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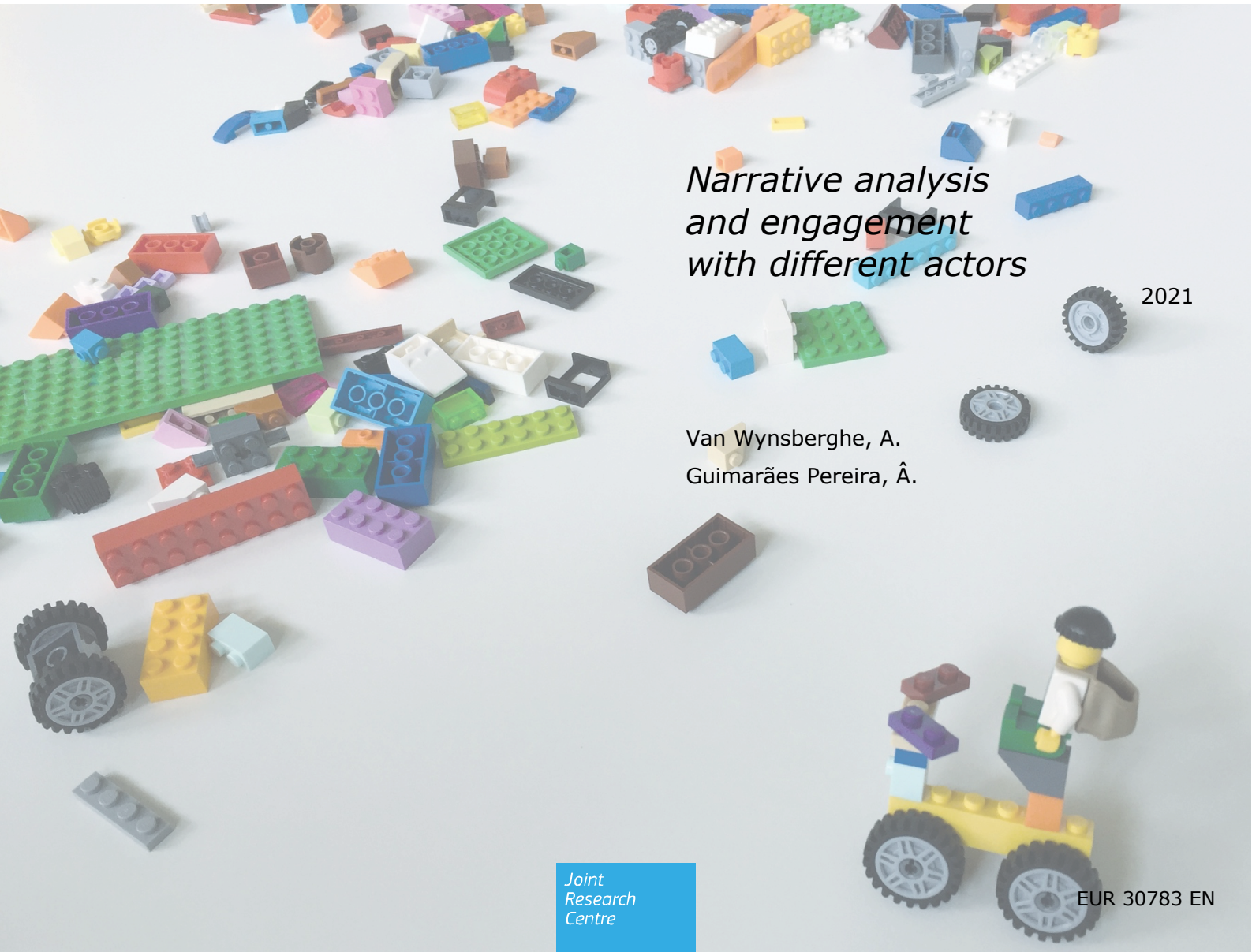
JRC TECHNICAL REPORT

Mobility Imaginaries: The Social & Ethical Issues of Connected and Automated Vehicles



Narrative analysis and engagement with different actors

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We would like to thank all interviewees who gave of their time to contribute to the discussions. We sincerely hope, we have reported with accuracy your insights about the currently proposed mobilities and technologies and your alternative suggestions about those.

The authors also are thankful to Maria Alonso Raposo for her thorough review of the report.

Abstract

This report summarises key findings and recommendations arising from narrative analysis of policy and industry proposals in the field of connected and automated vehicles, based on a hybrid methodology of 'discourse analysis' and a number of in-depth interviews conducted by the JRC concerning the future of mobility and in particular the issue of connected and automated vehicles. The central document examined was COM (2018) 283: *Road to automated mobility: An EU strategy for mobility* (European Commission, 2018).

This hybrid methodology was a first step towards critically reviewing the mobility futures presented in the Communication by making visible their underpinning political and social narratives. The work was then complemented by extending the review to citizens (see sister report: Van Wynsberghe & Guimarães Pereira, 2021) through a participatory journey in few EU countries.

This work was carried out under the framing of the NewHoRRIzon project (newhorrizon.eu), funded by the EU Framework Programme for Research and Innovation, Horizon 2020, which explores Responsible Research and Innovation (RRI) inspired governance modalities through a number of Social Lab experiments[1]. The project was coordinated by the Institute for Advanced Studies in Vienna (IHS). In September 2018, the JRC became part of the Social Lab experiments as a follow-up of a RRI Social Lab co-organised with IHS. As a concrete outcome of this partnership, the JRC conducted a pilot project on the topic of the future of mobility and the place of Connected and Automated Vehicles (CAVs) in current EU mobility visions enshrined in policy documents, such as COM 283 (2018). The pilot on 'CAVs and the Future of Mobility' assesses the potential implications and societal expectations of CAVs and explores various mobility narratives, ethical considerations, expectations and matters of concern toward this new type of mobility. The pilot has been providing the JRC with the opportunity to investigate whether a more persistent and broader RRI approach (Engagement, Ethics and Governance) could deliver more comprehensive knowledge to sustain policy design. This report illustrates the application of narrative analysis, as well as in-depth interviews with stakeholders, to address the social and ethical issues of CAVs, especially focusing on level 5 automation (www.sae.org). The document reports how various stakeholders and professionals in the field are questioning the mobility imaginary involving CAVs that the industries are promoting and investing in. Namely, they point out that there might be a rightful place for automated and connected mobility technologies, but that the emphasis put on the technology is not addressing mobility issues comprehensively. The imaginary of CAVs narratives place a lot of emphasis on the driver, while also not situating where CAVs are necessary and useful. Indeed, narratives and interviews seem to indicate that current policy making is problematically suggesting that technology will fix the broader economic and social contexts that have been shaping current mobility modalities in the EU. The challenges to the industry's imaginations of mobility identified through narrative analysis and interviews have led us to investigate alternative imaginaries of mobility and cities with

[1] A Social Lab is a container of social experiments for addressing complex ground-breaking social challenges on a systemic level. In the NewHoRRIzon project these are social challenges related to Responsible Research and Innovation (RRI) within the frame of Horizon 2020 (H2020) and beyond (Framework Programme 9 and national R&I funding programmes). (in newhorrizon.eu)

citizens through a number of participatory events, focusing on their matters of concern (see Van Wynsberghe & Guimarães Pereira, 2021). The CAVs technology has been an opportunity and prompt to re-imagine plausibility and desirability of different futures.

1. Introduction

The work described in this report[2] is part of the work agreed with the NewHoRRIzon consortium (a H2020 project) coordinated by the Institute for Advanced Studies in Vienna (Austria), which sought to explore Responsible Research and Innovation (RRI) inspired governance modalities using the social laboratory method – see Box 1. The NewHoRRIzon project is exploring governance methods inspired by RRI through a series of Social Lab experiments.

Box 1: NewHoRRIzon Project description and objectives – newhorrizon.eu

NewHoRRIzon is a project that aims at further integrating RRI in the research and innovation systems on national and international levels. The concept of RRI is an approach which intends to bridge gaps between science, research and innovation communities and society at large by fostering more inclusive, anticipatory, open and responsive research and innovation systems. In this frame, multiple stakeholders (from research, business, policy making, education and civil society) are involved in research and innovation on the project and system level to better align its processes and outcomes with the values, needs and expectations of society. A first big step was the operationalisation of RRI into the following six key elements: ethics, gender equality, governance, public engagement, science education and open access.

Objectives

1. foster the integration of RRI into European, national and local Research and Innovation practice and funding
2. organise 19 Social Labs and co-create pilot actions and activities and develop narratives and storylines based on the experience from these pilots
3. develop and disseminate a concept of Societal Readiness of Technology (= Societal Readiness Levels)
4. raise awareness on Responsible Research and Innovation and mainstream RRI best practices and NewHoRRIzon results
5. provide results on how to better integrate RRI into the next European Framework Programme
6. create a RRI Network including the national funding agencies and develop a RRI community starting with a RRI Ambassadors programme

Social Lab

A Social Lab is a container of social experiments for addressing complex ground-breaking social challenges on a systemic level. In the NewHoRRIzon project these are social challenges related to RRI within the frame of H2020 and beyond (Framework Programme 9 and national R&I funding programmes).

In September 2018, the JRC became part of the Social Lab experiments as a follow-up of a RRI Social Lab co-organised with IHS. As a concrete outcome of this partnership, the JRC conducted a pilot project on the topic of the future of mobility and the place of Connected and Automated Vehicles (CAVs) in current EU mobility visions enshrined in policy documents, such as COM 283 (2018).

[2] This is a sister report of Van Wynsberghe & Guimarães Pereira, 2021, which describes the process and outcomes of engagement of citizens in the imagination of future mobility.

The pilot on 'CAVs and the Future of Mobility' assesses the potential implications and societal expectations of CAVs and explores various mobility narratives, ethical considerations, expectations and matters of concern toward this new type of mobility. This partnership and the work agreed through it has been a further opportunity for the Joint Research Centre (JRC) to explore RRI as a way to develop socially robust knowledge in a particular policy relevant field.

