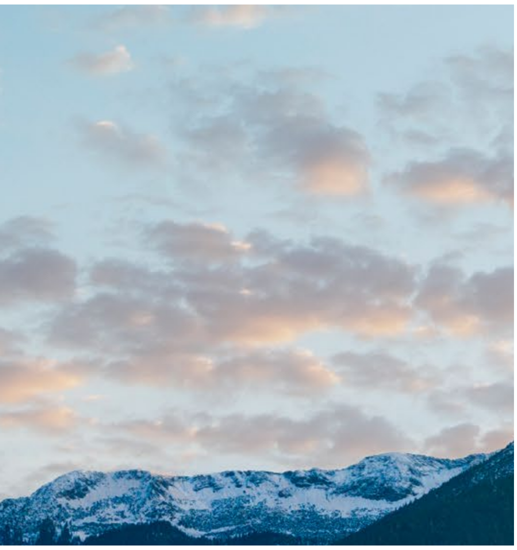
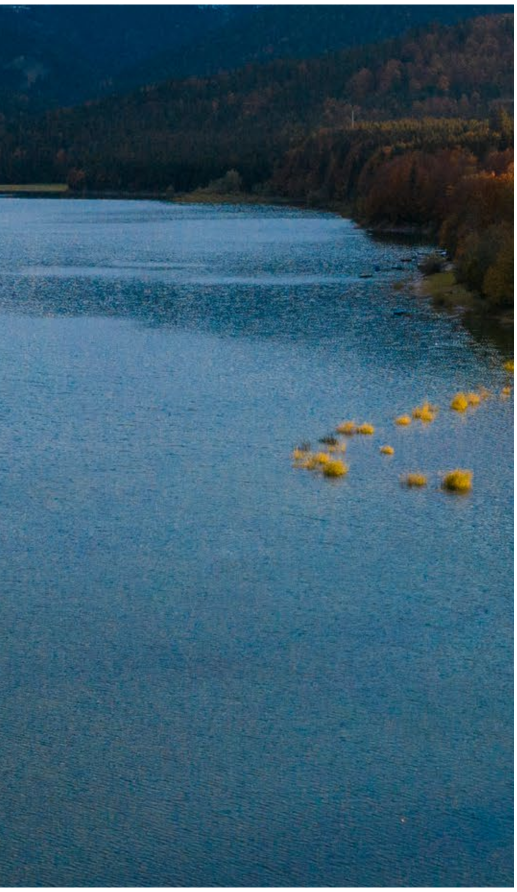
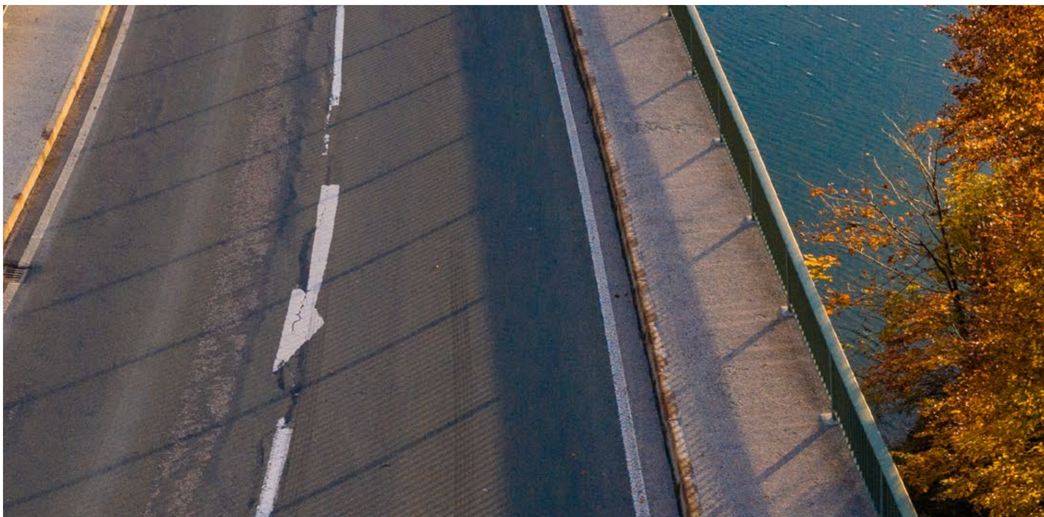




User acceptance in the context of autonomous driving:

What are the key drivers for creating trust and satisfying the need for safety in society?





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Content

1 Introduction

The increasing demand for new mobility is leading to a push by manufacturers to develop solutions for autonomous driving (AD). At the same time, authorities are attempting to create a framework for this disruptive technology via appropriate legislation and infrastructural development. The key question for many is how to advance the mobility revolution further. In addition to reducing environmental pollution through better use of resources, autonomous driving promises to increase overall traffic efficiency. Furthermore, it can create mobility for everyone, improve safety for all traffic participants and counteract the decreasing availability of drivers for logistics or local public transport due to demographic change.

Recent years have shown that, despite technological advances due to the exponential growth in available computing capacity, establishing highly automated and autonomous mobility solutions is complex and protracted. The different levels of automation are defined in the SAE J3016 and range from zero (SAE L0 – no automation) to five (SAE L5 – full automation)[1]. From SAE L4, the term AD is often used as the vehicle is capable of making and executing driving decisions without the need for a driver.

The creation of new standards or the amendment of Germany's Road Traffic Act (StVG) and the associated Autonomous Vehicles Approval and Operation Regulation (AFGBV) are only contributing slightly to an acceleration of development. Currently, there is a high degree of uncertainty among companies, as best practices have yet to be established. In particular, validating and verifying AD systems pose a great challenge due to their non-deterministic properties and associated safety and security risks. High complexity and variances in potential traffic situations and the underlying infrastructure strengthen this effect. By defining an Operational Design Domain (ODD), which relates to the approval of AD systems, an attempt is made to reduce the complexity and transfer the operation into a regulated and predictable framework.

1 SAE International (2021). Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles J3016_202104, 24–32.

Besides the regulatory and technical challenges, the human factor is vital to successfully establishing the technology. User acceptance links strongly to trust and people's need for safety. However, previous studies show that diverse reasons lead to a high level of mistrust towards automated vehicles among the population[2]. Additionally, previous studies reveal different factors explaining variations in trust concerning AD systems.[3] Based on the assumption that the degree of trust and acceptance towards the technology behind AD is elementary to unleashing its full potential, this study investigates the current state of acceptance in the German population. It also examines which factors might have impacted that acceptance, focusing on public transport and shuttle services as they are the most promising first AD use cases.

In the light of this evaluation, we conclude which measures or framework conditions will increase acceptance among the population. Moreover, we investigate the influence of the user group structure and associated factors such as mobility behaviour, technology affinity, age, or social class.

2 Bertelsmann Stiftung (2017). Automatisiertes Fahren: Aktuelle Einstellungen in Deutschland.

3 Hegner, S. M., Beldad, A. D., & Brunswick, G. J. (2019). In automatic we trust: investigating the impact of trust, control, personality characteristics, and extrinsic and intrinsic motivations on the acceptance of autonomous vehicles. International Journal of Human–Computer Interaction, 35(19), 1769-1780. Kaltenhäuser, B., Werdich, K., Dandl, F., & Bogenberger, K. (2020). Market development of autonomous driving in Germany. Transportation Research Part A: Policy and Practice, 132, 882-910.

2 Regulatory complexity in autonomous driving

Designing, developing, and deploying autonomous driving technologies poses both technological and regulatory challenges. These challenges exist because introducing artificial intelligence (AI) in mobility connects to AI-specific challenges, such as the public's understanding and trust of the technology – and legal requirements relating to road traffic regulations. More recently, norms and regulations relating to autonomous driving as a comprehensive technology have emerged. In the following chapter, we look at the regulatory response to AI and AD as they outline the forms and manner of AD technologies entering the market.

