This thesis has been submitted in fulfilment of the requirements for a postgraduate degree (e.g. PhD, MPhil, DClinPsychol) at the University of Edinburgh. Please note the following terms and conditions of use:

This work is protected by copyright and other intellectual property rights, which are retained by the thesis author, unless otherwise stated.
A copy can be downloaded for personal non-commercial research or study, without prior permission or charge.
This thesis cannot be reproduced or quoted extensively from without first obtaining permission in writing from the author.
The content must not be changed in any way or sold commercially in any format or medium without the formal permission of the author.
When referring to this work, full bibliographic details including the author, title, awarding institution and date of the thesis must be given.
FAST FORWARD: TECHNOGRAPHY OF THE SOCIAL INTEGRATION
OF CONNECTED AND AUTOMATED VEHICLES INTO UK SOCIETY

BY

XINYI WU

A THESIS SUBMITTED FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

SCHOOL OF SOCIAL AND POLITICAL SCIENCE
THE UNIVERSITY OF EDINBURGH
2021
Lay Summary

The emerging connected and automated vehicles (CAV), also known as ‘self-driving vehicles’ have caught much research attention in the past few years. However, in the CAV research domain, there exists a lack of in-depth qualitative studies of its socio-political aspects. To fill the gap, this Ph.D. project bridges the fields of Social Anthropology with Science and Technology Studies by adopting technography, an ethnography of technology, to enable a thick description of the CAV technology’s social integration into UK society. By critically drawing a holistic view of the ongoing process of the CAV social deployment, it aims to (1) unfold CAV’s potential problems and dynamic contributions to everyday life through the lens of sociotechnical imaginaries, and (2) reveal and analyse the development and deployment of CAV by policymakers, technicians, and industry stakeholders.

The project contributes to an understanding of a close encounter between the CAV technology and its imaginaries, which peels off the complex socio-political layers of bringing technology to society. It also explicates the importance of embracing multiple perspectives and calls for continuous research in this field.
Acknowledgement

I would like to express my most sincere appreciation to my principal supervisor Dr. Tom Boylston and my second supervisor Professor Francesca Bray. They have encouraged me to explore and make my own choices, whilst ensuring me working in the right direction. Without their continuous guidance and kind support in these three academic years, I could not have completed this project.

I thank my parents and friends for their love and support, and my participants for their inspiring and insightful inputs.

Special thanks must be given to the China Scholarship Council, who generously funded my Ph.D. programme at the University of Edinburgh.
Abstract

The emerging connected and automated vehicles (CAV) have caught much research attention in the past few years. However, a techno-centric bias in the CAV research domain implies the lack of in-depth qualitative studies. To fill the gap, this Ph.D. project bridges the fields of Social Anthropology with STS by adopting technography, an ethnography of technology, to enable a thick description of the CAV technology’s social integration into UK society. By critically drawing a holistic view of the ongoing process of the CAV social deployment, it aims to (1) unfold CAV’s potential problems and dynamic contributions to everyday life through the lens of sociotechnical imaginaries, and (2) reveal and analyse the institutional practice on its social rollout.

Based on pilot research and one-year-long fieldwork in London and Edinburgh, the thesis investigated a wide range of important socio-political aspects where fundamental topics such as trust, human-and-machine relationship, social safety, political transparency, and equity in transport systems were explicated. Different from the planners’ top-down CAV imaginaries that focused on its contribution to functional safety, environment, and the economy, the public’s bottom-up imaginaries highlighted issues that were related to their travelling experiences, such as inequity of transport service distribution and sexual harassment during commutes. These findings inspired thinking and rethinking on what constitutes the success of technology’s social deployment from multiple perspectives. In particular, it critically pointed out that safety means not only technological feasibility but also social safety that refers to a safe commuting environments. Such finding in my thesis thus suggests that CAV technology is not a one-size-fits-all solution to problems in our transport system and calls for research effort to the broader socio-political and ethical areas of this
technology. through an investigation of the institutional practice, it identified four major institutional forces, including technicians, industry stakeholders, researchers, and policymakers who have been working on these aspects with different approaches and priorities. Apart from acknowledging their efforts in building safety cases, pushing forward the CAV legislation, and engaging the public in trials, it critically explained challenges such as technical uncertainty and political tension in developing and implementing a legal framework.

Hence, the project contributes to an understanding of a close encounter between the CAV technology and its imaginaries, in which, technical and socio-political problems and potentials fabricate the richness in its social deployment. It also explicates the importance of embracing multiple perspectives and calls for continuous research in this field.

**Keywords**

Connected and automated vehicle (CAV), social integration, sociotechnical imaginaries, institutional practice, technography
# CONTENTS

Acknowledgement ......................................................................................................................... 3

Abstract ........................................................................................................................................ 4

Introduction ................................................................................................................................... 9

1. Sociotechnical Imaginaries and Developments of Vehicles...................................................... 12
   1.1 Desire for speed and safety innovation ................................................................................. 14
   1.2 Fun and feminism in the vehicle imaginaries ....................................................................... 17
   1.3 Imaginaries on social status vs. affordability ........................................................................ 18

2. My Research Questions ............................................................................................................ 23

3. Thesis Structure ......................................................................................................................... 30

Chapter 1 CAV Landscape: Setting the Scene ............................................................................. 37

1. What is a CAV? .......................................................................................................................... 37
   1.1 Terminology: a brief clarification ......................................................................................... 38
   1.2 CAV technology .................................................................................................................. 39

2. CAV in Society .......................................................................................................................... 48
   2.1 CAVs in the world ............................................................................................................... 48
   2.2 CAVs in the UK ................................................................................................................... 54
   2.3 CAVs in London and Edinburgh ......................................................................................... 59

3. Research on CAVs .................................................................................................................... 61
   3.1 Bibliometric Review and blind spots .................................................................................... 62
   3.2 Social research on CAVs ...................................................................................................... 66

4. Methodology .............................................................................................................................. 74
   4.1 Technography ....................................................................................................................... 74
   4.2 Technography and anthropological future studies ............................................................... 78
   4.3 Technography and my research .......................................................................................... 81
   4.4 Entering the Field and Making Ethical Choices .................................................................. 85

Chapter 2 CAV Terminology: Sociotechnical Imaginaries and Political Intentions .................. 93

1. The Terminology Puzzle .......................................................................................................... 95
2. The ‘Moral Breakdown’ in the CAV Domain and the Shifted Focus ..................262
   2.1 The Trolley Problem ..................................................................................263
   2.2 The Molly Problem ..................................................................................266
3. Ensure Responsibility: who to blame? ..............................................................270
   3.1 The AEVA 2018 .......................................................................................271
   3.2 “Black Box”: policing and insuring ...........................................................277
4. Building a UK CAV Legal Framework ..............................................................281
   4.1 The consultation papers ...........................................................................282
   4.2 HARPS and the Operator Licencing ..........................................................286
5. Conclusion ........................................................................................................291

Chapter 7 CAV Public Trials: embodiment, engagement, and the technology display
..........................................................................................................................294

1. Jump on an Automated Bus! ...........................................................................295
2. Look! Here’s a self-driving Pod! ......................................................................303
3. Conclusion ........................................................................................................319

Thesis Conclusion ...............................................................................................321

Epilogue ..................................................................................................................326

Reference ...............................................................................................................331

Appendix: CAV Glossary ......................................................................................364
Introduction

I was deeply intrigued by the humanoid self-flying taxi in *the Fifth Element* (1997) that can wittily chat with Korben Dallas (acted by Bruce Willis) and shuttle back and forth over the city sky. At that time, it was only a fascination that existed in bold imagination. I was too young to understand the sociotechnical imaginaries of a vehicle and how they could influence the development and deployment of vehicle technologies, but I had faith in the self-flying car’s realization. Twenty years later, I started my Ph.D. research that looks at the social integration of connected and automated vehicles (CAV).

Throughout history, science fiction has never stopped unleashing imagination on vehicles of the future where desires and expectations are embedded. To name but a few, the 74-Z Speeder Bike, a flying motorcycle in *Star Wars: Return of the Jedi* (1983), and the Spinner, a fast self-flying car in *Blade Runner* (1982) represent people’s wishes for speed and freedom (Sachs, 1992) from the driving task. Beyond people-movers, the vehicles in *Pacific Rim* (2013) can transform into giant human-controlled robotic soldiers. The extended robust bodies reflect people’s desire for strength and power, and their absolute control over the intelligent machines implies a human-dominant relationship with robots (Robertson 2010; Richardson, 2018).

Besides, Dr. Emmett Brown’s DeLorean DMC-12 is a car to travel through time, with which, he started not only scientific explorations of the outside world (Ingold, 2004) but also self-discovery (Laurier and Dant, 2012) and generated fun experience (Dennis and Urry, 2009; Coyne, 2016) with his family. Science fiction dramatises how in everyday life a vehicle carries various sociotechnical imaginaries that reflect ‘collectively imagined forms of social life and social order’ (Jasanoff and Kim, 2009:}
And these imaginaries can ‘open up future possibilities’ (Pink, Fors, and Gloss, 2018), ‘shed light on the hidden social dimensions’ of the transport systems, and ‘guide policies’ (Jasanoff and Kim, 2013: 190) in technology’s social deployment.

My PhD research explores various types of imaginaries of the CAV technology as well as how these imaginaries unfold socio-political questions and open up future possibilities, thus helping to shape the CAV’s technical development and social deployment. By critically drawing out a holistic view of CAV’s social integration into society, my research makes two main contributions. First, it builds a fuller understanding of the most important socio-political and ethical aspects of this advanced technology; this encourages (re-)thinking and practical efforts to ensure safety, equity, and responsibility considered separately from developing its technological feasibility. Second, an anthropologically informed exploration of CAV along with its possibilities inspires further imaginaries and thoughts on fundamental questions about the tech future such as human-and-machine relationships, trust, acceptance, morality, and embodied engagement. In the following sections, I set out my research questions and explain how I came to them, how I studied them, and what we may deduce from my research results.

In the first section of this introduction, I aim to show that imaginaries and vehicle technologies’ development are intertwined with each other, affecting the use and presentation of a vehicle in society. The rich vehicle imaginaries suggest that a vehicle means more than a tool to commute or to deliver goods, but also a way to realise freedom, socialise with others, pursue fashion and equity, and express oneself and her culture. Auto history has been shaped by these collective imaginaries and technology development such as electrification, advanced driver-assistance
systems (ADAS), and AI (artificial intelligence) has also been inspiring new vehicle imaginaries. The emergent CAV technology makes me think: how is new and advanced technology developed in society where agency is complex, and power possibly concentrated in the hands of tech companies? In the second section, I discuss representative STS approaches to studying the sociotechnical transition, which lays a foundation for my research design. Followed by a demonstration of my research questions about (1) people’s sociotechnical imaginaries of CAVs and (2) the process and institutional efforts of its social deployment, as well as a brief introduction to my research methods (details in Chapter 1). In the first question, ‘people’ refer to everyone since once CAV is integrated into society, anyone (whether she is a user or pedestrian or other vehicle user) will be affected. Later in my fieldwork, I consciously used the categories of ‘the planner’ and ‘the public’ to explicate the top-down and bottom-up perspectives. I explain this later in detail. Underlying these questions, I aim to openly explore public trust, human-and-machine relationship, public good perceived by the planners, and responsibility distribution, and contribute to an understanding of how CAV technology is planned, negotiated, and deployed when this technology is not yet fully developed. Finally, the last section is a signposting where I present the structure of the thesis along with a summary of each of the seven chapters.

Before looking at vehicle imaginaries, I want to briefly introduce what a CAV is, and to set out the main socio-political research angle that I follow and try to build upon. A CAV refers to a connected and automated vehicle, also widely known as a self-driving vehicle, driverless vehicle, or autonomous vehicle. Empowered by technologies such as autonomous driving, connectivity, artificial intelligence, and machine learning, a CAV is perceived and promised to be a disruptive technology to transport that can improve safety, convenience, the economy, and the environment
Currently, CAVs require a human safety driver or remote control to supervise, and they are trialled only in controlled environments at a small scale. Over the past ten years, research of CAV-related fields has been techno-centric, which I illustrate in detail later. Among limited socio-political studies, one influential voice from STS asks who is driving innovation and investigates the governance of the emerging CAV technology (Stilgoe, 2018, 2020). At the beginning of 2019, Stilgoe started and led the project ‘Driverless Futures?’ (with a similar project timeline to my own PhD research). With the main focus on how social learning – the processes by which society learns about new technologies – can be maximised¹, it explores stakeholders’ visions and governance possibilities for the public good. Have been inspired by Stilgoe’s work, I also looked at the CAV planners’ visions, negotiations, and efforts of pushing forward its social deployment. Apart from this, as a PhD student in Social Anthropology, I adopted a bottom-up approach to engaging the public in order to understand the concerns and expectations behind their CAV imaginaries, to identify and draw attention to the issues important to them, including how the possibilities afforded by CAVs might improve their commuting experience.

Further, using technography (explained below) to explore with technicians and the vehicle itself represents my attempt to bridge Anthropology and STS and potentially inspire other social disciplines to get involved in this field. My research focus is further explained after the discussion about vehicle imaginaries that paves the way for CAV imaginaries and beyond.

1. Sociotechnical Imaginaries and Developments of Vehicles

“A world without cars could be unrecognisable today. Over its brief 130-year

history the car has revolutionised the way we moved around, fuelled our
desire for speed, and transformed how objects are made and sold. In the
process, it has indelibly marked our landscapes, environments and
economies. The car is the one designed object that has shaped our world like
no other, accelerating the pace of the 20th century.”

(2020 London Exhibition: “Cars: Accelerating the Modern World”)

Empowered by technology, a vehicle is an invention that carries and realises
imagination. It is used to transport people and goods on highways or mixed urban
and highways. It also inspires the use of space in the transport systems and the
development of road infrastructure. Besides, it is the ‘myriad social roles, institutions,
and practices spawned by modernity: scientists, engineers, and designers; patents
and trademarks; auto-workers and big corporations; regulators; dealers and
distributors; advertising companies; and users, from commuters to racers’ (Jasanoff,
2016: 2), who, through constant innovations and imagination, endowed a vehicle with
functional, cultural, and symbolic meanings. Rethinking auto history, diverse
sociotechnical imaginaries are attached to vehicles and some of them became reality
due to technological and socio-political efforts. Meanwhile, technological and socio-
political efforts in shaping better vehicles trigger new imaginaries on vehicles of the
future. The encounter of imagination and technology is thus a circularly ascending
process of accumulative development of a vehicle.

---

1.1 Desire for speed and safety innovation

When automobile first came to the world in 1886, created by Karl Benz, it was not a thrilling invention. The Patent-Motorwagen can barely muster 10mph³ while, on average, horses gallop between 25 and 30 mph. The speed of automobiles at that time was not a selling point but its allure lay in the long distance it could travel. To publicise her husband’s invention, Bertha Benz took the Motorwagen No.3 for the first-ever cross-country drive, covering almost 60 miles. The idea that vehicles could be raced over long distances quickly took hold, and this growing interest pushed the design of vehicles to go even faster in the years to come.

Artists and designers well expressed this desire. For instance, in the 1939 World’s Fair ‘The World of Tomorrow’ in New York, Richard Arbib drew a painting of ‘Car of Tomorrow’ (his transport projections in 1954) where vehicles look like streamline style rockets that can run as quickly as lightning. This imaginary represented many people’s desire for a higher speed at that time and the lack of transport innovations such as flying cars (Hall, 2018) stimulated vehicle manufacturers to produce faster vehicles. In the 1950s, the American automobile manufacturer General Motors launched a series of concept cars known as ‘Firebirds’. Directly inspired by new jet fighter aircraft, these cars were crafted using cutting-edge technology and designed with fluid silhouettes, cockpit seats, and gas turbine engines that could reach 200mph. Such concept cars were often debuted at spectacular car shows to excite the public with possibilities of higher speed. Increasing speed, however, was not only for the purposes of commuting or delivering but sports, entertainment, socialization, and fun from the start.

The lust for speed pushed the technology and design of automobiles and grew racing sports. The thrill of going fast like never before gave drivers pleasure and a powerful sense of control from being behind the wheel (Duffy, 2009). However, road accidents have increased significantly (Hopkin and Simpson, 1995; Reynolds, 1956; White, 1992) since automobiles, especially when speed had a place in visions of modernity (Virilio and Bratton, 2006). Within private racetracks such as the first one built by the British entrepreneur Hugh F. Locke King in 1907 in Brooklands, the public can get thrilled by watching regulated races. The regulated races represent desires for safety, and such desires triggered imaginaries and inspired specialised driving accessories like goggles and body-belts. Outside of the race tracks, the popularization of faster cars still came at the price of lives. In the first half of the 20th century, Accident Prevention Campaigns to reduce traffic fatalities were mostly aimed at encouraging responsible driving rather than on making safer cars (see at the “Cars: Accelerating the Modern World” exhibition). Correspondingly, the UK Ministry of Transport and the Royal Society for the Prevention of Accidents commissioned graphic artists to produce posters that warn of the tragic consequences of dangerous driving and the UK government set different types of speed limits and speed limit zones\(^4\). It was considered a pioneering socio-political effort to regulate and ensure the safe deployment of automobiles, although the blame was mostly placed on bad drivers. In 1965, the ‘Unsafe at Any Speed’ campaign as a critical take-down of the car sector by the American lawyer Ralph Nader represent another perception. It exposed corporate cost-cutting tactics and a disregard for safety. Since then, ‘muscle cars’ such as Ford Mustang Fastback sparked massive debates among the public. Relatively affordable and equipped with high-performance engines, these cars

offered the middle and working classes an experience of speed that had once belong only to luxury sports cars (McCarthy, 2007). But their immense popularity was also seen to increase road fatalities. In other words, the blame was shifted onto vehicle manufacturers, and such socio-political pressure and the public’s longing for road safety further drove vehicle safety innovations.

The manufacturers found themselves at competing odds, compelled to find new ways to satisfy the public’s increasing need for speed, but also to protect them from road accidents. With a technical approach, General Motors pioneered a car with an enhanced front bumper, rollover protection, and a padded board running across the backseat to protect unrestrained passengers from minor impacts. The vehicle also included early use of airbags, which would be triggered impacts of over 30mph (information displayed at the 2020 London Exhibition: “Cars: Accelerating the Modern World”, see above). Besides, the German company Bosch introduced early electrical systems that paved the way for key safety features we now take for granted, like headlights and horns, and later digital technologies such as the ABS brakes. Seatbelts, pioneered by Volvo, have also had a major positive impact. These technical innovations dramatically reduced car-related deaths over the past century. It is interesting that in the safety mechanisms, the shifting responsibility between drivers and vehicle manufacturers revealed the socio-political complexity of vehicle’s social deployment, which deserves further study in the new CAV context. Apart from studying responsibility-distribution among drivers/users, tech firms, and manufactures, it is vital to understand how would technicians, industry stakeholders, and policymakers conceptualise and ensure safety while meeting the public’s need for speed.
1.2 *Fun and feminism in the vehicle imaginaries*

Back in the early 20th century when Hugh F. Locke King opened Brooklands, racing was not just sports or about a vehicle itself. People wanted to experience the thrills and races were intense social affairs where people could flaunt their automobiles and outfits while engaging in sports and leisure activities. Beyond travelling around, vehicles opened up possibilities for people to compete, entertain, and socialise (Kline and Pinch, 1996). Echoing my previous point, apart from transferring people and goods, vehicles also create fun experiences and contain socio-cultural meanings.

Car racing also became part of the women’s rights movement as it witnessed women challenging the traditional gender norms (Scharff, 1992). Celebrated female drivers like Camille du Gast in France and Dorothy Levitt in the UK often competed alongside their male counterparts, arguing that driving was about skill, not strength. Gender equity was thus attached to vehicles as a social imaginary. Nevertheless, the racing club Brooklands banned women from any formal competition. Women drivers persisted, using the track outside of official races and eventually overturned the ban. Brooklands drivers such as Jill Scott Thomas became powerful symbols in women’s rights movements due to her lifetime pursuit and bravery. Despite some of these positive events, the automobile industry is dominated by males. Representing power, control, and masculinity (Lumsden, 2013; Vick, 2003; Balkmar, 2019), vehicles are designed and manufactured to satisfy males, for instance, before 2011, even safety innovations like the crash-test-dummy were designed based on an average male’s weight and height (177cm, 76kg) and ignored female bodies’ characteristics, let alone pregnant females’ (Criado-Perez, 2019: 189). Since a driver is removed from a CAV, meanings such as power, control, and masculinity for males behind the wheels might be lost, therefore, some scholars suggest possibilities of a degendered trend in the
future (Balkmar and Mellsröm, 2018). I wonder if it would happen in the time of CAV? How will CAV technology affect gender politics? How can we ensure and improve gender equity through transport innovation?

1.3 Imaginaries on social status vs. affordability
Before mass-production, vehicles were handcrafted and expensive, affordable only to an elite few. The standardised and popular Ford Model T helped car ownership skyrocket, but in exchange for a decline in overall quality.

Spying an opportunity to cater to a select market, in the 1920s luxury car manufacturers distinguished themselves from the mainstream by returning to creating bespoke, meticulously crafted vehicles for wealthy consumers. An entire industry followed. As well as these luxury cars, consumers could indulge in high-end fashion items and accessories. Adverts in magazines like Vogue sold an image of motoring as one of glamour, conjuring up an expensive lifestyle with the car at its centre. ‘Customized for the 1%’, luxury cars symbolise and visualise class and power (Wang and Wallendorf, 2006; Balabanis and Stathopoulou, 2021).

Envisioning affordable vehicles for the majority, Henry Ford trialled an innovative method inspired by the animal carcasses process that uses a highly efficient assembly line. He broke production down into small tasks- with one person focusing on performing each job specifically- in his car factories, resulting in an endless stream of standardised products. The moving assembly line unleashed new levels of efficiency, allowing the company’s annual output to rise exponentially while prices fell. The highly standardised Model T boost the automobile industry and its assembly line provided millions of jobs in the 1940s. This is another good example of imaginaries
pushing technological development. Meanwhile, technology development also inspires new imaginaries, especially of vehicle as commodity, compare to public transport as a shared good. Today’s factory assembly lines have moved beyond the standardisation of human labour, to include the integration of robots into the workplace (Müller et al., 2016). Being manufactured in a more efficient environment, how would future vehicles look like? Will they be affordable to everyone or will some of them still contain luxurious elements to differentiate people’s social status? Underlying these questions is equity, which needs to be explored in the CAV context through the eyes of the planners as well as the public.

1.4 Self- and cultural expression through vehicles

When functionality reached a peak in the 1960s, people started imagining other possibilities featured by a vehicle. Car subcultures emerged around the world and people treated cars as raw materials to be fashioned and repurposed into symbols of personal expression (Miller, 2009; Miller, 2020). A documentary presented at the “Cars: Accelerating the Modern World” exhibition demonstrated how do people add new features to vehicles to express themselves and their cultures and further open up realising vehicle imaginaries in their everyday life.

Some of the examples include the dune racing in Dubai, the ‘spinning’ in South Africa, the vintage motorsport in England, and eye-popping dekotora trucks in Japan, which all demonstrated people’s imagination of vehicles and through vehicles. ‘Spinning’ and ‘Dekotora’ were the stories that intrigued me the most. "Spinning" involves performing dangerous stunts whilst a car is spun around in circles at high speed. The drivers lock the car into a spin and then, in clouds of smoke and squealing tyres, climbs out of the car or even hangs backward out of the window with
their heads almost brushing the ground. It has its roots in the early 1980s in Soweto, Johannesburg (Kynoch, 2005), where gangsters and criminals would steal cars to spin at the funerals of dead friends. It is now the fastest-growing motor sport in South Africa with a new generation pushing to make it mainstream. This subculture was introduced through the narrative of Stacey-lee May, a 23-year-old law student and one of South Africa's top female motorsport sensations. Her introduction to spinning came from being bullied in high school. At the age of 16, she joined spinning to grow confidence. Through her engagement with spinning, Stacey-lee expressed bravery and showed powerful inner strength beneath her tiny body.

The story from Japan is about Dekotora, which means 'decorated truck'. Inspired by the 1975 Japanese TV series, Torakku Yarō, which featured a trucker who drove his garishly decorated truck all over Japan, dekotora drivers spend huge sums of money customising their ride with extravagant hand-painted murals, neon and ultraviolet lights, and sparkling chrome fixtures. The main character, an old Japanese man said, on the truck he drove long distances and went to many places. It was an instinct to make a mark and show the world his existence- his flashy and exaggerated personality (Miller, 2020) through the decorated truck. These stories lead us to wonder, apart from the technical prospects such as speed, safety, convenience, and efficiency, how would a connected and automated vehicle enrich culture? How would it generate fun and inspire people to create and express? I also wonder whether users, in the CAV context where drivers are removed and potentially the rides are shared (vehicles as public goods only), will feel deprived of the satisfaction that comes with exercising driving skill, including fun, personal expression, and a sense of control?
1.5 New technology and new imaginaries

“Experimental self-driving vehicles are taking to our streets, skies and seas, powered by artificial intelligence (AI). They might transport you around cities, grow your food or deliver packages to your doorstep. They could reveal hidden glimpses of the world around you, and even save lives.

They are designed to outperform humans at specialised tasks, in very specific environments. But they are not quite ready to take full control.

Training their AI to interact safely with us in our complex and unpredictable world is still a significant challenge. Deciding how and whether they should be used is another.”

(Exhibition: “Driverless: Who’s in Control?”\(^5\))

The emergent autonomous driving technology triggers new imaginaries (Martin, 2021) and inspires rethinking of the existing sociotechnical imaginaries in the new context (Mladenović et al., 2020). At the “Driverless: Who’s in Control?” exhibition, I overheard an interesting conversation in front of an automated pod, where utopian imaginaries unfold possibilities afforded by the CAV technology while dystopian imaginaries reveal potential problems caused by this technology.

\(^5\) Exhibition: “Driverless: Who’s in Control?” was held in Science Museum in London in 2020.
“It would be handy and super cool to have one!” said a middle-aged man whose face light up with a boyish grin. His words suggest at least two prospects: first, it sets people free from the driving task and thus provide convenience and freedom; second, it is avant-garde and edge-cutting. I assume he had already imagined showing off this eye-catching vehicle to his friends.

His wife replied with suspicion, “No way. I don’t trust them.”

“Why?” the man was surprised but continued saying, “Even though the technology is not mature today, it’s somewhere close. And we can get there soon. Once allowed on roads, they must be safe.” Interestingly, the man assumed his wife’s concern was centred around technological feasibility, which appears to be a major concern among the public.

“I don’t like the idea that the car is in control. No technology can be perfect, you know. I don’t want to take the risk. At least, I won’t be comfortable having Teddy on a self-driving pod to school. I’d rather drive him myself.” Said the woman, “Although they’re good for delivering.” This implies not only her wish for humans to be in control and her low trust in technology but also that trust level may change in different contexts. Specifically, even if she is ready to try out the automated pod, it does not mean an acceptance of using it to pick up her children. Self-driving delivery pods are nevertheless imagined and acknowledged.

“You’re right, technologies aren’t perfect. But it’s a generation thing, you see, kids like the idea of self-driving cars. I bet Teddy will be happy to use it.” The man laughed
and looked at his son who was excitedly taking a selfie with the automated pod.

I found this short conversation fascinating because it revealed the social thickness of a technological system, which has been a central goal of the study of science and technology studies (Jasanoff, 2016). The convenience brought by autonomous driving technology, as the man claimed, triggered utopian imaginaries for him and his son with a prediction that younger generations will be more likely to accept and use it. The woman, though not detailing any dystopian scenarios, expressed her distrust of technology, especially when picturing her son as the passenger. It suggested that people’s perception and trust of technology shifts in different social contexts, which resonated with Jasanoff’s (2014) view that technology is embedded in social practices, discourses, norms, and institutions, and technology or its scientific knowledge alone cannot mirror the rich reality of our society. Besides, the lack of trust is associated with both the technical uncertainty and the unknown/unclear responsibility distribution among users, tech firms, and vehicle manufacturers if encountering road incidents. It triggered my deep curiosity: How do people imagine connected and automated vehicles? And how will connected and automated vehicles be legislated and integrated into our everyday life? Further, how would an understanding of the CAV technology’s development and deployment in society contribute to our knowledge and thoughts about trust, responsibility, and political transparency?