This report is the first part of this collaborative project on connected and automated vehicles (CAVs), focusing on the potential social and ethical issues they raise in the context of European policy-making. It is a part of a larger endeavour that examines this technology with different actors, namely stakeholders and citizens in order to contribute to a comprehensive understanding of the role of these technologies in the future of mobility and indeed the futures that are enacted through the imaginaries of CAVs – values, practices and materialities. This specific report is focused on narrative analysis followed by a number of in-depth interviews conducted with a number of stakeholders in the first quarter of 2019. The analysis of citizen engagement activities is the subject of a separate report (Van Wynsberghe & Guimarães Pereira, 2021). Another analysis has also been made by the JRC on this topic (Alonso Raposo, et al., 2019)[3].

Through an anthropological and sociological lens, this report aims to highlight the social and ethical issues arising from CAVs and their potential deployment and implementation throughout Europe. The work does not depart from the assumption that this technology will be, or should be, deployed. The work extends the CAVs debates about safety, efficiency and sustainability, which often offer a framework that is too narrow and that does not take into consideration wider concerns and values. Indeed, the wider social and ethical scrutiny of this technology has mostly been addressed within the fields of science and technology studies (STS), and philosophy. STS scholar Jack Stilgoe suggested that the task is "to anticipate the futures that could surround self-driving cars: the futures that such cars might enable and the futures that those advocating such technologies might push for" (2017, p. 5). The task of this report has been to delineate and analyse the mobility futures enacted through these technologies from the perspective of different stakeholders. What kinds of futures are the automobile and technology industry promoting? What are their promises and how do CAVs benefit society? What kinds of actors are promoting them, and who will benefit? Who remains overlooked? Whose values and ethics are being enacted and whose are being neglected? What narratives should be cherished and which should be contested?

The ERTRAC 'Connected and Automated Vehicles Roadmap' (ERTRAC, 2019) cites safety, efficiency and environmental objectives, comfort, social inclusion, and accessibility as main drivers of this technological development. However, these categories contain assumptions that overlook major issues and inconsistencies to do with CAVs. Whether vehicles will cause less accidents, increase the transport system efficiency, enable users to have more free time, or ensure mobility for all, remains to be debated (see also similar reflections by authors such as: Tegmark, 2017; Rothfeder, 2019; Stilgoe J. , 2017). Based on the in-depth interviews

[3] Also, the related policy brief:
https://trimis.ec.europa.eu/sites/default/files/documents/jrc_policy_brief_cavs-media-citizens-policy_v08_25112020_final.pdf

that we carried out, these assumptions are not only being questioned throughout this report due to key social and ethical issues, but also due to technological, regulatory and infrastructural challenges that may pose insurmountable obstacles for these promises. Despite these challenges, and a lack of consumer information and citizen engagement, a roll-out of this technology in Europe is being anticipated (European Commission, 2018 p. 5). The European Commission's 'Third Mobility Package', released on the 17th of May 2018, revealed that some deployments are envisaged in Europe within the next decade. The Communication emphasises truck platooning, which will be facilitated through the standardisation of data exchange and allow for more efficient travel of goods. Connectivity will furthermore be enhanced in new vehicles, as new models from 2022 onwards will be connected to the Internet. Companies from the technology and automobile industries such as Ford, Honda, Google's Waymo, Tesla have been announcing their own deadlines for the release of automated vehicles in the near future.

The social and ethical issues concerning automobiles have been debated for many decades. Lawyer and public safety advocate Ralph Nader's seminal Unsafe at Any Speed illustrated the safety risks of automobiles in 1965, and is advocating for caution concerning driverless vehicles today. He cites the lack of consumer information and the regulatory loopholes as cause for concern. There is not shortage of literature criticising the 'overhype' created by the automobile and technology industries concerning connected and automated vehicles (Stayton & Stilgoe, 2020; Stilgoe, 2020; Winfield, 2019; Driverless Futures?, 2020). However, key actors within the industry have also been raising flags. Heads of industries, such as Ford, have been speaking about the 'overpromising' and 'misinformation' in the industry, emphasising the complexity of the issue (Rothfeder, 2019). Indeed, as Stilgoe states: "Ethicists, lawyers and others have been quick to point out that, even if the vision of cars could be perfected, safety questions would not vanish" (2017, p. 4).

Based on the insights of the interviewees and literature review, this report highlights the gaps and complications arising from industry promises and suggests how policymaking can approach the CAV topic within a broader view of the future of mobility in Europe.

2. Methodology

2.1 The framing: Responsible Research and Innovation

Responsible Research and Innovation promotes heterogeneous actors' engagement in research and innovation, emphasising it as a *need* to the extent that the imagination and assessment of our science and technology futures demand co-creation and collaboration with all those concerned with such developments. This mind-set and approach go beyond consultation in that it actively supports democratic processes, allows for a variety of perspectives to enter research design and results, and fosters mutual understanding across diverse groups of people. Indeed, the Horizon 2020 work program emphasises a "trans-disciplinary and multi-stakeholder approach, involving citizens and end-users, the public sector, and industry, so as to link and take advantage of unique perspectives and knowledge" (European Commission, 2019). From April to October 2019, the JRC has led workshops and interviews with stakeholders, including industry leaders, and then participatory events with citizens, on the topic of the futures of mobility in the European Union (see Van Wynsberghe & Guimarães Pereira, 2021). In particular, the participatory events activity brought into the fore, demographics that are usually not included in discussions on the future of mobility, and strove to consistently adapt the project to questions and concerns that were raised throughout. All engagement activities have been informed by a preliminary study of narrative analysis of policy and industry documents in relation to the development and deployment of CAVs, which we report here.

2.2 Narratives about CAVs in policy and industry discourse

Narrative analysis is a qualitative method that identifies and analyses the narratives within a particular discourse. In this case, discourse within the field of CAVs—including actors such as policymakers, industry professionals and academics— was analysed in order to understand the prevailing mobility imaginary and how it is affecting the EU regulatory framework. A narrative is *not* an intentionally produced slogan for promoting a particular political agenda, nor is it a sort of 'motto' for a particular group of actors who want to achieve a goal. It is not something to be actively produced to push an agenda in a certain direction. In contrast, the narrative is a conceptual tool to direct attention to the taken-for-granted assumptions and 'naturalised' stories about the world (that include human and more-than-human actors in it) that guide the actions of individuals or collectives (e.g. information campaigns influence people's behaviour). Narratives are value-laden, made up of promises, assumptions, claims and beliefs, all of which can be analysed (Guimarães Pereira & Völker, 2020).

The analysis of these narratives can point us to areas in which actors' assertions about the technological capabilities of CAVs conflict with each other. For example, many actors make technological promises that are linked to this mobility imaginary of CAVs, but that conflict with the technological issues raised by others. Narrative analysis also allows us to identify the main issues being debated, and how they are being approached (De Fina & Georgakopoulou, 2015). Through narrative analysis, we have identified the main narratives that link CAVs and make up their mobility imaginary.

The narrative analysis was conducted along several categories, identifying for each journal, paper, book, or article:

- The social and ethical issues raised
- The promises of the technology
- The technological issues raised

By doing so, the main social and ethical issues raised could be identified across the literature; the divergences between some authors' 'promises' and the 'issues' raised by others could be looked into. Oftentimes, this conflictual information shed light on the ways in which the social and ethical issues of CAVs are interlinked with the technologies that they depend on.

2.3 In-depth interviews with experts and stakeholders

Semi-structured interviews were conducted with nine key interviewees (10 persons) within the technology and automobile sectors. Five of these interviewees were suggested by colleagues at the JRC, working in this sector. The other four interviewees were suggested during the interviews by the first group. The interviewees worked in a variety of fields such as ITS, electronics engineering, road infrastructure, safety, and research and innovation, amongst others. The interviews were recorded and transcribed, as consented in writing by the interviewees. They have subsequently been anonymised for the purposes of ensuring interviewees a safe space to critically examine the political and industrial proposal enshrined in connected and automated mobility. Although, we recognise that this is a limited number of interviews, we ensured the diversity of our interview sample, not only in terms of background, but also geographical: our interviewees coming from many countries such as the Germany, Netherlands, Belgium, France, the United Kingdom, and Italy. However, it is clear that many other voices exist. The key methodological point to bear in mind is that the set of in-depth interviews was carried out in order to help the authors to critically review their own narrative analysis, by ascertaining that their analytical framing was sufficiently comprehensive.

Throughout this process, the imagination of CAVs was examined in order to ascertain which mobility futures the technology and automobile industries are promoting. In order for our interviewees to remain anonymous, our interviewees will be referred to as: Interviewee A, B, C, D, E, F, G, H, I – see table 1 to know about their background.

The guiding questionnaire[4] included the following key moments:

1. Professional relationship of the interviewee to the sector
2. The place of CAVs in mobility
3. Critical appraisal of narratives extracted from COM (2018)283 (European Commission, 2018) and some industrial papers
4. Ethical and social aspects or other concerns that the interviewee could have
5. A key element to envision the future for mobility
6. Key actors that should be engaged in co-creating those futures

[4] See Annex.

Table 1: Interviewees characterisation.

Interviewee	Sector	Background & Expertise; affiliation.	Date & Duration
A	Business	Cooperation for research and innovation, Robert Bosch GmbH	April 2019, 60 minutes
B	Non-Profit organisation	Political scientist, the *Fédération Internationale de l'Automobile* (FIA)	April 2019, 45 minutes
C	Business	Automotive electronics engineer, designing electronic systems for cars made in Europe and US Allianz group	April 2019, 50 minutes
D	Business	Road infrastructure and the implementation of CAVs project, deployment of European programs (project manager of the European ITS platform), SINA	April 2019, 45 minutes
E	Business	Navigation and pre-GPS systems in the US and Europe, consultation for companies such as Jaguar Land Rover, for Nissan, Toyota, and Volvo	April 2019, 45 minutes
F	Supranational Organisation	ITS, traffic management systems, connected and automated driving, professor and national expert for DG RTD at the European Commission	April 2019, 55 minutes
G	Non-Governmental Organisation	Thematic working group on traffic conditions, POLIS	April 2019, 60 minutes
H	Automobile Association	Transport policy, traffic issues focusing on the digitisation of transport and automation at *Allgemeiner Deutscher Automobil-Club* (ADAC)	April 2019, 45 minutes
I	Non-Governmental Organisation	Responsible research and innovation, public dialogues concerning technology governance	April 2019, 45 minutes

2.4 Coding Framework

Overall, the study attempted to grasp the most important social and ethical issues to take into consideration when referring to CAVs. A coding framework was therefore developed to analyse the interview transcriptions. This coding framework was not only established through the guiding questionnaire but also to a preliminary overview of the answers.

