THE | AUTONOMOUS

# CHAPTER EVENT
# SAFETY & SOCIETY

Co-hosted by

McKinsey
& Company

# EXECUTIVE SUMMARY

Mobility will become a more convenient, safer, and cleaner experience. This will not happen 10 or 15 years from now. We are already in the middle of a transition, meaning fewer cars and less individual mobility. The change is not only affecting the players along the autonomous driving value chain but also the society overall and cities in particular.

On **May 19th, 2022**, The Autonomous and McKinsey & Company hosted a virtual Chapter Event on "**Safety & Society**" to explore the impact of self-driving cars on our society and quality of life in urban areas.

The event focused on 3 key themes:

## CUSTOMER ACCEPTANCE

Customer acceptance is one of the biggest drivers of autonomous vehicles adoption. The following topics were discussed:

- How does society see autonomous driving nowadays?
- How will customers receive increasing levels of autonomy, and – most importantly – how can the autonomous driving ecosystem make sure that customers accept the technology change?

## URBAN MOBILITY

Autonomous driving will change how mobility is used in cities and provides alternatives to private cars, likely integrated with public transit. In this session, the panelists answered the following questions:

- What are the implications of autonomous driving on the mobility mix?
- How will autonomous driving re-shape how cities look in the future?

## SUSTAINABILITY

Without regulation, lower price points for individual autonomous mobility modes could increase mobility and thus increase traffic. On the other hand, purpose-built autonomous vehicles for Mobility-as-a-Service offer new ways for players to introduce circular vehicle concepts bearing the higher cost of an end-2-end $CO_2$ neutral vehicle. The speakers discussed the implications of Mobility-as-a-Service using autonomous driving on the environment and how to improve this impact.

The virtual Chapter Event assembled a diverse lineup of speakers – leaders in business & technical roles from world-class organizations such as:

- Viktoriya Kolarova, Research Associate and Project Leader, German Aerospace Center (DLR)
- Joel Franklin, Associate Professor, Director Transport Science, KTH Royal institute of Technology
- Niklas Niemann, Associate Principal Operations & Sustainability – Lead of the Horizontal Sustainability, Volkswagen Consulting
- Florian Petit, Founder of Blickfeld
- Carter Stern, Senior Government Affairs, Cruise
- Jan Tijs Nijssen, Manager Corporate Strategy, Nederlandse Spoorwegen (main passenger railway operator in the Netherlands)
- Johannes Deichmann, Partner at McKinsey & Company
- Kersten Heineke, Partner at McKinsey & Company, Center for Future Mobility in Europe
- Ruth Heuss, Senior Partner at McKinsey & Company

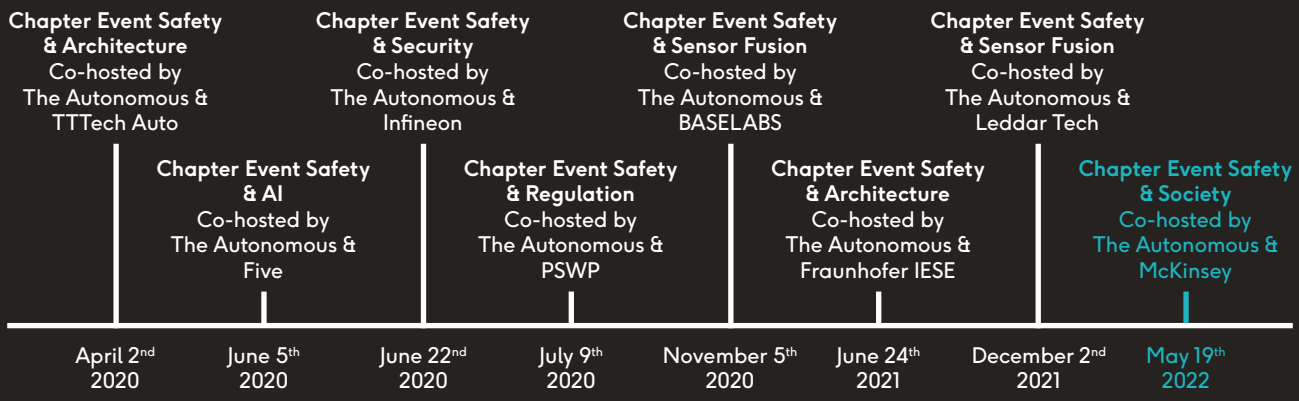
A moderator managed the interaction between the audience and the speakers. The audience participated by submitting numerous questions that were answered live by the presenters and by completing a post-event survey. This report summarizes the presentations, panel discussions, the Q&A sessions, and the results of the post-event survey.