2. My Research Questions

One of the major achievements in Science and Technology Studies in the 1980s is that technology is considered to be socially constructed (Bijker, Hughes, and Pinch,
1987; MacKenzie and Wacjman, 1999) as socio-political and economic constraints can undermine the technological outcomes. In the process of the socio-political configuration of technologies, a technological product is designed and modified through user activities and political negotiations where ‘some technical features embody a political aim or an intention to alter to the allocation of power, prestige, or wealth in a social formation’ (Pfaffenberger, 1992: 285). The idealistic view of introducing technology to society in a linear way is thus criticised.

A good example of transport technology’s social deployment is the Aramis project (Latour, 1996). Aiming at creating a revolutionary public transport in Paris that can integrate the efficiency of railways with the flexibility of automobiles, an ambitious Personal Rapid Transit system (PRT) project called Aramis was proposed in the 1970s. In 1973, the first Aramis prototype with four seats was tested near the Orly Airport runways. Before 1984, Aramis did not exist outside of its test field and after the full-scale experiment that year, construction began. Aramis in 1987 was designed as the two ten-passenger, nonmaterial coupling cars and was supposed to carry passengers swiftly to destinations without any stop. The ‘death’ of this highly anticipated project occurred a few months later that year. It was shocking because its ‘brother project’ VAL⁶ gained a huge success and Aramis was teamed up with the same engineers and admin people in VAL. An investigation of its ‘death’ through multiple voices and narratives of engineers, policymakers, admin people, and stakeholders involved in the project unfolded a failure of the relationship between the technology and the creators (Latour, 1996: 290-291): “the demand for Aramis is undefined, the feasibility of the vehicle is uncertain, its costs are variable, its operating conditions are chancy, and its political support is inconsistent”. As Latour

---

⁶ VAL refers to Véhicule Automatique Léger (Light automatic vehicle in English).
concluded (ibid.: 126), “the more a technological project progresses, the more the role of technology decreases, in relative terms: such is the paradox of development”. What Latour means is that even when technology achieves its technical maturity, it is still far from being a success in contributing to society. And that is when its rollout depends more on the socio-political, cultural, and economic factors.

Another case was EV1, an electric car produced and leased by General Motors from 1996 to 1999. It was the first mass-produced and purpose-designed electric vehicle of the modern era from a major automaker (Ridley, 2006). The EV1 was fast, quiet, and beneficial to the environment. Partly inspired by its potential contribution to the environment, the California Air Resources Board (CARB) subsequently passed a mandate that encouraged the production of zero-emission vehicles (ZEV), which was later withdrawn. Through limited lease-only agreements, EV1s were available to residents of the cities of Los Angeles, California, and Phoenix and Tucson, Arizona. The EV1 represented a potential new technological trend and received positive reactions from the consumers. However, GM believed that electric cars occupied an unprofitable niche of the automobile market and ended up crushing most of the cars with only a few EV1s delivered to museums and educational institutes. Like Aramis, this highly expected technological invention did not reach a large-scale use in society. Focusing on the demise of EV1, the documentary Who Killed the Electric Car? (2006) came up with a theory that GM self-sabotaged its own programme because it threatened the oil industry (Paine, 2006; Films, 2007). Meanwhile, it suggested the lack of demand in the market, the divisions of people’s attitudes, and the shortsightedness of the local agency. Similar cases across all industries have been studied by historians, sociologists, anthropologists, and STS scholars to enhance an understanding of the socio-political configuration of technology and that the technological change is ‘a negotiated outcome’ that reflects power dynamics in the
social contexts. Emphasising not only the outcomes of technological innovation but the ‘power-process’ that shape its final features and the way of deployment, the ‘process perspective’ (McLoughlin, Badham, and Couchman, 2000: 17) is put forward.

Having been inspired by both (1) sociotechnical imaginaries of vehicles and (2) practical effort of sociotechnical transition of vehicle technologies, I committed to a PhD research on the social integration of connected and automated vehicles (CAV) where I aim to critically draw out a holistic view of the ongoing process, unfold the socio-political fabricated complexity, and shed light on possibilities afforded by the emerging CAV technology from different perspectives. Below are my two main research questions.

(1). How is a CAV imagined?

Under this main research question, I would like, first, to study how the concept of a CAV is understood and perceived, considering the mixed-use of terminologies such as ‘self-driving’, ‘driverless’, ‘automated’, ‘robotic’, and ‘autonomous’? Preferences of different terms and the associated sociotechnical imaginaries can provide an overall understanding of the public’s perception and trust in the CAV technology. Underlying the utopian and dystopian imaginaries, it would also be interesting to explore human-and-machine relationships and other future possibilities afforded by this technology.

Second, I would like to investigate the planners’ CAV imaginaries in detail. By using the term ‘planners’, I refer to CAV technicians, researchers, policymakers, and
industry stakeholders. In doing so, I aim to study how do they imagine CAVs operating in society? What are their envisioned prospects and concerns? How would these imaginaries affect CAV’s development and deployment? And what are the drivers for the planners’ imaginaries and planning? Through this, we can learn about their perceived public good and priorities in its social rollout.

Third, I want to study the public’s CAV imaginaries where hope and fear generated by this technology as well as new possibilities brought by it can be further extracted. The reasons that I separately study CAV imaginaries with the planners and the public are: (1) I want to dive into people’s commuting experiences that impact their imaginaries. The on-the-ground everyday stories can help understand the current transport system, especially where appears problems, and lead to thinking about how CAVs can fit into the transport system to improve people’s commuting lives? (2) I want to compare and analyse imaginaries from different perspectives and understand what drives the potential differences, if there are any. Besides, I wonder how these imaginaries would impact the rollout, which leads to the second research question that concentrates on the practice of the CAV social deployment.

(2). How is a CAV integrated into society?

This research question is explored in the UK context for two reasons: (1) apart from the U.S. and China, the UK has also shown great ambition in the field of CAVs as the UK Government funded over 70 CAV related projects alone in 2018, and (2) I started my PhD study in 2018 in Edinburgh, time- and location-wise, it makes sense for me to concentrate on this context that I started building more knowledge of, follow the
ongoing projects, and reach out to various parties in the UK.

Under this question, I aim to investigate the practice/institutional efforts of pushing the CAV social rollout. Here I emphasise CAV as a ‘becoming’, in other words, the integration process is ongoing and might take long. Nevertheless, my research can reflect part of the process and draw out insights into its social deployment within a specific timeframe.

Since safety is the most raised topic (Mora et al., 2020) and question when it comes to CAV dialogues, first of all, I want to investigate how is CAV safety conceptualised and developed? How do planners set a safety standard and from their perspectives, how safe is safe enough? From this, we might be able to see how do different planners such as technicians and policymakers understand safety and negotiate a safety standard. Apart from studying what factors constitute CAV safety and what does CAV safety mean, I particularly want to look at the current technological feasibility (functional safety): What is the current tech level, and how does the CAV technology itself shape events in ways unanticipated by planners and the public? Along with this exploration, we might also gain insights into people’s perceptions of risk and trust in various contexts.

Second, I would like to study the CAV ethics and legislation in the UK, specifically, how do the British planners ensure responsibilities in the context of autonomous driving? What are their main focus and challenges in building a legal framework? Finally, I want to investigate how is a CAV presented to the public in demos or trials? How does it interact with people and influence their perception and trust? How would
these experiences contribute to our understanding of embodiment and engagement? And how would public opinions and feelings generated in trials influence the planners’ thinking and re-thinking, and further shape the CAV social deployment?

To answer these questions, I use technography (ethnography of technology), an interdisciplinary method that crosses over Anthropology and STS to study machines, techniques, and knowledge in everyday life, to investigate the social integration of the CAV technology into society. In other words, apart from studying different social groups’ imaginaries of and practice on the CAV technology, I closely look at the technology itself. I study tech cases, follow relevant projects, constantly chat with technicians, and participate in multiple CAV trials. Technography, from a technical dimension, contributes to social researchers looking at technology’s social integration, with considerations such as tech uncertainty, human-and-machine interaction, trust, and future possibilities in mind.

I started pilot research in April 2019 and my official fieldwork was mostly conducted in Edinburgh and London between September 2019 and September 2020. Under the influence of the COVID-19 pandemic, my research activities between April 2020 and September 2020 were conducted online. During my fieldwork, I interviewed over 20 planners from the UK Government, auto industry, research institutes, and the Law Commissions; engaged over 60 public members through interviews and workshops, and conducted participant observation in two CAV trials. My research methods are fully demonstrated in Chapter 1 along with research activities during the fieldwork period.
3. Thesis Structure

After an introduction to the CAV domain and my research methods in Chapter 1, through the lens of imaginaries, the first half of the thesis (Chapters 2, 3, 4) explores fundamental topics such as trust, acceptance, future possibilities, and human-and-machine relationships, and respectively dives into the planners’ and the public’s imaginaries to reveal their values, priorities, and concerns. It presents a full spectrum of the sociotechnical imaginaries of CAVs and analyses the most common ones as well as their importance and impact on the CAV’s development and deployment. The second half of the thesis (Chapters 5, 6, 7) investigates practical efforts in pushing the CAV social deployment. It demonstrates the current main focus on improving the technical feasibility as well as ensuring responsibility and political transparency in its operation, meanwhile, it explicates technological and socio-political challenges and calls for continuous research.

Chapter 1 aims to provide an overview of the CAV landscape, discuss key literature, and demonstrate my research methods. First, it briefly explains what is a connected and automated vehicle (CAV) from a technical perspective and clarifies the use of terminology in this thesis. It then presents the global landscape of CAV, highlighting representative CAV projects in London and Edinburgh, which are my fieldwork sites. Before demonstrating my research methods and sketching a literature review, I illustrate a bibliometric review that shows a techno-centric bias in the CAV research domain. Moreover, it shows that within the limited social studies of CAV, in-depth qualitative ones are underdeveloped. This gap calls for anthropologists to unpack complexity in the social integration process of CAV technology and bring attention back to the richness in everyday life. Although social research on CAV is rare, the broader literature review on transportation and mobility reveals important socio-
political problems that deserve anthropological thinking. Finally, the chapter introduces my methodology—technography and the detailed fieldwork activities. As an ethnography of technology, technography bridges anthropological insights with STS tools, which enables a thick description of technology’s social integration and enriches an understanding of technology’s dynamic contribution to everyday life. Hence, the exploration and use of technography empowers this anthropology thesis.

Chapter 2 uses a CAV terminology survey to study people’s preferences for related terms, including ‘automated vehicle’, ‘autonomous vehicle’, ‘self-driving vehicle’, ‘driverless vehicle’, and ‘robot vehicle’, through which, associated imaginaries reveal utopian and dystopian possibilities and imply people’s current low trust on the CAV technology. Through the lens of sociotechnical imaginaries, an analytical presentation of their term-selection touches on fundamental anthropological topics such as trust, acceptance, human-and-machine relationships, and future possibilities. These aspects are explored alongside discussions of relevant literature and inspire a closer look at the public’s CAV imaginaries in Chapter 4. Besides, my engagement with the planners strengthens a long existing anthropology and STS argument that a technological invention is politically presented (Bijker, Hughes, and Pinch, 1987). The planners’ inconsistent word use and different priorities are driven by various economic and socio-political purposes, for example, some consciously use the well-known and easy-to-understand word ‘self-driving’ to familiarize the public with this new technology while others use the technician-acknowledged term ‘automated’ to show knowledge and expertise. It suggests potential differences in CAV visions and prioritises among technicians, industry stakeholders, researchers, and policymakers, which leads to a further investigation in Chapter 3.
Chapter 3 studies the planners’ CAV imaginaries in detail through interviews with policymakers from the UK Government, industry stakeholders and technicians from the CAV-leading firms, and researchers from top institutes. Despite some different prioritises and concerns, it identifies a commonly existing approach to imagining and envisioning the CAV technology: the prospects-driven top-downing planning.

The chapter firstly unpacks the planners’ commonly acknowledged prospects for safety, the environment and the UK economy. These prospects are considered by the planners as public good and so largely drive their imaginaries, visions, and planning. At the same time, challenges such as technological uncertainty, the lack of investment, political transparency in the CAV deployment, and public trust are briefly mentioned. Secondly, it unfolds the planners’ vision of the deployment of the SEAV (shared electric and automated vehicle). As a vague assumption of automation walking hand in hand with electrification and shared mobility, the SEAV is widely used at a high level. However, experts of electric vehicles and shared mobility operation models suggest that integrating these trends into society as a holistic innovation is difficult due to both technical and social barriers. This finding implies that prospect-driven assumptions require more research, planning, and management to be transitioned into reality. Lastly, it elucidates the planners’ different CAV imaginaries when asked to think as users, specifically, once relating to their own commuting experiences, their considerations and expectations vary from the previous visions and plans. It sheds light on a gap between the top-down thinking and the bottom-up imaginaries of the CAV technology and thus paves the way for Chapter 4.

Chapter 4 explores the public’s CAV imaginaries that are shown at three events- the DC Emulsion and the CAV Forth workshop in Edinburgh and the Self-Driving Car
Meetup in London—where hope and fear, expectation and concern behind utopian and dystopian scenarios are analysed. Apart from some utopian imaginaries that echo the planners’ prospect-driven visions, the CAV imaginaries from the public tend to be problem-focused and are formed from a bottom-up approach that is based on people’s commuting stories and everyday life. The potential problems drawn from their imaginaries include both the emerging ones that are associated with new technology, such as data privacy, cybersecurity, and technological feasibility, as well as the long-existed ones in society. For instance, the lack of transparency in operation, biases in vehicle design, unclear legal responsibility, unequal distribution of transport services, and racial discrimination and sexual harassment in shared space during commuting, which, different from technical safety, constitute the socio-political safety of CAVs. It argues that technological advancement alone is not a one-size-fits-all solution to transport problems (Wu, 2020). Notwithstanding potential issues from the technical and socio-political dimensions, the public’s CAV imaginaries reveal possibilities of how do people want to use this technology to improve accessibility, convenience, and fun experience in commuting. Comparing with the planners’ top-down, prospect-driven CAV imaginaries in Chapter 3, the public’s bottom-up, problem-focused CAV imaginaries in this chapter inspire rethinking from different perspectives to push forward the CAV social deployment. The expression of ‘bottom-up, problem-focused CAV imaginaries’ does not mean that the public perceive CAV as either a solution or problem, but rather, when the public is asked to imagine the possibilities of using and being with CAVs, they tend to focus on the problems that exist in the current transport system and affect their everyday commuting experiences.

After exploring ‘how is a CAV imagined?’ in the previous chapters, from Chapter 5, the thesis dives into the question of ‘how is a CAV integrated into society?’ by looking
Since safety has been the most raised topic in the CAV discourses, Chapter 5 examines how is CAV safety conceptualised and built, with a strong focus on its technological feasibility/functional safety. It firstly uses historical events to showcase different types of risks and suggests that apart from technological infeasibility, faulty operation and regulation may also raise risks and cause disasters. This complexity along with people’s shifting perception of risk/safety throughout auto history explicate difficulties in setting a CAV safety standard. Secondly, the chapter studies how do CAV planners conceptualise safety by asking the fundamental question of ‘how safe is safe (enough) for a CAV?’ Whereas placing much effort in improving its functional safety through tests and safety cases, the planners acknowledge the challenges of improving CAV’s operation in a safe and transparent socio-political environment. Thirdly, it analytically presents the dialogues with technicians and OEMs that are centred around technological (in-)feasibility and demonstrates a CAV’s simulated test. In doing so, it elucidates the current incapability of machine intelligence compared to human intelligence, especially its incapability of improvisation, flexibility, and empathy. It shows that CAVs can only reach level 4 automation and run in the Operational Design Domain (ODD) under strict supervision in a short term. Finally, from the public’s narratives, it brings attention back to the non-technical risks such as the lack of social safety and political transparency that largely affect the public’s trust. It paves the way for an investigation on the CAV legislation in the next chapter.

Chapter 6 investigates the CVA ethics and legislation. First, it starts by introducing two thought experiments: the morality-focused debate ‘Trolley Problem’ and the legal responsibility-focused practice ‘Molly Problem’. The former thought experiment opens
up discussions about who to spar in a car collision while the latter one designs
specific questions to draw insights into legislation, for example, it studies the public’s
expectations about the self-driving software recall ability. Apart from explanations of
the two experiments, it explicates the planners’ shifting focus from the moral
dilemmas to the practical effort in building a CAV legal framework. Second, it reveals
four major institutional forces that affect the CAV ethical settings. These four forces
consist of technicians, academic researchers, industry stakeholders and insurers,
and lawmakers. Alongside analysis of their values and priorities, it discusses a power
re-distribution between the tech firms and the regulatory institutes. Since CAVs have
no human driver but a ‘black box’, policing and regulating in the CAV context requires
data access and knowledge to process it. In other words, tech firms gain more power
and control while law and enforcement are facing new challenges brought by
technology. Third, it elucidates the CAV legislation process with the Law Commission
of England and Wales and the Scottish Law Commission. Their consultation papers
contribute to civil and criminal liability issues and responsibility-differentiation
between operators (licence holders) and users/passengers in the CAV context.
However, political tension between the local and national regulators is considered as
a barrier to the implementation of a single national CAV system and the ongoing
process of the CAV legislation requires continuous studies.

Chapter 7 uses two cases to demonstrate that (1) technology display, as the
planners’ output (van Oudheusden, 2011), is used to engage the public and provides
them with a platform to gain embodied experience, where technology meets
sociotechnical imaginaries, and (2) feedback from the public is collected as input
(Hosio et al., 2014) to help rethink and reshape the CAV social deployment. The first
case demonstrates my first CAV ride in Glasgow. Apart from descriptions of the
automated bus’s performance and my feelings during the ride, it illustrates how do
planners use this demo as an output to enhance the public’s awareness and perception of the CAV services. The second case is my shared ride in an automated pod in London. Although the automated pod operates at a slow speed and only in a controlled environment, its physical existence and fun of the ride eliminate some doubts and misunderstanding and enhance the passengers’ trust in the CAV technology. Meanwhile, the project organisers collect the public’s feedback for further development and improvement. For example, how to commute in a safe shared space without human supervision, as a frequently raised socio-political safety question from the public catches the planners’ attention and leads to more research and discourses. Other commonly raised points such as data privacy, insurance, responsibility, and equity in accessing the transport services also contribute to thinking and rethinking the CAV social deployment.
Chapter 1 CAV Landscape: Setting the Scene

Whereas a connected and automated vehicle (CAV) has been experimented with in many laboratories and trialled on roads on a small scale, the majority are not familiar with it. Hence, I aim to use this chapter to set the scene and provide an overview of the CAV technology, its current status of the development and deployment in society and discuss the most recent research of CAVs.

This chapter, first, clarifies my preference of using the term ‘automated’ over ‘autonomous’, ‘self-driving’, and ‘driverless’ while occasionally mix them for contextual research purposes, and demonstrates the core technology of a CAV in a simple fashion. Second, it maps out the most recent CAV landscape in society by explicating major players in the field and demonstrating representative cases at both national and regional levels. This is then followed by an introduction to CAV’s development in the UK and my specific research sites- London and Edinburgh. Third, the chapter presents literature in the CAV domain where I signal and criticise a techno-dominated trend and point out the lack of in-depth qualitative studies of the social aspects of CAV. Last, the chapter explains my research methods and fieldwork activities in detail.

1. What is a CAV?

Before diving into the core technology of a CAV, it is important to understand its meaning and distinguish it from some similar and widely used ones. I started my journey with the term ‘autonomous vehicle’ mostly used, which is still often used on many occasions. However, I sometimes used terms such as ‘self-driving vehicle’ or ‘driverless vehicle’ that appear more understandable and straightforward to members
of the public than ‘automated vehicle’. I also noticed the mixed-use of these terms and different preferences in academic articles, government documents, and industry reports. The lack of a terminology standard triggered my curiosity and thus an investigation. Below, I briefly clarify my terminology preference. The story of my investigation along with interesting findings will be fully demonstrated in the following two chapters (2 & 3).

1.1 Terminology: a brief clarification

Thanks to the development of the economy and technology, various transport services have grown fast in the past decades. The increasing private vehicle ownership, the popularity of car clubs, the emerging business model of ‘shared mobility’, and the forthcoming fully automated vehicles... Having more and more choices is not a bad thing, however, too many of them cause confusion. For instance, when it comes to the discussion about vehicles empowered by AI/automation technology, there exist many terms to refer to: “self-driving cars”, “driverless cars (DC)”, “autonomous vehicles (AV)”, “automated vehicles (AV)”, “robotic cars”, “automated vehicles” and more.

Efforts have been placed in ‘standardizing’ these terms. For instance, the Consumer Technology Association (CTA) at Google rolled out a “common lexicon” (Fairfield et al., 2017) to explain the relevant terms. In 2018, the Centre for Transportation Studies (CTS) at University Virginia launched a 30-pages long glossary (Park et al., 2018) of connected and automated vehicles and the broader technological concepts such as artificial intelligence, machine learning, advanced driver assistance system (ADAS), and Lidar. The BSI Group has also launched two versions of the CAV-related glossary (2020). However, no authoritative standard has been enforced in the field, let alone to the public.
In this project, I adopt the term ‘(connected and) automated vehicles’ or ‘CAV’ in abbreviation. My terminology investigation and the reasons for my word-selection are explained in detail in Chapter 2, where complex questions about not just accuracy of the terms but people’s perception and imaginaries behind word-choice are discussed. In line with the word-use of my participants and the scholars whose work I cite, terms such as “self-driving”, “autonomous”, and “driverless” also appear throughout the thesis.

1.2 CAV technology
The design and development of robotic and intelligent vehicles have been benefiting from Artificial Intelligence (AI) technology. Artificial intelligence is generally considered an area of computer science that emphasizes the creation of intelligent machines that can work and react like human beings. AI is made to mimic the complexity of the human brain so that it, to some extent, is capable of decision-making and task-executing (Pomerol, 1997).

Thoughts of AI was triggered by the second World War (Buchanan, 2005). For the initial purpose of cryptanalysis, scientists worked on building intelligent machines/computers that could beat humans on the speed and accuracy of the calculation. In 1950, Alan Turing proposed a test to answer the question “can machine think?”, which is known as the Turing Test or the Imitation Game. Inspired by Turing’s research, AI pioneers John McCarthy, Marvin Minsky, and Claude Shannon organised a conference at Dartmouth College in New Hampshire in 1956, bringing researchers of informatics, neural networks, mathematics and so on together to discuss the field of AI. In 1960, Frank Rosenblatt invented an artificial neural network for image recognition. However,
it was a single layer of neural networks and cannot function the way scientists expected. Constant failures led to strong critiques and funding cuts in 1973. At this point, AI research stagnated and so commenced the ‘AI Winters’, a period of twenty years from the 1970s to the 1990s.

In 1990, Rodney Brooks called for a bottom-up approach to using neural networks that simulated brain cells and learned new behaviour (Brooks, 1999). Multi-layered neural networks were then designed by Geoffrey Hinton and his colleagues, which enriched Rosenblatt’s idea in the 60s. In 1997, the human chess champion was defeated by IBM’s Deep Blue chess computer, and this “Man vs. Machine” event helped AI researchers regain confidence and secure further funding.

Since the millennium, AI has been fast developed and largely applied, benefiting areas
such as education, health, finance, and transportation. One recent example is the AI-empowered mobility algorithm of LiFE. Designed by a Liverpool tech firm in 2017, LiFE can change traffic lights and clear the routes for emergency services based on a combination of historical data and real-time data. According to the pilot in Liverpool that year, it shaved off an average of three minutes of ambulance response time.$^7$

The application of AI technology to vehicles was encouraged in early 2000. In 2004, The Defense Advanced Research Projects Agency (DARPA) of the United States sponsored research teams to design driverless cars that can travel through the Mojave Desert on their own, and this funded competition largely encourages progress on autonomous vehicles. Although the 1st DARPA challenge failed as not a single team completed the journey, it encouraged more technicians to build robust automated vehicles. In 2009, Google launched its self-driving car project Waymo, which, spun off Google as a separate company in 2017 has led the field since then. Four years later, Tesla announced its Autopilot system. Car manufacturers such as Volvo and GM respectively launched DriveMe Project in Sweden and invested $500million in the Lyft AV partnership in 2016. This was then followed by a partnership between Toyota and Uber in the same year. Tech firms, whether to develop autonomous driving systems, sensors or other techniques, walk hand in hand with car manufacturers.

Provided with sensory functions and cognitive functions, including memory, logical thinking, and decision-making, AVs see, hear, and feel the road and are able to make quick decisions. Since automated vehicles combine a variety of sensors such as radar, Lidar, sonar, GPS, odometry and inertial measurement units, they have the capacity of

$^7$ The LiFE Project by RED NINJA, 2017: [http://www.redninja.co.uk/design-technology-work/life-project/](http://www.redninja.co.uk/design-technology-work/life-project/)
‘perceiving’ the environment. What they see and sense will be transferred to their AI-empowered ‘brain’ that uses machine learning to calculate and analyse as many potential road situations as possible. The final decision of how to react is then shown through the robotic bodies. AI-based autonomous vehicles thus contain a repetitive loop called “Perception-Action Cycle”.

Three components shown in AI Perception-Action Cycles take place repetitively. In “In-Vehicle Data Collection & Communication System”, AVs typically use cameras and sensors such as radar and light detection and ranging (lidar) to detect other cars, pedestrians, curbs, and recognise traffic signals. Lidar as an advanced sensor, creates a 3D rendering of the vehicle’s surroundings, facilitating object detection. Lidar’s detection in short distances is often more accurate, though fragile as it relies on the

---

spinning parts added on the top of the vehicle. Radar specialises in long-distance detection and is cheaper than Lidar, while less accurate in short distances or with complex angles. Lidar, radar, and other types of sensors can support and enhance the camera’s visual capabilities.

Another technique for AV’s perception is V2X, which makes AV connected as CAV. In terms of connectivity, there exist several types: vehicle-to-vehicle (V2V), vehicle to infrastructure (V2I), and vehicle-to-everything (V2X). V2X enables the wireless exchange of information between vehicles and connected devices. Connectivity helps vehicles to communicate, which means, an AV is no more fully dependent on its sensors but could navigate and operate by receiving information from other vehicles,
infrastructures, and smart devices (Jayaweera, 2019). This technology thus helps an AV to address the limitation of sensors.

Data will be processed by computer vision software and then be transferred to the “Autonomous Driving Platform”, also known as “Cloud”. In this platform, an intelligent agent-based on AI algorithms processes data and makes decisions about the driving environment. It is also known as the autonomous driving system that more and more software companies are committed to.

The last component, “AI-based Functions in Autonomous Vehicles”, conducts the driving task without human intervention. According to the Society of Automotive Engineers (SAE, 2014), there are six levels of automation (Level 0-Level 5). This classification is widely used in academia and the industry despite some critiques of its accuracy (Inagaki and Sheridan, 2019).
The first three levels strongly rely on human control on roads. Most traditional cars we drive today, whether Ford or Ferrari, are at Level 1 or 2. Level 3 AVs can drive and monitor the road yet require a human back-up for road emergencies. Level 4 AVs with high automation are able to handle all subtasks in the enclosed driving environments. Ambitious companies like Tesla and Jaguar Land Rover are pursuing Level 4 automation. It is vital to distinguish the semi-autonomous driving system from the fully autonomous driving system. For example, Tesla’s autopilot system belongs to semi-autonomous driving systems rather than fully autonomous systems (Level 3- Level 5) and so is generally considered as Level 2 CAV technology. While these companies are building higher level autonomous vehicles, one urgent task is to test them on the real roads.