The analysis was done according to several initial themes that intersect with the social and ethical issues of CAVs:

1) Technological Promises and Challenges

As CAVs have come to the forefront of public discussion, many promises have been made by the industry about what European citizens can expect. They do not only make promises about the technologies themselves, but also about how they will ameliorate mobility, urban spaces, energy, and pollution. Nevertheless, research done by the JRC (Alonso Raposo *et al.,* 2019) has shown that although experts and stakeholders in the field make similar promises, some also often conflict with data obtained from other sources.

2) User Acceptance and Experience

Many of the industry professionals posit a particular conception of the kind of 'user' that needs CAVs—imagining what they desire or need. This conception of the 'user' risks becoming a proxy, a stand-in, for industry professionals to advance their own vision for the future whilst using terms that frame their work as being done on behalf of the user. In our conversations with experts and stakeholders from the CAVs industry, they often assert how they are putting 'users' or citizens first, whether it appears to be the case or not.

3) Governance

The implementation of CAVs would require both a legal and a moral framework to be deployed. To this date, data governance has attempted to protect the data of European citizens and their privacy. However, with CAVs on the road, the data capture that this new technology allows and its need to 'communicate' with other cars and infrastructure could threaten these advancements (Stilgoe J. , 2017). This is one example of the need for comprehensive policy when addressing the implementation of CAVs.

4) Connectivity and Autonomy

The question of autonomy is central in the issue of connected and automated vehicles. However, there is no clear consensus within the academic journals of what CAVs' consist of. Even if SAE[5] sets clearly automation levels, it seems as though that companies that are competing with each other are putting forth different conceptions of what autonomous vehicles are, and what aspects of its 'autonomy' are most important to implement. What, then, do we mean by *full driving automation* vehicles, and is that something that European citizens want?

5) Energy and Sustainability

[5] See levels of automation of vehicles: https://www.sae.org/standards/content/j3016_202104/. In this work we were focusing on level 5 of automation of motor vehicles.

Some of the main arguments for the rapid implementation of connected and automated vehicles is a promise that the vehicles will: be more energy-efficient; curb emissions; use less parking space in cities, and will mostly be electric. Nevertheless, our narrative analysis work shows that the correlation between electric and connected and automated vehicles is not so clear. In fact, many developments in the CAV industry still rely on fuel. Furthermore, there are debates about whether car usage will diminish with the implementation of CAVs; carpooling and sharing is purported to be on the rise. But will current car-owners give up their own cars to share one with strangers? Or will this just mean more cars on the road, more traffic, more mile-usage, and a quicker turnover rate due to 'shared' vehicles? What about the resources needed to make electric batteries and other components of CAVs? How will they be sourced and disposed of?

In a nutshell, the methodological approach explored in this report to examine narratives of innovation in the CAVs sector is composed of both discourse analysis and the careful examination done with the in-depth interviews of those narratives with stakeholders. This first scrutiny, we contend, is the first step of a *responsible* approach to research and innovation.

3. Governance and Ethics

Governance and ethics matter when it comes to CAVs because, as socially constructed artefacts, technological systems embody legislative and social norms and regulations. Their development and implementation therefore need to be part of wider debates about the future of mobility—the debate will need to involve discussions about city planning, data and privacy, and human agency. CAVs may be able to function in a way that is 'connected' and 'autonomous' within their operational design domain (ODD), but they will always-already be enmeshed in an ecology involving both human and non-human actors—whether these involve safety drivers, or road assistance technologies. Their implementation therefore does not only have an implication on users but also on a wider range of stakeholders.

3.1 A Sociological & Anthropological Approach to Digital Technologies

The field of Digital and Media Anthropology, as well as Techno-Anthropology and Science and Technology Studies, have explored technologies from a perspective that destabilises current conceptions of big data and artificial intelligence. Rather than viewing technologies as 'discrete entities', New Materialist and Post-Humanist understandings have introduced a relational conception of digital materiality. Firstly, it appears that the use of these technologies is emergent; that is, the 'users of the technologies are not always those for who they are designed', and technologies additionally give rise not only to intentional uses, but also misuses, new uses, abuses, and so on (Pink, Ardèvol, & Lanzeni, 2016; Børsen, 2014). Secondly, the technical language used to describe certain processes does not always depict the full breadth of what they entail. For example, after an ethnographic study, Nick Seaver points out that the term algorithm has many different applications and boundaries *in the wild*. Even in the computer science field, different professionals make sense of their practice in different ways and algorithms are viewed differently by different actors: "some users tried to game the algorithm as they understood it, to generate more desirable matches; other users took the algorithm's matches as oracular pronouncements, regardless of how they had been produced" (2017, p. 5). The idea that technologies have a *fundamental behaviour* can be questioned, as they can also be hacked, tweaked or their functioning altered through the users' interaction with it. Indeed, the term 'functionality creep' refers to the phenomenon of personal or other data being used for purposes other than that which were designed into the system. Thirdly, the ideological discourse that showcases big data and artificial intelligence as offering more 'objective', 'neutral', or 'rational' solutions to society's problems should be carefully unpacked. Sometimes termed the 'Silicon Valley Ideology' or 'Californian Ideology', this techno-libertarian way of positing the pursuit of ever more advanced technologies as an inherently progressive endeavour has been heavily criticised by academics (Barbrook, 1996).

Indeed, the public is increasingly suspicious of claims that digital technologies will 'connect people' and create 'direct democracy' as has been promised in the past (ibid.). In terms of big data specifically, there is the notion that with more data, there is more objectivity, and we can arrive at more rational or neutral solutions. However, processes of data collection and classification themselves include ambiguities and frictions that often go unacknowledged—

human beings, after all, must decide what data are valuable enough to be collected, and the technological systems that collect and sort them, are necessarily mediating information according to their architecture. Data are therefore always-already representative of a narrative; with emotional, political and personal elements and biases tied up within its structure.

As per techno-anthropology, technologies are entities whose behaviour is contingent upon other human and non-human entities. This approach, however, is not completely novel; sociologists and historians have also argued for a constructivist approach to technology. For example, the seminal book, The Social Construction of Technological Systems by the Massachusetts Institute of Technology, argues that social and economic factors are bound up within technologies. They state that "right from the start, technical, scientific, social, economic or political considerations have been inextricably bound up into an organic whole," and that these are 'present from the beginning', rather than 'progressively introduced' (Bijker, Hughes, & Pinch, 2012, p. 78). Technological systems are therefore not isolated entities but 'are both socially constructed and society shaping' (ibid.). The socioeconomic impact of technologies should therefore not be thought of as a mere consequence of their implementation, but rather the factors which determine it that can and should be considered at the planning and design process. STS has also emphasised the material basis of digital technologies, focusing on the politics of their infrastructures, and standards, rules and norms (Stilgoe J. , 2017).

Despite the continued development of technologies, and their growth and consolidation, technological systems do not become autonomous. Rather, 'they acquire momentum', making them appear autonomous, meaning that "they have a mass of technical and organisational components; they possess direction, or goals; and they display a rate of growth suggesting velocity. (…) The large mass of a technological system arises especially from the organisations and people committed by various interests in the system" (Bijker, Hughes, & Pinch, 2012, p. 70). This social constructivist understanding illustrates that, even at the highest level of automation, the system is always-already part of a technological and organisational ecology, which necessarily involves human beings, whether they be engineers, programmers, or policy-makers. Even if vehicles reach a high level of automation, citizens in the EU should therefore expect new organisational structures, priorities, and variables that need to be taken into account. As the Artificial Intelligence (AI) solves one problem, it may inadvertently create other issues that policymakers, industry professionals and citizens will have to take into consideration and fix.

3.2 The Promises of Connectivity & Autonomy

The narrative analysis that has been conducted as part of this citizen engagement project has shed light on the ways in which the vehicle and technology industries assert their vision of the future of mobility. Through this narrative analysis, we have focused on the various terms and concepts that make up the mobility imaginary. Industry professionals and stakeholders working in the connected and automated vehicle industry put forward particular conceptions of 'connected' and 'autonomous' vehicles. The meanings associated with these terms vary depending on the company and the literature, and have also changed throughout the course

of history. The ways in which connectivity and autonomy are conceived of within the future of mobility also differs between different actors. Nevertheless, these terms are associated with a particular ideology of technological progress that can be analysed: one which promises that human beings can, and should, be relieved of tasks such as driving by operating systems using artificial intelligence. The promises of the CAVs sectors fall into two main categories: 1) technological promises, concerning the performance of CAV technology, and 2) social promises, referring to perceived social benefits as the outcome of its implementation. These promises have been identified through the discourse analysis, coding of interviews and their analysis through the identification of repeated statements over a certain threshold throughout the discourse analysis and interview analysis.

The European Commission's communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions is entitled 'On the Road to Automated Mobility: An EU Strategy for Mobility of the Future' (European Commission, 2018)[6]. The title already anticipates a future of automated mobility, and one that focuses on road mobility. The communication lays out many promises about what this technology will accomplish: "it is anticipated that driverless mobility will decrease transport costs, free driver's time, and foster car sharing, thereby improving air quality and urban planning." It frames the future benefits of automated mobility according to perceived benefits that users will reap: "[it's a] new level of cooperation between road users which could potentially bring enormous benefits for them and for the mobility system as a whole, including making transport safer, more accessible and sustainable." Nevertheless, the users' mobility imaginary does diverge from this narrative, as has been shown in citizens groups held by (see, Van Wynsberghe & Guimarães Pereira, 2021).