# BACKGROUND AND EVENT DETAILS

For all actors involved in the development of autonomous mobility solutions, who position safety as a fundamental value of their products - The Autonomous is a diverse ecosystem - that generates new knowledge and technological solutions to tackle key safety challenges that shape the future of safe autonomous mobility. Complementary to standardization organizations that establish uniform engineering or technical criteria, methods, and processes, The Autonomous will develop Global Reference Solutions for autonomous mobility that conform to relevant standards and facilitate the adoption of these solutions on a grand scale. The benefits The Autonomous will provide to the partners of the ecosystem are:

- Development of safe and best-in-class AD solutions thanks to the wisdom of the crowd;
- Reduction of potential product liability risk by (i) tightly working with government and regulatory institutions and (ii) developing common basis for regulatory bodies;
- Reduction of development costs by (i) developing modular and reusable Global Reference Solutions and (ii) sharing the development efforts;
- Reduction of potential product liability risk by (i) tightly working with government and regulatory institutions and (ii) developing common basis for regulatory bodies; Development of safe and best-in-class AD solutions thanks to the wisdom of the crowd; Reduction of risk of wrong development by joint definition of state-of-the-art and state-of-practice;
- Accelerating the learning curve by collectively learning from individual failures and field observations

Towards this vision, The Autonomous is hosting a series of events - "The Autonomous Chapter Events" - to facilitate discussions among experts and take the first steps towards the targeted Global Reference Solutions. The Chapter Event titled "Safety & Society" was hosted by The Autonomous on May 19th, 2022, together with McKinsey & Company.




*Summary of all Chapter Events that were organized so far.*

## EVENT DETAILS

120 registrations
44 different companies attended
77 unique views
45 questions asked by the audience

## FEEDBACK

Did the event meet your expectations?

Yes 100% No 0%

How would you rate the event?

4,8/5 ★★★★★

# CHAPTER EVENT REPORT

## CHAPTER EVENT SAFETY & SOCIETY

Edited by
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The Autonomous
August 2022

# CONTENT

# 1 CHAPTER EVENT RECAP

Autonomous mobility will change our lives in many dimensions. While some will be expected and anticipated, others will only evolve and manifest over time. In the following report, we will concentrate on three major changes whose impact can already be spotted on the horizon. These have been discussed in The Autonomous Chapter Event Safety & Society: Society & Customer Acceptance, Urban Mobility and Sustainability/Circularity. The event took place virtually in May 2022.

## 1.1 SOCIETY & CUSTOMER ACCEPTANCE

Looking at the most recent McKinsey ACES consumer survey[1], two factors for driving the adoption of autonomous mobility stand out. First, 64% of respondents point out that (perceived) safety and reliability of autonomous driving must increase. Second, 46% mention that they would need to experience autonomous driving functions themselves before really using them – indicating a clear lack of experience with autonomous vehicle (AV) features. Digging into these aspects a little deeper, it becomes clear that a lack of information mainly causes the perceived safety concern. There are no regularity frameworks or accepted benchmarks measuring the safety of AVs[2]. The lack of experience even starts when buying vehicles with self-driving features. As autonomous driving is mostly realized by software, it cannot be experienced easily, e.g., by going to showrooms and touching things. Instead, it takes specifically trained sales employees who can answer deeply technical questions or even simulators to allow for realistic driving experiences and understanding of the full scope of autonomous driving.