Technologies are not perfect. Software can freeze in your laptop or smartphone, causing the “software nightmare”. It is annoying but not fatal. However, if the software of automated vehicles dysfunctions, it may cause a life-and-death scenario. Some scholars believed that automated vehicles will certainly crash, even in ideal conditions (Goodall, 2014) and an automated vehicle’s decision that precedes certain crashes has a moral/ethical component (Lin, 2016). Lin introduces scenarios such as the trolley problem that implicate ethics and illustrates the complexity of AV’s decision-making since it is more than a mechanical application of traffic laws. These studies explicate the importance of exploring and clarifying ethics in the AV context and encouraged interdisciplinary methods to tackle the related ethical challenges. An AV crash contains issues such as safety, trust, acceptance, responsibility, and regulation, which I will explore in the investigation of CAV’s social integration.

Another important technique for an AV is localization, which makes the vehicle aware of its precise location. AV developers often rely on a set of technologies such as GPS and prebuilt maps (HD maps) which provide accurate information about road signals, lane sizes, and crosswalks.
Pic. 1.6 High Definition (HD) Map for AVs

Pic. 1.7 AV Localization

---


Driving data from road testing and simulations is also essential to make CAVs feasible. Tech firms use simulation to generate or augment simple datasets to train AVs and let them run additional miles on simulated roads. What is the testing distance to prove a CAV is safe remains a technically and/or politically question.

2. CAV in Society

Representing human’s desires for safety, speed, freedom, and better mobility, descriptions and fantasies about self-driving cars have long existed in science fiction. In the real world, early experiments on self-driving vehicles have been conducted since the 1920s and trials have taken place since the 1950s. The first self-sufficient AVs appeared in the 1980s, with Carnegie Mellon University's Navlab and ALV projects in 1984 and Mercedes-Benz and Bundeswehr University Munich's Eureka Prometheus Project in 1987 (Reilly, 2016). But the turning point of CAV’s history was the DARPA’s Grand Challenge. Since then, it has triggered a global wave of developing automated vehicles. This section maps out CAV’s development and its current status in society with key events and cases named. It then narrows down the focus onto CAV’s design and development in the UK and in my specific fieldwork sites- London and Edinburgh.

2.1 CAVs in the world

The Defense Advanced Research Project Agency (DARPA), also known as the U.S. government’s developmental laboratory, has been leading practical research on cutting-edge areas such as DNA editing and outer space exploration for years. After

https://thinkautonomous.medium.com/self-driving-car-localization-f800d4d8da49
9/11, the White House pushed American defense contractors harder to develop autonomous technologies. Tony Tether, director of DARPA, thus diverted the agency’s research efforts into autonomous vehicles/robot cars for military use. A $1 million prize was offered to encourage all American teams to join the race. The first race was set in 2004 in the Mojave Desert region of the United States. The 150-miles long course bisected the desert, running eastward from Barstow, California, to Primm, Nevada. The race turned out a big failure as none of the autonomous/robot vehicles finished the route, not even close (Thrun et al., 2006). Carnegie Mellon University's Red Team achieved the best record with its car travelled the farthest distance, completing 7.32 miles of the course. The $1 million prize remained unclaimed in that year (Behringer et al, 2004).

A second chance was provided in 2005 (Thrun et al., 2006). Huge progress and potentials light up people’s hope. In the second Grand Challenge, all but one of the 23 finalists in the race surpassed the 7.32-miles distance completed in 2004. Five vehicles completed the 132 miles course, with Stanley, the Stanford Racing Team, holding first place. In 2007, the DARPA Urban Challenge extended the initial race to autonomous operation in a mock urban environment. Followed by the 2012 Robotic Challenge, focusing on humanoid autonomous emergency-maintenance robots. The Grand Challenges continued and inspired R&D of autonomous vehicles from all over the world.

The global AV market is expected to expand at a CAGR of 36.2%, leading to global revenue of USD 173.15 billion by 2023, according to market research. CAV market

---

drives global vehicle companies and tech firms to place investments in its research and development. For example, Renault-Nissan partnered with Microsoft in 2016 to help advance its AV research\(^\text{13}\). In 2019, the company also partnered with Waymo to work on self-driving car technology for its vehicles. To provide a ride-hailing service, Ford invested $1 billion into AI-startup Argo AI in 2017 to develop Level 4 AVs\(^\text{14}\). In the same year, GM spent $581 million to acquire Cruise Automation\(^\text{15}\). Volvo and Uber are working together in 2019 and according to a claim made by Volvo’s CEO Hakan Samuelsson\(^\text{16}\), they will have a fully autonomous car on the highway by 2021. Car manufacturers and tech firms that focus on autonomous driving system, data and simulation, sensing, mapping, or connectivity (5G), form the AV landscape.

Major OEMs and big players in the field of AV tech are shown in the below diagram. 50% of the top 20 autonomous vehicle start-ups are from America and 40% are from China (Ferres and Klein, 2019). The leading AV system building companies are also mostly the US or China-based, for example, Waymo, Cruise (U.S.), Pony.ai, TuSimple (China), with two new forces- FiveAI and Oxbotica in the UK. AV manufacturers include Tesla, which is famous for its autopilot system, and new firms like Nuro, which focuses on developing automated delivery pods.


\(^{14}\) Argo.AI self-driving car project, 2017. [https://www.argo.ai/](https://www.argo.ai/)


Ferres and Klein (2019) also designed a diagram of AV partnerships and illuminated three trends: (a). software-focused AV suppliers are emerging; (b). alliances were created among many OEMs and tech firms to tackle technical challenges, and the most recent example is the partnership launched in June 2020 between Waymo and Volvo to develop level 4 automated vehicles; and (c). new players are emerging in China and the U.S. with the EU lagged behind. Nevertheless, some German car companies such as Volkswagen, BMW, and Daimler have strong networks and AV partnerships. Four notable firms who preferred to have in-house AV technologies without direct partnerships, including Tesla, Apple, and Uber also showed much strength and potentials in this field.
In terms of the development at national and regional levels, apart from the U.S., Finland, China, and Singapore are also making great progress. In March 2019, a pioneering trial of an autonomous bus was rolled out in the city of Helsinki, Finland. This vehicle, named Gacha, which features technology by Finnish autonomous-driving company Sensible 4 and a design by Japanese retailer Muji, is the world’s first autonomous shuttle bus for all weather conditions. It has been designed to operate in heavy rain, snow, or fog. Gacha can carry 10 passengers to operate a 62-miles long journey at the speed of 25mph with wireless charging for this electric vehicle as a back-up plan. According to Harri Santamala, CEO of Sensible 4, shuttle buses will become part of the daily transportation service chain and the first Gacha fleet is be expected to roll out in 2020. But due to the uncertainty caused by COVID-19 in 2020, experts in Helsinki suggests small-scaled commercial Level 4 AV fleets might operate at normal speed in

---

17 Autonomous shuttle bus project by Sensible 4: [https://sensible4.fi/fabulos-faq/](https://sensible4.fi/fabulos-faq/)
busy areas of cities in another two to three years.

China is also leading the way in CAV technology and electric and hydrogen cars. China’s State Council issued the “New Generation Artificial Intelligence Development Plan”, outlining an ambitious roadmap for China to lead the artificial intelligence sector in 2017, prioritizing the development of CAVs as a ‘strategic frontier’. Later that year, the Ministry of Industry and Information Technology (MIIT) enhanced China’s roadmap by announcing the Three-Year Plan for Promoting Development of a New Generation Artificial Intelligence Industry (2018–2020)\(^\text{18}\). With strong political support, tech firms such as Baidu keep recruiting AV experts and announcing AV R&D projects. In 2017, Baidu announced the Apollo Project\(^\text{19}\) as the first system-wide opening of the global automated driving technology. It is said as “a complete open automatic driving ecosystem” that can help partners in the automotive industry and autonomous driving to combine vehicle software and hardware systems to quickly build their own complete AV system\(^\text{20}\). During the Chinese New Year’s celebration in 2018, China Central Television (CCTV) staged a self-driving car showcase on the Hong Kong–Zhuhai–Macao Bridge- where more than one hundred self-driving cars successfully passed through the world’s longest sea bridge\(^\text{21}\).

During summertime in 2019, Singapore began testing one of its first autonomous bus shuttle services. Passengers can hail an autonomous shuttle via the App “Ride Now Sentosa” or kiosks along the 5.7km route\(^\text{22}\). The trials will be running throughout the

---


\(^{19}\) Baidu’s Apollo Project: smart transportation solution. [https://apollo.auto/](https://apollo.auto/)


\(^{21}\) The showcase video of Baidu’s Apollo: [https://www.youtube.com/watch?v=iJjoNcOMPWs](https://www.youtube.com/watch?v=iJjoNcOMPWs)

\(^{22}\) “Singapore’s first on-demand driverless shuttle buses to ferry passengers around Sentosa from Aug 26”. CAN. 20
whole year. Permanent Secretary for Transport and chairman of the Committee on Autonomous Road Transport for Singapore, Mr Loh Ngai Seng, said that autonomous vehicle technology has the potential to transform Singapore's public transport system and the way its people move around in the future\textsuperscript{23}. According to the most recent news, Singapore is opening as many as 620 miles of public roads so that companies can conduct tests with AVs\textsuperscript{24}.

Although the development of CAVs appears promising, we should not forget the fatalities associated with automated driving. A Tesla driver’s death in 2016 whilst the autopilot mode was on and a pedestrian’s death caused by a Uber self-driving car in 2018 raised public concerns about CAV’s safety and the related legal issues. It reminds us that if we want to integrate CAVs into society, we cannot treat CAV merely as a technological evolution. Rather, we should discuss the societal aspects of CAV and prepare for its social mapping.

\subsection*{2.2 CAVs in the UK}

Why do I look at CAVs in the UK? There are two major reasons: first, apart from the U.S. and China, the UK maintains its place at the forefront of the development and deployment of CAV innovation and technology, from solving issues relating to fundamental CAV technology, control systems, software and services, claimed by the Government (DfT, 2018). Second, by the time I started my research, the UK government had already shown its ambition in this field by establishing blueprints and

\textsuperscript{23} Same as the above.

\textsuperscript{24}“Singapore is opening up more than 600 miles of public roads to test self-driving cars”. Business Insider. 24 October 2019.  
relevant projects.

The industry conducted pilot research and made pitches to the UK Government that AV technologies will bring huge gains. AVs are foreseen to add up to £2.1 billion gross value to the UK economy by 2035 and support up to 47,000 jobs (Transport System Catapult, 2017) along with a wider economic benefit of £51 billion per year due to fewer road accidents (KPMG and SMMT, 2015) because AVs could reduce road casualties by 30% by 2033 (McAuley et al., 2015). The CAV technology along with its opportunities for safety, mobility, and efficiency of the transport systems are highly valued by the UK Government who aims to make the UK a world leader in the mobility field.

In 2014, the UK government made a £3.1m investment into Four Cities Driverless Car Trials (CCAV, 2020). These cities include London, Bristol, Milton Keynes, and Coventry. CAVs were only trialled in these four places before testing was permitted anywhere in the UK in 2015, if abiding by the Code of Practice (Department for Transport, 2015). This permission largely encouraged AV development and trials. Followed by the establishment of the agency CCAV. The UK’s Centre for Connected and Autonomous Vehicles (CCAV) was funded in 2015 to promote the development of CAVs. It focuses on three areas: regulation, R&D, and test infrastructure so that it works broadly with the governments, industry, academia, and local regulators. A £29m investment into 21 CAV projects was made by CCAV in 2016, followed by another £93m R&D investment into 25 projects in 2017. In 2018, a £32.6m investment into CAV R&D was made to support off-road tech such as simulation and modelling (CCAV, 2020), which marked the UK government’s efforts to ensure safety through various approaches. Likewise, in 2019, CCAV launched a three-year review of the regulatory framework of automated
vehicles with the Law Commission of the UK.

To name but a few UK funded CAV projects, in 2015, Innovate UK and the CCAV funded the GATEway project\textsuperscript{25} in Greenwich and Autodrive project in Milton Keynes. Led by TRL, a global centre for innovation in transport and mobility, the three-years long GATEway project saw a fleet of driverless pods without steering wheels or typical driver controls providing a 3.4 km-long distance shuttle service around the Greenwich Peninsula. It was the world’s first CAV project that invited the public to take part in its trials and share their opinion and experience. The vehicle was developed by Westfield Sportscars and Heathrow Enterprises, and powered by the tech firm Fusion Processing. The project website briefly introduces the CAV technologies, “Fusion’s software, CAVstar®, combines GPS with radar (for long range) and Lidar (for close range) to enable the pods to detect and safely negotiate objects in their path. This also allows the pods to operate in adverse weather conditions, or even in the dark – a global first for this technology\textsuperscript{26}. GATEway was completed in 2018 and the final report can be found on the project’s website, which illustrates the technology of the vehicle and the findings through studying the public’s acceptance and attitude towards CAVs. This project was recognised as a successful start for planning and integrating CAVs in UK cities.

Another 12-month long project MERGE was delivered by Addison Lee in Greenwich. It was a ground-breaking project which simulated how autonomous vehicle ride-sharing could integrate with public transport systems and was extended as the current Endeavour project. Endeavour project looks at a fleet of shared AVs in Greenwich to

\textsuperscript{25} GATEway project in the UK: https://trl.co.uk/projects/gateway-project/
\textsuperscript{26} Fusion Processing: https://www.fusionproc.com/
fill the gap between homes and public transport hubs. I will further introduce this project in the following section. The other interesting project, UK Autodrive, as a government-funded project to support the introduction of autonomous vehicles into the UK, started in 2015 and completed in 2018. It aimed to trial CAVs in the real world and provide insights for key stakeholders and decision-makers, including legislators, insurers and investors for future development. The project had several major milestones along the way, including the start of the vehicle trials – the first of which took place at the HORIBA MIRA Proving Ground in October 2016 and the final in October 2018 on the streets of Milton Keynes and Coventry, featuring the world’s first multi-CAV, end-to-end journey – connected car, to driverless car, to autonomous pod. In the last year of the programme, autonomous and connected cars and pods became a regular sight in Milton Keynes and Coventry.

In October 2016, a self-driving pod was demonstrated on UK public street for the first time. ‘The vehicle demonstration took place on pavements around Milton Keynes train station and business district. A trained engineer remained in the vehicle for the duration of the trial, ready to take back control if required and to give further reassurance to the public, but the pods navigated entirely by themselves’\(^\text{27}\). Beyond the technology demonstrations, UK Autodrive plans to examine some of the ‘bigger picture’ issues, such as legislation, insurance, communications and cybersecurity requirements, the future scalability of the technology, public attitudes to self-driving vehicles and potential business models for the wider rollout of the technology. Since then, small-scale trials have been implemented in Oxford, Cambridge, and Bristol with joint-efforts made by local governments, AI/engineering companies, vehicle manufacturers, and universities.

These trials adopted low-speed pods or mini vehicles.

The UK’s first full-sized autonomous was trialled in a Manchester bus depot in March 2019\(^\text{28}\). The software being used forms the basis for a significant autonomous vehicle trial due to get underway in 2020 when a fleet of five autonomous buses similar to this one will operate—carrying passengers—between Fife and Edinburgh, across the Forth Road Bridge Corridor (CAV Forth Project). Once complete, the ‘11.8m ADL Enviro200 vehicles will operate between Ferrytoll Park & Ride facility in Fife and the Edinburgh Park Train and Tram interchange. The bus will use both on-road and hard shoulder running, and will use the dedicated public transport corridor across the Forth Road Bridge that allows buses and taxis to use dedicated lanes between the M9 near Newbridge and Halbeath in Fife. According to the blueprint and claims on the project website as mentioned previously, the autonomous buses will provide a service capable of carrying up to 42 passengers 14miles across the Forth Bridge to Edinburgh Park Train and Tram interchange. With buses every 20 minutes this could provide an estimated 10,000 weekly journeys\(^\text{29}\). I will further introduce CAV Forth and briefly look at other projects in the following section.

Multiple parts join in the planning and integration of CAVs. The UK Central Government (eg. DfT, CCAV, Innovate UK), national governments (eg. Transport Scotland), local authorities (eg. TfL, Highways England, councils), tech firms (eg. FiveAI, Fusion Processing, Oxbotica), research institutes (TRL, UWE, DG Cities, Edinburgh Napier University), business partners (eg. Westfield, Conigital), consultancies, OEM, service


operators, and expert committees/independent experts are all involved to different degrees. The UK has also been a global leader in terms of establishing testbeds for CAVs. Supported by the government and the industry, Zenzic has been coordinating testing events and creating the roadmap for UK CAVs development. CAV projects are well underway in the UK. This is an exciting period of exploration of CAV technology in the real world and many aspects such as how CAVs integrate into people’s everyday life deserve constant research efforts.

2.3 CAVs in London and Edinburgh
I selected London and Edinburgh as my main field sites because multi-resources of CAVs, whether specific projects, major organizations in the field, or relevant conferences, are based in London and Edinburgh, and Edinburgh is the place where the first and only (to date) autonomous bus project is happening. Hence, I follow the ongoing project of CAV Forth and its related events in Edinburgh and reach out to big players (policymakers, industry stakeholders, researchers, and technicians) in London. Besides, I engage the public in both cities and attend CAV events in various British cities. I will illuminate my research approaches in detail in my methodology section. Below, I provide some background information on the CAV Forth project.

Starting from the end of 2018, the three-year-long project CAV Forth is estimated to cost a total of £6.09m, which as a collaborative project is partly funded (£4.35m) by CCAV\(^\text{30}\). A consortium of UK partners is in the process of designing and developing a fleet of full-size autonomous buses that will service a new Stagecoach operated 15 mile route running from Ferrytoll P&R in Fife, across the Forth Road Bridge into

\(^{30}\) Same as footnote 28.
Edinburgh Park's transport interchange.

The project will convert five full-size Alexander Dennis single decker manually driven busses into autonomous vehicles. These self-driving buses will provide a service capable of carrying up to 42 passengers 14 miles across the Forth Bridge to Edinburgh Park Train and Tram interchange. With buses every 20 minutes this could provide an estimated 10,000 weekly journeys and support the case for rolling out similar services across the UK. Led by Fusion Processing, the project also involves Transport Scotland, Stagecoach, Alexander Dennis, the University of the West of England (UWE), and Edinburgh Napier University.

Fusion Processing is a world leader in situational awareness and control systems technology. Until early 2020, Fusion has successfully run trials in London, Manchester, Bristol, and Glasgow. The 15-mile route between Edinburgh Park and Fife is expected to be trialled in 2020’s summertime. Alexander Dennis Limited (ADL)\textsuperscript{31} is a global leader in the design and manufacture of double deck buses and is also the UK’s largest bus and coach manufacturer. Stagecoach, a transport group, is the bus operator in the project and helps Edinburgh Napier University to conduct user experience research in the early stage. Bristol Robotics Laboratory (BRL) of UWE is involved for its expertise in simulation technology. As the national transport agency of Scotland, Transport Scotland guides the project’s practice and sets the future plan for CAV’s integration into Scottish roads.

\textsuperscript{31} Same as footnote 28.
3. Research on CAVs

In collaboration with my colleague Professor Luca Mora from Edinburgh Napier University who has expertise in smart city and sustainability research and my colleague Dr Panori Anastasia from the Aristotle University of Thessaloniki who specialises in modelling and data analysis, we built a bibliometric review that critically draws an overview of the literature on CAV-related domain. This interdisciplinary project (jointly authored as Mora et al., 2020) was separate to my PhD, but it contributed to my PhD study as it reveals a techno-centric bias in the CAV research domain.

Based on topic modelling and content analysis of over 18,000 publications in the past five decades, our paper (Mora et al., 2020) explicates the current trend and identifies a gap in the fast-expanding scientific knowledge on CAVs- ‘a gap between information processing requirements and information processing capacity’ (ibid.: 1).

Social researchers have long argued that ‘the more a technological project progresses, the more the role of technology decreases, in relative terms: such is the paradox of development’ (Latour, 1996: 126), which highlights the importance of studying the socio-political networks in which a technological invention is embedded in. However, we found that in the domain of CAVs, the research is still techno-driven as it is heavily oriented towards developing and examining techniques for its rollout. We therefore criticise the lack of social research in this field. Besides, we found that existing social research mainly adopts quantitative methods to ask commercial-driven questions such as how to improve users’ trust. In-depth qualitative research that challenges equity and inclusivity and covers multiple perspectives under a holistic view is missing. These gaps further motivate my exploration of the social integration of CAVs and the future
possibilities that are unfolded during the process.

3.1 Bibliometric Review and blind spots

As the second author of this publication (Mora et al., 2020), my proposed methodology for the bibliometric review combined citation-based community detection methods and topic modelling techniques to give a concise but comprehensive overview of how the CAV research field is conceptually structured. Thirteen core thematic areas are extracted and presented by mining the large data-rich environments resulting from over 18,000 scientific publications, which represent 50 years (1970-2019) of research efforts in CAV research.

‘Approximately 80% of these knowledge items have been published during the period 2010-2019 and the majority has been accumulated between 2017 and 2019. These three-years account for 55% of the Scopus-indexed scientific publications on autonomous driving released in the last five decades, and the production peak was reached in 2019, with 4,841 publications (26.7%)’ (ibid.).
It suggests that autonomous driving has become a relevant matter of investigation in the scientific debate on future mobility at a high speed. To reduce dimensionality and filter quality information describing the intellectual structure of the CAV research field, topic modelling was used to analyse each thematic cluster. The topic modelling phase concludes with the identification of the core research themes, which were derived by inductive reasoning. Based on the in-depth content analysis, we conclude keywords for these 13 thematic clusters.
Pic. 1.11 Document citation network and thematic clusters (ibid.)
Based on our analysis, the clusters CL.01, CL.02, CL.04, CL.05, CL.06, CL.08, and CL.13 all discuss the technical development for CAV detection and navigation, with each focusing on different techniques or adopting different approaches such as motion planning and algorithmic models. CL.10 is the only group of publications to identify the social and political implications of CAVs as a core topic. In addition, most of the research focusing on social and political aspects is based on user experience studies which explore market dynamics and how public acceptance of CAV solutions can be enhanced. ‘The proposed marketing strategies and implications suggest a commercialised-driven for CAV social research. Broader topics such as accessibility, affordability, liability, trust, business models, travel behaviour, and social and environmental impacts that can benefit CAV’s social integration in a sustainable way and generate long-term effects have remained underdeveloped’ (Mora et al., 2020).

Overall, our study suggests that CAV research is mainly technology-driven and is much more oriented towards examining the technological developments needed to enable the widespread rollout of CAVs, rather than exploring the social dimensions of a future socio-technological transition. As a consequence, the social science perspective fades into the background, dominated by a sense of technological determinism and utilitarian concerns.

Researchers in sociology, history, economics and anthropology have long emphasized the importance of breaking the dichotomy between technological determinism and social constructivism. The doctrines of technological determinism, as Sheila Jasanoff (2016; 28) suggested, “tends to remove values, politics, and responsibilities out of discussions about technology.” Whether a technological invention can be integrated into society and become a social innovation depends on various socio-technological
actions of different actors (Flichy, 2008) and the complexity of the socio-political environment where that technological invention is embedded often requires investigations into changes in markets, regulation, culture, industrial networks and infrastructure (Geels, 2005). The key to the success of CAV’s social integration is about the interdependency of technological feasibility, economic viability, political support, ideological opportunisms, and multi-cooperation and the socio-political complexity behind a technological invention. These findings call for a broader engagement of social scientists with CAV research, where their research efforts and deeper critical thinking are needed to shed light on the wide-ranging social implications of autonomous-driving technology.

3.2 Social research on CAVs
Among social research of CAVs, much effort has been placed on increasing adaptability out of profit-driven goals and political purposes. Intertwined with topics such as acceptance, public/customer perception, trust, travel behaviour, and travel decision-making, this part of the research has been led by industry stakeholders, governments, and research institutes. As Carmaker Ford claimed, “We don’t believe that the central challenge in the development of self-driving vehicles is the technology. It’s trust. Trust in the safety, reliability, and experience that the technology will enable” (Ford Motor Company, 2018). Many social studies are centred around trust and public acceptance (Lee, 2020) as also reflected in Cluster 10 (in the previous section 3.1). Some researchers also look at people’s willingness to pay for automation levels and shared AV services (Bansal et al., 2016; c et al., 2016). For example, a survey conducted in Austin indicates that people perceive a decrease in car accidents to be the primary benefit and equipment failure as the top concern. The study also finds that participants are more willing to pay for the service that can add a higher level (level 4) of automated technology to their current car than adding comparatively lower
automation (level 3).

These studies are often driven by commercialization and thus cause two problems within the limited social studies of CAVs: First, it highlights the lack of public trust (and implies that it is the public’s fault to not trust advanced technologies) without asking why and so what? Why do people need their cars to be connected and automated? And if their cars all become connected and automated, so what? What additional value can this technology bring to people’s everyday life? Second, user-experience research on AV trust is often driven by commercialization. In other words, builders and developers do such R&D for their consumers/clients. The question is, what about those non-users? How will their commuting experiences be affected by some other road users sitting on self-driving vehicles?

A study conducted by Foresight, Government Office for Science of the UK Government reviewed the evidence on ‘consumer decision-making in relation to current and emerging transport technologies and modes, including CAVs. It suggested that travel behaviour is affected by three factors: (1) self-reported motivational factors (autonomy, affordability, satisfaction), (2) unconscious factors (habit, social norms, symbolism), and (3) structural factors which include sociodemographic factors, the built environment, transport service provision, and the perception of these structural factors’ (Whittle et al., 2019: 302). By studying why people choose certain transport services, it further analysed the possibility of increasing people’s preference/acceptance of CAVs and pointed out that trust is a key factor. Influenced by the technological feasibility of automated systems (Sanders et al., 2011), people’s trust in CAVs affects the broad acceptability, adoption, and use of such technological applications (Parasuraman et al., 2008). The public’s attitudes towards CAVs and other transport
technologies were directly investigated by the Department of Transport (DfT, 2018) as well. When asked about the perceived advantage of CAVs, the most commonly reported advantage was safety (20%) while the safety of CAV equipment/system was also the most commonly cited concern (45%). One additional finding was that compared with the awareness of drones (94%), electric vehicles (93%), the public awareness of autonomous vehicles (87%) was low, which suggested a necessity for public education and demonstration.

Demonstrating the promises of CAVs is a good way to improve the public’s acceptance and adaptability. Governments and industry stakeholders thus sponsored much research on the benefits of introducing CAV technology to society. In general, automated driving technology is considered as a technology innovation (Manyika et al., 2017) that can largely improve road safety, save potential costs, and offer comfort to people who do not or cannot drive (Mutz et al., 2016). The most highlighted promises include, first, CAVs can reduce many of the existing negative externalities of personal automobile use. For instance, traffic accidents can be largely reduced by level 3 automation. “Crashes, injuries, and fatalities due to driver error under this condition would likely be substantially reduced” and there might be further risk reduction in the number of alcohol-related accidents with the transformation towards level 4 automation (Anderson et al, 2014: 15). Second, CAVs may help people who are unable to drive to achieve personal independence and access to essential services (Rosenbloom, 2012). Third, CAVs can reduce congestion in the following ways: (1) influencing total Vehicle Miles Travelled (VMT) per capita, (2) enabling greater vehicle throughput on existing roads, and (3) reducing traffic delays stemming from vehicle crashes (Anderson et al, 2014). These studies suggested that CAVs could be beneficial to certain groups of individuals and the broad society when we really achieve that technological level. However, the current insufficient research on its potential socio-political issues appears
a gap, which is likely a conscious choice. Criticised by Stilgoe (2020: 4), “policymakers are seduced by the promises of new technologies, which arrive without instructions for how they should be governed. It is too common for regulation to be an afterthought.” Therefore, scholars must understand why certain aspects of CAV research (eg. trust and acceptance) are popular and favoured? What are the drivers? Is there any other area that deserves further research? How can we fill such gaps?