2.1 Regulatory framework on artificial intelligence

AI is described as a family of technologies based on methodologies such as machine learning, logic – and knowledge-based approaches, and statistical search and optimisation methods meant to replace human decision-making.[4] Over the last decade, the regulatory debate has touched on many normative questions relating to AI. Researchers and policymakers have emphasised the 'black box' character of AI solutions while raising ethical concerns about safety, data privacy, explainability, and the need for human oversight.[5]

AI's 'black box' character implies that we cannot foresee an AI system's decisions. To ensure reliability, transparency, safety, and robustness, various country-specific initiatives have been initiated (e.g., the EU AI Act[6]) to provide a legal framework for bringing AI solutions into operation.[7]

Another significant aspect revolves around anchoring a right to explainability. Explainability in AI refers to the ability to understand and interpret the decision-making process of an AI system. It provides insights into how the system arrived at a specific output, making it possible to evaluate and ensure fairness, transparency, and accountability in AI applications. Explainability is, by definition, particularly relevant when designing human-machine interfaces, but also for the broader implementation of AI in contexts characterised by human-machine interaction.[8] Besides ongoing regulatory initiatives, standardisation bodies are also working on novel standards to foster a common understanding for implementing and using AI technology while acknowledging open challenges in AI application. For example, in the field of AD, ISO PAS 8800 is an upcoming standard focusing on the safety of AI in road vehicles.[9]

4 Compare Annex I EU AI Act.

5 Floridi, L., Cowls, J., Beltrametti, M., Chatila, R., Chazerand, P., Dignum, V., ... & Vayena, E. (2018). AI4People—an ethical framework for a good AI society: opportunities, risks, principles, and recommendations. Minds and machines, 28, 689-707.

6 Regulation 2021/0106. Regulation of the European Parliament and of the council laying down harmonized rules on Artificial Intelligence. European Parliament, Council of the European Union.

7 Floridi, L., Holweg, M., Taddeo, M., Amaya Silva, J., Mökander, J., & Wen, Y. (2022). CapAI-A Procedure for Conducting Conformity Assessment of AI Systems in Line with the EU Artificial Intelligence Act. Available at SSRN 4064091.

8 Sovrano, F., Sapienza, S., Palmirani, M., & Vitali, F. (2022). Metrics, explainability and the European AI act proposal. J, 5(1), 126-138.

9 Nouri, A., Berger, C., & Törner, F. (2022, August). An Industrial Experience Report about Challenges from Continuous Monitoring, Improvement, and Deployment for Autonomous Driving Features. In 2022 48th Euromicro Conference on Software Engineering and Advanced Applications (SEAA) (pp. 358-365). IEEE.

2.2 Ethics and the need for safety in the context of autonomous driving regulation

The regulatory implications of AD revolve mainly around irreversible consequences, particularly the impact of road traffic accidents on individuals' physical and mental health.[10] As the introduction of autonomous vehicles (AVs) unfolds, the impact on road traffic will be significant. Successful implementation requires a high level of acceptance of the technology by society and not only the users. The German Ethics Code for Automated and Connected Driving of 2017 addresses this point and identifies improving 'safety for all road users' as the main goal of all levels of AD.[11] Moreover, intensive discussions about the implications of changing risk distributions in AD have addressed trajectory planning and resolving dilemmas.[12]

Further AD-related regulatory questions have revolved around potential hacking attacks or technical failures, the exclusion of vulnerable groups, data governance and the autonomy of the human driver. International efforts, such as the UNECE working party on Automated/Autonomous and Connected Vehicles, have focused on creating principles and guidelines to prevent intolerable risks from autonomous driving.[13] At a national level, Germany and, most recently, South Korea established principles that deal with specific questions arising from the general AI debate, including safety issues, data use, and the responsibilities of owners, drivers, and manufacturers of AVs.[14]

2.3 German legislation on autonomous driving

To address safety and ethics, German legislation makes a strict differentiation between SAE L3 and SAE L4.[15] SAE L3 refers to a mixed functioning between human involvement and AD and was addressed by the 2017 Amendment of the Road Traffic Act. While a system's use is not confined to specific use cases or environments, SAE L3 systems require a human driver to take control in obvious circumstances.[16] Therefore, a vital aspect of the law is to ensure a safe handover between the autonomous driving mode and the human driver. In contrast to the 2017 Amendment of the Road Traffic Act, the 2021 German Act on Autonomous Driving concentrates on regulating driverless vehicles SAE L4.

The law regarding AD in Germany reiterates the principles discussed in the German ethics code: it places minimising risk and promoting safety, comfort, and sustainability at the centre of SAE L4 legislation.[17] To reduce the complexity of use cases, the current regulation implies that AVs are operating in clearly demarcated areas and under clearly defined conditions. Use cases discussed are people movers in factories and shuttle buses in public transport.[18]

Hence, the law allows driverless AVs only in specified ODDs. Moreover, it elaborates on the technical requirements of AVs. These include, for example, a software system that can operate without permanent human oversight or an accident mitigation and reduction system that can initiate a 'minimal-risk maneuver' in emergencies.[19] This notion was substantiated by the Autonomous Vehicles Approval and Operation Regulation (AFGBV), which lays out more concrete technical requirements and focuses on the criteria for using AVs in specified ODDs.

10 Luetge, C. (2017). The German ethics code for automated and connected driving. Philosophy & Technology, 30, 547-558.

11 The German Ethics Code for Automated and Connected Driving 2017 Art. 1

12 Geisslinger, M., Poszler, F., Betz, J., Lütge, C., & Lienkamp, M. (2021). Autonomous driving ethics: From trolley problem to ethics of risk. Philosophy & Technology, 34, 1033-1055.

13 UNECE (2020). World forum for harmonization of vehicle regulations. Framework document on automated autonomous vehicles. Retrieved January 31, 2022.

14 Hwang, K. Y., Song, J. I., Kang, M. H., & Im, I. (2020). An Importance Analysis of the Korean Ethical Guideline for Automated Vehicle Using AHP Method. The Journal of The Korea Institute of Intelligent Transport Systems, 19(1), 107-120.

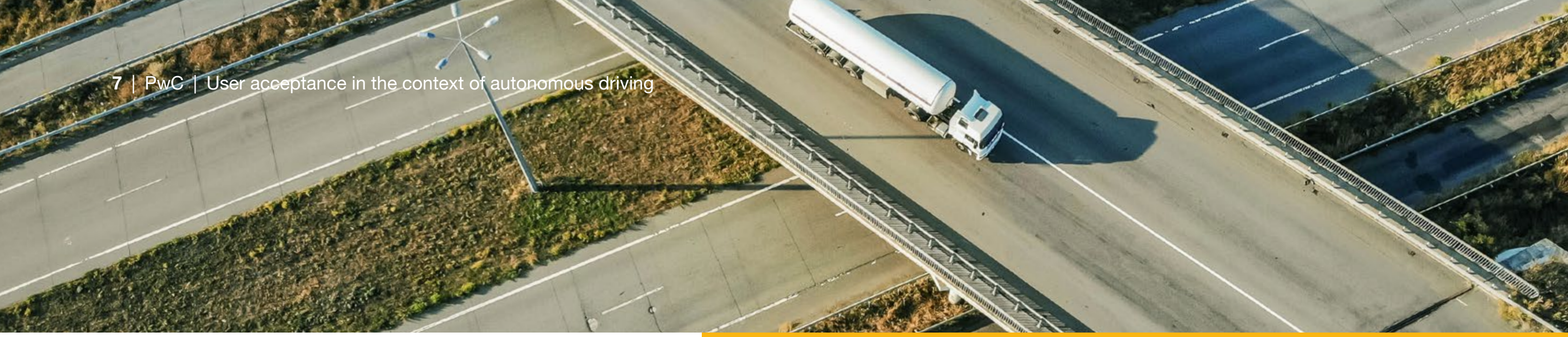
15 SAE International (2021). Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles J3016_202104. 24-32.

16 Compare: "2017 Amendment of the Road Traffic Act."

17 Kriebitz, A., Max, R., & Lütge, C. (2022). The German Act on Autonomous Driving: why ethics still matters. Philosophy & Technology, 35(2), 29.