Once these obstacles are overcome, the newly unlocked benefits and opportunities are manifold and huge. From an overarching perspective, they can be grouped in three distinct buckets: ***convenience, quality time*** and ***safety***. Convenience refers to all the benefits achieved by letting the vehicle take on tedious tasks like performing parking in complicated, narrow spots. Quality time refers to the additional time gained by not having to pay attention while driving and being able to do other things. Last, safety refers to the fact that autonomous vehicles are likely to be involved in fewer accidents allowing for, e.g., reduced insurance premiums.

For a vehicle with an L4 Highway Pilot, the monetary equivalent is estimated to account for~400 USD/p.a. for convenience, 2900 USD/p.a. for quality time, and 400 USD/p.a. for safety-related benefits, according to a recent McKinsey study[3]. In the previously mentioned ACES survey, McKinsey also asked what activities customers will most likely pursue while riding in an AV: Performing uninterrupted phone/video calls (30%), browsing the web (25%), or using messaging apps (17%) were the most common answers in this context.

In fact, the increase of quality time was also a common theme in all other talks during the Chapter event. For example, Joel Franklin (Associate Professor, Director Transport Science, KTH Royal institute of Technology) presented his framework of the “negotiated planes”, where six planes (control plane, budget plane, temporal planes, physical plane and carbon plane) determine how the uptake of autonomous driving

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[1] Involving 26k respondents

[2] Autonomous vehicle players tend to publish metrics like “autonomous test miles” or “miles-between-disengagements” – the latter indicating the number of miles between two consecutive disengagements of the autonomous driving functionality requiring an intervention by a human driver. However, due to the different operating domains, and, e.g., triggers causing a disengagement, comparing these numbers is difficult.

[3] Upcoming McKinsey publication “Why autonomous driving is more disruptive than electrification and how the industry can prepare”.

will look like in society. He pointed out that AVs may contribute to extending the "time-space prism" of the budget and temporal plane, allowing each participant to increase theirpossibility to spend time more wisely in AVs. Similarly, Viktoriya Kolarova (Research Associate and Project Leader, German Aerospace Center (DLR)) emphasized the importance of taking the usage contexts into account to understand what the customers desire most, e.g., for commuting, long-distance trips.