Driven by the purpose of improving the public’s acceptance/adaptability, social research has so far clustered around the first layer of CAVs’ “ripple effect” implications (Milakis et al., 2017). Having CAVs placed in the centre, the “ripple effect” refers to three layers of implications surrounding it. The first layer of implications contains traffic, travel cost, and travel decision-making. For instance, CAV technology may affect people’s choice between active travel and an (autonomous) pod for short distances. The second layer looks at the changes in vehicle ownership and sharing, land use, and transport infrastructure. Questions such as ‘how will gas stations be affected by automated cars?’ may raise. Will they go to certain stations to fuel/charge themselves in a more efficient way and thus require fewer traditional gas stations run by people? The last layer includes wider societal implications such as energy and environment, public health, and equity. For instance, who can access and afford CAV services? How will insurance work for CAV users? From what we have discussed above, the last two layers have not yet been properly studied and in the third layer, social equity of accessibility to transport technologies and services deserve further discussion in specific contexts, considering the differences in traffic rules, transport systems, travel behaviour and more.

Inequality of access to transport services or infrastructures has long been studied in
the broad context of transport and mobility (Lansing and Hendricks, 1967; Lopata, 1980; Yago, 1983; Rodrigue, 2016) while CAVs’ accessibility has rarely been studied by social researchers. Social studies suggest that inequities reside in the distribution of transportation services among the poor, the old, the disabled, ethnic minorities, and women (Ferreira and Batey, 2007; Martens, 2012). Population and employment distributions in cities created distance barriers that were amplified by the unequal transport service for these people (Davies and Albaum, 1972). The elderly, the disabled, and women were most vulnerable due to the poor transit service and lack of automobile ownership (Lansing and Hendricks, 1967; Lopata, 1980; Rodrigue, 2016). The gender gap was reflected in the inaccessibility of mobility yet it was also related to other issues of transportation services such as discrimination in commercial design (Balkmar and Mellstrom, 2018) and sexual harassment on public transport (Fisch, 2018). This leads me to ask who will be offered the accessibility to transport technologies and services and who or what might be left out in the new context, especially when technological applications are introduced to the market, they normally and exclusively serve few people rather than all social groups. If planners want to include the elder, the poor, the disabled, and women who are normally vulnerable due to the poor transit service and lack of automobile ownership (Lansing and Hendricks, 1967; Rodrigue, 2016), how will they fill the age, gender, and social status gaps reflected in the accessibility of transport services in the new context of applying CAVs and further to create smart transport for all through applying new transport technologies? Only by investigating these broad social aspects in detail, might we form a better understanding of transitioning a technological evolution to a social revolution that benefits all.

Addressing unequal access to transport technologies and services may also contribute to improving people’s acceptance of CAVs. Knowing that a promising service can be easily accessed, the public will be more likely to at least have a try. Apart from safety,
which as the most commonly raised concern, aspects such as liability, ethics, fairness, and trust (both in the transport system and in the vehicle) are also associated with the public’s concerns. Exploring these topics in the broad socio-political context and discuss how people imagine or perceive living with the uncertainty afforded by emerging technologies cannot offer an answer to the future, but it could serve as a processual opening up of possibilities (Pink, Fors, and Gloss, 2018). These aspects, however, cannot be fully addressed by the top-down approaches which are normally adopted by the planners. The top-down research contributes to drafting fundamental principles or blueprints while underestimating the day-to-day complexity and lacks a critical review formed by multiple narratives. Therefore, we need to use anthropological approaches to conduct in-depth investigations of the broad changes introduced by CAVs and bridge various perspectives to enrich a critical understanding of this new field.

Apart from social aspects shown in the “ripple effect”, CAV technology also inspired studies of new behaviour/body technique (Van Rhoon, et al., 2020 and Indahingwati, et al., 2019), new forms of social interaction and its meaning. The social interaction on the roads has been investigated by sociologists back in the 80s and the research suggested that inappropriate behaviours such as aggression were triggered due to traffic congestion or traffic noise (Korte and Grant, 1980). Individual stress-level went up and the solution of the anonymous and fleeting social relationship became the norm, which echoed Georg Simmel’s study of urban pathology, which suggested the cause-and-effect relationship between the metropolis and mental life. Studies that suggest negative relations between transportation and social interactions failed to show positive possibilities of the whole picture. Isn’t there a chance people use public transport to escape social interactions on purpose? Isn’t it possible that new social relations may be formed on transport? Or isn’t it true that some people prefer reading
and thinking on a train and feel inspired by that environment? In *Mood and Mobility*, Coyne (2016) criticised the negative impact aroused by transport yet also pointed out the beautiful curiosity triggered by transportation and the pleasure found while moving. Interactions, if not with others or oneself, but with the world or the vehicle through itself, may deserve more attention in ethnographic/technographic studies.

Different mobility practices offer different conditions for being exposed to others and the environment. Specifically, driving, cycling, walking, or using public transport offer people different levels of interactions with one’s social network and the physical environment and thus create a different experience of mobility practices. For instance, cultures characterised by walking and cultures of vehicle mobility offer people different perceptions of the outside world (Ingold, 2004). Different types of exposure on the road affect the sense of connectedness to others and society (Brommelstroet et al., 2017). To feel such internal and especially external connectedness to the environment/the city, one has to use senses as Van Duppen and Spierings (2013: 235) said, “our sensory body allows us to see, hear, smell, taste, and feel the city and its features”. In the context of CAVs, sensory interactions might be reconfigured. For example, the human driver may lose such experience while the ‘fusion’ resides in the design process as a trend of anthropomorphism. For the same purpose to improve people’s willingness to trust and use AVs, designers offer AVs with a name, gender, and a human voice (voice assistant) and this manipulation eases people while sitting in the vehicle (Waytz et al, 2014). Through such humanoid design, people’s acceptance of AVs is expected to largely increase.

Research on CAVs also involves the potential impacts on identity (Laurier and Dant, 2012), masculinity and embodied experience (Balkmar and Mellstrom, 2018), new
meanings of the car and mobility (Dennis and Urry, 2009) and many other aspects. The imagination of a world of automation, among which, especially intrigues many scholars. Balkmar and Mellstrom (2018: 50) emphasises the importance of “autonomous vehicle imaginary” which refers to an exploration of what “autonomous vehicles are about and how their users are imagined and (re)configured”. This imaginary is considered as a method for researchers to understand people’s behaviour as well as their shifting perceptions of CAVs. They also put forward the gendered implication that traditional vehicles for males to express masculine identities, status, the dominance of power are gradually undermined and some typical gendered issues such as road rage may be reduced. Eric and Dant point out that all little pleasures in driving that would disappear with the driverless car through his research on what do people do while driving and further imagine CAV’s impact on those actions (Laurier and Dant, 2012), though AVs may bring advantages of door-to-door services without the emotional stress of driving as well as the increased safety and convenience of night travels. As discussed in Coyne’s mood and mobility (2016), driving is a practice of identity expression and mood release. CAV technology will deprive of people’s driving experience but may replace it with new forms of interactions between passengers and passengers, passengers and vehicles, passengers and pedestrians...That says, while adding new functionality, meanings, and value to vehicles, automation may detach others. The gain and loss of a world of automation will affect people’s experience of moving around and their perception of smart transport or the broader futures.

After sketching and analysing the current research on CAVs, we found that first, comparing with the fast-growing technical studies on CAVs, social research of the CAV domain is insufficient. Second, within the limited social studies of CAVs, most are driven by commercialization and they often adopt quantitative research methods. In-depth social research that focuses on not just user experience and public acceptance
but broad socio-political aspects such as (in-)equity and affordability are yet to develop. There are countless social aspects, including existing and emerging ones, of CAVs. My research will not and cannot cover all of them with width and depth.

But having identified these gaps, I hope my research can make the slightest contribution to critically draw a holistic view of the social integration of CAVs in the UK, covering some important socio-political aspects, questioning and challenging possibilities of the future with CAV technology.

4. Methodology

In this section, first, I introduce my methodology—technography by explicating its definition and features. Second, I illuminate technography’s foundation in and relation to anthropology. Third, I explain the way in which technography influences and serves my exploration of CAV’s social deployment as well as its contribution to social scientists who study possibilities and imaginaries afforded by technology. Specifically, though fully-automated CAV technology does not exist, technography allows me to bring multiple perspectives together and actively engage in a wide range of participation, thus offering a reflexive and performative way to see CAV as a ‘becoming’. Fourth, by illustrating how I ‘entered the field’, ‘being in the field’, and ‘being influenced by the field’, I explained why I made certain research and/or ethical choices—people who I engaged with, events that I participated in, and topics that I deeply analysed.

4.1 Technography

Technography, the ethnography of technology, has been applied as an interdisciplinary method to study machines, skills, techniques, facts, and knowledge in everyday life. It
is considered a combination of “Technology” and “Ethnography” as it enables a thick
description of ‘the intimacy of technology, the relationships and feelings it is bound up
in’ and an understanding of ‘technology’s dynamic contributions to everyday
performance’ (Kien 2008:1103) that is beyond traditional approaches. It takes its cue
from ethnography in terms of using socio-political analysis and it further expands the
traditional analysis with the aspect of human ‘technologically contextualized’ behaviour
(ibid.). Although “ethno” is replaced with “techno”, technography is highlighted as
‘irreducible to categories of identity, community, nation, agency, and subjectivity’ (Fisch
2018: 6). In short, it suits the research of knowledge-generation of nonhuman parties
and the socio-technical configuration.

Technography has its rudimentary form in the early writings of Anthropology of Science
and Science and Technology Studies (STS) ethnography. A fundamental character of
technography gives the credits to Actor-Network theory (ANT), which, put forward in
the 1980s, refers to a theoretical or methodological approach to social theory ‘where
everything in the social and natural worlds exists in constantly shifting networks of
relationship’ (Siakwah 2017: 462). ANT explains technological development as
continuing socio-technical interactions that include human and non-human actors.
Neither technological determinism nor social constructivism should be simply adopted,
as Akrich (1992, 206) suggested that “technological determinism pays no attention to
what is brought together, and ultimately replaced, by the structural effects of a network.
By contrast, social constructivism denies the obduracy of objects and assumes that
only people can have the status of actors”. ANT rejects the dichotomic view between
social and technical factors by emphasising the relations and connections in the broad
socio-technical context. ANT was thus used by pioneering researchers to explain the
existence and the working of economic markets (Callon, 1999) and the advanced
invention in public transport (Latour, 1996).
In the 1990s, Actor-Network theory became influential in studying technology’s socio-technical networks and inspired the “distributed cognition” dimension (which I demonstrate later) of technography. At that time, STS ethnography valued four principles: causality, impartiality, symmetry, and reflexivity (Bloor 1991: 7). These principles also served extended studies of technology in the field of anthropology. Woolgar and Latour’s Laboratory Life (1979) went beyond the observation of technology and showed concerns about the writing process and about retaining outsiders’ perspectives in the laboratory. “Laboratory studies” led a trend of ‘asking how’ instead of merely ‘describing that’, which was internalized as an important feature of technographic writing. In recent words, technography is “immanent, exploratory and procedural rather than declarative” (Connor 2016: 18). This ‘asking how’ discourse emphasises an awareness of the process of its own meditation (Purdon 2018: 7) and embraces in-depth thoughts while writing. In Purdon’s eyes, technography encourages writings that shed light on the technicity of text and the textuality of technics. STS ethnography put forward a concern of “modest intervention” (Heath 1997: 79), referring to a research focus on technology’s social construction, and more importantly, the exploration of better constructions.

Latour’s Aramis, or The Love of Technology, as we discussed before, creatively presented a collection of narratives in a hybrid text. Although Latour described his work as an ethnography of a high-tech case about Aramis rather than technography, his research method and writing style reflected the rudiment of technography. Presented in the form of documents, policy reports, newspapers, interview excerpts, diagrams, maps, and an imagined voiced of Aramis, the narratives of policymakers, stakeholders, engineers, and Aramis itself were intertwined in the same socio-technical context,
providing both explanations of the ongoing progress and expectation of the future progress. Combining different types of data and especially adopting diagrams to show the shifting narratives can draw a holistic picture of the researcher’s mind map of the project. Latour’s Aramis inspired me to bridge the ‘top-down’ and ‘bottom-up’ perspectives and present them in the form of interview excerpts and diagrams. Furthermore, Latour’s work embraced the socio-political perception of technology as well as the unceasing discussion of future trends and possibilities, which sheds light on my study of people’s imagination of the future technology and the future interactions between human and non-human.

After 2000, technography was applied widely in the technology case study. Published in 2007, the series of “technographies” (Nocks, 2007; Post, 2007; Magoun, 2007) contains life stories of technologies concerning communication, transportation, military-related technologies, and robots. Each placed efforts investigating interactions between technologies and societies. Similarly, studying how the team of farmers, engineers, and technicians solve problems, Jansen and Vellema (2010) conducted a technography of agricultural production. Through this project, they concluded three dimensions of a technographic study. The first dimension is “making”, which refers to the study of ‘performance’. In this dimension, technography is an approach to the socio-technical configuration. However, it is stressed that more than ‘knowing that”—the performance layer, technography pushes the study of ‘knowing how’—situated action and embodied knowledge. In order to understand how and why technology interacts with people and meets their needs in everyday life, observation and even participation should be considered in the field. The second dimension of technography is “distributed cognition”. Originated from psychological theories, distributed cognition suggests that “knowledge lies not only with the individual but also in the individual’s
social and physical environment. Within a technographic study, distributed cognition requires to look for task-related information that might be projected onto a surrounding or a social network. This dimension helps researchers to think under a bigger framework and search for hidden knowledge. The third dimension of a technographic study is “the construction of rules”, which concerns the role that a relevant institution or association plays. A technography in this dimension explores the roles, protocols, and standards within such a decisionmaking place (Jansen and Vellema 2010: 170-73). When three dimensions are examined and reflected under the framework of a whole project, a contributory technography can be expected.

As discussed above, the contribution Fisch made highlights the interactions between humans and machines with respect to ANT, which leads me to think from the technical perspective - apart from the socio-political network, how does the feasibility of technology itself affect its social integration?

4.2 Technography and anthropological future studies
Anthropological studies before the 20th century mainly focused on the past and the present life. An interest in cultural forecasting grew among anthropologists such as Margaret Mead in the mid-20th century. Instead of predicting which cultural path makes a certain future, they acknowledge ‘the ability of humans and their agency to choose and make different futures’ (English-Lueck and Avery, 2020: 1). At the beginning of the 21st century, anthropologists like Raymond Firth (2003) argued for a change in the field of anthropology to jump out of the box of the past and present and called for attention to both the discipline’s future and contemporary society’s future. Such an argument

32 ‘Socially distributed cognition’, see Psychology Wiki: https://psychology.wikia.org/wiki/Socially_distributed_cognition
along with a fast-growing interest in science and technology studies, which often trigger future-oriented thinking, encouraged anthropologists to look at the future.

Future-orientedness is described by anthropologists as “part of who we are and how we experience everyday life. We are pulled in the direction of the future in numerous affective ways—by hope and great expectation, through anticipation or fantastical speculation, or by acts of faith or believing in fate” (Bryant and Knight, 2019: 202). Knight discussed the above future orientations and considered them as theoretical tools to help anthropology move beyond an overweening emphasis on the past (ibid: 3). Recently, more anthropologists have placed efforts in designing and developing anthropological approaches to future studies and some came up with a new term “ethno-futures”. At the talk ‘Exploring Ethnofutures’, Miriam Lueck Avery and Jan English-Lueck presented a diagram where ‘ethno-futures’ was positioned in the intersections among anthropology, applied anthropology, future studies, and other applied disciplines. Future researchers in academic anthropology, applied anthropology, and other applied disciplines are recognised having a share system perspective (Miller, 2018: 64) and the sweet spot between these disciplines can inspire innovative and practical approaches to tackle cultural and technological futures.

Why has there been such a huge shift? Why have anthropologists started paying more attention to the future rather than sticking to the past and the present? Besides, anthropology of the Future and future-oriented studies are often associated with emerging technologies (Eglash, 2012; Pink et al., 2016). So why technological futures in particular?

Fundamentally, anthropology is the study of groups of people and their relations to the environment where they live. Our world has been affected by technologies more and faster than ever before. To understand the fast-changing society and our relation to the elusive future that shapes “perception of the familiarity of everyday life” (Bryant and Knight, 2019: 15) and contributes to the re-imagination of “the present from the perspective of the end” (Miyazaki, 2006: 157), anthropologists are applying the technique of ethnography to technological studies and thus forming and developing the use of technography.
Technography, with all its features we have discussed above, is a suitable anthropological and STS approach to investigating the future that is shaped by emerging technologies. A socio-political discourse can be revealed as it has theoretical roots in anthropology. Therefore, I consider my methodology resides in exploration between ethnography and technography. If not fully technographic, under its influence, the thesis highly values the technical perspectives - both from technicians and the CAV technology itself, and explores the human-machine interaction/relati on through imaginaries, discourses, participant observation, and embodied experiences in a new context of CAV.

**4.3 Technography and my research**

Theoretically and practically, technography has at least three distinctive positions as suggested by Jansen and Vellema (2010) that suit my research goals. First, technography develops a unique position in the “technological versus social determinism” debate as it values both social factors and technical factors. It encourages me to study the sociotechnical network of CAVs rather than any dichotomy. Having adopted “a realist position” (Jansen and Vellema 2010: 174-76), technography requires a realistic understanding of actual technological applications that their success relies on both technical factors and many sociocultural and political ones. In my research, the technological feasibility is key to the success of CAV technology while its social integration into society requires more, including but not limited to sustainable transport planning, responsible and ethical regulatory framework, and public trust and acceptance. Technography can thus help me see a bigger picture and consider various factors that shape CAV’s development and deployment.
Second, technography is against the view that the social sciences and natural sciences should be separated. That says, apart from breaking the dichotomy between technological and social determinism, it emphasises the collaborative correlation between social sciences and natural sciences. In my case, I truly see the importance of multiple perspectives and interdisciplinary knowledge. Without engaging AI scientists and attending AI/car-tech events, I couldn’t form an understanding of where CAV is and where it is headed. Besides, only by combining the expertise of data scientists and social researchers, did our team (me as the second author) complete a bibliometric review (Mora et al., 2020) of CAV research that covers over 18,000 papers and found gaps in the current research trends.

Third, technography looks at the incorporation of materialism and imagination. Physical items such as production, properties, infrastructures, and in my case, connected and automated vehicles, are technography’s concerns. But such physical items are not necessarily visible or tangible, for instance, software or algorithm also belong to the materialistic side. It thus leads me to not only seek imaginaries or discourses, but go to labs, showcases, and testbeds to observe and try the material side of CAV. From there, followed by a deeper understanding of the CAV reality that either clashes or resonates imaginaries.

The three dimensions of a technographic study, therefore, shape the width and depth of my research. Influenced by Fisch (2018: 6) who does not just ‘think about’, but ‘think with’ technologies, and presents the flow of technologies’ operation, I engaged technical perspectives and discovered the ways in which technological development and its uncertainty shape CAV’s social deployment. Particularly, after seeing and trialling CAVs myself, from my viewpoint of ‘thinking with’ the current CAV technical
level, I better foresee some positive possibilities ahead while some promises afar. Below I explained my research approaches and some fieldwork activities in detail.

I commenced pilot research in April 2019 in Edinburgh. As a stakeholder-insight researcher on the Festival Transport project, I interviewed residents, tourists, bus drivers, Uber drivers, and festival workers to understand the pain points in traffic during the international Fringe festival. The pilot research granted me a rich understanding of Edinburgh’s transport system, transport research methods, and built network in this field. Although this mini project did not involve a study of using automated vehicles as a solution, I heard many interesting commuting stories and formed an understanding of people’s expectations for future transport and mobility. The pilot research also helped me build the networks, especially with those who work on the CAV Forth project, and encouraged me to think about the ways in which CAV technology may address traffic problems during the Fringe festival in the future.

After my first year PhD annual review in September 2019, I started my (official) fieldwork in Edinburgh. From mid-January to mid-March 2020, I relocated to London to conduct interviews and access trials. I moved back to Edinburgh to collect further data on public perception and engage the CAV Forth project. Due to the COVID-19 pandemic, my research between April and September 2020 was conducted online. In my fieldwork, I adopted various methods to explore the two major research questions (see Introduction).

1. How is a CAV imagined?
2. How is a CAV integrated into society?
Having been confused with the mixed-use of CAV terminologies, I launched a survey which aims to investigate people’s preference for terms such as ‘automated’, ‘autonomous’, ‘self-driving’, ‘driverless’, and ‘robotic’. In doing so, I form an understanding of not only people’s familiarity of these terms but also their perception and trust in this technology. Utopian and dystopian scenarios triggered by these terms also unpack various CAV imaginaries and lead to thinking about human-and-machine relationship and future possibilities with the CAV technology.

I attended, facilitated, and organised workshops to engage members of the public. At the workshops, my participants and I together generate future scenarios of having connected and automated vehicles in society and how will they affect our everyday life to trigger CAV imaginary. Through utopian and dystopian scenarios, I analysed participants’ hope and fear. I also conducted multiple one-on-one interview sessions with hand-picked UK residents to listen to detailed commuting stories and then encouraged them to imagine using CAVs in the short-term and long-term futures, and what these futures might look like.

I interviewed policymakers, industry stakeholders, technicians, researchers, and lawmakers to study the prospects and challenges from their points of view. Apart from interviewing some representative planners, I attended various related conferences for a broad picture and extra views. Engaging these multiple players in the field, I studied the planning and practice of CAV’s social integration, which supports to answer the second research question. Moreover, to enhance my tech mind-set and understand how CAV technology itself shapes the social integration process, I conducted participant observation in two CAV trials where I gained embodied experience and
observed other participants’ interaction with the vehicles. The embodied experience through trials alongside discussions with technicians enabled me to gain an understanding of how CAV technology itself shapes its social integration process, which addresses the third research question.

Under the influence of the global COVID-19 pandemic, I also conducted some online interviews and joined several additional CAV-related virtual conferences and webinars. I also presented my work during some of the online events to get feedback of my study and gain new perspectives. Below I insert a flowchart where I noted down my main research activities on the timeline.

4.4 Entering the Field and Making Ethical Choices

Throughout my first-year PhD training and fieldwork preparation, I engaged with a wide range of literature reviews that include but are not limited to social studies of transport planning, policy of technology, the socio-political and technical development of automation, artificial intelligence, and machine learning. At the same time, I paid close attention to CAV projects in the UK and reviewed the most updated government and industry reports. Based on my accumulated knowledge of CAV and its related areas, I identified CAV projects (CAV Forth, Capri) to follow and big players to interact with, including policymakers from CCAV, DfT, and DIT, and industry stakeholders from companies such as Stagecoach and FiveAI. After passing my upgrade via and my first-year annual review, where I proved the value and feasibility of my PhD research project and was granted the ethical approval by the University of Edinburgh to conduct my fieldwork, I mapped out an initial list of key participants, focusing on the ‘planners’ category. I considered policymakers, technicians, industry stakeholders and
researchers who are on board CAV projects ‘planners’ for their expertise and directly impact on the development and deployment of CAV.

I also had been benefited from my pilot research in the first year. The Edinburgh Living Lab, a research laboratory that bridges scholars from the University of Edinburgh and stakeholders from governments and the industry, was looking for a research associate who is passionate about smart transport and is qualified to conduct qualitative research for the ‘Festival Mobility and Transport’ project, which aims to identify pain points in Edinburgh’s transport system during the International Fringe Festival and propose solutions. When I saw the job post in the university’s internal channel, I immediately asked my supervisors about their opinion on it. I applied for this position with their encouragement and advice on how to best use this opportunity to learn and reflect on transportation while snowballing my networks in this field. Since the project required me to interview many residents about their commuting stories, this research experience inspired me to think and question different social groups’ perceptions on transport/transport technology. I thus started my research journey, openly exploring CAV views, imaginaries (since it does not exist), and visions while consciously tightening findings to critically build a holistic view of this ‘becoming’.

I anticipated difficulties in accessing the field, especially with the industry stakeholders and technicians who might withhold information due to commercial sensitivity. After careful consideration, I chose to reach out to scholars who have been involved in CAV research or projects. For instance, Professor Nick Reed was one of my first interviewees for his appreciation for PhD research and willingness to introduce me to others in the field. With his help in London, I met Dr Mike Short from the government and Lucy Yu from FiveAI. They also kindly pointed me to more policymakers,
researchers, technicians, independent consultants, and industry stakeholders. With these planners who accepted my interviews, I asked for and received their written consent for audio recording and quotes. However, I did not get to interview all planners on my initial and growing list. One particular example, among all, was the hard rejections from the insurers. To understand the associated responsibility-distribution and insurance policy, I tried multiple ways to talk to insurers, in both formal and informal ways. Both my ‘cold call’ through LinkedIn and emails with references failed to gain any access with insurers. Despite the disappointment, I adjusted my research angle to explore how do lawmakers perceive CAV-related legal and ethical issues, and how is/will a CAV legal framework be built in the UK?

My thesis also included second-hand materials such as quotes from public speeches and conferences, only with which, I did not ask for the speakers’ consent.

Whereas my experience with planners in Edinburgh was quite different. Apart from the project with the Edinburgh Living Lab, I also my engagement with Edinburgh Napier University as a visiting PhD student. Initially, I wanted to join their transport institute as it consists of many transport researchers and planners and has a strong tie with transport companies who were on board the CAV Forth Project. I assisted the institute with a workshop that was exclusive to parties who were involved in the CAV Forth Project. Researchers from the institute did not offer me the visiting position but introduced me to a manager at Stagecoach (the bus company in the CAV Forth Project). I further helped this manager with his workshops and the Co-Design Panels that were open to the public. A casual conversation with a scholar in Edinburgh Napier University’s Business School accidentally led me onto another trajectory. Professor Luca Mora, who specialises in urban innovation, transport innovation, and
sustainability research, showed strong interest in my PhD research. With his invitation, I became a visiting student at their Business School and co-authored the paper ‘Mind the Gap: Developments in Autonomous Driving Research and the Sustainability Challenge’ (Mora et al., 2020) that criticised the techno-centric bias in the CAV-research field and called for research on CAV’s socio-political aspects. My active participation with the Edinburgh Living Lab and Edinburgh Napier University empowered me with not only a good understanding of the social ecosystems in transport- who is in charge, who has access to transport technology, and who plans the CAV Forth Projects, but also opportunities to meet more planners. Nevertheless, my research in Edinburgh was not one-hundred-percent smooth: Fusion Processing, the tech company (software) in the CAV Forth Project ignored my interview requests.

Although I managed to interview some CAV technicians, they were not from companies that were directly involved in Government-funded CAV projects. It made me think and question, with those who have and withhold key technology, how will transparent policy and CAV-related investigation process be built? And how will advanced technology play a role in power distribution between tech companies and policymakers? These questions all contributed to my later thoughts and investigation. Altogether, I conducted 23 interviews with the planners.

My engagement with the public in both Edinburgh and London took inspiration from my pilot research. In addition to my assisted workshops with Stagecoach, I reached out to some of the participants who I met at the workshops for followed-up informal chats so that I can ask questions that were not designed and asked at other people’s workshops. Having considered that some of these participants were either transport planners/enthusiasts or people who have heard of the CAV Forth Project (thus might have some
understandings of CAV), I consciously wanted to widen my sampling to get different and broader perspectives or questions. I asked my friends who lived in the UK for consent to conduct interviews. I used direct and indirect quotes and consciously either changed their names or adopted anonymity to protect their personal information and privacy. I launched a survey and circulated it through social media (Facebook, Twitter, and LinkedIn) and emails. I also started casual conversations with people who I met in train stations, bus stops, and other non-CAV related workshops. When I asked them about their perceptions and imagination about how they might use CAV in their everyday life, I did not record the conversations. Rather, I recalled them and took notes. Since I did not use direct quotes or reveal their personal information, I did not give consent forms to these ‘random participants’. Although they are unlikely to read these words, I thank them for their contribution to my research.