3.2.1 'Revolutionising society'

Technology and automobile companies, as well as, actors within the policy sector, frequently state that CAV technologies have revolutionised, or will be revolutionising, society. Daziano, Sarrias and Leard state that the emergence of driverless technology is considered an 'unprecedented revolution in how people move' (2017), whilst Cohen and Cavoli (2019) positions automated vehicles as 'enhancing common wellbeing and prosperity'. Furthermore, the development and implementation of CAVs is being positioned as inevitable, even by actors that have remained critical of such technologies. CAVs are described as representative of opportunities, which must be seized and capitalised on now; creating a sense of urgency and perceived benefits despite a lack of clarity on what these will be. Phrases such as 'connected and autonomous vehicles are coming'[7] are common within discussions within the sector and media, and they effectively enact and pave the way for a future of connected and autonomous transport by neutralising critical and dissenting voices advising caution. Furthermore, the way

[6] After this work was carried out other policy documents were issued, such as the Sustainable and Smart Mobility Strategy' together with an Action Plan: https://ec.europa.eu/transport/themes/mobilitystrategy_en, Available here: https://eur-lex.europa.eu/resource.html?uri=cellar:5e601657-3b06-11eb-b27b-01aa75ed71a1.0001.02/DOC_1&format=PDF

[7] See e.g., https://www.autofutures.tv/2019/09/10/shift-automotive-the-future-of-mobility/

in which CAVs are illustrated often depicts them as contributing to technological progress, which is out of the hands of citizens and other stakeholders. This creates mounting pressure within both the private and public sector to buckle to the interests of technology and automobile industries and realign national and regional priorities in order to allow such a transition to happen faster and more efficiently. Questions such as: "What are you doing to seize the CAV opportunity to better meet your city's mobility objectives and improve quality of life?" and "Who's driving your future?" can be observed in reports addressing this sector (Arcadis, 2018). In other words, the narrative of autonomous and connected mobility becomes naturalised.

3.2.2 Technological & Social Promises

Despite laudatory remarks on CAVs and their perceived impact, the overpromising of the technology and automobile industries has become widely reported in the latter years. Elon Musk implied in 2015 that his vehicles will be fully driverless—without wheels or pedals—in 2017, and stated that buying any other vehicle than a Tesla would be like 'buying a horse' in twenty years (Thompson, 2015). In May 2016, Uber projected that it would manufacture 75,000 autonomous vehicles by 2019, and that they would not need human safety drivers by 2020 (Rothfeder, 2019). After lawsuits and lethal accidents, most of these companies are releasing more cautious figures. Nevertheless, the industry remains prone to overpromising, due to its desire to capture the market, to gather the support of politicians and to secure user acceptance.

Many academics (already quoted in this report), industry professionals and stakeholders are concerned not only about the promises that have been made by the technology and car industry, but also by the considerable impact these could have on society. Our interviewees all had at least several concerns about the technology and its implementation in society. For example, interviewee **B** (a political scientist) was concerned about the assumption that 'once full automation is reached', this will equal 'full benefits'. Indeed, many interviewees remained sceptical about automated vehicles 'changing the world' and have criticised early announcements concerning automated vehicles. Interviewee **H** (automobile association) illustrates the difference between the current portrayal of the shift towards CAVs, and its complex reality:

> "In many of those visions a miracle happens, and all the cars are automated and connected from one day to the other. In reality, we have millions and millions of cars in Europe and the exchange of the cars will be very slow and this technology can only, let's say, drain into the fleet with new cars. You can't actually retrofit existing cars with automation, so that will take a very, very long time actually to come to the fleet." [Interviewee **H**]

Interviewee **H** also questions this vision of the industry:

> "we frankly did not believe that what we were reading in the press about this rosy future that vehicle manufacturers and other sorts of AV enthusiasts were selling us. I mean, we just didn't think it would just be, you know, 'automated vehicles are going to solve our congestion problems, are going to solve our road safety problems'. They have a contribution to make, but if the implementation or if the deployment of these vehicles

> is not done in some sort of managed way, then the situation could be worse. Essentially, we didn't buy-into what we were reading in the press, what was coming out of some research and we felt there were other issues that weren't being addressed. (…) we don't know what the future's going to look like. We don't know how automation is going to change things. It could be you know, the heaven and hell scenario; on one end of the spectrum, it could be great, at the other end of the spectrum it could be dire." [Interviewee **H**]

When automated vehicles are mentioned, they are often positioned as being able to seamlessly overtake the driving task from human beings. A vehicle at a level 5 automation (SAE: full autonomous driving level) may be able to perform almost perfectly when it comes to overcoming accidents caused by 'human error'. As Interviewee **H** illustrates, "[industry professionals] expect less people to die or get injured in accidents because the car doesn't get tired, the car doesn't drink." A report by KPMG International states that 'removing human error risk by moving to automated vehicles should deliver an enormous reduction in vehicle-related deaths' (KPMG International, 2019). However, the system may need a newly configured or renovated infrastructure in which to function. When a prototype self-driving Volvo XC90 failed to conduct its test drive as expected during a meeting with the Mayor of Los Angeles, the Volvo executive blamed the lack of clear lane markings and therefore the public infrastructure. Indeed, for him: "the limitations of his self-driving Volvo were a function not of its naivety or myopia, but of the messiness of the outside world" (Stilgoe J. , 2017, p. 7).

Interviewee **C** furthermore explains that automated vehicles have the potential to reduce road fatalities, but that this is not yet the case and remains to be proven:

> "One is highly-automated or automated cars somehow and then there is driverless and there's a huge difference between these two. (…) I think that the automation that you know, starting level 2 plus or 3 and 4 and going all the way up. That adds safety potentially that can reduce road fatalities, that can bring mobility to, as you said before, a category of users, for example, isolated people, elder people, disabled people, who cannot drive, can give them this possibility to drive. But, this is not something which works with all the levels below 5, it needs to be absolutely driverless and they need to work anytime anywhere and we're not there yet and I'm not even sure we will get there at any point in time, at least with what we know today. So, I believe that automation can increase the safety, and this remains to be proven." [Interviewee **C**]

The way in which CAVs are discussed creates an image of automation in which the operating system can function seamlessly. However, the 'messiness' of 'reality' can never completely be controlled for. Indeed, automated vehicles, even at level 5 (SAE: full autonomous driving level), will have to function within particular predetermined parameters in order to function 'optimally'. Their ODD can be defined as the operating conditions "under which a given driving automation system or feature thereof is specifically designed to function" and these can include "environmental, geographical, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics" (ERTRAC, 2019, p. 6).

Indeed, many of these conditions often remain obfuscated within the literature, and policy documents on CAVs. However, infrastructure requirements such as 'clear road markings, communications infrastructure and reliable data' could pose considerable financial strain on road authorities, causing a need for new business models to be developed (POLIS, 2018, p. 11). Their ODD could additionally affect the regions in which CAVs can reasonably be deployed, and their limitations in those areas.

The technological promises emerging from the technology and automobile industries remain uncertain due to challenges that have presented themselves over the course of the development and testing stages of CAVs. The social promises, being dependent on the first category, can therefore be considered doubly uncertain, due to the additional complexities that surround the implementation of connected and automated vehicles. These promises are additionally predicated on many assumptions, such as that: CAVs will need little to no human input; they are driven by social needs like road and driver safety; and perceived benefits of CAVs far outweigh perceived risks. As it has been illustrated above, the current narratives concerning CAVs promote a lack of critical engagement with its perceived technological and social benefits. The depiction of CAVs as an inevitable technological development that public officials and citizens will have to come to terms with, already disempowers critical and dissenting voices. This additionally presents a universal vision for the future of mobility, which may not apply to certain regions due to geographical, cultural, or other factors.

3.3 The 'Users'

The promises that have been outlined above are based on a particular notion of the CAV 'user'. The way in which industry professionals, and even policymakers and academics, have been referring to users within these debates has skewed the discussion on what CAVs should do and why. In COM(2018) 283, the European Commission (EC) frames mobility 'as a service' (European Commission, 2018). However, the CAVs technologies could disrupt many other factors of life than simply how people move. Indeed, as sociologists state, technological systems tend to solve problems and fulfil goals according to the vision of their architects, and "the problems have to do mostly with reordering the physical world in ways considered useful or desirable, at least by those designing or employing a technological system" (Bijker, Hughes, & Pinch, 2012, p. 47). The conception that policymakers and industry professionals seem to have of CAVs users, needs to be made explicit in order to contribute to a more inclusive and holistic understanding of what an *official* future of mobility in Europe is expected to look like. Who are those users? And how will they move according to current policy imaginary?

When asked who will benefit from the deployment of CAVs, our interviewees had several answers, but most of them emphasised citizens in big cities, environmentally-conscious citizens, and demographics such as the disabled or elderly. Interviewee **A** (Business) focused on demographics that are interested in sustainability and stated that the 'users' will include "everyone who wants to do something for environment and everybody who is keen to improve traffic safety." They state that initially companies would prioritise high-end and luxury cars and that "those who will be able to afford these functions" will benefit first. Indeed, who

benefits will depend on how they will be deployed. Interviewee **H** (Automobile Association) illustrates various scenarios:

> "If we are talking about private cars, then it's most likely that sophisticated technologies will be introduced to high-priced executive cars in the beginning. So, probably it won't be cheap, it's for those people who can afford such a high-priced car. On the other hand, if you think of public transport, if we introduce automation in public transport vehicles and buses then probably the public transport organisation, let's say, offer better services to their customers and basically everybody will benefit from that. Also, in goods transport if freight forwarders can reduce costs by saving on labour, then that will also make transport cheaper and everybody has a benefit from that, right." [Interviewee **H**]

Our narrative analysis and interviews with industry professionals additionally showcased that matters of concern are usually seen as obstacles to innovation rather than as pathways towards a common mobility future. Throughout our interviews, issues involving 'user acceptance' were framed as ones that should be overcome through a change in citizens' understandings of CAV technology and how it can benefit their lives. However, when asked further, many admitted that user's concerns such as a lack of personal agency, safety, and data collection and usage are not being approached seriously enough by manufacturers. When asked who the CAVs are for, Interviewee **D** (Business) admits that CAVs are 'surely something very dangerous from a citizen point of view', citing the breadth of data collection needed. However, they maintained that as long as the technology fulfils particular needs, and is effective at doing so, users will not concern themselves with data or privacy issues:

> "This is something that the citizen is not interested in (…) From my perspective the program of acceptance of this kind of technology, it will be just a problem of: 'how is this kind of information useful for me?'." [Interviewee **D**]

Another participant echoes this sentiment:

> "My personal impression is that as soon as any such technology actually is at their hands, consumers very quickly embrace it. They may have concerns beforehand, but as soon as they actually let's say, can touch it and they can use it, then they very soon understand the benefits they can have from that and then they very quickly embrace it. So, even if there's at the moment still some reluctance to automation, I'm quite positive that people will very quickly adopt the technology, nevertheless." [Interviewee **H**]

This approach towards user or public acceptance is common within the CAVs field, and also reflects the modus operandi of disruptive technologies. In other words, citizens are seldom involved in the design of technological innovations or even on discussions about their desirability. Instead, they get engaged as *users* when those technologies are already out there or under the radar of policymaking. The focus has additionally mostly remained on end-users and on people whose jobs would be impacted by the implementation of CAVs. However, end-users should not be the only ones whose acceptance and trust the industry attends to. Many other citizens are, and would be, implicated by their implementation, since the type of AI software that the vehicles would deploy do not only capture the driver's data but also those of its surroundings. This includes the capture of data concerning local businesses, city officials, road-side homes, people using public spaces, pedestrians, and road side workers.