**In which ODDdo you expect SAE L4 AD series production vehicles to operate first?** – Share of answers (Percent)

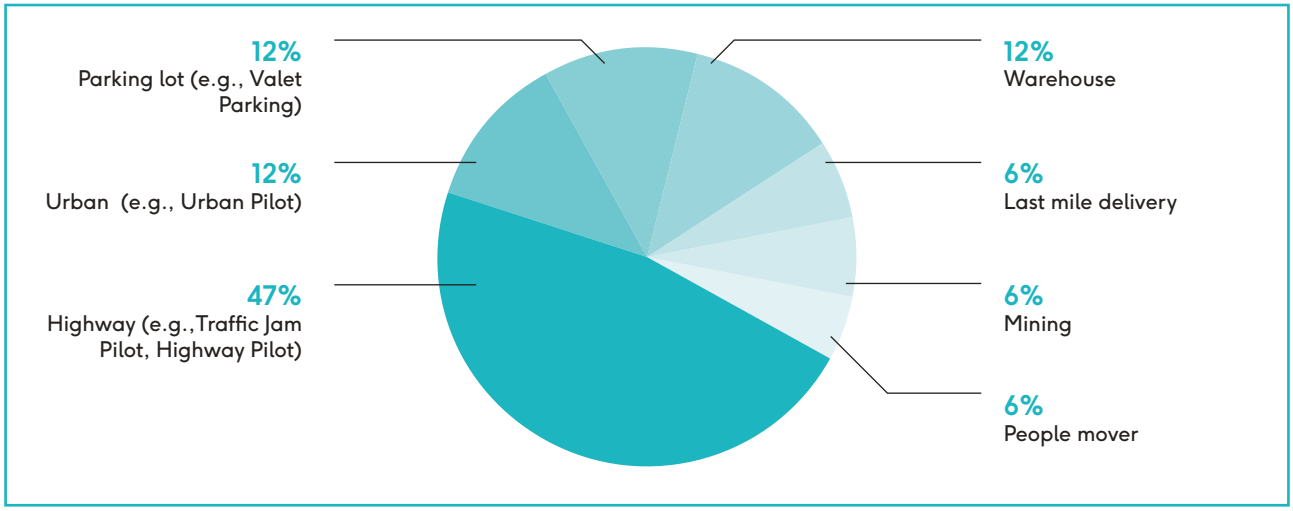


*Figure 1. Most experts see the first use cases for L4 driving on highways. Indeed, with drives being longer on average here, increasing quality time plays a critical role.*

The importance of the usage contexts is also reflected in the survey conducted as part of the Chapter Event. For Figure 1, experts were asked which operational design domains they would consider the first L4 vehicles to operate. By a vast margin, 47% of experts' responses argued for highways to be the most likely domain where autonomous driving willto happen. Automated valet parking and other urban use cases only received 12% of the responses.

**"Highway will be the first use case for L4 because it involves the long monotonous distances, where drivers would like to do something else and for most of us driving is no fun anymore."**

**– Expert survey**

To tackle the question of how the obstacles are overcome, various approaches have been considered. One outstanding project in this context is PAVE – an acronym for "Partners for automated vehicle education". It consists of a diverse group of stakeholders of autonomous driving, including OEMs (Daimler, GM, Toyota, Ford, etc.), tech players (Argo, Waymo, Aurora, Intel, Nvidia), academic and non-profit institutions (AAA, American Public Transit Association) aiming at educating the public, policy makers and the media about the limitations, capabilities and benefits of AVs using educational websites, social media channels, but also hands-on demonstrations at trade fairs, which aims to improve upon the previous obstacle of lacking opportunities to experience this technology. This is also the point where so called "Living Labs" come into play as Viktoriya Kolarova pointed out, a concept that Toyota currently pushes in the Woven city in the Japanese prefecture of Shizuoka, where a smart city prototype is built to study and learn how new technologies get adopted by society.

## 1.2 URBAN MOBILITY

Apart from customer and societal acceptance, the impact of autonomous driving on urban mobility will be significant. This is particularly true when modal mix changes are considered.

All panelists (Jan Tijs Nijssen - Manager Corporate Strategy, Nederlandse Spoorwegen; Carter Stern - Senior Manager Governmental Affairs, Cruise, Kersten Heineke, Partner and co-leader at McKinsey Center for Future Mobility) agreed that there will not be one common development, but rather a diverse set of archetypes to emerge that are determined by various factors like regulatory landscape (parking restrictions, emission zones, congestions zones, license plate restrictions), consumer behavior (eco-friendliness, traditional habits of commuting) and macroeconomic effects (demographic split, GDP effects). For a comprehensive perspective, the McKinsey Center for Future Mobility took on this effort and clustered 1700 metro areas worldwide into 27 archetypes to model the development of the modal mix until 2040.

Jan Tijs Nijssen also stressed the importance of having such a granular view based on archetypes in his talk about the potential roles of a public transport operator in the future autonomous mobility regime. Understanding the local mobility system and its requirements is key to anticipating and foreseeing which roles are played by whom.

Specific insights for this can also be drawn from Figure 2 and the respective answers from the expert survey. 53% of the respondents assume that cities will play a role as mobility doorman and actively manage the fleets and the players, e.g., utilizing dedicated tenders which have already begun to emerge for micromobility modes, for example, in Paris in the summer of 2020.