In London, I built my online meetup group and organised a workshop to discuss CAV technology and its potential impacts on our life and society. This was because, first, I did not collaborate with any institute or company and thus have more time and freedom to arrange my workshops instead of assisting theirs. Second, my experience in Edinburgh made me realise that I would be free to ask all questions that I wanted to ask if the workshop is organised by me. My post on the Meetup website was open to everyone. Although it inevitably might attract more transport tech experts/enthusiasts, it brought in perspectives outside as I had participants with very different backgrounds who attended it. I took notes at the workshop and recalled some conversations later. I well noticed participants about my PhD research and thesis, and received their verbal consent for direct and indirect quotes. To further protect their personal information, I changed names or hid information about their organizations. My engagement with the public contributed to opening up many bottom-up, on-the-ground questions such as equity and social safety, which well fabricated the socio-political complex networks of
technology together with the top-down perspectives from some policymakers, technicians, and researchers. Overall, I interviewed over 35 public members, engaged about 60 through workshops and trials.

In addition to my engagement with different social groups, I adopted the typical anthropological method ‘participant observation’ while focusing more on its performative part. This was because I wanted to gain my embodied experience with the technology both as a researcher and user. This method allowed me to understand CAV feasibility not only from other people’s mouth but my senses and feelings. It triggered my imaginaries and reflexive thoughts of CAV. Besides, my two shared journeys- on the automated bus and the automated pod- gave me opportunities to closely observe other passengers’ engagement with this technology, through which, I drew out deeper insights into trust and public engagement.

The very last part of fieldwork was conducted online due to the global pandemic (Covid-19), during this period, I attended online webinars and conducted a few more interviews through Zoom or Google Meet. I fully explained and reflected on this part of the research in the epilogue and based on this, I pointed out future research directions.

My fieldwork was designed, planned, and adjusted to overcome difficulties and uncertainty. Despite some disappointing moments, I enjoyed it and appreciated everyone I met during this journey.
Timeline for Fieldwork Activities (2019-2020)
My Research Journey
The fieldwork is an important learning experience for me to explore the ongoing CAV social integration process. After discussing CAV scenarios with some public members and planners, I noticed that people have been opening up possibilities by bringing in more topics or posing more questions, which helped me widen my exploration with multiple perspectives while focusing on key aspects of the CAV dialogues. I looked at long-existed social aspects and emerging areas that are associated with CAVs or might be affected by CAV technology in the future. These research activities empowered me to reflect on the whole process of the social integration of CAVs and picture the possibilities of the future. It is my hope that knowledge in the CAV domain, whether regarding its technological feasibility or the socio-political and ethical aspects can quickly accumulate.
Chapter 2 CAV Terminology: Sociotechnical Imaginaries and Political Intentions

Since Donna Haraway (1985) pointed out the limitation of binaries between humans and machines, more attention had been placed on the more-than-human multiplicities through interactions with machines, robots, atoms, big data, automation, and artificial intelligence. Deeper understandings drawn from the rich reality of everyday learning, experiencing, and using of technology further inspired the sociotechnical imaginaries of being among them and being them (as hybrids and more). The physical/tangible technological inventions are often less accessible to the public in a short period on a large scale but the imaginations triggered by them—the ideas of advanced technological products or some new technical terms—never lag behind and they can be both exciting and anxiety-provoking. CAV, as the abbreviation of connected and automated vehicle, is one of the new technical terms that stimulates different feelings, opinions, and imaginaries. Alongside this term (automated vehicle), others such as ‘autonomous vehicle’, ‘driverless vehicle’, ‘self-driving vehicle’ have been widely used by the public, the press, scholars, technicians, and policymakers.

The lack of clarification and unification of these terms leads me to investigate two things in this chapter: First, what are the sociotechnical imaginaries of CAV-related terminology? How do different terms such as ‘automated’, ‘self-driving’, ‘driverless’, and ‘autonomous’ affect people’s perceptions, understandings, and imaginations of this technology and thus impact trust, acceptance, human-machine relationships and other aspects? What are the future possibilities these terms/this technical idea direct to? Second, how do the CAV planners, including technicians, industry stakeholders, researchers, and policymakers understand and use these terms? Why? What drives
their choices and what does that mean for the CAV social deployment?

After describing the terminology puzzle, I first explained my understanding and imaginaries of these terms. Second, I reached out to the public with a short survey, from which, I collected not only their preferences but also sociotechnical imaginaries of the CAV technology. With this method, I merely aimed to get a quick sense of the terms that were widely used among the public and trigger some thoughts. Hence, I treated this survey with a small sample size as a conversation starter to pave the way for the following research. Analyses of these imaginaries opened discussions about trust, acceptance, control, and human-and-machine relationships in the future and demonstrated various possibilities afforded by CAV technology. It contributed to an understanding of people’s hope and fear of technology, the desired technological futures, and areas that we should further explore to transit the present to the future with CAVs. Third, I selectively presented interviews with the leading technicians, researchers, policymakers, and industry stakeholders where I interpreted and analysed their socio-political choices of using the certain term(s). The choices driven by different socio-political and economic reasons as well as technical knowledge suggested that a technological invention is a political presentation (Bijker, Hughes, and Pinch, 1987) after a process of negotiation and modification in the socio-cultural contexts (Pfaffenberger, 1992), which revealed the complexity of introducing and deploying CAV technology to society despite many of its potential prospects.

Through the lens of terminology, the chapter paves the way for an in-depth exploration of the CAV imaginaries and an analysis of the socio-political effort in its social rollout.
1. The Terminology Puzzle

Before the fieldwork, I struggled with the multiple terms that I can potentially use in my research. Should I say ‘automated vehicles’ or ‘autonomous vehicles’ to my participants? What about ‘self-driving cars’? When it comes to the discussions about the AI-empowered intelligent vehicles (connectivity technologies excluded), there exist many expressions: “self-driving cars”, “driverless cars (DC)”, “autonomous vehicles (AV)”, “automated vehicles (AV)”, and “robotic cars”. All these terms appeared in field-leading readings such as Autonomous Driving: Technical, Legal and Social Aspects (Maurer et al., 2016), Driverless: intelligent cars and the road ahead (Lipson and Kurman, 2016), No one at the wheel: driverless cars and the road of the future (Schwartz, 2018), Driver Reactions to Automated Vehicles (Eriksson and Stanton, 2018), and Robot, Take the Wheel (Zon and Ditta, 2016). Apart from academia, the mixed-use of these terms was also adopted by the industry and governments. For instance, the joint unit CCAV, between the Department for Transport and the Department for Business, Energy and Industrial Strategy, UK Government, refers to the Centre for Connected and Autonomous Vehicles while projects run by the department showed different preferences of these terms. “Autonomous” and “driverless”, for example, are equally used in the MERGE Greenwich Project\(^\text{34}\) while “automated” in the MOVE_UK project\(^\text{35}\) and “automotive” in the 5StarS\(^\text{36}\) project.

I was haunted by the inner struggle of not being able to define nor decide ‘the right’ term for my PhD project. First, I cannot justify any selection with my limited technical

\(^{34}\) The Merge Greenwich is a UK funded autonomous ride-sharing vehicle project. [https://mergegreenwich.com/](https://mergegreenwich.com/)

\(^{35}\) The Move-UK project focussed on reducing the timescale and cost of validating Automated Driving Systems (ADS). [https://www.move-uk.com/](https://www.move-uk.com/)

\(^{36}\) 5STAR is a UK funded project to develop an assurance framework for accessing the cybersecurity of vehicles. [https://5starsproject.com/](https://5starsproject.com/)
knowledge of automation. Second, the differences among these terms seem more unclear and blurred in my first language (Mandarin) than in English: both “self-driving” and “driverless” refer to “无人驾驶” (“wu ren jia shi” in pinyin) while both “autonomous” and “automated” can be translated into “自动化” (“zi dong hua” in pinyin). “自动化” and “无人驾驶”, likewise, are mixed in dialogues in Chinese industry, governmental departments, and academia. Differentiating the nuance between “self-driving” and “driverless” as well as the one between “autonomous” and “automated” is quite challenging.

Let me present my subjective feelings and intuition as a bilingual: “autonomous”, “automated”, and “自动化” all emphasise the machine or robotic elements but could raise different emotions. “自动化” is as neutral to me as the word “autonomous”, which leads me to picture the collaboration between machines and humans, especially the scenarios where robots can think and conduct most labour work under human supervision. For instance, I would link it to the IBM factory where they use AI solutions for agriculture, manufacturing, and supply chain. The factory is highly autonomous with hundreds of different types of robots (robotic arms, mini-robotic trucks, etc.) focusing on different tasks and engineers (human supervisors) are the rare animals there.

Comparatively, “automated” gives me a feeling of slight passivity (maybe the ‘-ed’ in the word gives me that impression). This term leads me to imagine an assembly line where equal numbers of robots and humans work together and the less advanced robots (some basic robotic arms) can only assist with the tedious, repetitive work without thinking. In other words, the nuance between ‘autonomous’ and ‘automated’
tends to convince me of a bit more intelligence in the word ‘autonomous’.

“Self-driving”, “driverless”, and “无人驾驶” all highlight the fact of no-human-in-charge. In Mandarin, in particular, “无人驾驶” literally means “no human/without human”. I personally do not like the connotation of the above expressions as they replace a feeling of safety with wildness and even recklessness. Completely detaching ‘human touch’ in a traditional human task frightens me and I feel a transition that gradually enhances automation level will ease my nerve. Therefore, I started my research with the term “autonomous” used most frequently. The rest of these terms were used to supplement my research because I realised that when reaching out to participants, especially those who have limited knowledge of automation or this new type of vehicle, I needed to use at least two of them (eg. ‘autonomous vehicles’ and ‘self-driving car’ at the same time) to clarify what I refer to. Also, the mixed-use of these terms was adopted in the thesis in line with specific CAV projects and other scholars’ work.

During the period of my research, efforts have been placed in ‘standardizing’ these terms. For instance, the Consumer Technology Association (CTA) at Google rolled out a “common lexicon” (Fairfield et al., 2017) to explain the relevant terms. In 2018, the Centre for Transportation Studies (CTS) at University Virginia launched a 30-pages long glossary (Park et al., 2018) of connected and automated vehicles and the broader technological concepts such as artificial intelligence, machine learning, advanced driver assistance system (ADAS), and Lidar. The BSI Group has also launched two versions of the CAV-related glossary (2020). However, no authoritative standard has yet been set within the field (mixed uses still exist), let alone unifying terminology among the public.
The issues with the unclear terminology including but are not limited to (1) misunderstandings of concepts, and (2) that the nuance resides in different terms might trigger different sociotechnical imaginaries of this technology, thus affecting people’s trust and acceptance.

2. Sociotechnical Imaginaries of a (Self-driving) Car

Sociotechnical imaginaries were first studied by anthropologists in the 20th century as “technoscientific imaginaries”, which, as a concept, was used to study futures and possibilities in the scientific workplace. What was of interest to anthropologists was the imaginaries of scientists “tied more closely to their current positionings, practices, and ambiguous locations in which the varied kinds of science they do are possible at all” (Marcus, 1995: 4). Beyond the context of the scientific workplace, anthropologists use the term “sociotechnical” to investigate how imaginations through different social actors shape technological development and realise the collective preferred futures.

This concept thus bridges the study of imaginaries in cultural and political space and of sociotechnical systems in science and technology studies. As Jasanoff (2015: 4) defines, sociotechnical imaginaries refer to “collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology.” In Jasanoff’s eyes, sociotechnical imaginaries are collective and contain expectations for the good and resistance to the bad. The imagined utopias or dystopias afforded by a certain technology not only open up possibilities but also carry various socio-political and moral implications that reflect
our current reality and societal values and thus affect how we diverge the technological paths towards preferred futures. Throughout history, technological choices were made or shaped by politics and morality through imaginaries where hope and fear of certain technological future were expressed. Clone technology, for instance, raised controversy when the birth of Dolly sheep touched the nerve of humanity— who are we as humans? Can we be cloned, too? Are we allowed to clone another human or any living beings at all?

The potentials of this breakthrough biotechnology were claimed by DNA researchers and acknowledged by the U.S. government, but the U.S. congress also immediately held hearings and proposed regulatory drafts because they consider the potential achievements to be unclear from a moral standpoint.

‘To Senator Frist, cloning held the potential for “both good and evil.” Senator Jeffords declared, “this research at once completely fascinates me and scares me to death.” Senator Kit Bond, sponsor of legislation to criminalize human cloning, was less equivocal: “Human cloning is something that we as a society cannot and should not tolerate”.’ (US Senate, Committee on Labor and Human Resources 1997, cited in Dennis, 2015: 65)

The cloning technology raised massive moral debates among the public and their moral imaginaries eventually constrained the applications of this technology and regulated its direction of future development. This event sent a message to those who believe in technological determinism that society does not only passively react to technological changes but actively forming a complex socio-political and moral network
to embed the technology and its futures. In other words, technological choices have moral and socio-political connotations that are reflected through sociotechnical imaginaries.

The same applies to the auto industry. Karl Benz was encouraged by his sociotechnical imaginaries of steam engines empowering a vehicle to travel long distances at a high speed and brought the first car to the world in 1886 (though with a low speed at that time). Beyond its original function, people imagined using it for sports, fashion, socialization, forming and re-shaping their cultures and some of these imaginaries were later transformed into reality (as discussed in the introduction). Despite all the proven prospects and the possible utopian ones, this technological invention, with its increasing speed, was perceived by others as an evil machine. For instance, in the 1965 “Unsafe at Any Speed” campaign in the U.S., activists imagined speedy, muscle cars such as the Ford Mustang as the end of humanity and produced disturbing posters that described how mass production of such cars will trump capitalism by depriving lives on roads. Such sociotechnical imaginaries of cars woke the authorities’ and industry’s morality and inspired safety innovations such as seatbelt and sensitive brakes.

Car innovation never stops. Nor do the sociotechnical imaginaries of cars. With the improvement of AI and automation technology, people started hearing more about the idea of ‘a car drives itself’. I wonder what are the sociotechnical imaginaries of this technology? With the terminology puzzle left unsolved, I prioritise another question in this chapter: how do different terms (‘autonomous’, ‘automated’, ‘self-driving’, ‘driverless’, and ‘robotic’) trigger different sociotechnical imaginaries? What are the differences? Which term(s) is/are preferred to describe a collectively desired future?
What does people’s choice of terminology tell us? What insights or implications can be drawn here?

Before diving in, here is something interesting I would like to signal, which snowballed some of my questions: nearly all reports of the below event adopted the term ‘self-driving’, with only a few ones using the word ‘driverless’.

Elaine Herzberg, a pedestrian who was walking with her bike on a Spring evening in Arizona, was knocked dead by a Volvo SUV with self-driving technology. Rafaela Vasquez, who sat on the driver’s seat and monitor the operation of the vehicle as a “safety driver” was absent-minded at the moment right before the collision. The ‘autonomous’ mode was on but the vehicle failed to recognise Elaine and did not react on time. This Arizona self-driving car crash generated many dystopian imaginaries, raised practical concerns about the technological feasibility, and explicated some legal and ethical challenges of deploying it to society: ‘Was it a human’s mistake (pedestrian or safety driver) or technological failure?’ ‘Who is responsible?’

What interests me is: Why did the press simultaneously choose the term ‘self-driving’ to describe this tragedy? Would it make any difference if they describe it as an ‘automated vehicle crash’ or ‘failure of an autonomous system’? Will these similar terms equally generate dystopian imaginaries and concerns? Also, regardless of the differences in terminology, what are the sociotechnical imaginaries of this technology in general?
3. Imaginaries in the Terminology Survey: using and being with CAV

Before 2019 Christmas, I designed a 1-minute terminology survey and circulated it through emails, Facebook groups, WeChat groups, and Twitter. The survey was launched on a small scale in a short period to merely draw a general picture of the public’s preferences of terms and more importantly, to capture people’s imaginaries associated with these terms: when people see these terms, how do they imagine using and being with CAVs?

In a month, I received over 60 responses, among which, 52 are useable. Additionally, 33 extra comments for Question 4 provide me with rich insights into people’s understandings and imaginaries of this technology. The survey consists of three single-choice questions and one open question. Below I demonstrate the questions and responses, followed by my analysis.

(1). Which of the following terms are you familiar with?
   a. Autonomous Vehicles
   b. Driverless Vehicles
   c. Self-driving Vehicles
   d. Automated Vehicles
   e. Robot Vehicles
   f. Other terms, please specify:

(2). Which term gives you positive feelings the most or you prefer to use?
   a. Autonomous Vehicles
(3). Which term gives you negative feelings the most or you prefer not to use?

a. Autonomous Vehicles
b. Driverless Vehicles
c. Self-driving Vehicles
d. Automated Vehicles
e. Robot Vehicles
f. Other terms, please specify:

Participants can only select one answer but can leave comments under Questions 1, 2 & 3.

The optional open question is:

(4). Why do you like/dislike that term the most? Any thoughts on those terms' effect on your feelings and understandings?

The first three questions studied people’s familiarity with these terms and feelings about these expressions at a high level. The last question left them space to describe their imaginaries of this technology. Over 63% of participants leave their comments under the last question, suggesting a major willingness to further explore this topic.
Regarding the first question, the responses (see chart 1) are ‘Autonomous Vehicles’ (26.92%), ‘Driverless Vehicles’ (13.46%), ‘Self-driving Vehicles’ (46.15%), ‘Automated Vehicles’ (13.46%), and ‘Robot Vehicles’ (0.00%). The responses imply that ‘Self-driving Vehicles’ is the current most well-known term, followed by ‘Autonomous Vehicles’. One participant comments that s/he is familiar with all the above terms and another participant claims, “disaster waiting to happen (regardless of terminology)” in capitals.

Among 51 completed responses to Question 2, a majority of 35.29% of participants suggest that they feel positive about the term ‘Self-driving Vehicles’ and 31.37% of participants choose the term ‘Autonomous Vehicles’ (chart 2). In comparison with the first question, we can draw a rough conclusion that people tend to be positive about
what they are familiar with and feel negative about what they are less familiar with. The terms ‘Automated Vehicles’ (19.61%) and ‘Driverless Vehicles’ (3.92%) more or less generate some positive responses. Not a single participant holds positive feelings about ‘Robot Vehicles’.

![Chart 2.2 Responses to question 2](image)

In contrast to Question 2, Question 3 aims to find out the term that generates the most negative feelings among the public. A majority (42.31%) of participants select the term ‘Robot Vehicles’. Followed by the terms ‘Driverless Vehicles’ (28.85%) and ‘Autonomous Vehicles’ (13.46%). ‘Self-driving Vehicles’ (7.69%) and ‘Automated Vehicles’ (1.92%) generate the least negative feelings among participants (chart 3). Two extra comments highlight a concern about ‘this whole concept’, saying that this
technology will lead us to a dystopian society.

The final question shifted the focus on terminology to the technology that these terms refer to and inspired broad imaginations of the technological future. As seen from responses to the first three questions, the least accepted term is ‘Robot Vehicles’. Some participants explained in detail that this term arises negative meanings, “robot sounds inhuman. And I want the car to make human driving decisions (not inhuman ones). Even though there are errors.”

Another participant provides an equation: robot = terminator + hackable + dangerous self-driving car = sd + car = sd + familiar object (‘sd’ refers to self-driving), which reflects a deep dystopian root in science fictions. Another participant says, “robot sounds old fashioned for something brand new” in the hope of new terms to come.
These responses reflect common fear of robots taking over in people’s imaginaries - a concern that roots in the “robots enslave humans” dystopian scenarios. Such fear, known as ‘robotophobia’ and ‘cyber-dystopianism’ (Halpern, 2012: 139), centred around the category of ‘bad cyborgs as mutilator’ while neglecting others such as ‘good cyborgs as positive technoscientific progress’, ‘unmarked cyborgs as a neutral analytic tool’ and ‘sign-of-the-times cyborgs as a signifier of post-modernity’ (Dumit and Davis-Floyd, 1998: 1-20). Imaginaries under the category of robotophobia are vividly demonstrated in novels and films, where images of robotic killers (Terminator, 1984) and robots’ revolution humans (I, Robot, 2004) are in the hearts of the audience. Humans’ attitudes toward robots in contrast to robotophobia is the ‘cyborgian desires’, with which, people show ‘enthusiastic about the transformation of cyborgs’ (Hables Gray, 2002: 190). Cyborgian imaginaries represent a desire for faster, stronger physical bodies and even immorality. The term “Robot Vehicles” in this survey is the tipping point for dystopian imaginaries, in which humans suffer from using or being with machines.

Similar to ‘Robot Vehicles’, some participants felt the term ‘Driverless Vehicles’ has a negative connotation of losing human control. “This suggests that something and not someone is in charge of the vehicle; it sounds too much passive and negative (-less). Moreover, it seems to focus only on the vehicle itself without human as an autonomous and rational subject.” Likewise, some participants elucidated that driverless vehicles incite fear and apprehension about how technology has overtaken humans in different fields rather than just providing comfort and convenience to the human race. Another critique was: “Driverless- Something without a driver, makes no sense. The vehicle has a driver, it’s the computer instead of a human driver.”
It was interesting to see that despite an agreement on the imperfection of human driving, people highly appreciate having humans in control (even bad drivers), which fundamentally suggests a lack of trust in machines/technology. As a consequence, terms such as “Robot”, “Driverless”, and “Self-driving” that have no or little ‘human control’ can easily touch people’s nerves. Human control versus robot control is by nature a battle between trust in machines and self-confidence. Scholars have drawn such attention long ago, for instance, Lee and Moray (1992, 1994) studied the operators’ utilization of automation when they have the choice between an automatic and a manual mode. They found that “as experience increases, operators can reach a feeling of dependability and then of predictability” (Hoc, 2000: 838). The increase of trust in machines encourages cooperative futures between machines and humans along with various positive imaginaries. Judging from the participants' responses, such positive imaginaries are still rare. Standing in a time spot of 2020, I wonder if CAV technology will make a difference? Will CAV technology win more trust and strengthen the relationship between humans and robots?

The term ‘Autonomous Vehicles’ received both positive and negative responses. Participants who favoured this term explained that, “The term autonomous vehicle sounds more official (& professional) and way better to describe a self-governing vehicle that can guide itself without human conduction.” However, others suggest that “it is more like a simplified way to describe self-governing vehicles and I don't think the term itself includes all the complexities and meanings behind it.” Other comments address the same concern that "Autonomous" leads to the idea that “the car has the ability to act upon its will or create its own freedom. An example is the Stephen King classic ‘Christine’, and we know how that turned out.”
Two comments, in particular, reflect participants’ acceptance of the term ‘Automated Vehicles’: (a). “Automated to me is a positive technological advance, rather than something taking over such as a robot. We also went from manual to automatic transmission, so this may be the next step: manual to automatic driving” and (b). “I like automated because it’s easy to understand, while driverless sounds a little dangerous.”

In the first comment, the term “autonomous” was associated with a positive future image where machines supporting and collaborating with humans (similar to the IBM AI factory that I described in my imaginaries before). The second comment implies an expectation of a clear and easy-to-understand term that excludes the meaning of ‘vehicles/machines taking over’. Through imaginaries, the future where machines co-work with humans is desired. It leads me to think beyond hope and fear, control and trust in people’s imaginaries and explore the fundamental human-and-machine relationship in the CAV futures. I carried this thought and went through the 33 extra comments for Question 4. Centred around concerns about robots taking over, many participants express that they do not like any of the above terms since the whole concept of intelligent vehicles sounds dangerous, “those vehicles are unsafe. I am not interested in dying by the hands of a machine”. Others hope that intelligent vehicles should be guided by humans rather than themselves, which refers to a repeated willingness to have absolute human power over automation technology. The second participant also expressed his/her confusion about the difference between “automated” and “autonomous”. It was almost a relief to find that the ambiguity among these terms does not only concern me.

Another participant highlights the cybersecurity threat. S/he says, “the idea of a vehicle
driving itself is disturbing. These cars can be hacked by individuals with malicious intentions.” Massive crashes and data invasion might be caused if an intelligent vehicle is hacked. This imagined dystopian scenario, though directly caused by humans, also suggests a concern about the machine flaw that gives space for human manipulation, leading to vicious consequences.

As a complementary method to engage people to share their opinions on terminology and sociotechnical imaginaries of using or being with automated vehicles, the results of this small-scale survey demonstrate people’s familiarity with and preferences for terminology, fear of losing human elements/control, and hope for having them. Beyond, it reveals moral concerns about the human-and-machine relationship in the future with CAV technology.

It was clear that though participants do not have an agreement on terminology, they tend to accept easy, clear, professional-sound terms such as ‘autonomous vehicles’ and ‘self-driving vehicles’. When I ask my former flatmate about the terminology, she laughed, “I can’t be objective anymore. All I hear is you talking about autonomous or automated vehicles all day. So they’re the words I’m ‘forced’ to be familiar with.” Likewise, one of my interviewees said, “I am familiar with the term ‘autonomous vehicles’ as I feel this is the word the UK Government has been advertising. At least, this word shows the most frequently in the press.” It shows that people do not always actively choose a term but simply remember what they see and hear the most. It further implies the importance of knowledge-sharing and public engagement since the more people know about these terms/concepts, the more likely they are willing to use/accept them. Besides, the least accepted term ‘robot vehicle’ shows a negative connotation of machines taking over control, which raises massive concerns among participants.
further suggests that (1) participants prefer to have control over the vehicles no matter how intelligent the vehicles are or will be, and that the (2) human elements of the vehicle (design) are wanted. The imagined dystopian futures are also bound with real challenges such as technological feasibility, cybersecurity, and personal data privacy.

I was intrigued with the human-and-machine relations implied in the participants’ imaginaries. The responses to the survey tend to show a dystopian future where monstrous robotic vehicles destroy human society. But as mentioned, this survey has limitations in terms of time and scale and so is not able to capture all types of human-and-machine imaginaries and future possibilities.