Furthermore, the industry's conceptualisation of 'users' exemplifies the ways in which their development of CAVs is conceived of as a service that customers can 'use', rather than a development which will always-already impact citizens and their environment, whether they choose to use such vehicles or not.

When asked which groups of people tend to be excluded from discussions about connected and automated mobility, our interviewees mostly underlined that the voices of citizens, public organisations, and cities are underrepresented. Indeed, it appears that in some cases the CAV sector may be working towards aims those cities may not necessarily perceive as priorities, or would not be willing to invest in. Industry professionals acknowledged that although some cities are involved with 'shuttle service type projects' most city officials may not be planning for automation developments due to this lack of perceived benefits. Interviewee **G** (non-governmental organisation) states:

> "Cities aren't necessarily opening their arms to connected and automated vehicles and then to that I would say—why should they? I mean, what's the benefit for them? If they don't see a value, then they're certainly not going to facilitate or enable it. (…) When it comes to connected and automated vehicles, there are just so many uncertainties about when they'll be there, what the different levels of automation are, when it will really have an impact on the way which people behave, and on the overall mobility of a city." [Interviewee **G**]

It was also mentioned that the voices of citizens and city officials remain the most overlooked in these debates.

Establishing user acceptance or trust was often framed by interviewees belonging to industry professionals category, in terms of risk, productivity and comfort and to a lesser extent in terms of other factors, such as the pleasure of driving, or a user's agency and control. The main concern for the industry appears to be overcoming the public's 'trust problem', often positing users' priorities as 'preferences' rather than as concerns (Stewart, Musa, & Croce, 2019). Several core assumptions are made by the industry literature on user acceptance. The core assumption is that the biggest obstacle in user acceptance in CAVs is the fear of loss of control and the misunderstanding and/or misrepresentation of CAV technologies such as AI. Secondly, another core assumption is that citizens' concerns—such as those about privacy and human agency—can be overcome once connected and automated vehicles are made efficient and safe. The current industry and policy framing of citizens as certain kinds of 'users' already works to exclude alternative imaginations of mobility than that which is pushed by industry interests. Interviewee **I** indeed criticised the notion of 'driverless futures', which disempowers current drivers and their stake in their futures. The interviewee states that there is a need in the industry to 'put the people at the heart of the discussion about the technology, rather than the technology at the heart of the discussion about the people'.

4. Mobility Futures

Connected and automated vehicles have been part of the imagination of mobility for many decades, and their functions have often appeared as a blend between technology and magic—being depicted as flying vehicles, automated shuttles, or teleporting devices in popular culture. The discourse on CAVs and the promises that the technology and automobile industries are making about their implementation put forward particular imaginaries of mobility that remain connected to this cultural history of mobility. Driverless vehicles have been a preoccupation for innovators and thinkers since the early nineties. In 1925, the RCA radio-controlled car by the The Houdina Radio Control Company was the first demonstration of an automated vehicle—a sedan mounted with an antenna operated its electric motors via radio signals. In this demonstration, another manually-driven vehicle that followed the phantom car was responsible for emitting the signals. Such experiments showcase that technological advancements are the result of both sociocultural and technological phenomena—within contemporary developments, artificial intelligence may map the environment for the vehicle, but the industry demonstrations create the illusion of seamless autonomy.

4.1 The Mobility Imaginary

The mobility imaginary articulates many promises around CAVs, and the ways in which connectivity and automation can grant us an avenue towards a 'greener' and more 'sustainable' future. CAVs are illustrated as harbingers of a new era in which people are rendered more mobile and productive. Current imaginaries position connected and automated vehicles as shaping Europe into a more sustainable, competitive economy and offering new modes of transport that will increase access to mobility, lower costs, and transform cities into more liveable urban centres. An analysis of the images and schemas of connected and automated vehicles today mostly showcase a white-collar city-dweller who uses their time in transport in order to be more productive. Vehicles are represented with blue glowing lights and schemas of connected technologies, representing the incarnation of a futuristic aesthetic.

It was not so long ago, however, that automated vehicles were represented as family-centred vehicles. The mobility imaginary does not only change over time depending on current concerns, but it is also being shaped by a multitude of stakeholders in order to advance their own priorities.

We used a frequency word counter (to be more precise we used the package consider.ly) in order to determine what types of mobility the nine interviewees mentioned overall, and at what frequency they did so for each category – see figure 1. Words designating the same type of mobility (e.g., car and cars; metro and subway) were counted in the same mobility category. Any other type of mobility than those in the graph (figure 1) were not mentioned throughout the course of the interviews. Throughout our interviews, we focused on using the term 'vehicle' and the future of 'mobility' in general. Nevertheless, interviewees tended to refer to particular types of mobility, with cars taking precedence over any other type of vehicle – see figure 1. However, although specific types of public transport were mentioned less overall, the mention of public transport in general was more prominent during the interviews.

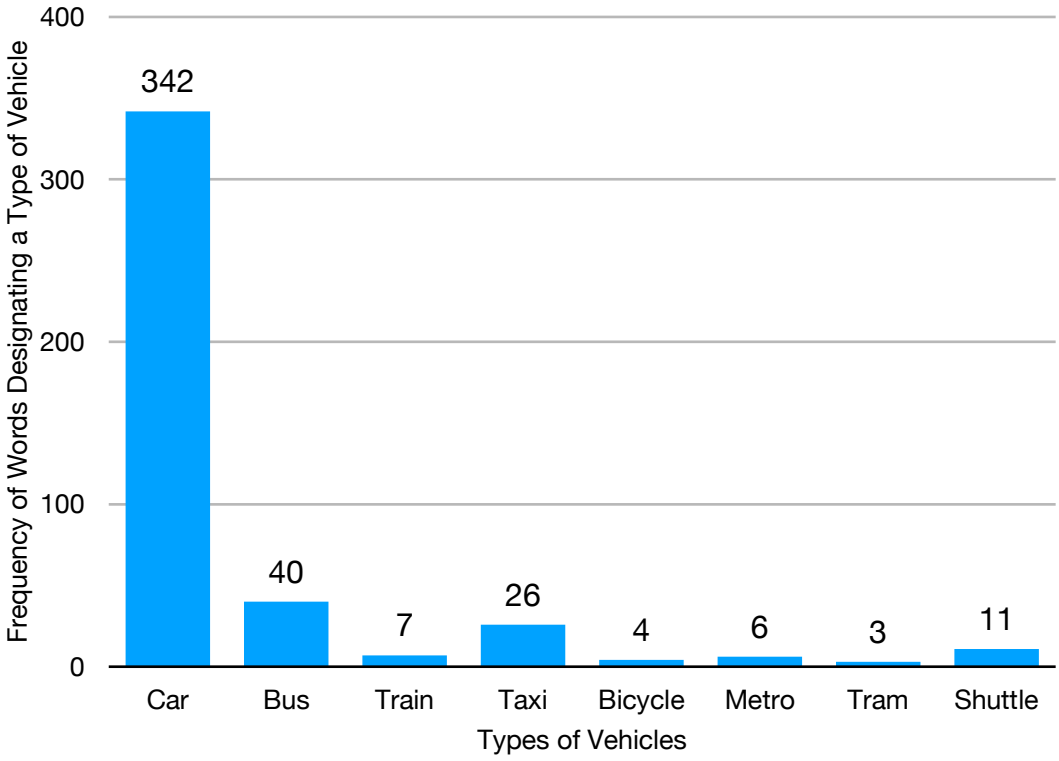

Figure 1: Types of Vehicles Mentioned in Semi-Structured Interviews with Stakeholders

This analysis also led to further findings to do with whether connected or automated mobility was more emphasised throughout the interviews, and what level of automation was most discussed. Connected mobility was mentioned less often, with words such as 'connected' (150 times), and 'connectivity' (25 times). Automated mobility was mentioned more often, with words such as 'automated' (249 times), 'automation' (87 times) 'autonomous' (21 times), 'driverless' (18 times), 'autopilot' (3 times). Throughout the course of the interviews, the prospect of *connected* mobility was emphasised as being probable in the near future (if not already there), whereas many concerns arose over *automated* mobility, which to the majority of them was quite a different story. Despite this, it is interesting to note that automated mobility remains more present in discussions about the future of mobility. Interviewee **H** emphasised automation as 'a piece of technology that will pour into different transport systems'; such as rail, sea shipping, air traffic, and possibly even bicycles. However, the graph in figure 1 shows that the current imaginary of the future of automated mobility focuses largely on road mobility. Words such as 'driver', 'drives', 'drive', 'driven' and 'driving' were also frequent throughout the interviews.