**What role will cities play in the future mobility game?** – Share of answers (Percent)

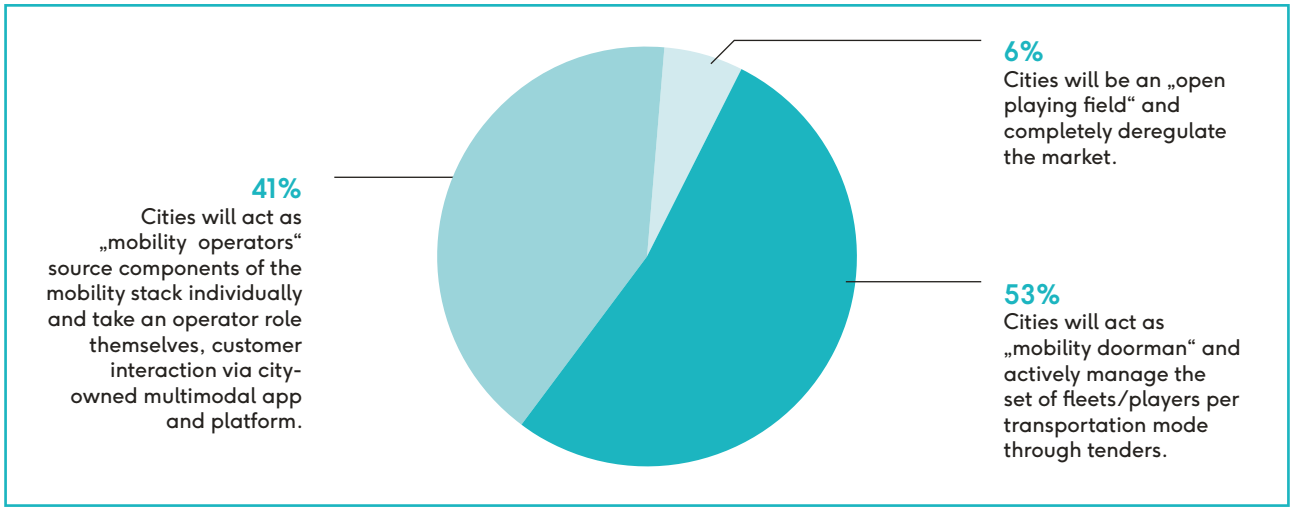


*Figure 2. Role of cities in urban mobility scenarios – most experts foresee a strong active role of cities which will manage the set of fleets/players per transportation mode through tenders.*

Looking at the extremal sides of those 27 archetypes with the different willingness of adoption for autonomous mobility (employing robotaxis and roboshuttles), we find the archetype of “strictly car-reliant cities” (e.g., Marseille) on the low adoption side as well as “metropolis cities” (e.g., Berlin, London) with high openness to new modes.
In an accelerated scenario of the McKinsey Center for Future Mobility model with a focus on Europe (expressing a particularly favorable outcome for autonomous mobility), 11% of all passenger miles travelled (PMT) is estimated to be performed in robotaxis and roboshuttles in car-reliant cities. In contrast, this number may be twice as large (24%) for metropolis cities in 2035.

To enable these new forms of mobility, cities will have to invest in their infrastructure by:

- Providing communication infrastructure (5G and beyond): Autonomous mobility relies on high-speed, high-reliability links, e.g., for remote vehicle control.
- Providing AV maintenance, storage, and charging facilities on the edges of the metro area to ensure high up-times and utilization rates.
- Aligning on strategies for curb space: the need for designated pick-up and drop-off locations, especially for high-density locations, may involve reducing parking space for privately owned vehicles.
- Setting up advanced traffic management and routing systems to optimize the traffic flow and reduce congestion.
- Setting up dedicated AV lanes to improve traffic flow and travel times.