18 BMVI. (2021). Germany will be the world leader in autonomous driving. Retrieved January 31, 2022.

19 Gesetz zur Änderung des Straßenverkehrsgesetzes und des Pflichtversicherungsgesetzes—Gesetz zum autonomen Fahren. [Act on Autonomous Driving]



For autonomous vehicle (AV) approval under the AFGBV, evidence of suitability between technological implementation and the chosen ODD is a significant precondition (compare § 7 AFGBV). Considering the legal framework, the established requirements and norms have major implications for defining the correct division of labour between legislators, quality assurance and standardisation organisations, manufacturers, and AV operators.

2.4 Regulatory gaps and considerations for autonomous driving

Comparisons between the regulatory debate and Germany's actual legislation reveal that not all aspects and issues accompanying the introduction of AVs in road traffic have been addressed. Manufacturers and operators have many options on what kind of use cases and implementations to concentrate on.

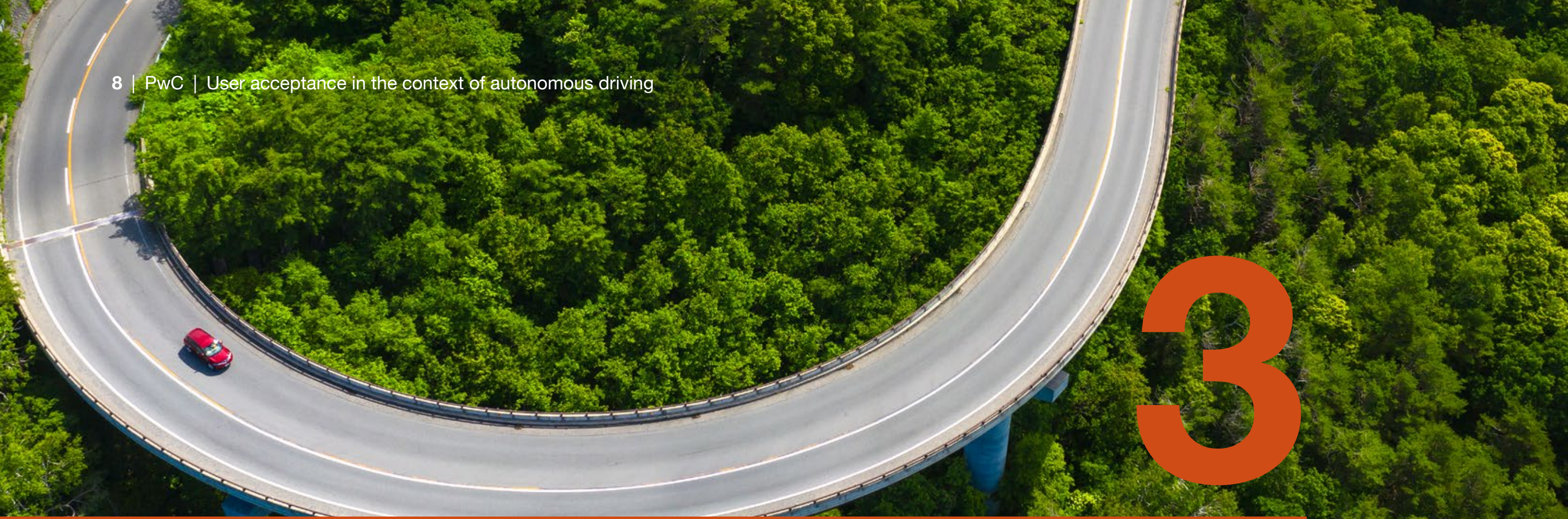
The use cases are generally characterised by aspects where risk is perceived subjectively, e.g., maximum speed or the presence of infrastructure such as school zones or hospitals. So, public and user acceptability is critical for successfully integrating the technology into society.[20] However, although the regulations offer a frame for understanding the potential designs of AVs and how to implement the technology, they do not indicate whether users and bystanders will accept the technology.

In the following chapters, we investigate the topics which the regulatory and safety-related conversations on autonomous driving have explored:

- **Loss of human autonomy:** How open are individuals to utilising shuttle services with or without a safety driver, and how do their answers differ depending on their subgroup and demographic characteristics?
- **General fears:** What worries do individuals associate with autonomous driving technologies in public transportation as users/ members of society?
- **Technology design:** How can such worries be addressed using technological designs?
- **Safety needs:** What kinds of measures would help increase users' trust in AVs?
- **Use case design:** What ODD specifications are generally accepted or not accepted from user/ societal perspectives? What use of AVs would individuals prefer?
- **Division of responsibilities:** Which division of labour between legislators, quality assurance organisations and manufacturers is seen as trustworthy?

In our assessment, we distinguish between preferences for AV use (what do I need when using the technology?) and general societal preferences (how should the technology be implemented even if I do not use it?). This distinction is relevant as AVs' success will depend both on those using it and society's broader acceptance of the technology.

20 Marangunić, N., & Granić, A. (2015). Technology acceptance model: a literature review from 1986 to 2013. Universal access in the information society, 14, 81-95.



3 Deep dive: The results of our survey on autonomous driving systems in Germany

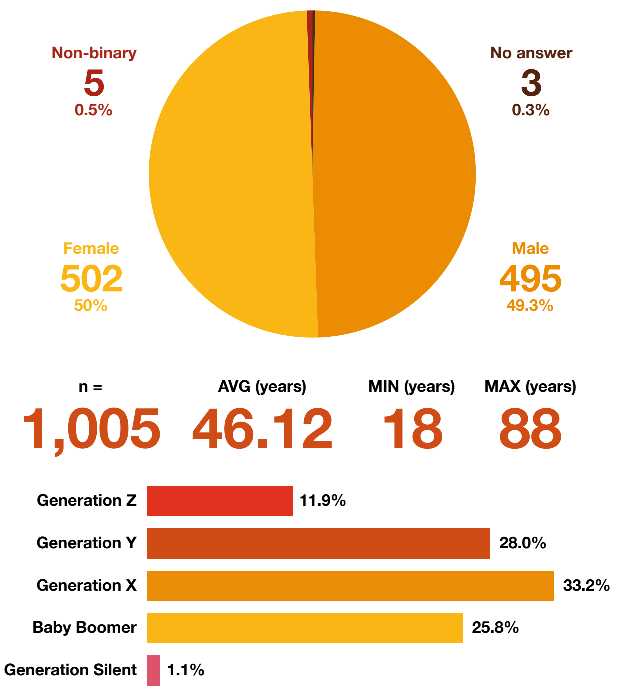
In this section, we present the most important findings of our study, considering the main questions arising from the previous chapters. In the first part, we delve into the methodology and outline the study's potential limitations. We then describe specific findings, evaluate whether they seem surprising, and discuss the possible implications for different stakeholders.

3.1 About the Study

We created the survey questions in December 2022. Our objective was to obtain the most comprehensive view possible of the German population's perceptions and preferences for introducing AD.

We collected the answers from January 13 to January 20, 2023, via a Qualtrics online panel. The sample includes the total population aged 18 years and older. We used age and gender quotas to establish representativeness for Germany.

The sample of the survey results is as follows[21]:



A total of 1,005 people participated in this study. The responses presented are those of the participants and do not necessarily represent the views of PwC Germany. iuvenal research GmbH supported PwC Germany in the study's preparation, implementation, and evaluation.

21 We defined the generations as follows: Generation Z (1997-2010), Generation Y (1981-1996), Generation X (1965-1980), Baby Boomer (1946-1964), Generation Silent (1928-1945).

3.2 Main Findings

During the study, we asked respondents about their attitudes regarding introducing AVs in road traffic. Our goal was to understand what measures companies and public policymakers must take to ensure a mode of implementation that aligns with social expectations. In the following, we present seven key takeaways.

1 A noticeable part of the population has a negative attitude towards AD despite existing trust in the reliability of the technology.

Our results show that, on average, our surveyed population is moderately excited to ride in an AV. However, one-fifth is not excited at all, making the deviation within the studied population very high. The implications for policymakers and companies are clear; addressing this group's opinions will be challenging.

