important findings for the developers of self-driving vehicle technologies, policymakers and the wider public.

Willingness to ride differs across urban and rural use-cases, but less so by time of day: less than a fifth (17.6%) believe travelling in a self-driving vehicle in an urban environment at night would be safe, compared to in a rural environment at the same time of day (15.5%), whilst daytime travel was rated slightly safer (urban: 24.7%, rural: 22.1%). These differences were non-significant, and highlight a general view that travel in a self-driving vehicle is still viewed as generally unsafe by the general public.

ALKS technologies are viewed with some scepticism by the public, with only a quarter (25.2%) looking to use them in the future. Almost three fifths (59.3%) of those we surveyed would not use ALKS technologies if they were made available to them. Less than half (48.7) do not believe that ALKS will improve road safety, whilst almost a quarter (24.6%) are yet to be convinced.

Assurance processes such as annual software MOTs and independent software audits were considered to have the potential to significantly enhance trust by respondents: The highest rated impacts were annual software MOTs (49.8% believed it would have a positive impact) and independent software audits (48.4%), illustrating the importance of assurance processes to the public.

Access to a trained driver and/or safety personnel was the key safety feature for survey respondents and deliberative workshop participants. Out design workshop highlighted the value that participants place on access to a trained individual able to support in the event of an emergency, and to maintain a comfortable riding environment.
CONCLUSION

Safety is commonly cited by researchers, policymakers and industry as a key benefit of self-driving technology. What is less well known is if and how the public perceives its safety benefits, and what safety means within the context of self-driving services. This research highlights the importance the public places on safety, trust, and the more nuanced definitions of safety in different contexts.

What is clear is the extent to which the language of safety includes reference to trust across various important dimensions, including control, surveillance, and data management. It is clear from our deliberative programme that there are steps through which policymakers and industry should go to build trust – including addressing trust in organisations and institutions, providing access to learn about self-driving technologies, and most importantly, much greater emphasis on co-design of services for all user demographics.

Safe self-driving services hold much promise in the eyes of policymakers and industry. Their potential to change the way we move safely through our environment could be transformational if services are designed with communities front and centre. Our study highlights that if this is to become a reality, we must ensure people are engaged at every stage, as without them it’s likely that safer mobility will remain out of reach.
ABOUT THE AUTHORS

DG CITIES
DG Cities is an urban innovation consultancy, specialising in helping clients harness the power of technology and data to transform our towns and cities.

Within the D-RISK project, DG Cities is ensuring that public opinions are heard and shape the development of AV technology. DG Cities has invited the public to share their views on what is ‘appropriate’ behaviour for automated vehicles through online surveys and workshops.

DG Cities also leads on building the public edge case library to ensure that real-life experiences are programmed - and appropriate responses generated - within AV software.

CLAYTEX
Claytex is a consultancy, developer and distributor of modelling and simulation solutions for systems engineering. Claytex is a market leader in sensor-realistic simulations for AVs.

Ed Houghton, Head of Research and Service Design at DG Cities
Ed is a thought leader in systems-thinking, system resilience, and AI in different contexts. He is a mixed-methods researcher who specialises in evidence-based policy and practice development. Ed leads the research and service design practice at DG Cities.

Nitika Raja, Project Manager at DG Cities
Nitika has a background in digital transformation, focusing on user experience. She combines this user-focused approach with her interest in pioneering technology to develop strategies and deliver projects with a positive social impact.
Isobel Madle, Behaviour Scientist at DG Cities

Isobel uses research to develop behaviour change interventions for clients, ranging from reducing fly-tipping behaviour to promoting the up-take of AVs. She has a range of experience applying behavioural science to business and communications problems for private and third sector clients.

Balazs Csuvar, Head of Delivery at DG Cities

Balazs leads the delivery of our innovation projects, solving challenges through the integration of new technologies and holistic thinking. His approach is founded in strategy consultancy with technical expertise in the electric vehicle, connected and autonomous mobility and smart cities sectors.

Marcin Stryszowski, Head of AV Safety at Claytex

Marcin leverages his experiences in nuclear safety, control systems research and automotive management consultancy to develop new methods of testing the level of safety of AVs.
APPENDIX

SURVEY DEMOGRAPHICS

Demographics for unweighted sample, post data cleaning.

Figure 9: Age

Base: n = 651

Figure 10: Sex

Base: n = 651

Figure 11: Ethnicity

Base: n = 651
Figure 12: Disability status

Base: n = 651

TO FIND OUT MORE ABOUT D-RISK VISIT WWW.DRISK-PROJECT.ORG