As Carter Stern also pointed out in his talk, once these requirements are met and autonomous robotaxis find their bespoke role in the modal mix of a city, the impact on the previously mentioned dimensions (convenience, quality time, safety) is enormous – in particular with regard to safety, taking into account that 94% of all severe collisions in the US are caused by human error.

To accelerate this breakthrough, different measures along the previously mentioned three levers can be taken:

**Regulatory:**

- Strengthen new mobility modes: Legislation may ban private car ownership, opening up the need for extended autonomous mobility offerings
- Heavy investments in AV mobility players: the government finances autonomous mobility players to manage the switch to a new integrated mobility and public transport approach
- Simplified regulatory landscape: develop a common, e.g., Europe-wide legislative framework for the operation of L4+ vehicles under given operational design domains beyond initial, national endeavors (e.g., Germany's "Act on Automated Driving (Eighth Act amending the Road Traffic Act)")

**Consumer:**

- Increased eco-responsibility: Awareness of climate change and the need to stop it becomes more apparent, causing more and more individuals to abandon their own cars and adopt MaaS offerings.
- Experienced cost/convenience advantages of AV mobility: increased costs of personal ownership (e.g., through taxes, and energy costs) may lead to higher uptakes of MaaS solutions.
- Experienced validated safety records in practice: Transparent benchmarking system is required to provide detailed insights into safety improvements of autonomous mobility in general, but also individual solutions of OEMs & mobility players.

**Technology Levers:**

- AV stack price reduction due to larger economies of scale: Technological advancements lead to a larger decrease in HW/SW costs than previously anticipated, lowering the costs of ownership and operation for the vehicles.
- Massive technology improvements, incl. covered ODDs and mapping efforts: Breakthroughs in the enabling AI and ML models, as well as sensors (LiDAR, RADAR) allow a faster and broader rollout of autonomous mobility.

**What role will current mobility provider (Uber, Lyft, FreeNow, etc.) play in the future?** – Share of answers (Percent)

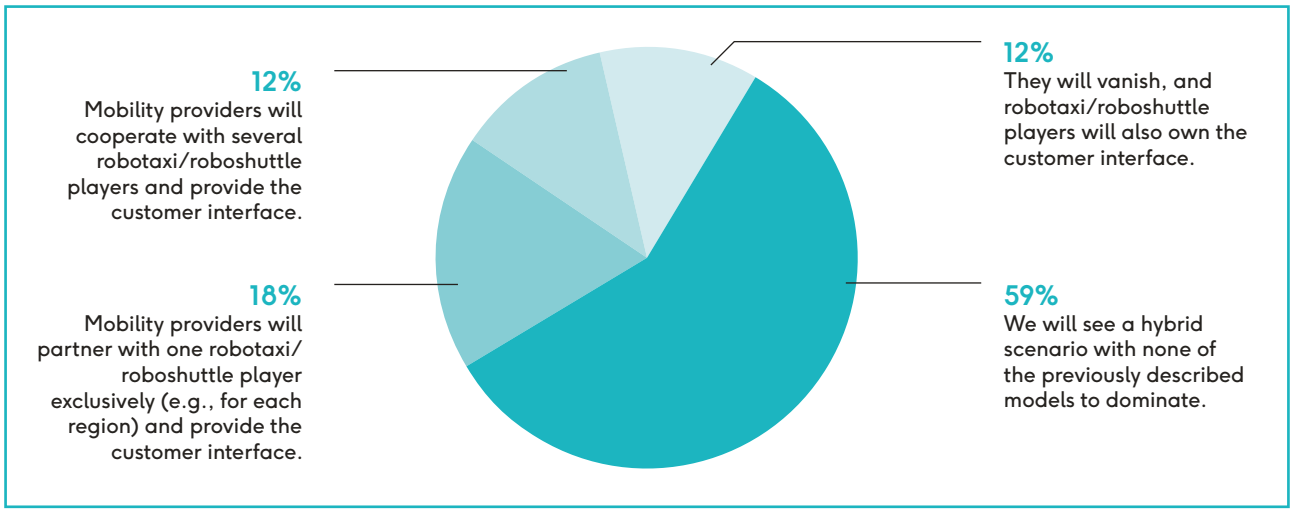


*Figure 3. Experts do not expect one dominating business model for the mobility operators in the future, but rather a diverse one that is tailored to the individual setting.*