Sketching the history, we would find that images of automata, robots, and intelligent machines have long existed in our imaginations, flourished in writings and films, and eventually became part of our reality. The first science fiction written by Mary Shelley in the 19th century, though infused with elements of the Gothic novel and Romanticism, told a tragic story: Dr Victor Frankenstein created a gigantic and monstrous figure and was murdered by his own creation. The novel inspired scientists to advance intelligent robots, philosophers to think about personhood and humanity, poets to explore love and beauty, and social researchers to discuss relationships between humans and machines. Academic attention was largely drawn to human-computer interaction (HCI) in the mid-20th century due to the rapid growth of information systems but in the 21st century, with more public and private sectors stepping into the field of manufacturing and managing with automation and AI technology, discussions were again centred around autonomous machines/robots. These machines ‘not only process information, but also act on dynamic situations as humans have done in the past, managing stock exchange, industrial plants, aircraft, etc.’ (Hoc, 2000: 833).
In “The ghost factories: histories of automata and artificial life”, historian Jones-Imhotep introduces a ghost factory that appeared in mid-18th century France. The owner Jacques de Vaucanson invented sophisticated automata, including ‘defecating ducks, tambourine- and flute-playing androids’ that fascinate his audiences but the real legacy of Vaucanson, emphasised by Jones-Imhotep, was to ‘popularize a way of talking about machines’. The ghost factory was thus ‘a capsule for the concerns, omissions, and erasures that stalk the history of automata’ (Jones-Imhotep, 2020: 3-4) and it opened up imaginaries of automated possibilities. From a historian’s viewpoint, mechanical romanticism flourished as autonomous machines lifted the curtain on modernity, leading to either utopias or dystopias where humans and machines have new and complex types of relations. And these relations are formed and developed by the socio-cultural richness, far beyond the machines’ initial functions. For instance, they inform “practical and ideological programs of factory owners, slaveholders, and imperialists, underpinning the classism, racism, and sexism” (ibid.: 5). Jones-Imhotep highlights not only the mechanical philosophy triggered by the birth and growth of automation but the socioeconomic and political transformation done by it. Philosophically, the development of intelligent machines encourages thinking on cultures of self and personhood (Voskuhl, 2018). Socio-politically, the first generation of autonomous machines/robots was employed in the industry to replace humans (Hoc, 2000). It raises debates about human labour and rights, which questions industrialization and challenges social organizations and law. Our imaginaries of and through machines, shaped by culture, history, and current socio-political reality is, hence, a mirror that reflects our hope and fear of the future possibilities afforded by machines, on which we project societal values and morality.
Machines with different functional features are invented for different purposes and such differences enable a variety of human-and-machine relationships. Assistant machines typically seen at industrial assembly lines are used to reduce simple, repetitive labour work and enhance cooperation between humans and machines, such as the automata in Vaucanson’s ghost factory. Assistant machines also serve as extended bodies for us to see and experience the world, for example, prosthesis, glass, and VR. The recent technological development further entitles assistant machines with engaging abilities. For example, robotic shopping assistants at smart stores, designed with ‘a cognitive architecture, grounded in machine learning systems’ (Bertacchini et al., 2017: 382) are able to interact with customers and study their shopping behaviours. These robots are often humanoid and can perform social-like interactions such as providing shopping guidance and assisting customers with shopping decision-making. In other words, they could engage humans with a certain level of emotions. Imaginaries of assistant robots/automation often reflect hope for convenience and efficiency as well as fear of massive unemployment due to the replacement of human labour with machines.

Empowered by sensors to detect humans’ physiological states and artificial intelligence to recognise and analyse emotions (Cheok et al., 2019), companion robots are designed and deployed to emotionally satisfy humans. Such robotic advancement unfolds future possibilities such as healthcare, for instance, increased social acceptance for using companion robots for the old (Heerink et al., 2008) was found by scholars. Another example is Jennifer Robertson’s research on robots in Japan. In line with the former Prime Minister Shinzo Abe’s vision for Innovation 25, robots are promoted as a cure for post-war Japan. In his vision:

“Robotics as the industry that would save Japan. According to his utopian vision,
industrial robots would accelerate production; household robots would provide elder care and child care and thereby make married life and motherhood more attractive to women; and robotics spin-off ventures would generate employment and profitable investments and exports. ” (Robertson, 2018: 29)

Companion robots are particularly studied in Japanese families. Under the influence of Shinto (kami-no-michi), a nature religion that originates from Japan, robots are considered as ‘living things’ (ibid.: 15) like all things, facing less social stigma than in Western society. As extended family members, these robots harmoniously live with people and perform labour work that is normally done by Japanese females. Robertson argued that robots in Japan are imagined and designed for a nostalgic future that is dominated by traditional social values. Imaginaries and practices of machines thus imply social and moral values as well as political and economic priorities. It further raises questions about human identity, selfhood, humanity, who we are and who we will be? What values do we hold? How can we use technologies such as AI, automation, and big data to deliver values that we believe in and prioritise?

Apart from assistant/cooperative machines, companion robots, a relationship with intimacy is also imagined between humans and machines. Sex robots, using “a combination of existing artificial intelligence (AI) technology, sensory perception capabilities, synthetic physiological responses, and affective computing” (Gutiu, 2016: 186) for sexual interaction with human users. Since most commercialized sex robots are designed as ‘females’ to fulfill male’s sexual desire, the imaginations about and production of sex robots received many critiques. Gutiu argued that they ‘are an expression of the direction that human intimacy is heading and the role that women will be assumed to have in sexual relationships’ and criticised that sex robots devalue
female personhood and impair values about women’s role in society (ibid.: 188). Richardson (2016) also pointed out that the design and use of sex robots is a reflection of patriarchy and it encourages misbehaviour and violence against women in real society. Moreover, researchers raised moral and legal concerns about sex robots in the shape of children (Strikwerda, 2017), which helps to form regulation in this domain. Intimacy is also desired in the form of pure romance, seeking spiritual connections. In “From Sex Robots to Love Robots: Is Mutual Love with a Robot Possible?”, Nyholm and Frank (2017) demonstrated a desired emotional intimacy with robots to reduce loneliness in modern society and Levy (2016) predicted that human-robot marriages to take place in Massachusetts around the year 2050. Such studies cast light on the possibilities of new types of love in the future.

A car is also a machine/robot that accumulates different types of technological innovations and socio-cultural meanings. The automobile was first invented to replace horses as a more sustainable tool and it was used as an extended body to travel through space. Since mass production, cars have been endowed with more functions and symbolic meanings for exploration and expression that reflect not only the social norms but also class, gender, power, and new forms of human-and-machine relations (see Introduction). For instance, with the accumulation of new technologies such as voice assistant, vehicles can interact with passengers and offer companionship, thus developing some intimacy. Besides, automation and AI technologies are bringing efficiency while also being accused of putting humans out of jobs. It suggests a trend: from ‘machines/robots assist humans’ to ‘humans assisting machines/robots’. In a study of grocery technologies, Anthropologists Mateescu and Elish (2019: 11-12) found that ‘self-service technologies for grocery retail workers shifted customer service roles to hovering human chaperones mediating between customers and machines’. They referred to this meditator, who approaches customers when the self-check machine
fails to work, as the ‘human infrastructure’ because s/he is the ‘integral human component of a socio-technical system’. Such ‘human infrastructure’ is called the ‘safety driver’ in the context of automated vehicles. The ‘safety driver’ monitors the car’s operation and backs up when things go wrong. In other words, during most of the journey, the car is in control and this proportion of power and control of a car will keep growing. This new relation to cars with a dramatic shift of roles excites some and worries the others.

So far, we have studied the public’s terminology preference and the sociotechnical imaginaries that are intertwined with them. Furthermore, we explored the potential future possibilities of how we would use, interact, and be with robots, automation, and machines. The variety enriched an understanding of people’s current perception of CAV technology and hope and fear of the technological future. However, I would like to highlight some limitations in this terminology research: first, as mentioned, due to the limitation of time, research scale (mostly UK-based groups) and resources, this survey only served as a ‘taster’ to learn the public’s imaginaries of CAV technology and it placed much effort on discussing the use of terminology in particular. But it paved the way for my further investigation and discussion in chapter 3 where I demonstrate a wider and deeper picture of the public’s CAV imaginaries.

Second, I did not differentiate ‘car’ with ‘vehicle’, which could lead to discussions about the private use and the public use of CAV technology. It might reveal the participants’ expectations for levels of intimacy or privacy while using and interacting with intelligent vehicles. There were two considerations: I aimed to encourage broad imaginaries of this technology, regardless of functions, designs, or the way to use it. Whether participants picture an automated bus or an automated private car contributes to this
exploration. Also, in the following chapters where I presented in-depth interviews with different social groups, scattered discussions about the use of automated cars, buses, and shared pods.

4. Seeking Authority: the socio-political and technical choices of terminology

Technology and politics can never be separated. As Alpert argued that scientific freedom is “a fundamental value in political society” (Alpert, 1954: 107). Experts’ political choices shape the sociotechnical imaginaries of the technology and the direction of deploying technologies. For example, the sociotechnical imaginaries in the early Cold War were centred around an imagined monster Lysenkoism, “representing all that had gone wrong in the Soviet experiment and serving as a powerful reminder of paths not to take in forging the postwar relationship between science and the state” (Dennis, 2015: 57). Dennis believed that the monstrous Lysenkoism was used to refer to the state’s intervention into scientists’ world and the dominated power over technological development, which directly reflects strong political purposes. This explicates the importance of inclusively studying how politics and socio-political values affect technological development as well as how power is fabricated through technological choices.

The presentation of a technological invention in society, from the initial choice of its terminology use, is shaped by socio-political and technical negotiations and this choice, vice versa, reflects the socio-political, cultural, and economic purposes or intentions. After talking to policymakers, researchers, technicians, and industry stakeholders in this field, I realised that the CAV terminology is still not unified among these planners/insiders. Although many of them tend to use the term ‘automated vehicle’ with
a shared technical understanding, different or mixed uses of other terms are applied in various contexts. The inconsistency of terminology use is confusing but in some of the planners’ justification, industrial collaboration and public engagement form different expectations and leaving some flexibility could contribute to meeting those expectations in different contexts. Besides, it takes time to reach common ground, before which, other term(s) might have been used by authority and thus caused wrong impressions.

Below I present two exhibits: the first one is a brief bio of the planners I interviewed for this part of the research, the second one demonstrates a summary of their terminology preferences in a table. Followed by the extracted interviews and my analyses.

Exhibit 1: Bio of the planners (in chronological order of interviews)

**Professor Nick Reed**, Founder at Reed Mobility[^37], is an independent consultant in future mobility. With his expertise in psychology and human factors and over fifteen years’ research experience in transport, Nick serves as an expert on a panel convened by the European Commission to determine the best approach for CAV ethics. He has worked on CAV projects such as the GATEway[^38].

**Dr Mike Short** is the Chief Scientific Advisor, Department for International Trade (DIT), UK Government. He has had 40 years in telecommunications and electronics. In this post, Mike managed the launch of 2G (GSM) and 3G mobile technologies in the UK, and led research and development for Telefonica Europe. Since 2017, he has been advising the department on the technical aspects of future trade.

[^37]: Reed Mobility is a consultancy that works on safety, technology, and joy in transportation. [https://www.reed-mobility.co.uk/](https://www.reed-mobility.co.uk/)

[^38]: GATEway (Greenwich Automated Transport Environment) project saw a fleet of driverless pods providing a shuttle service around the Greenwich Peninsula to understand public acceptance of, and attitudes towards, driverless vehicles. [https://gateway-project.org.uk/](https://gateway-project.org.uk/)
Dr Alan Peters, a systems engineer and Principal Technologist at Connect Places Catapult\(^ {39}\) (CPC), specialises in the design and assurance of complex and novel systems particularly autonomous vehicles. He has worked on CAV projects such as the LUTZ Pathfinder Automated vehicle project\(^ {40}\), the Flourish project\(^ {41}\), and the automated Heathrow Personal Rapid Transit (PRT) system\(^ {42}\).

Lucy Yu, Head of Public Policy at FiveAI\(^ {43}\), specialises in combining start-up business with technology policy and regulation. Prior to FiveAI, she held roles as Head of MaaS at the Centre for Connected and Autonomous Vehicles (CCAV) and the Department for Transport (DfT) and spent nearly fifteen years building internationally renowned tech companies and establishing technology policy teams in the government. (Though she used to work for the government, when I interviewed her, she was Head of Public Policy at FiveAI and thus her view drew from my interview came from the standpoint of an industry stakeholder.)

Jaime Hodsdon, the Ethics & Accessibility Policy Advisor for the Centre for Connected and Autonomous Vehicles (CCAV), has backgrounds in psychology, education, and International Relations and Politics. He looks at the ethical aspects of automated vehicles and works on public engagement.

Tom Webster, Principal Technologist at Connected Places Catapult with rich experience in Transport engineering and specialises in AV virtual testing, driving code of conduct standards, and cybersecurity. He used to work at the Centre of Excellence for Testing & Research of AVs, developing the regulatory and support processes for the safe and effective deployment of self-driving vehicles in Singapore.

\(^{39}\) Connected Places Catapult is a new non-profit organization that combines the Transport Systems and Future Cities Catapults. It aims to grow businesses with innovations in mobility services. [https://cp.catapult.org.uk/](https://cp.catapult.org.uk/)

\(^{40}\) A self-driving pod project tested in Milton Keynes, using Oxford-developed autonomy software. [https://ori.ox.ac.uk/projects/lutz-self-driving-pods/](https://ori.ox.ac.uk/projects/lutz-self-driving-pods/)

\(^{41}\) A multi-sector collaboration that helped to advance the successful implementation of connected and autonomous vehicles in the UK. [http://www.flourishmobility.com/](http://www.flourishmobility.com/)

\(^{42}\) A driverless personal transport at Terminal 5, Heathrow Airport. [http://www.bristol.ac.uk/research/impact/heathrow-personal-rapid-transport/](http://www.bristol.ac.uk/research/impact/heathrow-personal-rapid-transport/)

\(^{43}\) FiveAI is a UK tech firm that builds self-driving software and development platforms to help autonomy programs solve the industry's greatest challenges. [https://five.ai/](https://five.ai/)
Exhibit 2: Terminology preference

<table>
<thead>
<tr>
<th>Name</th>
<th>Sector</th>
<th>Role</th>
<th>Terminology preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nick</td>
<td>R&amp;D</td>
<td>Researcher/Consultant</td>
<td>‘Automated’</td>
</tr>
<tr>
<td>Mike</td>
<td>Gov.</td>
<td>Policy Advisor</td>
<td>Mixed; highlight ‘connectivity’ in ‘CAV’</td>
</tr>
<tr>
<td>Alan</td>
<td>Industry</td>
<td>Technician</td>
<td>‘Automated’</td>
</tr>
<tr>
<td>Lucy</td>
<td>Industry</td>
<td>Policy Advisor</td>
<td>Mixed; ‘self-driving’ used more often</td>
</tr>
<tr>
<td>Tom</td>
<td>Industry</td>
<td>Technician</td>
<td>‘Automated’</td>
</tr>
</tbody>
</table>

Why did they choose what they chose? How did their socio-political, economic, or technical values/purposes affect their term selection? And how will their opinions and use of terminology impact on shaping the technology’s socio-political value? Having these questions in mind, I went through the interview transcripts.

When I met Professor Nick Reed in early 2020, he was supporting some R&D agencies to build an ‘autonomous driving’ glossary. He felt it essential to clarify the currently mixed-used terms so that people in- and outside the field can know this technology better. In his viewpoint, ‘automated vehicle’ accurately defines this technology.

“I think it primarily is related to the SAE’s definition and they prefer automated to autonomous to driverless or self-driving. There are many levels of automation so you need to be careful in how you describe the technology you’re referring to when discussing these technologies. And I think this one is simpler and more straightforward to stick to.”
“The glossary I’ve been working on,” He said and showed me an Excel on his phone, “now we have version 1.0 with 60 relevant terms. That’s it and it will be published any minute. (Nick refers to the BSI publications v1.0 & v2.0, 2020. See the reference.)”

Since the interview with Nick, I have been following the publications of CAV terminology. Until the write-up of my research, the BSI Group has published two versions. Both define technical concepts such as “Automation”, “ADAS”, and “Machine Learning”, with a small expansion in the second version. In the R&D area, there were no hard standards at that time but efforts in setting one. To confirm ‘automated vehicle’ as the tech term, I talked to the CAV technologist Tom Webster. Based on the SAE\textsuperscript{44} definition (J3016), he interpreted the technicians’ selection in a simple fashion.

“The industry generally adopts the terminology defined in SAE. This, essentially, defines referral to levels of ‘automation’ and this is what most people do in technical documents, although ‘Autonomous’ is often still used in a casual context.

“SAE don’t like using the term autonomous for vehicles as it can lead to confusion/give the wrong impression, for higher levels of automation the vehicles generally employing a level of intelligence for object perception etc., but don’t have complete independence/freedom/self-governance which the term ‘autonomy’ indicates.

\textsuperscript{44} SAE refers to the Society of Automotive Engineers. Founded in 1905, it is a professional association for engineering.
Something else SAE does is say that the automated driving system (ADS), rather than the whole vehicle should be made the subject of automation – i.e. the dynamic driving task is performed by the ADS and not the vehicle as a whole.

“The self-driving/driverless terms are used when talking about the technology generally, although ‘driverless’ is used by SAE quite a bit, I personally hate this term as it makes it sound like the vehicle is out of control. I think it is reasonable that consider that a human or automated system can fulfil the role of ‘driver’ but it remains to be seen how this ends up being defined in regulations.”

But not everyone follows the technical definition. Within the UK Government, emphases vary from one department to another regarding the selection and the use of CAV terminology. For instance, ‘autonomous vehicle’ and ‘automated vehicle’ are often seen and heard from reports or event announcements in Department for Transport (DfT) but ‘self-driving’ appears more popular in Department for International Trade (DIT). Above all, Dr Mike Short from DIT, emphasised the concept of “connectivity” rather than “automation”. He suggested that when we discuss CAV, the “C” is always missing or less appreciated while the “AV” catches major attention. The “C”-connectivity technology is believed by Mike to be the substantial technique for now and for the following few years. We will hear his explanation about this later. Regarding the use of “AV”-focused terms, he suggested a flexible use and a potential mix according to the contexts.

“With the public, I prefer the term ‘connected cars’. For trade reasons or research reasons, I prefer CAV. Some of the reasons I make the difference is because for the public, CAV is not well understood. But actually, when you bring in connected cars, it’s
better understood and you can start to say, well, what are the connections today and what might be the connections in the future. The use of CAV started as very much a trade research debate rather than a consumer debate. So CAV as an abbreviation for connected and autonomous vehicles was an easy one for the government to adopt for trade and research discussions. What I observe is that there’s much more attention on the automation of vehicles, or the robotic aspects, and less attention at the moment on the connectivity aspects.”

Mike’s flexible use of these terms implies a political-economic driven. When experts approach the public, they adopt easy-to-understand and sound-familiar terms, which lead to positive imaginaries and perception, and further increase public trust and acceptance. While the abbreviation “CAV” is preferred among colleagues, partners, and competitors for trade reasons. The use of abbreviation thus seems professional and authoritative, which was agreed by Dr Alan Peters. From his technician’s perspective, the full expression of ‘AV’ is ‘automated vehicle’.

“Because it (automated) is not implying that the vehicle is sort of making its own views, rather, it is responding to some human inputs.”

But Alan is not always strict with the use of this term:

“Two years ago it was a real mix of people using different terms, but now I think you can almost get the level of expertise by whether they use driverless cars, perhaps, it is because they are trying to talk to the public, or they use autonomous, somewhere in the middle, but we have a technical problem with that. Using automated is a sign that they are familiar with the literature, that’s my view anyway. Or they stick to the
Abbreviation ‘CAV’. I do use all of the terms, depending on whom I talk to.”

Apart from Mike and Alan, the flexibility of mixing terms is also appreciated by Lucy Yu. “Driverless” is what she tries to avoid because she feels it triggers negative imaginaries among the public, instead, “self-driving” is often used by her and her colleagues at FiveAI.

“I generally prefer not to use driverless. I sometimes do when talking to the public, but that’s partly because I think the public maybe understand driverless a bit better than autonomous or automated. But one of the reasons I don’t like driverless is, I think it implies there’s no driver at all. I think even if the computer is driving the vehicle, the vehicle is still under the control of something whereas driverless to me implies completely out of control.

“Self-driving is a term that we use quite a bit in FiveAI, because I think it avoids some of the blur areas between automated and autonomous. Some people would argue that automated is like lower levels of automation. Things like driver assistance, whereas autonomous is like the higher levels but not everybody recognizes or makes that distinction. Different people think about it in different ways. If you use self-driving, you don’t necessarily get bogged down into that terminology discussion.”

Despite using ‘self-driving’ in FiveAI, Lucy suggested “automated” to be adopted from a legal perspective and that a legal approach can grant some authoritativeness to the CAV terminology. She mentioned a legal instrument- the Automated and Electric Vehicles Act (2018), in which ‘automated’ is adopted. As an initial piece of legislation
in the UK, it implies using ‘automated’ to define this technology through the legal process. Whereas the UK governmental department CCAV itself is ‘the Centre for Connected and Autonomous Vehicle’. The inconsistency of the terminology use cannot be further explicated.

I brought this question to Jaime Hodsdon in the CCAV. Jaime shared a bit of history that when CCAV was founded, people were not particularly having this terminology conversation. They used the term ‘autonomous’ and it stuck as the historical name.

“CCAV refers to the Centre for Connected Autonomous Vehicles. However, the name was chosen (in 2015) before many in the government realise that ‘automated’ is, in fact, more precise as a tech term according to the SAE definition. It took time to form that understanding. Now we tend to use ‘automated’ in the department (in 2019).”

I asked him, “Now that they formed this understanding of CAV terminology, why didn’t the department change “Autonomous” to “Automated” instead?” Jamie shook his head and laughed, “It’s too expensive to change it.”

Hence, we can conclude that before 2018, the term ‘autonomous vehicle’ was accidentally picked and used in the name of a governmental department. However, the choice of sticking to it until that interview in 2020 (and to the date of this write-up in early 2021) was a political one, irrelevant to their technical knowledge. As Jaime suggested, changing the name of a governmental department is effort- and money-consuming, therefore, they chose the status quo over changes. I am not in a position to criticise this decision but I do feel that to keep in line with the UK law, the CCAV
needs to correct its name. Also, the longer it is left unsolved, the more expensive it would be, financially and administratively.

5. Thoughts of the Terminology Investigation

Driven by the curiosity about the CAV terminology use, I studied the public’s opinions on terms, including ‘automated vehicle’, ‘autonomous vehicle’, ‘driverless vehicle’, ‘self-driving vehicle’, and ‘robot vehicle’ and explicated their sociotechnical imaginaries of the CAV technology triggered by them. I consciously selected ‘sociotechnical imaginaries’ as the research lens for it suggests people’s perception and trust of technology (Jasanoff, 2014). Firstly, I found that different preferences and uses of these terms show the public’s unfamiliarity with this technology, yet, the common ground of wanting human control and human elements reflects a lack of trust and low acceptance of robots/automation and machines in general. This finding of the commonly wanted features of CAV resonates Jasanoff’s argument for the ‘collectively imagined forms of social life’ (Jasanoff and Kim, 2009:119). Notwithstanding that the unification of the terminology use was not found among the public, it left space for the future-oriented imagination that unfolds rich possibilities of using and being with CAV, and opened up broad discussions about the human-and-machine/robot relationships in the future. This part of the investigation eased my nerves of having this terminology puzzle in my head for a long time. No longer obsessed with finding “the correct expression”, I developed an interest in learning more about people’s imaginaries of this technology and the socio-cultural, political meanings and moral values that reside in them.

Secondly, the mixed uses of these terms also appeared among the planners, which
suggested both flexibility and inconsistency. Some planners chose to mix these terms on purpose so that they can clarify this technology to different groups of people on different occasions. It says that the socio-political, economic and technical factors together shape the process of the social integration of a technological invention into society, from the initial terminology selection to its final political presentation. I agree that, the mixed-use of these terms, as a transition, is a good way to bring this new technological concept to the public, considering the diverse levels of understanding, expectation, and acceptance. Whereas inconsistency of the use of CAV terminology within the government and the industry concerns me. This inconsistency has different causes and it is important to differentiate them: for one, it requires time for anyone, including planners to form a clear and shared understanding of a new technology. As a consequence, the beginning of a technological introduction can be accompanied by misunderstandings, misuses, and mistakes. This is largely associated with a natural process of growing technical knowledge and perspectives. But the inconsistent use of tech terms can also be a political or economic choice and such thoughts led me to explore power distribution and tension between different ‘planners’ later in my thesis.

Finally, the different terms used by the public and the planners showed a knowledge gap in this field and it inspired my further questions of ‘how will this knowledge gap be filled- though technology displays, performative learning activities, or other forms?’ ‘Among planners, who will mainly guide such activities to educate the public, is it the policymaker, the technician, or the industry stakeholder?’ and ‘to what extent does the public need to learn about CAV to develop trust?’ These questions contributed to angle-framing and idea-framing for the following research, even though the rest of my thesis may not be able to answer them, as part of the outcome of my technography, they have been helping peel off the socio-political layers of a technological system.
The terminological investigation encouraged me to further explore the public’s perceptions, imagination, and expectations as well as the planners’ vision and planning of the CAV technology. In addition, it suggested possibilities of diving into fundamental questions about the human-and-machine/technology relationship in the future. In the following two chapters, I respectively discuss my findings with the public and the planners.
Chapter 3 CAV Visions: the top-down planning

Looking at self-driving technology from a political angle, STS scholar Stilgoe (2019: 28) questions ‘who’s driving (tech innovation)? Where are we heading to? Who decides and who benefits?’ He suggests that technologies and governments both have a profound long-term influence on people’s lives and so people should have the right to ask such questions. He also points out the fact that technologies are often ‘done to them rather than by them or for them’ (ibid.: 17). It implies a gap between what people want and what are planned for them (by policymakers or authorities) due to the different perceptions and purposes held by the public and the planners. Different priorities and allocations of resources are thus shown through actions, for example, that the U.S., as the world’s richest country, was ‘able to put a man on the moon but unable to solve the problems of its poorest citizens’ (Nelson, 1977 in Stilgoe, 2019: 28). Through my engagement with the planners and the public, I noticed their different focuses in terms of how to use CAV technology and which aspects to prioritise. That said, the phenomenon-based, inductive anthropological approach empowers me with critical eyes to see the differences between what is extracted from the rich reality of our everyday life and what is planned at a macro level.

In Chapter 3 and Chapter 4, I respectively present views from the planners and the public where I signal these differences in detail: the top-down planning was driven by potential prospects that can add values to safety, the environment, and the economy while the bottom-up imaginaries emphasise risks and problems brought by this technology. In other words, despite that the planners recognising challenges and the public foreseeing benefits, the planners tend to focus more on its prospects whereas the public concerns more about emerging technical risks of data invasion and
cybersecurity and questions about how CAVs may (or may not) address some long-existent issues in their everyday life such as unequal distributions of transport services and gender bias in vehicle design.

In Chapter 3, my interviews with the planners from the UK Government, the CAV-leading firms, and academia suggest that, first, when sharing visions, their top-down thinking emphasises the potential prospects for safety, the environment, and the economy. Challenges and risks such as the technological uncertainty, insufficient investment in this ‘tens of billions problem’, as claimed by both Lucy and Alan, the lack of political transparency in the CAV demonstration and deployment, and the low public trust are briefly mentioned. Second, the planners’ visions of the CAV deployment are also associated with the application of electrification and shared mobility, which as a vague assumption of the SEAV (shared electric and automated vehicle), is widely used at a high level. It turns out that integrating these trends into society as a holistic innovation is difficult due to both technical and social barriers. Therefore, some of the prospect-driven assumptions require more research, planning, and management to be transitioned into reality. Last, I encourage the planners to adopt the user’s perspective and think about how they want to use it in their lives. When relating to their everyday commuting stories, the planners’ considerations and expectations vary from the previous visions and plans. It shed light on a gap between the top-down thinking and the bottom-up imaginaries of CAV technology and thus paves the way for Chapter 4.

1. The Prospect-Driven Preferred Future

Whereas imagination unfolds possibilities, visions are driven by the positive likelihood and point out the preferable future directions. Although not representing all planners’
mindset, a method introduced by Stuart Candy to explore the relationships between 
the domains of futures, design, and politics echoes the dialogue of CAV planning at 
the 2nd Smart Transport Conference and some thoughts from my interviewees, which 
 Covers ‘a range of interventions and media from immersive performance to stand-alone 
“artifacts from the future”’ (2010: 4) and explicated the concept of ‘possible, probable 
and preferable’ futures.

In Candy’s hyperspace of possibilities, these concepts are intertwined with each other 
yet distinguishable. ‘Possible’ leads to an exploratory question of ‘what could happen?’; 
‘probable’ refers to a way to predict ‘what will happen?’ and ‘preferable’ implies a use 
of a normative strategy to answer ‘what can a specific target be achieved?’.

---

45 The 2nd Smart Transport Conference was held at Birmingham on 18 September 2019. 
https://www.wmca.org.uk/events/#/event/smart-transport-conference/
suggested that this dimensional method can narrow the trio of these three concepts down to two (ibid.: 32-35):

“One for all kinds of preferable, ranging from the fantasy ‘utopian’ ideal to the dystopian nightmare -- an axis of desire; and the other for likelihood -- an axis of fate, so to speak -- spanning from impossible at one end (probability of zero) to inevitable at the other (probability of one). This incorporates not only ‘possible’ and ‘impossible’, but also all degrees of ‘probable’ and ‘plausible’. This potential for a more nuanced, ‘greyscale’ map of possibility space remains to be explored on another occasion.”