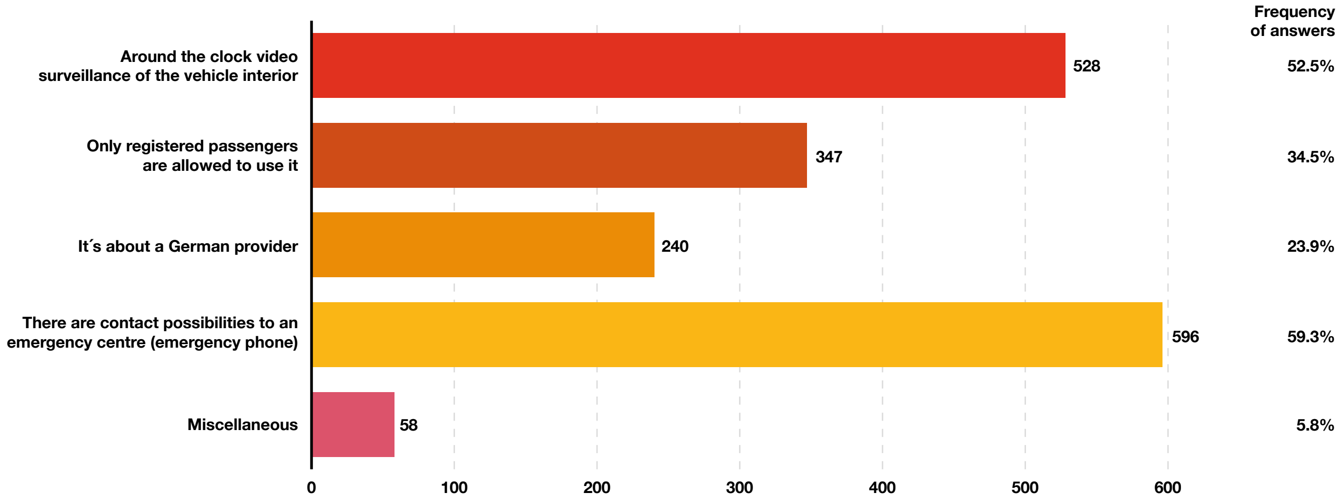
Concerning the reliability of the technology, we highlight that about half of our survey participants showed positive expectations, answering that AD can work reliably. About a third is unsure. Only a smaller part, about 17 %, of our participants showed strong reservations in this regard. This positive result can pave the way for meaningful dialogue influencing the possible acceptance of AVs. In other words, the focus should be on understanding the forces and limitations of AVs so that future users or bystanders can trust their robustness.

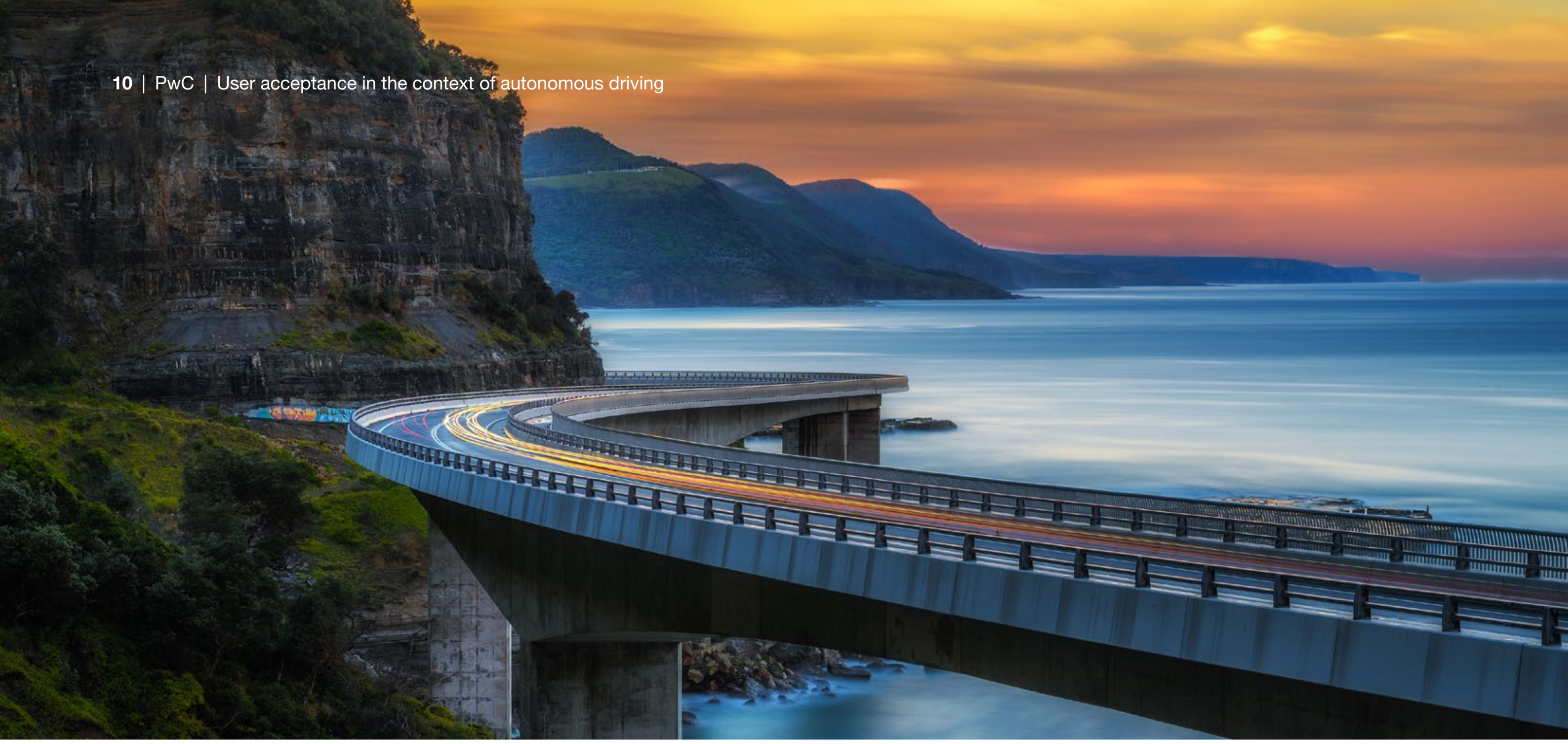
2 We can improve trust through technological advances and better design.

To successfully implement fully autonomous shuttle systems (without safety drivers), we looked at the measures, methods and qualities that could enhance trust in AVs.

The survey shows that most respondents (59.3%) perceive the possibility of connecting to an emergency centre (emergency phone) as a trust-increasing measure. Furthermore, a considerable part (52.5%) welcome video surveillance of the vehicle interior. Such surveillance could be an effective measure against assault or theft by other passengers.

What would increase your confidence in using an autonomous shuttle service without a safety driver?