Both of these findings show that aside from technological issues and social and ethical concerns around CAVs, the mobility imaginary consists mostly of a future in which connectivity and automation is applied to cars—whether for private or public use. It also showcases that

other types of vehicles rarely feature in discussions about connected or automated cars; whether in conversations about safety, traffic, or sustainability. One of the interviewees highlights how the conversation should shift to focus on different types of mobility in order to meet the social promises of CAVs:

> "if I was a policy person and if I was involving the public and stakeholders, it would be about what cities of the future do we want and what do we want the transport to be like? (…) It wouldn't feature self-driving vehicles expect for, like the congestion charge in London, if you are a disabled person or you are this, that or other, you can get dispensation for driving you single vehicle into town and if you're not, you're going to have to pay a lot. I think those future of transport issues are almost totally disconnected from the self-driving, it's how we want our cities to look and how we want to be free of vehicles and how we want to facilitate different modes of transport like cycling and walking and you know, buses and trams and trains. That's the conversation really that I think I don't see. I see academics getting money for self-driving cars because that's what the tech industry wants." [Interviewee **I**]

AUTOMATED MOBILITY: A EUROPEAN PROJECT?

The European Commission's communication 'On the road to automated mobility: An EU strategy for mobility of the future' (European Commission, 2018), states that "The new market for automated and connected vehicles is expected to grow exponentially and large economic benefits are expected, with for instance revenues exceeding EUR 620 billion by 2025 for the EU automotive industry and EUR 180 billion for the EU electronic sector". These technologies are being tested Europe-wide via 'Living Labs'; open laboratories in urban environments. One of these Living Labs has recently been implemented in the JRC's Ispra site in Italy, through which researchers will collaborate with actors and stakeholders from the industry.[8]

The interviewees illustrated the ways in which industries in this sector are positioning themselves in order to abide by the EU's priorities. Indeed, EC policies focus on maintaining the European Union's competitivity within the automobile and technology sector. For example, Interviewee **G** states that the EC is positioning the issue of CAVs in order to 'preserve and enhance the automotive industry in Europe' and remain competitive in the technology sector. Interviewee **H** also highlights global competition as a key factor:

> "One of the reasons is that everybody else in the world is doing it. I mean, if you look towards the USA or Japan or whatever, they're really investing in this as well, and that's what the Commission usually starts its statement with, that Europe needs to remain a global player, to have a leading role in this new technology." [Interviewee **H**]

[8] See: https://e-novia.it/e-shock-living-lab-jrc-european-commission/ and see https://ec.europa.eu/jrc/en/research-facility/living-labs-at-the-jrc.

5. Critical Assessment of the Outcomes

In this section of the report, the main claims about CAVs will be analysed focusing on their potential impact outlined for policymaking. The imaginaries of mobility of the technology and automobile industry have been delineated above. In this discussion, the promises of the CAVs field will be critically engaged with, in light of our findings and of that of other relevant research. We offer some recommendations on the basis of the narrative analysis described earlier and including the interviewees extended review of CAVs narratives.

5.1 Key Issues

The following key issues and their discussion are based on the most prevalent matters of concern that emerged throughout our research. The key issues have been derived from discourse analysis of the current academic and industry literature on the development and implementation of CAVs, the data gathered from our interviews with key industry professionals, but also to some extent to the citizen engagement events held with European citizens[9], which is the subject of another report. Addressing these key issues will shed light on the current thinking about CAVs and their potential impact throughout various sectors in society.

The key issues that will be assessed throughout this section are the following:

- Safety & Security
- Data & Privacy
- 'User Acceptance' & Agency
- Sustainability
- Implementation: Hybridity, Mixed Driving & Car Sharing
- EU Regulation & Competitivity

5.2 Safety & Security

In its communication 'On the Road to Automated Mobility', the European Commission asserts that "Automated vehicles will have to be safe, respect human dignity and personal freedom of choice" (2018). The main claims that have been put forth for the implementation of CAVs is that they will reduce, if not eliminate, car accidents, and that they will free users from the burden of driving (Tegmark, 2017). Although most accidents are caused mostly by human error, claims that automated vehicles will 'remove human error risk' overlook many variables (KPMG International, 2019). Indeed, the impact of road infrastructure, and other variables, has a considerable impact on the rate of accidents. Statistics for the accident rates of self-driving cars are often compared with that of human-drivers, despite contextual differences such as weather, infrastructure, and other variables. 'The Trolley Problem'[10] can never be completely resolved by an AI because "in the real world, algorithms must work with incomplete information and imperfect control" (Stilgoe J. , 2017). The first fender bender

[9] See companion report Van Wynsberghe & Guimarães Pereira, 2021.
[10] See Jarvis Thomson (1985).

was due to the assumption of a Google vehicle's system that a bus driver would yield once the vehicle pulled out before it (Tegmark, 2017). Hence, although the AI systems of CAVs may address particular human errors known to cause accidents, they can also render the car, and therefore passengers, pedestrians, and even whole cities and countries, vulnerable to other kinds of dangers, as we will discuss in the next section.

Interviewee **E** comments on the 'promise' coming from the industry about the removing of the human error factor in accidents:

> "They keep the mantra: 95% of accidents occur because of human error. If we can eliminate the human, we eliminate 95% of the accidents. We'll have 100% safe vehicles. I don't believe that. I never have, but that's the main purpose of, well the main reason that's been given." [Interviewee **E**]

A New Category of Accidents

The case studies of CAV car crashes can be used to deduce that although artificial intelligence may control for human errors, they can equally introduce a new category of accidents. Interviewee **D** mentions how newfound reliance on add-ons in vehicles can create new scenarios that pose challenges to safety and security:

> "now the paradigm is maybe shifting because maybe people will start to rely more on vehicles and maybe accidents are happening because of that" [Interviewee **D**]

In the global race for the implementation of connected and automated vehicles, several countries have allowed the piloting of automated vehicles without a steward onboard on public roads. The safety of others has already been endangered by the testing of these vehicles. Citizens, whose neighbourhoods companies have been testing in, have protested the presence of these vehicles after a lethal accident and many incidents. In Arizona, citizens have attacked Waymo's driverless vehicles by slashing tires, throwing rocks, and waving revolvers (Romero, 2018). Furthermore, there have been several cases of drivers filmed asleep in Tesla vehicles using cruise control or autopilot at around 90 km/h by concerned citizens on the highway—a system, which necessitates the driver's full attention and hands on the wheel (The Guardian, 2019). Interviewee **I** talked about the fatal Tampa incident[11] and calls out the dangerous assumptions technology and automobile companies may be making about human behaviour:

> "People are supposed to concentrate when they're not really going to concentrate. The most basic understanding of human nature tells you that we can't concentrate. When you're in a self-driving vehicle it's never going to happen. So, for the car manufacturers to have even the test people do that, it's just not fair. It's not fair to us. It's unrealistic and it's not taking into consideration the nature of people, human nature." [Interviewee **I**]

[11] See https://www.theguardian.com/technology/2016/jun/30/tesla-autopilot-death-self-driving-car-elon-musk

There is a claim that 'self-driving cars unleash the driver from the steering wheel and thereby increase available time' (Hars, 2016). 'Freeing up travel time' is considered a 'big opportunity' as is revealed in our interviews with industry professionals. However, a combination of AI failure, and human distraction, can cause fatal accidents. For example, the first lethal accident was caused by combination of 'bad assumptions': that the bright side of a trailer truck represented the sky, and that the driver Joshua Brown—allegedly watching a film—would be alert enough to notice and intervene (Stilgoe J. , 2017; Tegmark, 2017). Despite the promise of the 'relaxing' elements of automated driving, human drivers that have tested these functions appear more anxious and apprehensive than relaxed, as they must be 'prepared to take the wheel at anytime' (Stilgoe J. , 2017). For example, Polis (2018) points out that studies have already shown that "it can take anything between 1.9 and 25.7 seconds for a driver to take back control of the driving task in a hands-off and eyes-off driving situation". Indeed, it seems unlikely that a driver would be able to remain attentive for hour-long drives, and that this behaviour during cruise control or autopilot would not affect their habits once they regain the wheel. Such a demand additionally refutes the industry promise of 'freeing time' and creating a more 'relaxing' driving experience for level 5 automation. This is exacerbated by the current legal confusion over liability in the case of accidents whilst this system is operating.

It is important to note that the technological system itself cannot anticipate its own shortcomings—therefore, in the case of a glitch or fatal misunderstanding, it cannot warn the driver. Research from the AAA Foundation for Traffic Safety showcased that drivers that have used advanced driver assistance systems (ADAS) can be prone to 'potentially negative behavioural adaptation' such as increased distraction and complacency, and over-reliance on ADAS systems in dangerous contexts (Dunn, Dingus, & Soccolich, 2019). Furthermore, they state that "adding to this danger is the possibility the driver may not fully understand the limitations of the ADAS and may overestimate its ability to prevent crashes" (ibid.). Drivers of connected and automated vehicles may need particular training in order to learn how to use systems such as these, and to become aware of the potential dangers that exist even after they have learned and adapted to them.

Hacking & Cyberwarfare

As per our interviewees, hacking and cyber warfare has become a major concern:

> "the first word that comes to mind is cybersecurity. We're talking about cars that are connected, that are hackable, so this is a risk that has been discussed a lot and is currently being addressed (…) I think that the first step [is to] address the issue of cybersecurity; of 'how we can make these vehicles safe enough' so that people trust this technology and are willing to use it." [Interviewee **H**]

The hardware and software needed to understand machine learning and artificial intelligence is now accessible to citizens. This can be considered a positive trend which allows users of these technologies to understand how such technologies work, test their limitations, and importantly contribute to further innovation. However, the claim that automated vehicles *are safer* than manually driven vehicles may suffer due to the increase in vulnerabilities that such a system has. This can be seen as amounting to a substitution of human 'errors', replacing

involuntary errors with deliberate ones. Indeed, nefarious groups and governments can also have access to these tools and could potentially endanger many lives.

Furthermore, hacking and cyber warfare is not only a concern in terms of external entities gaining control of private vehicles or a fleet of vehicles in order to induce harm. It is also a concern in terms of the possibility of the user tampering with its vehicle's software and rendering its personality on the road more aggressive. Despite the moral and legal framework being taken into account in the design and implementation of the connected and automated vehicles, these can be manipulated by experienced hackers. Furthermore, these vehicles could be tampered with in other ways that do not require cyber hacking. Researcher and artist James Bridle illustrates with just a pocket of salt how to paralyse an automated vehicle by tracing two lines around the car in 360 degrees resembling lane markings. In an interview, he states "I don't see why cab drivers of the future shouldn't be chalking white lines on side streets to derail self-driving Ubers which are putting them out of work, and I also think we need more eyes and hands on the tools which are shaping all of our futures" (Mufson, 2017). In such cases of creative tampering, the deterministic nature of the systems driving automated vehicles can be used to work against it. Indeed, Waymo's vehicles in Arizona have been run off the road or been caused to pull over by citizens who protested their testing and understood how to manipulate the system's own parameters. Indeed, the testing of CAVs requires 'real world examples', but citizens do not want to be their 'real world mistakes' (Romero, 2018).