Eventually, having these levers available, a natural next question is how and by which players in the current mobility landscape these are being brought into action in the future. In Figure 3, the expert survey shows that 60% of the respondents see a diverse set of possible setups rather than only one particular business model to strive for. For example, some regions may encounter an exclusive partnership of a mobility provider (owning the customer interface) with a single robotaxi player. At the same time, partnerships with various robotaxi players will turn out most prevalent or even scenarios where the robotaxi players own entirely the customer interface may emerge.

## 1.3 SUSTAINABILITY

With ESG topics gaining more and more momentum in everybody's attention, including capital markets, the impact of autonomous mobility on sustainability is also central. Autonomous mobility can be a major contributor to the net-zero transition as it uses electric vehicles – a notion that was first pointed out by Carter Stern in his presentation about Cruise, the robotaxi operator launching its first operations, but also shared by all other panelists of the sustainability session, including Florian Petit from Blickfeld and Niklas Niemann from VW Consulting.

Apart from the transition to electric vehicles, Florian Petit also pointed out that smart infrastructure and ubiquitous connectivity are additional key enablers for enabling this approach. As a joint study with the Ingolstadt University of Technology (THI) showed, 20% of fuel can be saved with foresighted driving – an ambition that is much easier to achieve if it is executed by an autonomous car rather than by a human individual.