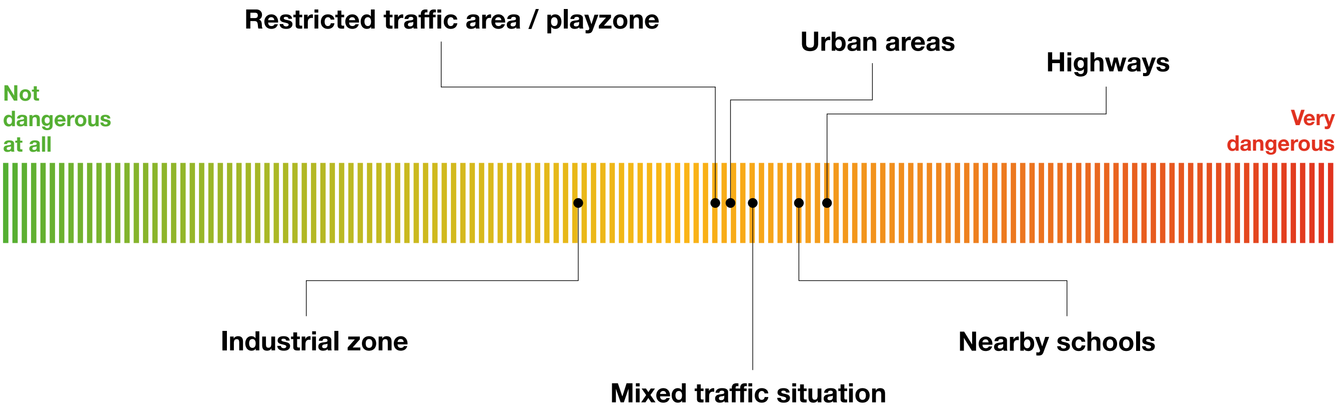


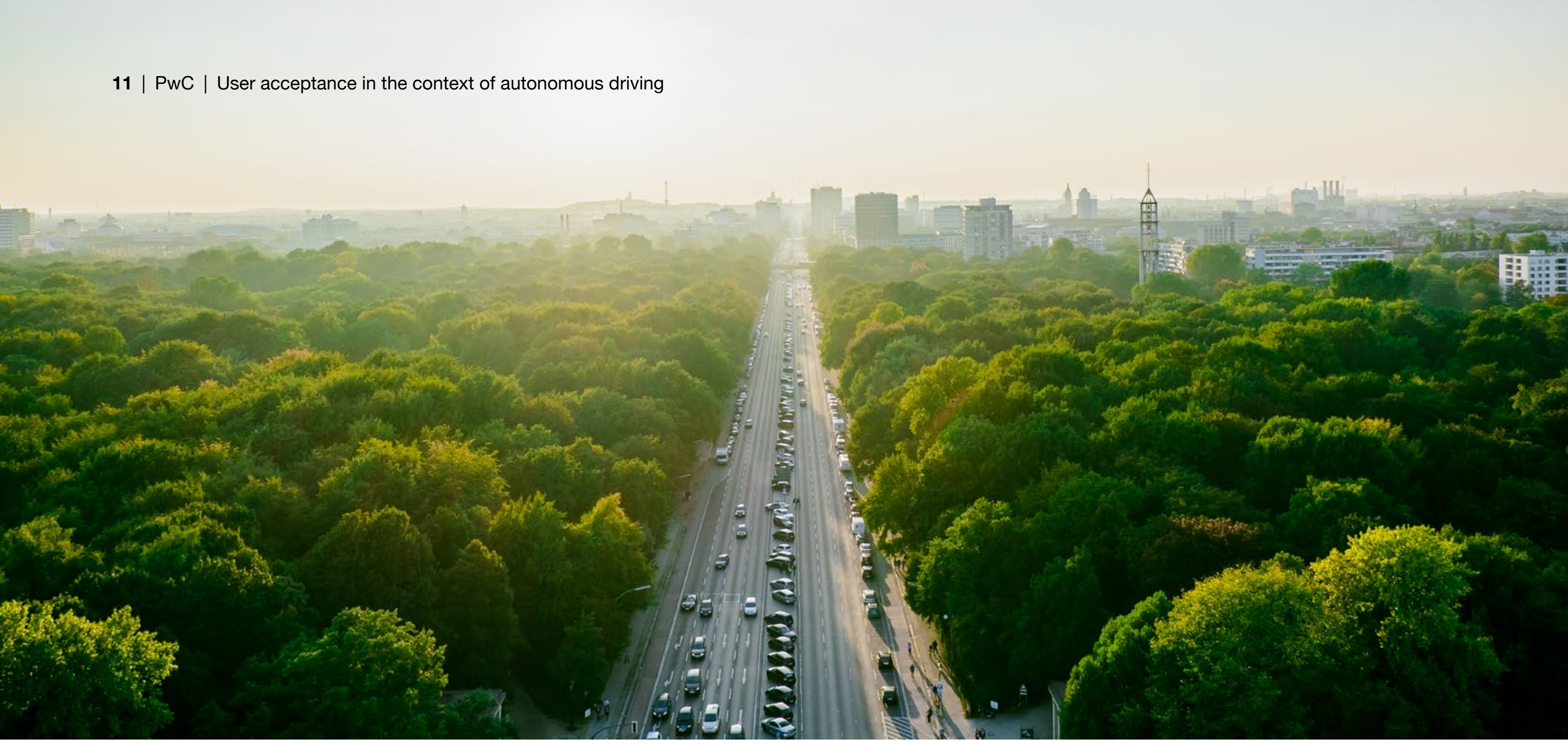
3 Discussions surrounding risk trade-offs are relevant to the population. When planning the implementation of autonomous shuttles in society, policymakers should consider the perceived risks in different urban areas according to their demographics.

We asked the respondents for their thoughts about different applications for autonomous shuttles. The findings reflect the debate surrounding potential ODDs to focus on when rolling out AVs. But they also illustrate which ODDs require further or specific measures to ensure a higher degree of trust.

The survey reveals that factory grounds are considered much less dangerous than areas near schools, for example, or places where people drive at high speeds, such as highways. Highways were rated the most dangerous, although the traffic situation is less complex than in urban areas. Speed limits seem to be a relevant factor for the trusted operations of AVs. 78.1% of the surveyed population stated that AV's maximum speed limit should be 50 km/h. The findings could inform and motivate specific choices when implementing test-sandbox areas for autonomous shuttles.

How do you rate the following areas of application for autonomous shuttles?





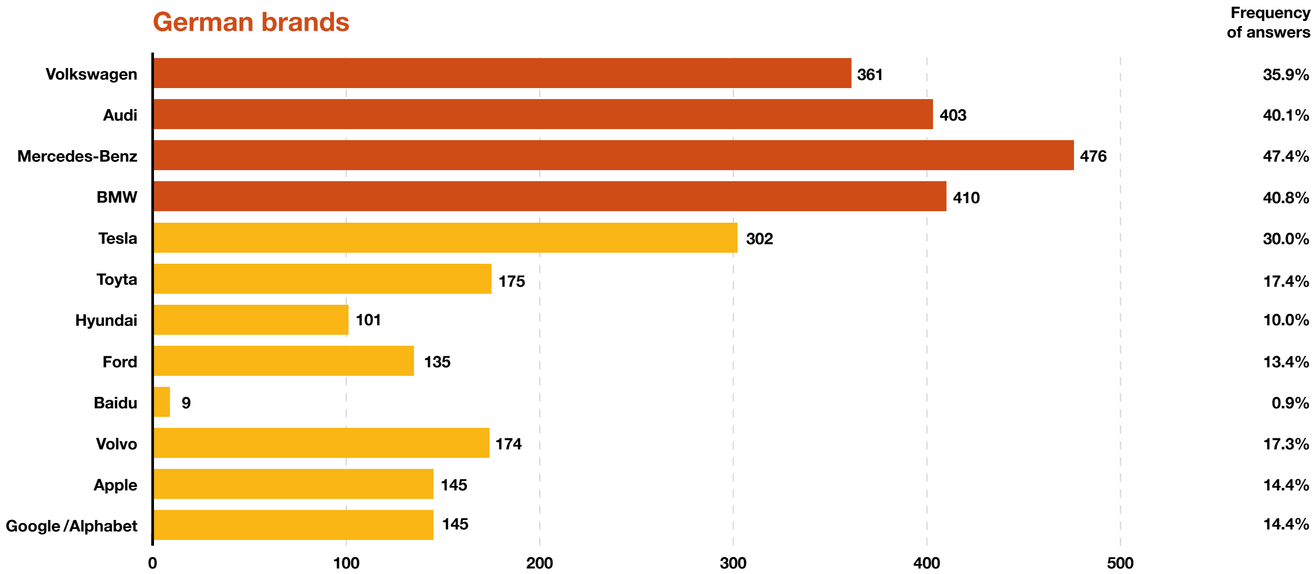
4 The population expects clear benefits from introducing autonomous driving systems in Germany.