Recommendations

Safety on the road therefore cannot be achieved just through the implementation of such systems but also through a thorough understanding of their limitations and appropriate consumer education when it comes to their use. New types of incidents involving CAVs suggest that more studies need to be conducted in order to ensure that systems such as cruise control and autopilot, as well as other increasingly automated systems, are safe and can be met by safety drivers. Furthermore, such a need for 'safety drivers' also calls into question the utility of CAV technology.

5.3 EU Regulation, Data & Privacy

The capture of data is an essential part of CAVs insofar as the development of their artificial intelligence systems relies upon this data to increase its capabilities. Therefore, the General Data Protection Regulation (GDPR) could pose an obstacle for the development and deployment of this technology within the European Union. Interviewees also noted that good governance is necessary in order to ensure that developments do not focus on individual car ownership, as expressed in this quote:

> "The incentive alignment is wrong, because it's incentivising individual car ownership, so that needs to be a different… and car manufacturers need to be incentivised through governance and through various financial incentives, to do things differently." [Interviewee **I**]

User Rights

With the increase of 'connectivity' and 'autonomy' developed in vehicles, there is a decrease of human agency when it comes to the ownership, use and repair of vehicles. This does not only affect drivers but also dealers, road traffic agents, policemen, and mechanics. The rise of these vehicles has increased the gatekeeping power of companies such as Google and Tesla when it comes to their services and products. Despite a 'Right to Repair' act in some US states[12], Tesla has no dealerships and has refused to sell its parts to users and third parties. Tesla underline their safety concerns when addressing this policy. However, when a series of Tesla vehicles proved to have faulty airbags, they refused to commit to a repair until the controversy caused them to reconsider. An interesting case has developed in the United States whereby a mechanic purchased crashed and flooded Tesla vehicles in order to keep their salvage parts and learn repair work for Tesla. He states, "I think that your fundamental consumer right is your ability to fix what you rightfully own. The fact that people don't have an alternative than to go to the manufacturer, that's a huge issue. (…) There's a lot of grey area as to what you actually own with these cars, because in order for the major functions of the car to work, they have to talk to Tesla." (VICE, 2019). Indeed, this gatekeeping stance bodes badly in terms of the sustainability and longevity of these vehicles, and could breed an unregulated black market.

Recommendations

If CAVs are to be deployed in the European Union, interviewees suggest that companies should be obliged to share their technological and mechanical insights with dealers, other third parties, and their users in order to ensure best practice. It should also be highlighted that since CAVs must 'talk to' companies through their systems, these vehicles are caught in a complex technological ecology that creates important dependencies.

5.4 Sustainability

The vision of CAVs is often associated with a switch from fossil fuels to *clean* energy such as electricity. But, whether CAVs will reduce fossil fuel consumption remains uncertain. From our interviews with industry professionals, however, these are two parallel developments rather than EVs being intrinsic to the success of CAVs. Our interviewees also emphasised that although connected and automated mobility may have benefits in terms of sustainability, they are only one aspect of a broader ecology of initiatives that must work together to guarantee a more sustainable future, as expressed in this quote:

> "I think the future will not be just automation; it will be a combination of everything that is new and better in the mobility of tomorrow. We're talking decarbonisation. We're talking electrification. We're talking automation. We're talking all sorts of things that as a whole package should lead to clean, sustainable, better mobility for the future and for everyone." [Interviewee **H**]

[12] See: https://en.wikipedia.org/wiki/Motor_Vehicle_Owners%27_Right_to_Repair_Act

Truck Platooning

Truck platooning in particular has become the focus of connected and automated vehicle developments, in large part because it is easily networked and contained. Industry professionals and policy-makers can delay coping with issues of mixed driving, privacy, and the user acceptance of current drivers. The promises of truck and vehicle platooning include a substantial reduction in fossil fuels and energy consumption, due to the coordination of the vehicles within the network. The energy consumption could be reduced by 4% to 25% as vehicles in a platoon will have less air resistance (Wadud, 2016). However, the link between truck platooning and sustainability may be more tenuous than it appears. One of our interviewees also states that although consumption can be reduced in areas such as truck platooning, they do not believe that automated vehicles will reduce the mileage travelled by people, and that it may increase traffic, as expressed in this quote:

> "You can have an opportunity from let's say the environmental point of view, and I'm not so convinced that we will have one because I'm not sure that this kind of technology will reduce the mileage that will be travelled by people. Probably it's exactly the opposite (…) For instance, if you start operating trucks on a platooning let's say mode of operation, this is something that will impact and is expected to have maybe 16%, 15% or reduction in the consumption of fuel on each truck. And then this is very important for the truck industry, but it is even important for the environment of course and sustainability. But, maybe even the traffic is increasing." [Interviewee **D**]

Energy efficiency

Interviewee **H** stated that 'most people think that automated cars will come electrified anyways, but this is not a technical link'. CAVs may also have the potential to improve energy efficiency, but this depends on travel demand. The introduction of autonomous vehicles thereby equally has the propensity to exacerbate pollution. However, as a professor in transport and energy interactions states, "as a society, our interest lies in reducing total energy use, or total carbon emissions – and energy efficiency forms only one half of this picture" (Wadud, 2016). Interviewee **G** additionally notes that in regards to air quality, exhaust emissions are not the only contributors. Hence, even if automation is combined with electric vehicles, they state that "the air quality problem will largely dissolve but not completely, because we know that some pollution is caused by the friction between the tires and the road, for instance." Furthermore, the mining of resources needed to make the batteries within electric vehicles—such as lithium and cobalt—is renowned for its use of exploitation and child labour in order to obtain cheap raw materials. In the first lawsuit of its kind, companies Apple, Google, Microsoft, Dell and Tesla are now being sued for the death and injuries of the children of 14 Congolese families who worked at illegal cobalt mines used to make electronics (Ongweso, 2019). This lawsuit showcases the social and ethical issues behind the imagination of the future role of electric, connected and autonomous vehicles.

Emissions

Although CAVs could cause exhaust emissions to drop, Interviewee **G** emphasises that a big shift towards manually-driven electric vehicles 'may well happen before we have automation, so automation will not necessarily help'. As Interviewee **F** notes, such developments might increase fleet size, or miles travelled. If such mobility options are cheaper and more accessible, then there may be a greater travel demand. The attractiveness of traveling by connected and automated vehicles, rather than public transport, could mean that demand for such transport could exponentially grow. Polis state that "automation may well accelerate the private car option, since time stuck in traffic could be spent doing other things" (2018, p. 4). Interviewee **H** also highlights these emerging technologies as tools to use towards the traffic efficiency issue, but not as solutions in and of themselves:

> "Technology of automation and connection for that matter in itself does not guarantee at all that it will solve traffic problems. It's just a tool and in fact it could happen that this does make road transport more attractive and would even increase the mileage and increase congestion and the problems we have nowadays." [Interviewee **H**]

Indeed, they could also encourage demographics who could previously not own cars or have access to cars to own or to access an automated vehicle—such as the elderly, disabled, or children and young people without a driving license. Another claim is that the introduction of CAVs could lead to the elimination of car parks in the city centres, which would allow for more parks and public spaces. However, there remain no guarantees that these spaces will be redeveloped in this way. Furthermore, if this is the case, and CAVs are not combined with sharing services, they could once more increase pollution and traffic as cars travel with no users for certain distances.

Recommendations

These review and interviewees' considerations suggest that a shift towards a more sustainable transport sector in Europe cannot solely rely on the implementation of CAVs. Greater mobility could come at the cost of an increase in carbon emissions, rather than a decrease. Public health could also be affected as citizens choose CAVs over other travel options such as biking and walking. Several of our interviewees have emphasised that, depending on its implementation, CAVs could have the adverse effect of heightening automobile use and traffic, as well as increasing CO_2 emissions.

5.5 Implementation

Whether CAVs will reduce CO_2 emissions, reduce traffic and congestion, and reduce car ownership, will largely depend on how they will be implemented and on the countries' road infrastructure. Many scenarios were outlined by our interviewees, but what was mostly emphasised was that the transition to fully automated cars or fleets would be a complicated and lengthy process:

> "The period will be extremely long." [Interviewee **D**]

"One of the aspects that's very often, let's say, neglected is that it will take a very long time actually to let's say, exchange that vast fleet of vehicles that we have on our roads nowadays. In many of those visions a miracle happens, and all the cars are automated and connected from one day to the other. In reality, we have millions and millions of cars in Europe and the exchange of the cars will be very slow and this technology can only, let's say, drain into the fleet with new cars. You can't actually retrofit existing cars with automation, so that will take a very, very long time actually to come to the fleet." [Interviewee **H**]

"Without the enabling technology you will not have the service. So, they are the driving force, but they need roads on which they can put their products, a surface and they also need legislation to allow it. So, once you have let's say enabling technology, it still needs to be allowed (…) then, you still have consumers that need to buy or use the service; without consumer demand, there will not be a successful deployment. So, that means that you also need user acceptance and society embracing this development." [Interviewee **F**]

"On the liability aspect, that is a thing that is rather unclear. I mean, what's clear is that if the driving task is moving from the human to the machine most of the liability will move in the direction from the human to the machine, but it has to be with either one, it cannot be 50:50 or you know, it cannot be a grey zone. And for the different levels of automation and especially for transitions of control and handover situations, it is not always clear who is exactly in control and who should be liable. I think this is also a whole phase where in the legal framework it has to be decided and made clear who is liable, and this is difficult to do upfront." [Interviewee **F**]

Interviewees cited factors such as enabling technology, testing and certification, the legal framework, governance, market competitivity, and user acceptance, as barriers for the implementation of CAVs.