The method was developed with an additional concept of ‘plausibility’ implicit in the zones of “possibility” and “probability” (Dunne and Raby, 2013). The preferable futures lie in the space between probable and plausible. It means to realize the preferable from all possibilities, a reduction under the guidance of vision must be performed with planning and practice, and flexibility should be adopted in facing uncertainty.

I briefly mention this method because some of the CAV envisioning and planning process looks similar: the planners talk about what is likely to happen (map out possibilities or plausibilities), highlight the prospects and challenges they foresee, and suggest what is preferred and actionable.

Most of the planners acknowledge challenges such as the low public acceptance. Nevertheless, they tend to focus on the prospects of the CAV technology that can lead us to the preferred future where a higher level of safety on roads is reached, the economy is boosted, mobility is improved, and pollution and congestion are reduced.
Some of them also believe that the combined technological application— the shared electric and automated vehicle (SEAV) is a great opportunity for less congestion and zero-emission. Besides, in a short-term, some plan to operate CAVs in limited Operational Design Domains\(^{46}\) (ODD) at a small scale. In the following section, I fully demonstrate these recognised prospects and challenges from the viewpoints of policymakers, industry stakeholders, technicians, and researchers.

2. Dialogue with the CAV Planners

In this section, I bridge the planners’ views on the prospects and challenges of CAV. While presenting both sides, I demonstrate the planners’ tendency to highlight and focus on the prospects and interpret their views on public good and assumptions of how CAV technology will walk hand in hand with electrification and shared mobility. In so doing, we will see how the top-down vision and planning amplify prospects at a high level and underestimate some of the barriers.

2.1 The Prospects and Challenges of CAV

A few years ago, Business Secretary **Greg Clark**, Future of Mobility Minister **Jesse Norman**, and Meridian CEO **Daniel Ruiz** expressed the UK government’s ambition to lead CAV’s development and use and the target of having autonomous vehicles on UK roads by 2021. CAV deployment is prioritised by them to revolutionise travel in the UK, bring big economic opportunities in the long term, and consolidate the UK’s leadership in this field (Department for Business, Energy & Industrial Strategy and The Rt Hon

\(^{46}\) ODD refers to “operating conditions under which a given driving automation system or feature thereof is specifically designed to function, including, but not limited to, environmental, geographical, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics.” (SAE, 2018: 14)
Greg Clark MP, 2018).

“It will open up and improve transport services for those who struggle to access both private and public transport.” Said Greg, highlighting its potential to improve mobility and accessibility. “The UK is building on its automotive heritage and strengths to develop the new vehicles and technologies and from 2021 the public will get to experience the future for themselves.”

Forecasting a £52 billion UK market for CAVs by 2035, Jesse emphasised this transport innovation’s prospects of safe travel and economic boost. “This pioneering technology will bring significant benefits to people right across the country, improving mobility and safety, and driving growth across the UK.”

Daniel believed that having the talent, the tool, and strong government support will consolidate the UK’s leading position in this transport revolution. “The (CAV) business decisions are an endorsement of our capabilities in this globally competitive sector.”

Since then, big players in the UK have been putting more effort into developing CAVs to realise the British ambition for technology innovation and the economy. I was fortunate to meet many leading experts, especially that most of my interviews were conducted face-to-face before the 2020 Covid-19 pandemic. Most of my interviewees agree that the biggest advantage of CAV is a higher level of road safety. Realising this “cliché”, I started asking them, what other advantages can CAV bring to society and individuals? And I am persistent in asking about CAVs’ downsides and the challenges the industry is facing.
Dr Mike Short, Chief Scientific Advisor at DIT, said, “Beyond safety, it’s going to help reduce congestion with more shared vehicles and help with the adoption of cleaner fuel cars, electric vehicles for example. It will also help with the better identification of parking slots and real-time information to the vehicle, speaking of which, I think the connected services that come with this are very important.”

Mike mentioned CAV’s benefits for the environment and traffic operation, in fact, what he means was not CAV but connected, electric, shared automated vehicles. Here is a common understanding among the planners that the automation technology alone will not lead to the envisioned future mobility, but only combined with other technologies and traffic planning such as electrification and shared mobility. However, there is also an assumption that these things will easily and naturally come together and thus SEAV-shared, electric, and automated vehicles, as a concept becomes popular in the field. I will highlight and discuss the repetition of this assumption along with the underestimation of barriers to achieve SEAV in detail in the following parts of this chapter.

What Mike truly emphasised here is connectivity. He believes that if vehicles are highly connected, there is a potential to provide very kind of demand-responsive and shared services that use the road space efficiently. He also implies a view that currently, highly automated vehicles are (technically) hard to build while better connections are achievable. Once a vehicle is connected to infrastructures such as traffic lights or remote-control centres, safety can be improved. If it is connected to personal devices, it also improves convenience for people to access updated information on insurance or road traffic. That said, Mike suggests connected cars bringing safety and
convenience as public good.

Mike: “I think the biggest disadvantage with CAV is the benefits are not well understood. Trust still needs to be built in this area. We're not expecting full CAV on the road for a few years yet, because the trust needs to be built up with the public within the trade, and also within the regulatory or political committees.”

Me: “Who should address such trust issue?”

Mike: “I believe the government has a role, and some of the trials and testbeds are about helping to build up understanding and, therefore, trust in this area. But I also think the car companies have got some responsibilities in this area, and their representatives such as trade associations. I also think that some city authorities have leadership responsibility in this area because we would see large scale deployment. If cities adopt a smart transport policy within a smart city.”

Me: “Do you mean cities like London?”

Mike: “London will be one of the last cities to actually deploy everywhere, but I can see smaller towns and cities like Milton Keynes, adopting it. Driverless cars tend to be more robotic so would work in a grid type structure, Milton Keynes is more of a grid road structure. Cities like Edinburgh and London are very old and very complicated, so we need to see what is fit for purpose in each city.”
Mike foresees small-scale operations in some UK cities very soon whilst it takes time to scale up. In Mike’s vision, CAVs need to be designed in different types and deployed in different ways according to the operational environments. One example would be Tesla, the big-sized American car: its autopilot (semi-automated) mode works well on wide U.S. roads and newly-built highways in general, but it does not function well on some narrow UK roads where infrastructures lack updates (Chapter 7).

Another interesting point is the potential trust issue mentioned by Mike. His approach to addressing the public perception and trust issue is encouraging different UK governmental departments and test bodies to closely work together and fully demonstrate the capability. It sounds abstract but inspires me to think about the political factors in the CAV social rollout. Following up on his thought about local authorities having leadership responsibility in this area, I noticed that Mike implied the importance of transport departments working together with DIT. Although DIT is not a leading department of transport matters, it has an interest and shared responsibilities in the CAV area. Mike suggested that DIT supports CAV innovation based on international collaboration and they expect to see exports. “UK could be an exporter of, perhaps, software or ITS solutions in this area. We also want to attract inward investment in this area so the UK can be a leader in driverless cars and cars of the future.” That said, another potential prospect that interests him and forms his positive attitude is CAV’s contribution to international trade businesses.

Similar to Dr Mike Short who concerns public trust, Professor Nick Reed, Founder of Reed Mobility, pointed out the issue with the public’s perception of technology.
Nick: “The biggest non-technical challenge is the perception, the public’s perception of technology. There is a risk that media outlets misrepresent the benefits of automated vehicles. But I also think it’s really important that the manufacturers go to enormous lengths to show the safety benefits they have so that when the question arises, they have to show ‘this is why we have implemented this system. These are the safety benefits that can address the tragic collisions in the future.”

The media has been misleading people with automated crash news and various dystopian scenarios, according to Nick.

Me: “Correct me if I am wrong, does it mean that the public doesn’t place trust in CAVs due to a lack of proper education or public engagement, such as demos? And do you think it’s the manufacturers’ job to fix it?”

Nick: “Yeah, I think it is. At the end of the day, they are commercial organisations looking to sell these technologies. Securing public trust is an important part of them being able to sell these technologies. They have a role in giving the public confidence. I also think there’s a role for the public sector. If the belief is that these vehicles can help improve the prosperity of the public or businesses that use these vehicles, in which case, the government might want to support the development of these technologies.” He continued with another concern, “though CAVs can play a role in addressing social issues, I’m nervous it might not. As it won’t be the top priority of the organizations that are developing the technology.”

He suggested that the social issues CAVs might address include congestion, pollution,
and accessibility/mobility for the disabled. What is not explicated but implied is the organizations’ top priority of commercialization. As mentioned before, the potential benefits for the UK economy and tech innovation drive the planners and the industry. Nick was worried that the above social benefits may not be as attractive as the economic one as thus be neglected by the planners and the industry.

Nick told me that there are positive signs such as the nine principles in “Future Mobility Urban Strategy” (Department for Transport, 2019) that include benefits should be available to all segments of society. The subtext is that it should be the technologies to help solve challenges of improving the inclusive transport system, suggesting the government’s awareness of it. Nick expressed that the reason for him critically pointing out some of the issues is, in fact, his strong wish for making it work in society and that he believed the advantages outweigh the disadvantages.

**Lucy Yu**, Head of Policy at FiveAI, shared her views on CAVs’ advantages, disadvantages, and challenges as an industry stakeholder. Like Business Secretary Greg Clark, Lucy also mentioned CAVs’ potential to improve mobility and accessibility for more people, especially for those who cannot drive for whatever reasons. Moreover, she considered CAV as an opportunity to effectively accelerate the electrification of transport and explained it from a business perspective.

*Lucy: “Lots of governments have made commitments around certain dates in the future, from which it will no longer be possible to sell new internal combustion engines on the market and so that’s a switch to electrification. For automated vehicles, there is the potential to get there faster and that’s particularly true if we start to see models of AVs*
in the market where they are a mobility as a service model. So, if you think about people owning their own individual vehicles, the rate at which they upgrade or change their vehicle for new ones is typically slower than the rate at which somebody who’s operating a fleet of vehicles as a kind of transport service would upgrade those vehicles. To make bigger impacts in the market and the whole system more quickly, you will target the fleet of operators rather than private individuals with their own vehicles. If they can persuade people to use AV services rather than buy their own vehicles, the level of a fleet of services electrified can be greater and more quickly. So there’re opportunities around clean air and less congestion.”

Lucy and Mike both mentioned the potential for CAVs to walk hand in hand with electric vehicles (EVs) and shared mobility. AVs, EVs, and shred mobility services are considered as three revolutions towards better mobility (Sperling, 2018) and the use of shared, electric, and automated vehicles is introduced as SEAV (I briefly mentioned this concept before). Lucy and Mike are not the only ones who hold this SEAV assumption, but I use their representative examples to show a common high-level principle: automated vehicles should be combined with EV technology and adopt the shared mobility operation model. It is not very clear to me how these three elements will walk together and if they will work well as a holistic tech innovation in society? My interviewees from the planners’ group suggested that this concept/tech is at an early stage, and they were not sure about what will happen. Therefore, they could not give me much explanation of HOW SEAV will work. However, not knowing how it will work did not stop them from assuming the use and success of SEAV. Having noticed this vague yet repetitive assumption, in the next section (2.2), I further explored the trends of electrification and shared mobility as well as how they might contribute to CAV deployment.
FiveAI develops the automated driving system, which are complex systems with a lot of sub-components. Lucy says they also focus on developing tooling to support their own system and help other people develop their systems. There are specific components that are common to all developers, for instance, every developer has something that would look like perception component, which is like, how the power of the driving system perceives the world around. FiveAI has some tooling which just focuses on perception and helps developers assess the performance of their perception system, understand where some of the limitations are, and understand where more work needs to be done.

Me: “What is the biggest challenge in this field or that FiveAI is facing?”

Lucy: “It’s difficult to look into the future.” Lucy replied, “Obviously there are lots of different futures you can imagine. I think it probably is important to at least look at the wider context as some of the policies of conversations that are already taking place. So I talked earlier about carbonization and it is not happening in a vacuum. Around 20 cities in the UK will follow in the next year or two, who have committed to basically becoming net-zero by whatever year. Because transport is such a big contributor to carbon emissions, there has to be some thought about how do we address this.”

“In terms of the challenge we are facing, well, funding is a bit of a challenge in the industry. Generally, it is a challenge for UK SMEs (Small and medium-sized enterprises) altogether. The landscape for fundraising in the UK is improving, but it’s still tougher than the equivalent landscapes in the US and China, where overall venture capital
markets are much larger.”

I asked Lucy how much funding is expected. She said to punch all the way through, the quantum of capital we need to put into this industry is SIGNIFICANT.

Lucy: “You can look at companies like Waymo as a yardstick. We recommend probably put about 10 billion US dollars roughly. At the moment, they’re putting about one to two per year, so obviously they are pumping cash into self-driving projects. Even so and even though they have advanced systems, they are in the early stage. And they need to put many more billions.”

According to Lucy, this is a cash-burning business that only deep pockets can sustain. She expects to see some shakeout and some consolidation. Some of the small companies in this space will cease to exist altogether in the next few years. The prize and the reward are huge, so is the cost.

Hence, she thinks over the next five years we will start to see some limited Operational Design Domains (ODD). For instance, we will see some systems operating in a small part of a city or campus of universities, and/or some commercial systems operating (probably 100 vehicles) in the next five years, without anything scaled on the roads in that time. These possibilities of operating CAVs in ODDs are due to the limitation of technological feasibility but they are likely to improve safety, convenience, and accessibility on a small scale. A longer term is hard to call because the more people spend money on it, the more they realise they underestimate it how much it needs. Also, investments do not always guarantee improvements or success because of the
technological uncertainty.

Lucy: “If you take FiveAI as an example, they are making a pivot of their strategies—
they are going to be a providing test service rather than doing AVs now. Although they
have spent tens of millions of pounds, and they’ve got more. That’s just not enough to
really tackle the tech problem, which is also called a ‘tens of billions problem’.”

After hearing the challenges of building the public trust of the CAV technology and
developing the CAV business, I was keen to understand the technical challenges the
CAV field is facing. Hence, I asked Dr Alan Peters, Principal Technologist at Connect
Places Catapult, about challenges both in the technical and social dimensions. He
thinks the biggest challenge now is that no one has a clear view of how to prove the
vehicles are safe to do what we think they are going to do.

Alan: “Currently vehicles have a type of approval process, you can agree a set of
principles on the vehicle, and it doesn’t matter where do you set it, France or Holland,
you can drive it in the UK. The approval process is quite simple- it’s based on simple
deterministic tests you can write on a paper. But if you try to represent an AI system
embedded in a complicated machine and a complicated environment, you can’t really
write down the requirements for that type of systems. Then you can’t test against it in
approval way and this is why people are starting to look at the role of simulation as a
way to prove the performance of your vehicle. But all that is still immature. So, we can
get to a point where vehicles look like they are driving safely, and perhaps they’re
driving safely. Proving scientifically that they are safe and safer than a human driver is
a challenge.”
How to prove the vehicles are safe? If that is the current issue, I want to step back and ask, “How safe is safe (enough)?” Further, we can ask it in a political way- “Who decides how safe is safe enough for all of us? Who sets the standard? Technicians, car manufacturers, or policymakers?” Having these important questions in mind, I particularly explored the aspects of ‘safety’ and ‘ethics’ with the planners and the public. I critically present and analyse them in Chapter 5 and Chapter 6 respectively.

In 2018, FiveAI published a blog titled “Autonomous vehicles: how safe is safe enough?”47. It, however, does not address the political question I posed above. This blog indeed provides some background about the technology and it suggests that this technology has the potential to be far safer than human drivers as AVs “are just twice as safe as human drivers would lower collision rates to as little as 200 per billion driven miles” (Tong, 2018). It also says that Level 5 is the goal and currently we are approaching Level 4 and the human input is still required. It implies a human fault in the recent autonomous driving crashes that some drivers “quickly place too much faith in the car’s ability to handle any scenario and start checking email or watching movies” (ibid.). Technically, it seems unlikely to reach the safety level (Level 5) that has been promised by many governments and the industry. When they tell the public that AVs bring safety, few of them explicate the imperfectness of this technology and the requirement of human attention to road situations being in those vehicles, so how can we put blame on the “careless” human drivers? Should the public/the humans always play the role of scapegoats when the imperfect AVs collide? And realistically, considering the difficulties in developing and testing the vehicles and the challenge of

maintaining the cash-burning business, when can we, or can we ever have Level 5 AVs where people in the vehicle can check emails and mobile phones and still be truly safe? Again, what is the standard of safe? What is the safe level that CAVs can bring to us in different stages? I will investigate aspects centred around the CAV safety from both a technical perspective and a socio-political one in Chapter 5.

Tests on CAV safety have been undertaken in the UK. However, researchers (Kalra and Paddock, 2016) pointed out that testing the vision-based control systems of autonomous vehicles is a complicated task (Abdessalem et al., 2016; Abdessalem et al., 2018; Behere and Törngren, 2016) and the challenges as autonomous vehicles need to be driven ‘hundreds of millions of miles and sometimes hundreds of billions of miles to demonstrate their reliability in terms of fatalities and injuries’ (Kalra and Paddock, 2016: 2-3).

Alan: “Even if you drove a thousand miles, you wouldn’t see most of the events you could encounter on the road- it’s a statistic thing, billions of billions of miles you have to do to prove something is safe. It’s not an achievable number, so that’s an issue.” What could compensate for it is the simulation technology that allows the AI systems to ‘drive’ in stimulated environments 24/7. One example of such CAV training is demonstrated in Chapter 5 (the digital London).

The biggest social challenge named by Alan is similar to Lucy’s. He said in the domain of CAVs, it is very hard to get the short-term or mid-term return on investments. If companies aim at full autonomy, that might be a ten-year plus away. As many have noticed the heavy financial burden and the risks of technological uncertainty, the UK
CAV industry decided to re-set a realistic goal to focus on reaching and enhancing level 4 automation rather than aiming at level 5 (full automation). This agreement was shown in SEAV 2018 and the Law Commission’s consultation papers.

“How do you keep a company financially sustainable during that time is a big challenge. You need other sources of revenue. The reality limits.” Alan sighed. Behind this sigh was his passion for developing this technology’s feasibility. The ambivalence for him is that due to the current status of CAV, safety represents both the biggest prospect and the biggest concern. Nevertheless, with the technology becoming mature, he thinks more people will see the huge benefits and adopt it.

Jamie Hodsdon, the Ethics & Accessibility Policy Advisor at the CCAV, showed ethical concerns about CAV’s social integration. He said that a big challenge is “algorithmic transparency” and explained it in detail.

Jamie: “If technology is at a level where we don’t have to decide how they behave because there’s a safety driver, then big ethical questions don’t come in. But what we need to understand is in an event of collision where there’s no safety driver, why do the AVs do what they did. And we need to be able to interrogate to some extent. The key point here is that by algorithmic transparency, it’s not about exposing commercial competitiveness. It’s about being able to explain to the public in a fairly high-level sense: Why do CAVs do what it did.”

The challenge Jamie pointed out, again, brought our attention to the political transparency issue. Although Jamie refers to ‘the algorithmic transparency’, it implies
the Government’s responsibility to show the public how this tech innovation works and make this process transparent from a political standpoint. It says that the technology itself, in its social networks, is intertwined with various socio-political aspects that have been reconfigured by this in-the-process technology. The common ground is a belief that the impacts of CAV prospects are significant, which as a driver, pushes them to work on its social deployment.

Let me summarise the findings in this section. First, when it comes to the CAV vision, the planners’ top-down planning tends to focus on its prospects and highlights the environmental and economic benefits for the UK society. Second, the planners also named various challenges although they did not dive into any. These challenges include the public perception and trust, the political transparency for demonstrating and operating this technology, the financial investment in CAV development, and the technological uncertainty. Third, we identified a common assumption among the planners that the rollout of CAV will be accompanied by the application of electrification and shared mobility and thus, there is a concept of the SEAV that refers to shared, electric and automated vehicles. Since the assumption of SEAV was not well explained by the planners, in the following section, the trends of electrification and shared mobility are studied to explore their relations to the CAV deployment.

2.2 electric vehicles and shared mobility

Based on my interviews with EV and shared mobility experts, the electrification of automated vehicles is considered by them to generate environmental benefits and the application of shared mobility is believed to reduce private car ownership and thus decrease congestion and support a smooth operation of CAVs/vehicles in general. However, deploying SEAVs as planners envisioned in the previous section is not an
easy job. Despite a growing trend, the EV adoption rate is still low, the battery capacity is less satisfactory, and the EV infrastructures are not accessible. The planning and management of shared mobility is poor and social safety remains a big problem, for example, the public shows concern about sexual harassment and racial discrimination when sharing a journey with strangers. Hence, I believe the planners’ assumption of SEAV comes too easy and whether we can combine CAVs with EV technology and the shared mobility model requires more concrete research, planning and management.

I met Vincent Heibron, CEO of eVie Innovations, in November 2019 at a consulting company’s celebration party in London. Founded in 2018, eVie entered the market with an aggregated platform selling electric cars, using EV car comparison information with helpful guides and calculators to steer you through the buying/decision-making process. Vincent said EV sales will reach £60 billion over the next ten years alone in the UK. However, customers today have surprisingly little support for such a high-value purchase. That’s why he established eVie Innovations to address this market and help consumers make informed purchase decisions.

I have been curious about Vincent’s view on the EV market and how the technologies of EV and AV might affect each other. He suggested that (C)AVs are in the future and they are full of uncertainties while EVs are the present. But he also said that the increase uses of EV will boost the deployment and adoption rate of autonomous driving.

“EVs is a necessity if people really want to have a better environment before it’s too late. AVs, EVs, and flying vehicles, these technologies one day may merge and become one. But we don’t know that yet, and I size the present and hope to see more
changes and investments in EVs. Especially now that the battery capacity is getting better.”

“Apart from the significant benefits on our environment, are there any other benefits of using EV?”

“There’s a study of why people use EVs and that perhaps implies the biggest benefits (Clean Technica, 2016). The first and biggest reason is environmental. Due to climate change and global air pollution, more and more people have an awareness of using environmental-friendly vehicles. The second biggest reason is based on financial considerations. EVs can save a lot of money for users. You don’t pay for oil in the first place and the average life span of EVs is longer than traditional cars. So EV is a financially friendly choice for consumers as well. The third reason is, actually I would highlight this, the third reason is the tech mindset. For those people who have a tech mindset- know how EV works, how EV contributes to the transport system, and how EV services could benefit their economic lives- they are the people who use EVs or other technologies to think ahead.”

“What would you consider as the key to EVs’ scale-up at the moment?” I asked Vincent.

“Good question. Umm, I would say it’s the upgrade of infrastructures. More charges, for sure. Beyond that, we need smart infrastructures that can connect to the vehicles.”

“Connectivity.” I highlighted the C in CAV as my mind was brought back to the chat with Dr Mike Short.
“Yes,” Vincent said, “I’m not an expert of AVs but say, people talk about Connected Autonomous Vehicles and here, the connectivity building applies to EVs or any other smart vehicles too. Some traditional car manufacturers build EVs and consider them only as electric vehicles without seeing the links to a bigger picture. And that’s also what I mean we need a tech mindset. For example, Tesla. If you think Tesla is only an electric car company, you are wrong. It’s a tech company that has been building, selling, and connecting EVs to everything. That’s far beyond traditional car manufacturers and that makes Tesla the future.”

I was impressed by Vincent’s tech mindset and his passion for EV. Being an EV expert, he believes that electrification can be applied to many innovations, including CAVs. This is similar to Dr Mike Short’s view- since Mike has expertise in IoT, 5G, and connectivity, he emphasises the development and application of connected technologies to CAVs. But both of them only talked about how these technologies can be technically added to and benefit the CAV, leaving the social integration of these technologies a question. Vincent highlighted a growing adoption rate of EV but acknowledged the current incapacity of its battery, which hinders a further growth in the EV adoption. I also believe that infrastructures for operating EVs on a large scale, for instance, chargers, are not accessible in many cities, let alone rural areas. In other words, the deployment of electric CAVs in society is easy to assume but hard to realise.

Another trend that has been brought up to the frontline is shared mobility. Like EV technology, the concept of shared mobility is not new. From car clubs to Uber POOL, the concept of business model has been implemented in different forms yet having limited impacts. Today, when policymakers and industry stakeholders highlight it at
talks and conferences, is that just old wine in new bottles or if it will truly make some difference along with the design, development, and integration of AVs?

The largest carbon-emitting sector CREDS\(^4\) published a report on Shared Mobility (Marsden et al., 2019) where 20 recommendations were made to the government. The pitches were based on their research on the current status of shared mobility, its potentials, and the finding of a lack of “coherent national or consistent local policy framework for integrating shared cars within the wider set of mobility options” (ibid.: 3). CREDS defined shared mobility as “part of a continuum between private and public transport” (ibid.: 8) and it can exist in various forms such as “shared vehicles” and “shared trips”. It cited a diagram of shared mobility continuum (Golightly et al., 2019, see in ibid.: 8) and demonstrated detailed features of shared mobility in different conditions such as ‘pure sharing’ or ‘collaborative access’, ‘personal owned’ or ‘owned by the third-party’.

\(^4\) CREDS is a research centre that helps the UK leaders understand the changes in energy demand needed for the transition to a secure and affordable, low carbon energy system. [https://www.creds.ac.uk/](https://www.creds.ac.uk/)
The report encouraged further work on shared mobility because through ‘reducing the size of the car fleet and using the vehicle miles that are driven more intensively, it can make major reductions in carbon consumption’ (ibid: 11) which meets the government’s goal and help shift to a Net Zero economy. The authors believe that the large-scaled shared mobility is reachable and provide relevant evidence- a summary of shared mobility innovations, including car clubs, peer-to-peer car sharing, life sharing, ridepooling, bike share, and demand-responsive transport. Beyond that, some researchers also studied different forms of shared mobility innovations such as scooter sharing (Shaheen and Cohen, 2019). Despite studies that claim the prospects and emerging innovations of shared mobility, some studies show concerns about data privacy during shared journeys (Ebert, 2019) and explicate that apart from the loss of comfort and privacy (DfT, 2018a), the biggest barrier that stops people from giving up car ownership and using shared vehicle 

![Diagram of shared mobility continuum](image)
services is the safety concern (DfT, 2018b). An eye-catching article “Lies, Damned Lies, AVs, Shared Mobility, and Urban Transit Futures” (Currie, 2018) spotted several lies. The first lie is that public transport does not work and AVs and shared mobility are progressive alternatives and they grow fast; the second and the third lies are specifically around shared mobility: it involves vehicle sharing (Currie believes by collectively using public transport such as trains and trams, we are sharing), and shared mobility is transforming shared vehicle use in cities (he doubts its growth and impacts in cities). The trend as he believes, is “transit fusion”, which was defines as “the adoption of transit vehicles, infrastructure, and service design to integrate the best features of better performing modes into new transit modes and services to improve overall service performance, attractiveness, and effectiveness outcomes” (ibid.: 27). Currie thus emphasised a system thinking for transport planning and argued for public transport’s leading position in cities in the future.

I also have doubts- doubts about how this trend will scale-up and doubts about how to ensure safety when travelling with strangers. At a global transport conference in 2020, I heard many promises of developing shared services and thus creating better mobility while also encountering attendees who complain about this concept. “It hasn’t been growing big for many years, why now? Just because of some new technologies, a not favoured business model is going to triumph now?” And suspicions such as “the industry just wants to use ‘shared mobility’, ‘electric’, and ‘autonomous’- all these fancy ideas to, in fact, sell more vehicles. That’s what manufacturers do, right?”

“Look who’s talking there. They are white, rich males who fit in the shared mobility user category.” One female transport researcher said, “there isn’t enough care or real planning for the majority out there (outside transport conferences). They underestimate
the difficulties we (women) face on a shared ride with random people."