Respondents see the benefits of introducing autonomous vehicles in personal financial aspects ranking first. Reducing mobility costs is considered the most convincing argument for introducing AVs in road traffic, with about 38% in agreement. This financial perspective is interesting, as it departs from the original expectations in the regulatory discussions, which have largely revolved around safety aspects. That being said, safety is the second most important factor, with about 29% in agreement. The following three most convincing arguments are reducing greenhouse gas emissions, reducing stress, and the financial benefits for municipalities. These topics, therefore, seem to be the ones to put forward in the future and investigate in more detail to ensure German society accepts the technology.

5 The population trusts technical services (e.g., TÜV) more than public policymakers and companies regarding product safety and quality.

The regulatory discourse mentions how to address safety and ethical concerns in AD. Different actors are involved in defining and developing the standards for AVs, including legislators and technical inspection associations such as TÜV. Our study reveals that respondents trust quality assurance infrastructure or technical inspection associations more than the legal framework. Existing approval authorities – e.g., the Federal Motor Vehicle Transport Authority (KBA) – already require conformity approvals by technical services. Our results prove that technical services bodies' close involvement in the approval process is the right way.

Which of the following brands would you rate as most trustworthy when it comes to autonomous driving?



6 Respondents tend to trust well-known manufacturers more than start-ups.

Trust in the manufacturers of autonomous driving systems is a decisive factor for successfully introducing AVs.

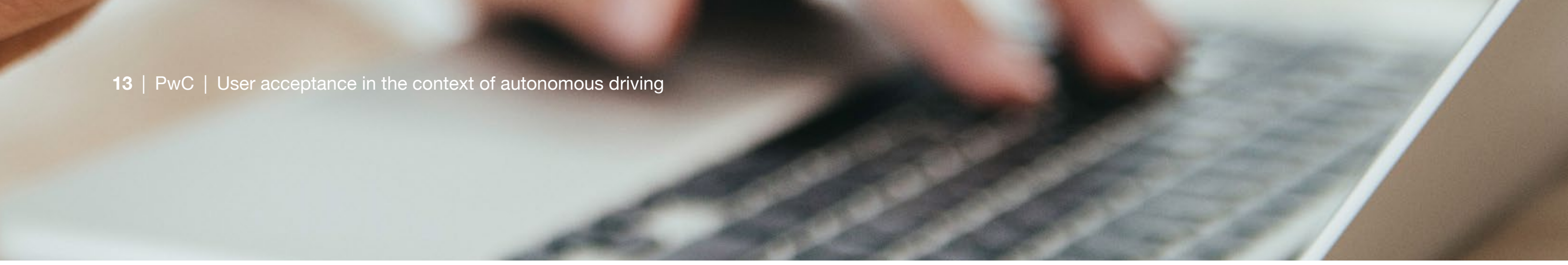
When looking at the study, we observe that well-known domestic manufacturers enjoy a particularly high level of trust in Germany. The respondents appear to have lower trust in American tech companies – and foreign tech companies in general, regarding AD. Chinese companies face the hardest conditions for entering the market.

This finding is emphasised not by looking at the brand itself but at the types of companies able to propose such products. Established German companies are much more likely to be trusted with developing safe autonomous driving systems, with an approval rate of 43%. In contrast, only 10.2% think specialised start-ups can be entrusted with developing such systems. Another finding that aligns with previous responses is the gap between German and non-German car manufacturers. This confirmation strengthens the claim that German car manufacturers have the best chance in the German market for implementing AVs.

7 Trust in humans' abilities is significantly higher than trust in machines' capacities, although most accidents are caused by human error.

One finding observed throughout the study is that the human factor continues to be a critical aspect. This fact becomes evident, for example, in the question of which measures would increase trust in autonomous shuttles.

Measures that would directly involve contact with individuals – such as communication with a central office (50.8%) – or action by humans – such as taking over control of the vehicle in case of emergency, the fallback option for the driver to initiate a breaking maneuver, and the quality testing of the vehicle by experts (55.4%) – are considered significantly more helpful to build trust than, for example, software solutions. Moreover, human supervision of AVs by qualified test institutions ranks higher (47.2%) than technical design aspects (12.8%). Interestingly, the human ability to take back control in an emergency seems to be of the highest importance for our participants, highlighting the relevance of human oversight and overriding the system's design and, thus, of the regulations or soft laws around it.



3.3 Conditional Findings

By clustering the study population according to origin, age, gender, income, mobility behaviour, and experience and technology affinity, new perspectives emerge on the acceptance of autonomous driving and trust in the technology.

1 Age influences the openness towards the technology behind autonomous driving.

The study results show that openness to autonomous driving decreases with age. Reasons for this can be diverse, but it is a contributing factor that younger generations have a higher affinity with technology and easier access to the necessary information.

The survey results underline this effect: the openness to ride in an autonomous shuttle without a safety driver lowers with increasing age. Furthermore, as people get older, they demand the option of intervention to increase their confidence in AVs (Baby Boomer 65%, Gen X 61%, Gen Y 47%, Gen Z 41%), e.g., by having the ability to initiate a braking maneuver at any time. This effect is most strongly influenced by a group of people in the older generation who show no willingness at all to use these new mobility concepts (trend opposer). Hence, measures are required to promote the benefits of AD for this generation, e.g., marketing campaigns or dedicated on-site test offerings.

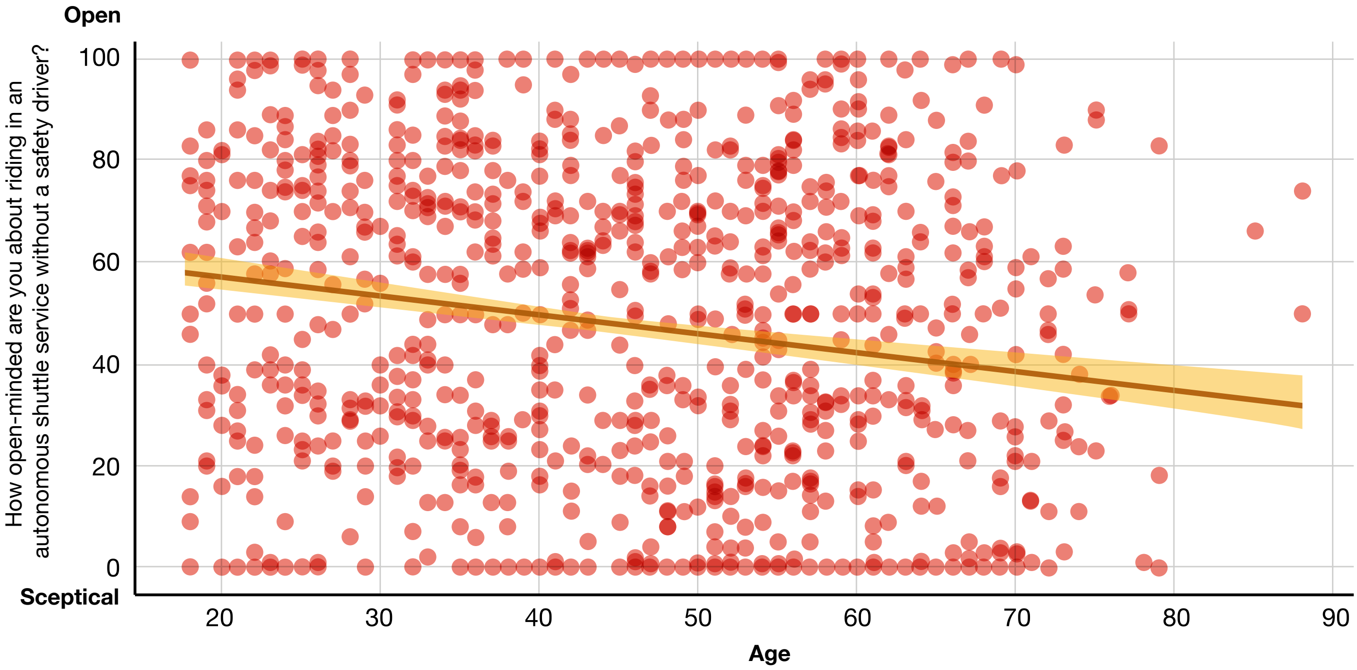
However, there is always a group of people who is neither interested nor convinced.