Car Sharing

Car sharing has been put forward as one of the ways in which CAVs will increase energy efficiency when it comes to mobility. Several industry professionals interviewed stated that car sharing will be a major factor in the CAVs meeting their promises. For example, one of our interviewees illustrates how this assumption is shaping the development of CAVs:

"The assumption is that in the future we will have what they call shared mobility (…) I think that's the big assumption that the OEMs are working on and lots of other stakeholders in this area. So, we'll move away from private ownership. We'll be using more car sharing, more on-demand transport, so pretty much what we have today. (…) most of the OEMs have a smart mobility or an urban mobility department, which is really building-up their portfolio of services related to urban mobility, because they see that that's the future. (…) That's what a lot of cities are saying today, that more and more people who live in the city are starting to give up their car, or maybe just use it in the evenings, at weekends. That doesn't mean congestion is getting any better." [Interviewee **G**]

Nevertheless, Interviewee **F** stated that shared mobility "does not necessarily need to be automated, but it is often mentioned as a combination." Whether current car-owners will give up their own cars to share one with strangers remains a question for manufacturers and developers. If so, it additionally remains to be seen whether car sharing will just mean more cars on the road, more traffic, more mile-usage, and a quicker turnover rate due to the damage caused to shared vehicles and companies upgrading their models. Companies such as Uber or Lyft have paved the way for the conception of a future of 'car sharing', but their current users indicate that it is not the private car owner the one who uses such services, but rather other demographics who usually use public transport—they are therefore increasing car travel in urban areas. Furthermore, research states that such companies are responsible for an increase in pollution and traffic congestion, and a decrease in the funding of public transport. In a study of US mobility, expert of new mobility services Bruce Schaller stated (Schaller, 2019):

> "Shared ride services such as UberPOOL, Uber Express POOL and Lyft Shared Rides, while touted as reducing traffic, in fact add mileage to city streets. Even with these shared services, TNC[13]s put 2.6 new TNC vehicle miles on the road for each mile of personal driving removed, for an overall 160 percent increase in driving on city streets. Shared rides add to traffic because most users switch from non-auto modes. In addition, there is added mileage between trips as drivers wait for the next dispatch and then drive to a pick-up location. Finally, in even a shared ride, some of the trip involves just one passenger (e.g., between the first and second pick-up)."

Ride-hailing or ride-sharing services could undermine other forms of transport which are more sustainable, such as the metro and bike. Indeed, an increase of cars on the road means less space for bike lanes and pedestrians. Furthermore, although increased accessibility of personalised transport for the elderly or disabled has been claimed by CAVs industry, the automation of car sharing services could have a detrimental effect on the safety and well-being of these demographics. It has been noted, for example, that despite automated vehicles taking over the professional driving service, there are other functions that professional drivers have which are primordial to these users. Some tasks include helping the elderly or disabled get in and out of the car, helping with heavy packages, and care-taking riders that are experiencing a medical or other emergency. Furthermore, despite automated vehicles facilitating car sharing, they can equally drive without anyone in the vehicle. As Interviewee **G** stated:

> "We could see some spam cars, so some automated cars running around with nobody onboard and the congestion situation could just get worse."

Mixed Mobility

Interviewee **D** states that a long period of co-existence and transition is to be expected, and that this could be problematic due to mixed mobility. The mixing of automated and manually driven vehicles indeed poses multiple challenges; for example, humans may learn to cut in front of driverless vehicles on the assumption that these will give way in order to avoid an

[13] Transportation Networking Companies.

accident, and the actions of human drivers become increasingly difficult to predict in a mixed driving situation (Sparrow & Howard, 2017). Due to the complexity of mixed driving, it has been suggested that dedicated lanes be reserved for automated vehicles. However, many European cities do not have the space to add another lane to their roads, and such infrastructural changes would create financial burdens for cities. Indeed, Interviewee **G** called this a 'fantastical suggestion':

> "Firstly, why should they do this? I mean, whether it's an automated vehicle or not, why should they give them a dedicated lane? Secondly, there just isn't the space in cities. Most city roads are single lane, so there just isn't the space to provide a dedicated lane." [Interviewee **G**]

Infrastructure

There is uncertainty when it comes to who will be accountable to resolving the new sets of issues and pressures that connected and automated vehicles will have when it comes to retrofitting, traffic, liability, road infrastructure. Indeed, several of our interviewees highlights this as the main concern. Interviewee **G** states:

> "I think there's an assumption the infrastructure will be there, and it will be perfect, and it will be able to accommodate automated vehicles. I simply don't think that's the case. I think there are massive changes that will need to be made for the infrastructure to be in a state it will need to be to enable automated vehicles. When I say the infrastructure, I mean the physical infrastructure. So, for instance, today no road authority can guarantee that there will be good quality road markings and clearly visible road signs. That's just not there today and if this is a requirement for automated vehicles to be able to operate efficiently, then we will need big changes. We will need big investments. We will need new powers for city authorities." [Interviewee **G**]

The implementation of electric vehicles is given as a good example of the infrastructural issues that could prevent autonomous vehicles from being deployed. The lack of charging infrastructure has been a major reason for the low level of user uptake. C-ITS, offering vehicle to vehicle and vehicle to infrastructure communication, may play a direct role in whether, and how, automated vehicles are implemented. Their development and deployment may fulfil the demand for traffic efficiency, road safety, and network coordination 'independently of vehicle automation developments', as noted in a Polis study (2018). Conversely, they could serve as the enablers of automated vehicles due to their enhancement of the connectivity infrastructure. The infrastructure needed for the implementation of this new technology therefore needs to be more thoroughly evaluated, taking into consideration fringe examples such as the covering of lane markings by car accidents or road work. Many policy documents, such as that of ERTRAC, emphasise a progressive implementation of CAVs throughout the next decade (ERTRAC, 2019). However, our interviews, focus groups and research call into question whether a progressive approach would be possible without considerable changes to city and road infrastructure as well as data protection regulation.

Recommendations

The interviewees and literature seem to suggest that CAVs should not be implemented across Europe with a 'one size fits all' approach, and that stakeholders, as well as, citizens, are consulted on the various factors that are involved in the implementation of CAVs. It is advisable that studies are conducted in each country in order to determine the particularities of the driving culture, road infrastructure, public transport system, and user needs. Interviewees also emphasised that companies must be incentivised to apply connected and automated systems to forms of transport, such as public transport, that do not prioritise individual car ownership.

6. Final Reflection

> "[Connected cities] is a great opportunity because everybody's got a stake in it." [Interviewee **I**]

The social and technological promises of the CAV sector have been problematised throughout this report by both the narrative analysis and interviews. CAVs may offer new opportunities for innovation and rethinking cities, mobility, energy, and sustainability, but the promises are unlikely to be actualised through the deployment of CAVs alone. The framing of mobility as a technological problem does not seem to be fit for purpose as many of the interviewees have suggested. As has been outlined in the previous section, the promises that the technology and automobile industries have outlined such as traffic efficiency, sustainability, increased public space, free time, and safety rely on many other factors in order to be realised. Therefore, even the assumptions under which such imaginaries of mobility futures may require contextualisation.

Much like the realisation that artificial intelligence has trouble coping with the 'messiness' of reality, the vision of urban mobility that the CAVs industry proposes appears to exist in a world without complexity. The imagination that the industry has created points to a future of sustainable cities, and where everyone can benefit from increased and personalised safer mobility options. However, the literature and the interviewees emphasised that the technology itself remains insecure and its promises are yet to be seen; the current stage remains one of trials and tests. There remain important technological challenges that inevitably impact the viability of the social promises that this sector has made. Furthermore, many of these promised benefits directly necessitate public funding; such as for new road infrastructure and digitised systems.

The interviews that the JRC had with actors from the technology and automobile industries showcase that industry actors are aware of these complexities and obstacles, but that marketing and raising stock value, as well as appealing to EU competitivity, have left this vision of mobility relatively unexamined. In our discourse analysis, we identified several academic fields and public-led initiatives that are critically engaging with this future of urban mobility; these include the field of digital and techno-anthropology, sociology, philosophy and STS. Throughout this research, the industry has appeared interested in the thoughts of end-users on the future of connected and automated vehicles, but their framing has remained one which aims to locate obstacles to user acceptance, rather than include citizen perspectives on mobility from the beginning of their design processes. These futures of mobility are heterogenous and highlight precisely what the interviews with the industry professionals pointed towards—that the futures of mobility will be as 'messy' and 'complex' as the realities that today's AI and policy makers are attempting to control.

There remain many important political, technological, social and ethical challenges that must be addressed in the development of CAVs. These challenges will not only concern the technology and automobile industry; its potential impact would affect many other sectors. It is therefore important to keep bringing new voices into these debates—voices from cities, other areas of policy and from citizens. When asked which stakeholders were not being consulted enough on this topic, interviewees stated that citizens and city officials needed to

be more involved. Several additionally pointed us towards initiatives which are attempting to do just that—inform citizens about the complexities of connectivity and automation, and engage them in shaping their mobility futures. As is pointed out by one of our interviewees, the work of such initiatives is important because they 'tell the real story of automation, and not the marketing story'.

Finally, the Responsible Research and Innovation framework has been useful to exemplify how to extend the mobilisation of relevant knowledge into debates about deployment of technology of such complexity, as CAVs. Hence, the work described in this report falls methodologically with both examining and assuring responsibility of innovation. This report focuses mostly on the scrutiny of justification narratives for the CAVs technology and vision, extending the examination of CAVs narratives to different actors. This is at the heart of RRI. At the same time, it has sought to extend the imagination/creation of future mobility and the place of CAVs with those actors. In another report (Van Wynsberghe and Guimarães Pereira, 2021) we have furthered the inclusion of different voices in both processes, of review and co-creation by working with citizens. We suggest that this methodology can be extended to other areas of innovation, but ideally within a design phase, avoiding the so-called Type II error, i.e. solving the wrong problem.

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List of Acronyms

Artificial Intelligence	AI
Connected and Automate Vehicle	CAV
European Commission	EC
European Road Transport Research Advisory Council	ERTRAC
European Union	EU
operational design domain	ODD
Responsible Research and Innovation	RRI
Science and Technology Studies	STS

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