**What are the most critical points from an ESG perspective concerning autonomous vehicles?**

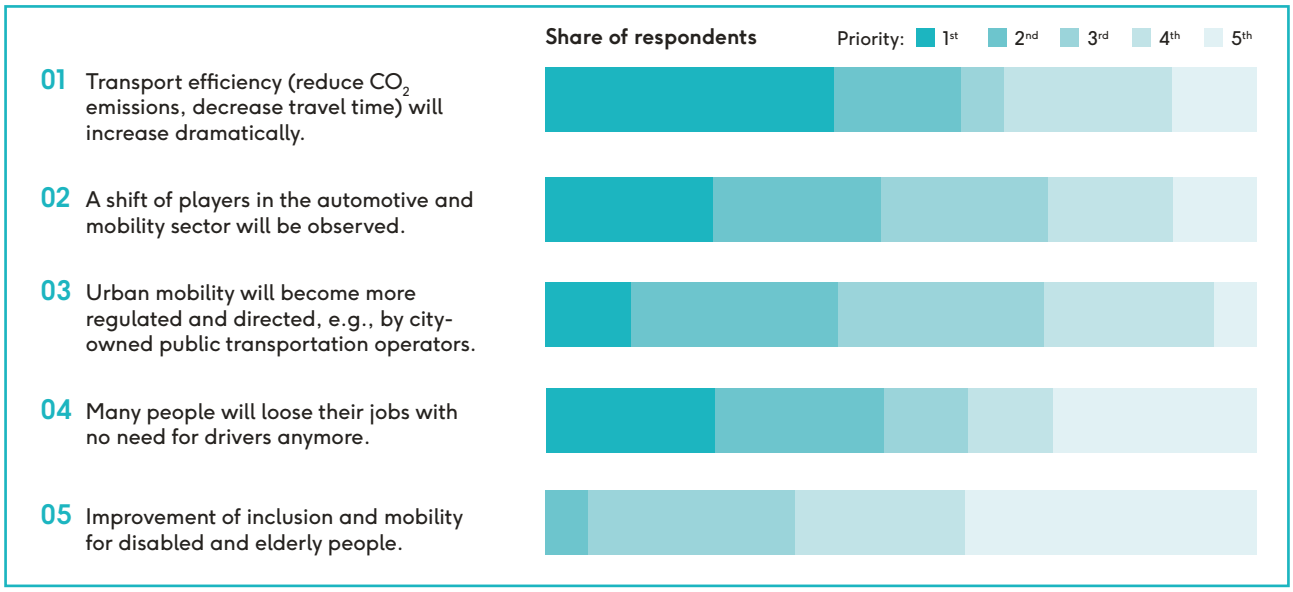


*Figure 4. Experts consider the increase of transport efficiency (reducing $CO_2$ emissions, decreasing travel time) as the most crucial point from an ESG perspective.*

These aspects are also well reflected in Figure 4, showing the factors in the environmental, societal, and governmental domains that are considered most important by the expert survey. As for the panelists, increasing overall transport efficiency (reduced $CO_2$ emissions, improved travel times by various route optimization techniques) stands out by a far margin. Additionally, a shift of the current players and the extent of involvement will change as well (see also Figures 2 and 3). On the societal side, experts mention the potential negative impact on the job situation (e.g., for bus and taxi drivers) as well as improved mobility options for disabled and elderly people.

Looking on the first point of transport efficiency and the reduced carbon footprint a little closer, an analysis by McKinsey (also presented by Niklas Niemann in his talk as part of the previous work for the CEO Alliance for Europe's Recovery, Reform and Resilience) showed that current BEV based robotaxis have a $CO_2$ footprint of 27g per passenger mile traveled, which already improves upon a private Diesel vehicle (204g $CO_2$/PMT) or private BEV vehicle (35g $CO_2$/PMT).

However, as it turns out, robotaxis designed with a focus on circularity will be able to reduce this amount further to 6g $CO_2$/PMT by three specific improvement levers:

- Design: The design of the vehicle can be improved such that longer vehicle lifetime mileages become possible
- Supply chain: a 43% reduction of 27g $CO_2$/PMT can be gained by purposely using "green" components, i.e., selectively adjusting sourcing decisions towards components and suppliers known to have a better carbon footprint.
- 2nd life/recycling: last but not least, circular robotaxi/roboshuttles provide the unique opportunity to control the entire lifecycle by one central entity, e.g., the mobility platform operator or the OEM. As a result, after reaching the end of life of the robotaxi, materials can be recycled in a controlled fashion, whereas private cars often tend to be sold to developing countries where no advanced recycling approaches exist yet in the required extent.

**"Robotaxis and especially roboshuttles can be another ingredient to optimize the city's low emissions and increase city mobility."**

**– Johannes Deichmann, Partner at McKinsey & Company**

# 2 | APPENDIX

## A. SURVEY QUESTIONS & RESULTS

Due to rounding, percentages may not always appear to add up to 100%.

## B. ACKNOWLEDGEMENTS

First and foremost, sincere thanks to all keynote speakers, namely Viktoriya Kolarova, Joel Franklin, Niklas Niemann, Florian Petit, Carter Stern, Jan Tijs Nijssen, Johannes Deichmann, Kersten Heineke, and Ruth Heuss. Their constant support and in-depth knowledge resulted in outstanding presentations and discussions.

Furthermore, profound gratitude to all the participants at the virtual Chapter Event as well. Their questions enriched and deepened the discussions. Special thanks also go to the contributors of the post-event survey who enhanced the quality of discussions and ultimately of this report. Sincere thanks to McKinsey & Company for co-hosting this event with The Autonomous. It has been a pleasure working with you on this project.

## C. FEEDBACK

In our continuous effort to develop The Autonomous as an open platform and space for dialogue among different stakeholders, we welcome all feedback and interest in making safe autonomous mobility a reality. We highly value any comments, ideas, or suggestions you may have to help improve the outcome of this report or contribute to the initiative.

Please do not hesitate to contact us at: contact@the-autonomous.com.


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