2 Income and education level are decisive factors in trust in the underlying technology of autonomous vehicles.

We observe that income significantly affects trust in AI as an enabler for autonomous driving. While low-income persons (<45,000€/year) trust a human driver more, trust in AI is markedly higher among middle – (46,000€/year<75,000€/year; $p<0.001$) and high-income (>75,000€/year; $p<0.05$) persons.

A possible reason might be a difference in education level between these groups. While a high income might correlate with higher digital literacy, understanding the technology might increase, eventually enhancing trust. Analysing the trust from another perspective reveals that the education level is a decisive factor. While looking at the group of academic-oriented people, we find they tend to have significantly more trust than those without academic backgrounds. However, although these findings show significant differences between discrete income and education groups, confidence must be increased in all cases for a comprehensive AD roll-out. In this regard, thorough technological education addressing the public appears to be an effective measure to increase overall trust in AI and AD technology.

Attitude towards riding in an autonomous shuttle without safety driver.



3 Residence does not play a role in the perceived impact of autonomous driving.

When analysing the perception of AD according to location, we find no difference in the perception of the overall impact of AD concerning whether people live in rural or urban areas. While public transport is less developed in rural areas and people generally must commute longer distances, it may seem surprising that AD is not perceived as a greater chance for better service and better use of time.

However, since urban drivers are often affected by long commute times due to congestion despite shorter distances, AD can also help increase efficiency, creating a better traffic flow in big cities and thus might be perceived as a chance. In both cases, however, people also perceive autonomous driving as a risk, leading to an indecisive assessment of the overall impact. This implies that existing reservations about the technology need to be addressed by dedicated measures.

4 Experienced accidents strongly influence trust in AI technology.

The results show that involvement in accidents influences trust in AI technology, where 'serious accidents' involve people being harmed or killed and 'small accidents' involve only material or no damage. While trust is comparably low in both cases, no difference in magnitude is observable between small and no accidents. We identified a significant difference ($p < 0.001$) regarding serious accidents; those involved in accidents trust AD and AI around 20 points more on average. The reasons can be diverse, but a significant driver might be the fact that human errors cause around 88% of accidents. People who have already been involved in serious accidents are much more aware of this statistic, thus incorporating it into their decision. Increasing awareness about the negative impact of human decision-making in road traffic could lead to a higher acceptance and society's trust in AD.

5 Mobility behaviour does not affect trust in AD technology.

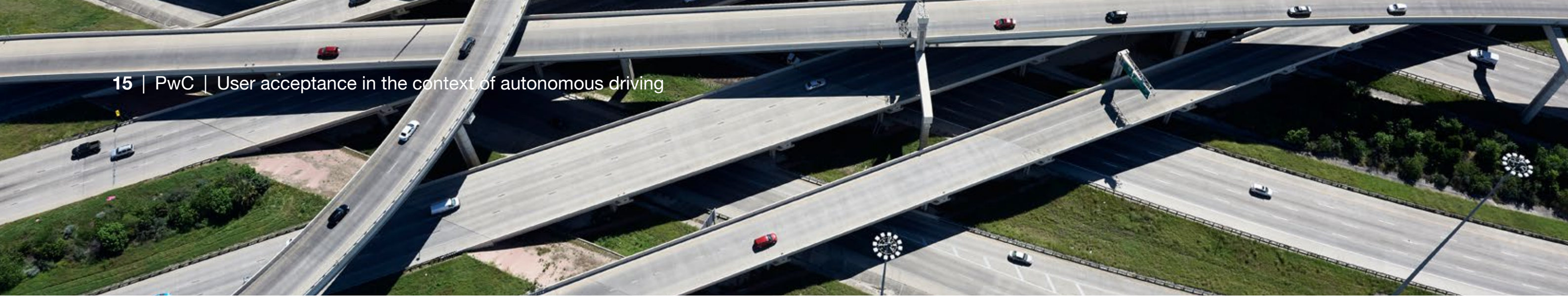
The results of the study show that car use does not affect trust in AI as a decision-maker in traffic. The sample could be biased, as a large part of the German population (27.6%) is concerned about losing the fun of driving, and these people might tend to overestimate their driving abilities. Neglecting this group ends in a minor distribution change, but we found no significant difference between utilisation. This implies that people who use cars regularly can be convinced with similar arguments as those who use cars occasionally.

6 Trust follows an understanding of the technology.

The results reveal a significant relation ($p < 0.001$) between understanding the technology behind autonomous driving, especially AI, and trust. With a better understanding of the technology, trust increases. Although this observation seems obvious at first glance, it is nevertheless remarkable. After all, it is not uncommon for a very good understanding of a technology to lead to people becoming more sceptical about it. The result allows companies, legislators and quality assurers to formulate a clear call to make AD technology more understandable for the general non-tech public.

7 Trust in quality assurance infrastructure influences openness to autonomous vehicles.

We observed that openness to using autonomous vehicles without a safety driver increases significantly ($p < 0.001$) with trust in the quality assurance infrastructure. The reasons for this finding can be diverse, but it generally shows that trust in quality assurance companies normally extends towards new technology trends. We find it concerning that this does not apply here. Thus, an important aspect of promoting safe AD in society appears to be strengthening trust in the quality assurance infrastructure. One idea could be to enhance the credibility of quality assurance institutions through targeted campaigns or political incentives, particularly regarding AD, to increase acceptance and trust among the population. The impact of such measures can be further improved if, for example, by identifying a common cause for mistrust specifically in connection with AD.



8 Technological understanding has an impact on the measures to foster trust.

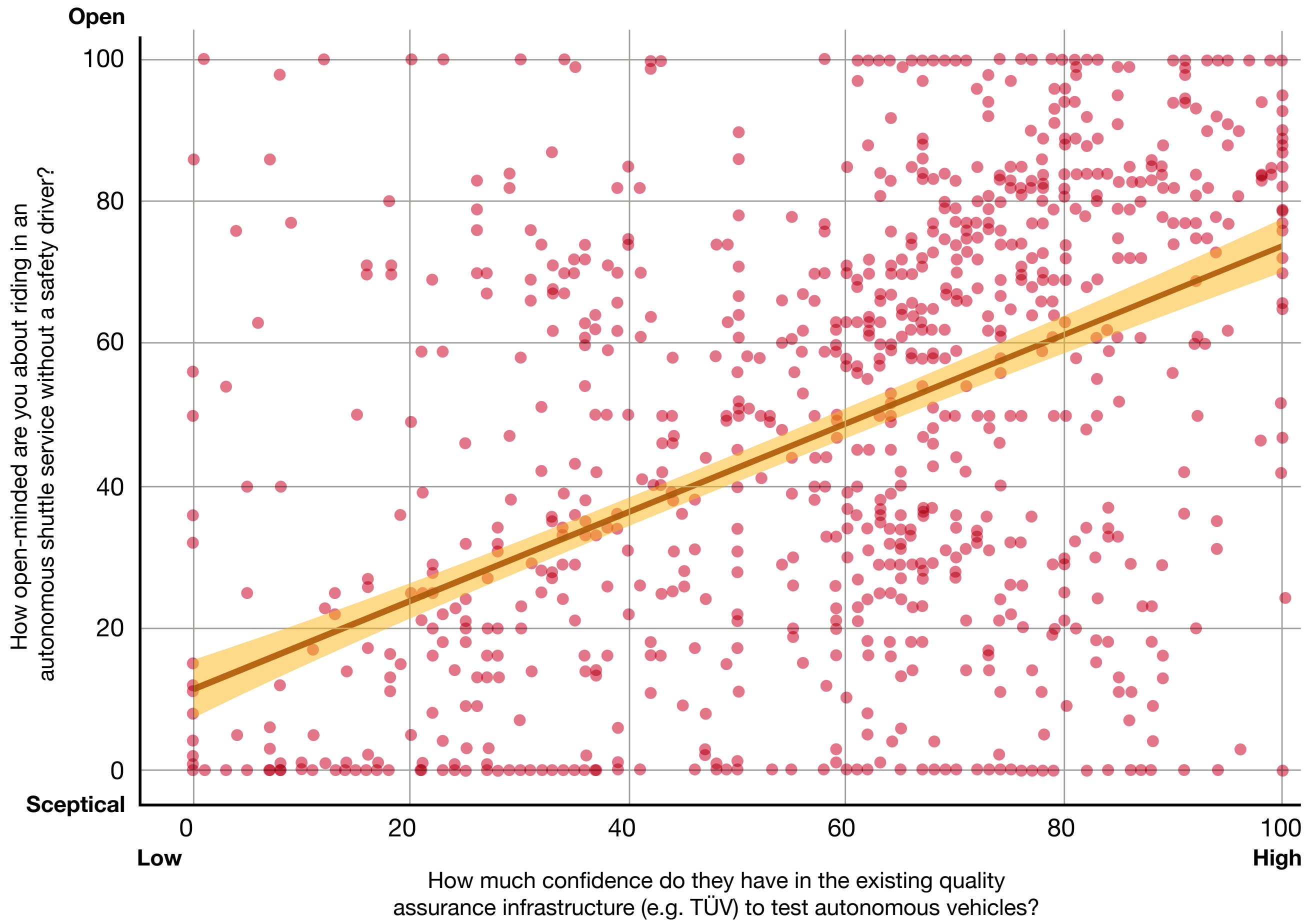
A closer look at technological affinity shows a strong correlation between understanding ADs underlying technology and actions that increase trust. People with lower technological affinity prefer to override AI decisions and take control of the vehicle. On the other hand, those with high technological affinity significantly prefer measures where the underlying technology is thoroughly validated over the ability to override AV decisions.

Interestingly, the only measure where both groups agree is the need for AVs to be regularly quality checked by qualified assessors. It appears that promoting trust in the quality assurance infrastructure is an excellent way to improve faith in AV technology among the general population. That being said, the results show that the two groups should be targeted specifically for their need to build trust in AD.

9 Doubts can be addressed with considerations of decision-making authority.

People who are uncertain about the reliable functioning of AD will play a decisive role in comprehensive technology adoption. It is, therefore, crucial to accurately address the doubts and concerns of this group. The study's results show that uncertain individuals are significantly more likely to say that the ability to intervene in a vehicle's actions increases their confidence in AD. There may be other measures, but the ability to intervene in AD behaviour appears to play an essential role that targeted campaigns can address. These should emphasise that the driver can take decision-making power over the vehicle at any time.

Openness about using autonomous shuttle services in relation to confidence in quality assurance infrastructures.



4 Policy implications

In this chapter, we derive and discuss recommendations for actions based on our findings. We propose to orient ourselves towards the following implications:

1 Gradual introduction and testing

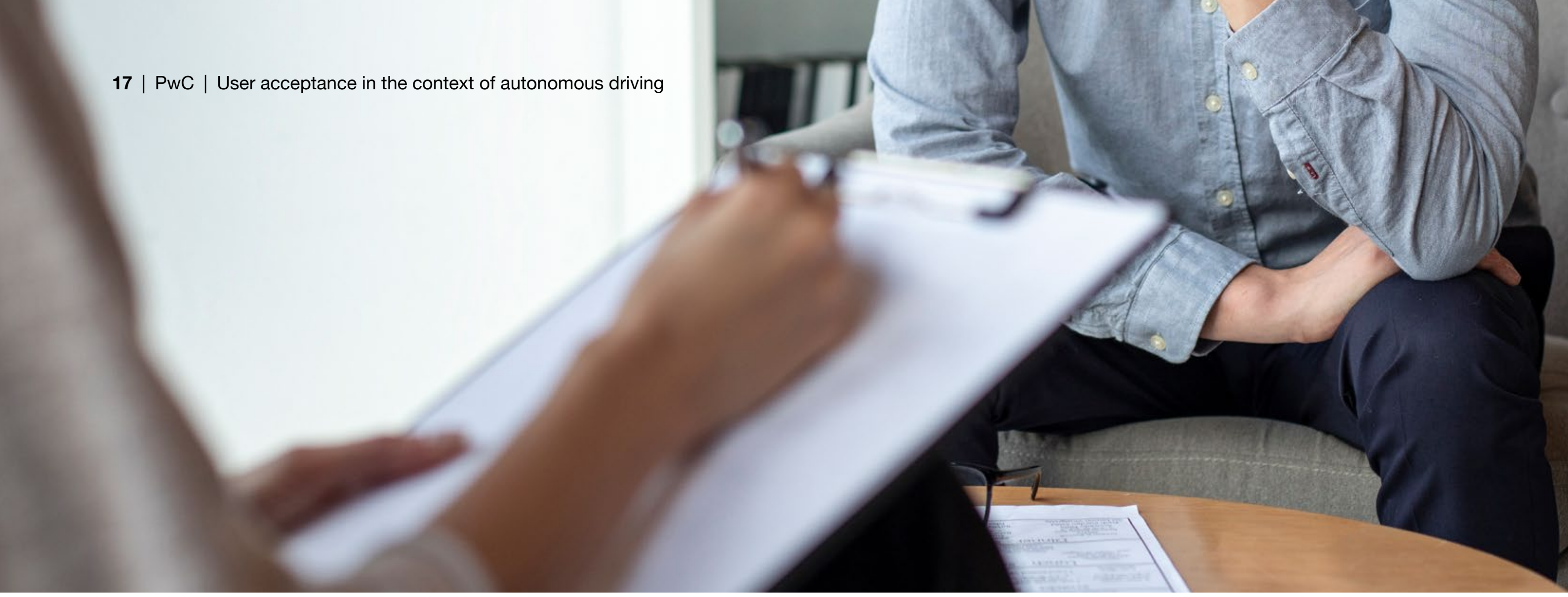
We see that the population could be overwhelmed by directly introducing comprehensive and advanced use cases. We recommend that municipal providers implement systems in a phased manner. Using a safety driver as a first step would be a possible measure. Moreover, we see clearly that potential users and bystanders want to understand the technology better to be able to trust it. As seen in our findings, a considerable number of participants want to test AVs. Such tests, and the implementation of testing areas in general, should consider the population's perception of risk relating to the different locations where AD could be deployed.

2 Transparency

The public must be informed and educated about the technology. Figures and data about past accidents, descriptions of the technology used with its strengths and limitations, and visual and understandable representations of vehicle decisions should be made available to the public. Additionally, fostering an understanding of the underlying technology contributes to trust. With this, trust through understanding and recognising the robustness of a vehicle can be reached. We strongly recommend that companies develop transparent communication measures early and make knowledge of new technologies a mandatory part of education.

3 Regulation

The public expects clear rules for AD systems. Based on our study, we recommend starting deployment in a less complex ODD with low-speed limits and increasing the complexity of traffic situations and vehicle conditions in an iterative process.



4 Certification

The study clearly shows that the public desires certifications by trusted and recognised technical services. In this context, companies and legislators should enter into an early exchange with field experts regarding standardisation and include their input in legislative initiatives. Furthermore, the early involvement of technical services in the approval process is an appropriate means of creating trust. Based on this, a comprehensive ecosystem is required in which all stakeholders (individuals, society, legislators, authorities, technical services, and manufacturers) work hand in hand. In addition, enabling technical services in the context of AD and its framework conditions is a decisive factor for trust, acceptance, and the feeling of safety.

5 Understand people's needs

Firstly, convincing the group of opposers remains very important for providers and regulators. A separate path must be defined for this group by understanding their specific needs and wants regarding accepting this technology. Factors the public has already depicted as necessary must be put forth and built on to develop and maintain enthusiasm and trust in implementing AVs. As our study reveals, these factors mainly relate to financial relief, safety, and convenience through reduced stress.

6 The human factor

The study clearly shows that the human element remains important for many participants. A contact option to an emergency centre in case of problems with shuttle services, human testers for vehicle quality, and overriding the system's power are listed as highly important for trust. Indeed, concerns about safety risks due to a lack of human fallback are greater than concerns due to human error, such as theft or assault by other passengers. Human oversight and override should be considered a high priority.

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