The attendees felt that the current discourses of transport planning are very exclusive among male experts and authorities. The concerns behind it include the lack of engagement and communication with the public as well as gender bias in transport planning and management. Apart from these potential socio-political problems, the current poor planning and management of shared services is criticised by users and experts like Frederic John.

Frederic John, specialises in finance and future mobility studies, works at Neckermann Strategic Advisors⁴⁹, a consultancy with an exclusive focus on smart cities and smart mobility. Frederic thinks there are four pillars of autonomous vehicles’ development: Technology, Regulation, Infrastructure, and People and his work is strongly related to the People pillar. He also joined that transport conference and agreed that the concept of “shared mobility” had been over-repeated. Though having space for business growth, he thinks there is a long way to go.

“We’ve already had shared Ubers, shared bicycles, shared e-scooters, but they are not really shared. They have limited users, they are less regulated, and they don’t solve traffic issues. There are a lot of business opportunities to develop shared mobility… but at this moment, we only see a mess. We see the industry just throw their products, for example, shared bicycles to people and say, ‘hey, here’s the solution for micro-mobility’ without offering a service that can be integrated into the existing transport

⁴⁹ Neckermann Strategic Advisor, London-based consultancy that looks at smart cities and future mobility.
https://www.neckermann.net/
system." He named the shared bike ‘OfO’ as an example. OfO was considered an innovative disruptor in mobility that can encourage active travel, reduce pollution and congestion caused by private cars. Despite all these prospects, more problems occurred when deploying in major global cities such as Shanghai and London. For instance, the bikes were not evenly distributed across the cities on time and, as a consequence, the overlap and the lack of service appeared at the same time in different areas of the cities. The surplus in some areas led to random parking and blocked the pavements. Besides, the stealing and damage of shared bikes caused much financial loss to the company.

“Lack of planning.” I said.

“Yes. It is about planning and also, back to the point, to know PEOPLE. We did some research and found an interesting result that millennials are less willing to share their rides,” Frederic said, “so we need to know who wants to use it.”

Frederic criticised that OfO did not conduct enough research to understand people’s needs and failed to integrate the shared bike services into different cities’ transport systems. Rather, they just threw millions of bikes to cities and let the society figure it out. This critique also applies to the assumption of the general shared mobility model that ‘because it can reduce the number of private cars and thus congestion, it should work well in society and be part of the better future mobility.’ While in reality, this kind of assumption needs to be accompanied by research and trials.

50 OfO is a global bicycle sharing company founded in Beijing in 2014.
“Also, selling them the concept of ‘shared mobility’ is not a good way. Instead, if the industry can find an alternative method to offer the lost feeling of owning/ownership… perhaps, more vehicles can be really shared.” Frederic continued, “Besides, it’s about the vehicle design. If the shared big vehicles can offer passengers personal space rather than remaining the same appearance as traditional cars… now there’re not many visual differences between normal taxis, cars and shared Uber cars, Zipcars, right? So I think the poor design needs to be fixed. You see, right now the seat beside the driver on a Uber car is empty most of the time. Why not design it and empower that space with other uses or functions?”

Frederic thus called for innovation in vehicle design and alternatives to what shared mobility may take from people (good feelings generated by ownership). He also mentioned that millennials, apart from having safety concerns and value personal space, worry about how insurance policy will accommodate shared autonomous services.

I have these concerns as well. I keep wondering what if the software of a shared autonomous car is damaged or the car itself is damaged with my presence, even though that damage is possibly caused by previous passengers? Will shared services lead to shared responsibility among users? Above all, will the autonomous car be insured or passengers insured in the first place? Having these questions in mind, I reached out to insiders in the insurance industry.

“Insurance hasn’t changed in more than a century. But the ways that we live, work and
travel have. Traditional, annual insurance policies can’t keep up with our ambitions. From flexible working to vehicle-sharing, one policy no longer fits all.” said **Harry Franks**, COO and Co-Founder of Zego⁵¹.

By law, commercial vehicle insurance can cost from £2,000 to £3,000 a year for a scooter, putting off many prospective freelancers. Having noticed this gap, Harry and his colleague started Zego to sell motor insurance by the hour, targeting self-employed, delivery and transport workers in the UK and beyond. At the heart of this service is an understanding of the need for gig-economy workers zipping around cities on scooters, bikes, in taxis, and perhaps, in autonomous vehicles in the future.

Zego uses software to tackle the personalization of products. I asked Harry how does it work and what kind of data does it capture.

“The software we built internally is less around how do we capture more information, rather, it is more around what do we do and how do we use it. One of the big challenges within insurance is that everyone runs off systems that were built in the late 80s and the early 90s, and what that means is whilst you may be able to get a lot of information about a user, the structures of the premiums in the policies that you can deliver to that end customer are very rigid. Our platform allows us to sell policies that are more in tune with the data we’re receiving. On the data capture side, we work with people who are already capturing data.” Harry explained, “For instance, we’re integrated into Uber, we can understand every Uber trip, all of the amount that the driver’s being paid and we can see the distances that they’re going. We’re also developing our own ability to

⁵¹ Zego is an insurtech startup that offers non-commercial pay-as-you-go motor insurance. [https://www.zego.com/](https://www.zego.com/)
track driver behaviour so that when they're doing those trips we can see how they're driving during that time.”

“With such data to understand driving behaviour, how does Zego come up with insurance policies?” I asked.

“Every policy that we sell is almost unique, it’s tailored to that individual.” Harry said they have huge spread policies that last for one minute and that last for a year and so the prices are very different.

I shifted questions in the context of CAVs. “I was thinking that the foundation of driving legislation is that we take drivers into account. Now that we have automated technologies and drivers will be moved out of the vehicles. How will this affect the car insurance industry in general and how will Zego cope with this challenge?”

Harry believes that drivers are the biggest influence of risk and premium calculation. When a driver is removed, the question becomes ‘what is the quality of the party who’s in control?’

“That’s where that could be variance between the quality of an autonomous BMW and the quality of an autonomous Audi. I don’t really know what will happen, but the key for us is that some things don’t change: we need to understand what the vehicle is doing, who is doing, what, where, and when? It is how we price today.”
Harry pointed out that brand could be a factor that influences on customers’ choices of purchasing CAVs or using shared CAVs. Because the members of the public may not have deep knowledge of AV technology, but it’s likely that they will project the technical quality to the vehicle’s brand and place trust in the trustworthy car manufacturers. Technology matters, so do brand, insurance policies, design and many other aspects. This is an interesting point and deserves research efforts. However, due to research time and space limits, I do not dive into it.

Harry then suggested how the insurance industry might consider complicated situations where a CAV is involved. “We can say that a vehicle is driving autonomously or not or in the case of a Tesla autopilot, at night, it’s more likely to have an incident than during the day. If it is driving on wet roads, it’s more likely to slide than if it’s driving on dry roads. So you can take all that contextual information as well. One of Zego’s benefits is that it can actually do things on this, we’re not just going to ensure an autonomous vehicle and say, this is the price for the next year. We will take into account how often is the vehicle on the road and what sorts of things is it doing.” It implies Harry’s vision of personalising and contextualising the CAV insurance. But currently, it stays as an early-staged idea without concrete designing or planning.

“Regarding shared mobility or shared AVs,” Harry added, “for things like (Uber) Pool, the policy works based on the fact that the vehicle carries passengers for hire and reward but without a variance based on the number of passengers on a trip. I do think that this is something that in time could be used as a variable to create price changes—its less risky with one passenger than four, for example.”
This financially-friendly idea, again, explicates safety concerns while using shared services. As Jamie Hodsdon from the CCAV said before. ‘The issue with shared mobility is that if you are somebody who feels that there might be a risk from other passengers, you’re not going to use it even if it is cheap. If you look at Uber Pool, the majority of people who use it are young white men because they don’t feel a risk. But if you’re a woman or if you’re disabled, you may not feel safe. The cost-and-benefit analysis here is not “oh, it’s cheap so let’s do it” because the cost is not just money but also safety. So unless there’s a way of assuring people’s safety inside the shared vehicle, I don’t think it really matters how great the automated technologies are. And as we talked about it before, if we remove drivers on autonomous buses, passengers may feel unsafe without that supervision and regulation. So it’s also an issue with shared mobility.’

Safety in mobility refers to more than no collision but also social safety. Sexual harassment has long been a threat for females to use public transport and ride-sharing services. Discrimination against females, the old, the disabled, and ethnic minorities create an unsafe feeling among them and an unhealthy social environment for all transport users. A Seattle based experiment showed that trip request coming from people with African American sounding names take “between 16 to 28 percent longer to be accepted for both UberX and Lyft services” (Ge, 2016: 2) and “chatty” drivers take extremely long routes with a female passenger’s presence, sometimes even “driving through the same intersection multiple times” (ibid.: 18). We will further explore and discuss some of these issues and concerns in the next chapter from the public’s viewpoints.

The model of shared mobility has been ever promoted despite such problems left
unsolved. Why do planners envision a fusion of Shared Electric and Autonomous Vehicle (SEAV)? Why are these trends expected to walk hand in hand? Alan Peters at CPC gave me some thoughts on it.

**Alan:** “My concern is that if we only replace traditional vehicles with automated vehicles, congestion and pollution is still there, and worse, those who already have vehicles may get one more automated vehicle. In that case, things go down. So, it needs to be coupled with having autonomy as part of the public transport system. I don’t know how we can do that but look at the experience of Uber where you get a lot of negative consequences that are driven by commercial purposes, AVs can be a positive thing only when deployed in a good way, combined with EV technology and suitable business models. However, what worries me here, with some business models, are congestion and the potential reduction of public transport.”

It goes back to the earlier point that shared mobility might be an excuse for the industry to sell more vehicles, the only difference is that these new vehicles are empowered by electric and/or automated technologies. The targeted users are within certain social groups (young, white males) and the commercial approaches to the personalization of products prioritise these users’ needs and want. Donald Norman considers Human-centred design harmful and explicates one concern that “the focus upon individual people (or groups) might improve things for them at the cost of making it worst for others. The more something is tailored for the particular likes, dislikes, skills, and needs of a particular target population, the less likely it will be appropriate for others” (Norman, 2005: 16). If safety issues are not addressed, for instance, then even the number of users of Uber Pool or other shared services increases, these users come from the same target group(s). So the question is, what about the excluded others? Who shares
future mobility or the SEAVs? Besides, the relationship among AV, EV, shared mobility and other forthcoming trends is not clear as we do not know how they will co-exist or fuse. These questions and challenges, again, suggest that despite of the many potential prospects, the social integration and deployment of technology is complex and nonlinear, and that the high-level vision of combining automated vehicles with EV technology as a shared service is an assumption that needs a lot more planning efforts.

2.3 “How Would I Use It?”

After discussing the prospect-driven CAV visions with some challenges and concerns highlighted, I decided to disrupt the top-down planning by asking some of the planners how would they personally like to use this technology in their everyday life? In doing so, first, I want to see if there is any difference between their high-level planning and their personal wishes. Second, it is because that anthropologists value context and I would like to understand how the use(s) of CAVs can fit in their different commuting experiences, which might open up new possibilities or reveal issues. Third, by asking this bottom-up question, I want to encourage empathy-building so that the planners use their first-person narrative to think about future planning.

Professor Nick Reed uses public transport and cycles in London. He is generally satisfied with the transport services but has concerns for cyclists. He said he would like to see CAV technology to improve his cycling experience and if the technology is mature, he would be delighted to encourage his daughter to cycle to school.

Nick: “If automated vehicles were doing more of the trips in the urban environment and they are electric and they drive in a very safe, predictable manner that improves the air quality and improves the nature of the interaction between walkers and cyclists and
vehicles, it will then make those active modes more attractive. And school children would feel more comfortable cycling to their school rather than having to be driven.”

Having considered the contextual nuance, Nick said he was encouraged to think more about the road interactions, especially CAV’s interactions with children who commute in different ways.

Mike: “I've travelled all over the world but mainly lived in London. London has pretty good transport, but it can be polluted and noisy as other big cities are.” said Dr Mike Short, “I hope to see autonomous vehicles replacing buses. I don’t think it will replace tubes, even if we have some driverless trains already. They may replace some buses, probably first on straight-line routes.” He believes that automated buses are more efficient than traditional ones in terms of arriving time and driving orders.

Apart from pollution and noise, Mike pointed out congestion as another issue. He explained that London will need some car-sharing arrangements, and autonomous buses (better electric, too) or other forms of public transport might reduce the number of taxis on the road. When he wished for sufficient electric and automated bus services, he expressed a vision for more public transport than private vehicles. Well-planned electric and automated bus services, in his eyes, can reduce private car ownership and further benefit the environment and traffic operation.

Lucy Yu said the biggest challenge on her commute is getting to and from the tube station. “I have a last-mile challenge. I live about three quarters of a mile from the main station, which is fine in good weather conditions and if I don’t have lots of luggage. In other circumstances, that’s not ideal. There is a bus that I can take but it’s not a demand
responsive bus, so there are only three every hour. You know the worst case is you are waiting 20 minutes for the last mile, which probably also takes you 20 minutes to walk.”

She said this is a chronic pain point she and many others who do multimodal trips face. Automated shuttle buses are considered by her as a solution, and she recalled her colleagues’ experience.

Lucy: “A lot of my colleagues live outside London and they take the train. Quite often, there are disruptions, cancelled services and delays. If a train is cancelled today, there could be a rail replacement bus service, but it’s only because there’s engineering work that has been known weeks in advance. What you don’t have is something that can step into the breach for a very short notice like unforeseen cancellations, delays, and disruptions. The ability to crowdsource demand for transport in real-time could certainly be valuable and CAV technology might get us there.”

Having considered their own commuting experiences, we noticed that they did not only mention some of the aspects/issues that were not previously discussed while planning at a high level, but also that, as a matter of fact, they dived into more interesting and thought-provoking details. Having considered his daughter’s journey to school, Nick dived into thoughts on CAV’s interactions with other vehicles and road users. Based on his knowledge and experience of London’s transport, Mike thinks it makes more sense to automated buses than other types of vehicles in central London. Lucy thanked me for pushing her to think how to use CAV technology to address some on-the-ground problems like the last mile issue that she experiences on a daily basis.
It implies a gap between the top-down planning and the bottom-up thinking/imaginaries and increases my interest in people’s everyday commuting experiences where expectations and concerns are very contextual. Therefore, in Chapter 4, I interpret the public’s CAV imaginaries, study their everyday commuting stories, and analyse how CAV can/(not) realise the safe, clean, and efficient future as planners envisioned.

3. Conclusion

In this chapter, I interviewed the CAV planners to understand not only the prospects and challenges of CAV deployment, but also why did they name these prospects and challenges and how did they frame their visions, plans, and/or assumptions. I did not agree or disagree with their claims. What interested me are their perspectives and approaches. Above all, despite acknowledging various challenges, the planners’ top-down thinking was prospect-driven. The challenges they briefly mentioned are centred around the technological uncertainty and the demanding investment in its R&D. Besides, the planners are concerned about the public’s perception and acceptance of this technology. Some planners believed that people’s trust in CAV is associated with the way of introducing this technology, specifically, how to clearly explain to the public why CAVs did what they did and how regulation works for the CAV operation. It implied the importance of political transparency in technologies’ demonstration. As I have discussed in the literature review that technology is institutionally stabilised and publicly performed (Jasanoff, 2015), my finding here inspires questions of what kind of efforts do the planners make to ensure transparency in the CAV field? How is the CAV law or policy framed and implemented?
When it comes to the prospects, the planners agreed on CAV’s three major contributions to safety, the environment, and the UK economy. Autonomous driving technology was seen to better ensure road safety than human drivers, thus benefiting drivers, passengers, and all road users. The planners also envisioned CAVs to be combined with electric vehicles and deployed as public services in a shared model, which can respectively reduce the CO2 emission and the private car ownership. Lower car ownership was considered to further contribute to the CO2 reduction and congestion reduction. In other words, the planners believed that the CAV deployment can lead to cleaner and smoother transport, though it was based on an assumption that CAVs will be combined with electrification and shared mobility. Furthermore, the planners forecasted a £52 billion UK market for CAV by 2035, which can boost the economy and consolidate the UK’s leading position in transport innovation and therefore, benefit people in the UK. The three major prospects for public good drove the top-down thinking and planning for CAV social deployment.

Based on the discourses of the CAV prospects, I identified a common assumption of the use of the shared, electric and automated vehicle (SEAV) that the CAV technology will be naturally combined with the trends of electrification and shared mobility. I had questions and doubts about the concept of SEAV because the practice of it was obscured in the high-level CAV visions. To better understand how these trends can support CAV and whether they can be rolled out together, I talked to experts of electric vehicles (EV) and shared mobility services. It was confirmed that the concept of SEAV can potentially create cleaner and smoother transport. However, the experts revealed various difficulties in realising the SEAV. For instance, challenges such as the incapacity of EV battery, the insufficient EV chargers, the current poor management of the shared transport services, as well as the safety concerns about sharing rides with strangers all suggest a hard job to combine CAV with electrification and shared mobility.
In other words, the promising assumption of the SEAV requires a lot more effort to be transitioned into reality and that some top-down thinking and planning currently remains at an abstract, early stage. It inspired me to challenge the planners to think about the application of CAVs from a user’s perspective. In doing so, I encouraged empathy-building and pushed them to consider CAV’s social integration at a detailed level from the first-person narrative (as a user). Based on their everyday commuting stories and expectations, I saw a gap between the top-down planning and the bottom-up imaginaries. For example, considerations about CAV’s road interaction with cyclists and CAV’s impact on the last-mile issue were brought up only when the planners relate to their own travelling experiences, which was very different from the previous visions for public good. It led me to fully explore the public’s CAV imaginaries to draw out the social thickness in the next chapter.
Chapter 4 CAV Imaginaries: the bottom-up commuting stories

Having sensed the differences between the top-down and the bottom-up opinions on CAV technology, this chapter further draws out the thickness of CAV possibilities from the public’s imagination. The discourses with the planners in the previous chapter and the public’s engagement through imagination in this chapter, together, form a picture of how an abstract idea of technology is understood by different people, and how different perspectives can enrich an understanding of the potentials and challenges of the CAV social deployment. We found that the public’s imaginaries are studied by researchers and industry stakeholders for them to better design, develop, and deploy CAVs. In other words, the impact is reciprocal: while the planners aim to educate and engage the public through imagination exercises, the public’s imaginaries also shape the planners’ understanding and potentially, their planning (also see Chapter 7).

Imagination in this chapter is used as a tool to engage the public and unfold possibilities of the CAV technology. Initially, imagination was depicted by philosophers as the first faculty of a person that nourishes all the others (Kant, 1978) and the anthropological approaches to it varied in many important ways. Charles Taylor (2002), for instance, used the notion of the ‘social imaginary’ to study holism, through which, a totalised set of meanings of human thoughts and actions can be explained and interpreted. Benedict Anderson (1983) explicated the function of imagination in forging a community identity. However, he argued that in the process where a nation or a community emerges as a political entity, imagination constitutes only an emergent effect rather than socio-political holism. More recently, Vincent Crapanzano (2004) contributed to empirically studying imagination through the lens of social phenomenon. Imagination, in his vivid ethnography, opened up “a horizon of the possible, escorting
the project, the hope, the fear, speculations...it anticipates and pre-views, serves actions, draws before us the configuration of the realizable before it can be realized” (Starobinski 1970, cited in Crapanzano 2004: 19). This view resonates with my intention in this chapter, besides, I agree with Tim Ingold’s (1997) opinion on the technological systems that they are not just technically shaped but also socially constituted with the imaginative effects brought by people’s engagements. Apart from opening up possibilities afforded by the technology, imagination also supplements people who are not familiar with the technology to ‘overcome logical limitations’ (Sneath et al., 2009: 24).

The “autonomous vehicle imaginary” is considered as an exploration of what ‘autonomous vehicles are about and how their users are imagined and (re)configured’ (Balkmar and Mellstrom, 2018: 50). Moreover, imaginaries and the use of technology can change people’s sense of their identity and potential as ‘they come to understand what they can do, and even who they are, in novel and unpredictable ways’ (Jasanoff, 2016: 144). CAV imaginary is thus a means to open up possibilities of how people using and being with this new technology as well as how this technology changes and challenges people.

To capture as many dynamic imaginaries as possible, I participated, facilitated, and organised workshops in Edinburgh and London where I engaged over 80 public members with different backgrounds in terms of age, gender, profession, and mobility condition. The participants’ imaginaries combined hope for a fancier future afforded by technology (Marvin, 1989) and fear for a dystopian one. Their fear and concerns, in particular, led to discussions about emerging challenges such as data privacy and regulation on automation as well as long-existed ones such as safety, design basis,
and the unequal distribution of transport services. The problems-focused imaginaries bring attention back to the current pain points in the transport systems and society because social safety and equity are not yet delivered. Through my work on the project ‘Festival Transport and Mobility’ and interviews with UK residents, I discuss and analyse some of the existing problems in transport and some emerging ones that concern the public, which might contribute to re-thinking the social deployment of CAVs.

1. Hope and Fear of CAVs

During the period between September 2019 and March 2020, I joined, facilitated, and led different CAV events where I closely studied people’s imagination of CAV technology. In the following section, I demonstrate and analyse my empirical study of CAV imaginaries at the DC Emulsion, the CAV Forth workshop, and the Self-Driving Car Meetup event. Despite the differences in events’ format and the participants’ backgrounds, similar hope and fear of this technology were reflected in the imagined scenarios. In utopian imaginaries, CAV added credits to safety, efficiency, and convenience as well as risks to safety, privacy, and liability while in dystopian imaginaries, various new and old problems were put forward.

1.1 Driverless Car Emulsion

On 19 November 2019, I participated in the full day ‘Driverless Cars Emulsion’ session in Edinburgh from 10 am to 4 pm. I found this event on LinkedIn and registered it in July 2019. At that time, this workshop series had already been running in several cities in England.

It was Professor Glenn Lyons’ brilliant idea to organise the events and open an in-
depth dialogue of Driverless Cars (or “DCs” as he prefers). Before this, he had been researching on DCs and future mobility. The ‘Driverless Cars Emulsion’ is an initiative promoted by “frustration at the lack of shared thinking and debated regarding what can be considered the wicked problem of what DCs could and more importantly should mean for the future of mobility. The ‘lovers’ and the ‘haters’ of DCs seem to exist in separate echo chambers” (Lyons, 2020: 2). It was a series of six workshops taking place around the UK between July and November 2019 and it included over 100 participants with various backgrounds, who represented evangelists, opponents, and agnostics of this technology. In doing so, the initiative aimed to create scenarios of ‘plausible utopia’ and ‘plausible dystopia’.

I reached the Apex Hotel (the venue) at 9.40 am. Twenty minutes later, attendees were invited to an event room where four tables were settled. A middle-aged man who works at a transport consultancy, a female professor from Leeds University, a young girl who just started her position at Transport Scotland, and a facilitator joined my table. I did not count the specific number but there were over 20 participants in the room. Females participants were about seven or eight, making male participants the majority, as in any of those transport or tech-related events. Participants’ age ranged between twenty and mid-sixty.

Professor Lyons asked each of us to give a quick self-introduction and indicate why we are here. Besides, he asked us to provide one positive point and one negative point regarding a DCs feature.

I remembered saying that I was fascinated with transport technology and wanted to
hear different opinions on autonomous vehicles to enrich my research. I named two positive points: “safety” and “freedom”. I said, “I’m a terrible driver and so hope AI-empowered vehicles can do a better job than me, that refers to safety. Besides, I’ll be able to deal with emails or just chill out in the car and that’s regarding freedom.” In terms of the negative side, I said, “I am not sure whether this technology will take the pleasure away from those who like to drive and how it may affect drag race. Although I am a bad driver and don’t like to drive, I would miss F1\textsuperscript{52} if they cancel it in the time of automation.” I heard concurring opinions in a low voice from other tables.

Other participants who come from Transport Scotland, Research institutes, major consultancies, National Transport Strategy, Stagecoach, Bus Service, AV software companies and universities shared their reasons for being here. Some were experts in this field and wanted to exchange minds while some said they had no idea about DCs at all but felt curious and wished to know more about this sci-fi-like invention.

When it came to the positive and negative points, I heard various answers that differ from mine. Some mentioned DC’s potential benefits for the environment, mobility for the disabled, and place-making. Meanwhile, they stressed negative sides such as the infeasibility of this technology. This warm-up session appeared a successful brainstorm for CAV imaginary. The following up session was ‘starting position’- an interaction that asked participants to stake out their starting position concerning the proposition “DCs are a great opportunity for society” along with the reasons for their position on a wall-chart. I positioned myself between ‘agree’ and ‘strongly agree’. After marking myself as one of the evangelists, I stood near the wall for a while, observing others’ positioning.

\textsuperscript{52} Formula One (F1) is the highest class of single-seater auto racing.
With Professor Lyons’ verbal permission, I took photos of the display wall and notes during the workshop.

Only one guy put his sticky note on the ‘strongly agree’ area, with the majority gathering between ‘undecided’ and ‘agree’ as well as the area between ‘agree’ and where I positioned. Four chose ‘disagree’ and another three participants positioned themselves in the area between ‘disagree’ and ‘strongly agree’. As my eye moved to the endpoint of the wall, I saw one participant chose ‘strongly disagree’, which well-balanced the opposite side of the wall.

“I smell a war.” Professor Lyons looked at the results and said, “May I ask who’s strongly agreed and who’s strongly disagreed with the proposition?”

“It’s me who strongly agree with it.” said a male participant who is in his forties, “just now we all named many different advantages of driverless cars, I cannot not be positive. I think this invention has huge potential to tackle many issues reside in our transport system and cities in broad. And as we see the technology is quickly coming along, I think we can soon achieve those positive points.”

The Scottish government has shown strong ambition in implementing the CAV technology in the past few years because CAV is considered a social and economic opportunity. Being a professional at Transport Scotland, this participant also showed his personal optimism and enthusiasm.
“Me.” said the professor from Leeds University, “I strongly disagree with it. My background is in engineering and computer sciences and I know very well how far we are from those utopian fantasies. That’s the technologically saying, let alone we also face many social challenges. For example, social acceptance and new forms of regulation. And I don’t believe this invention can alone address all the issues - air pollution, congestion, delays, parking, etc. It could be an overlap, it could be a fancy thing sold well among the young and the rich. That all says, DCs as an invention could be a good experiment in the laboratory but it is far away from being operated on real roads and benefiting society.”

If not dystopian, her understanding of the technology’s infeasibility, at least, diverted her imaginaries far from utopias. Moreover, having considered the social integration of CAVs/DCs as a complicated, nonlinear path, real-life challenges are at the heart of her imaginaries and perception.

“Having challenges is normal. All technologies have challenges before they’re integrated into society. It doesn’t mean we should deny the prospects.” The evangelist argued back, assuming challenges will be overcome.

Others joined the debate.

“I agree with it because DCs can unlock urban space and reduce car ownership.”

“And it has the potential to massively safe lives from the car crash.”
“But we haven’t reached that level yet. We don’t know if it’s safe on public roads or not.” Said a middle-aged male, who suggested that previous participants’ points were all based on the premise that this technology would be 100% trustworthy. Rather than giving positive or negative assumptions, he emphasised agnosticism.

“I kind of disagree because driverless vehicles may increase inequality. Say, who can access those fancy technological applications? The vulnerable groups like the poor and female passengers may be excluded again.” Said a young woman. In her view, technology, if not used properly, will amplify social issues associated with class and gender.

“Exactly, and I think DCs conflict with cultural richness and may discourage active travel in cities.” Agreed by a middle-aged man who had lived in Boston. Based on his experiences, he feared that DCs would turn everyone “American” (driving too much) and cause laziness and obesity in the future. Psychologists found a positive relationship between health and active travel and argued that the latter one benefits both physical and mental health (De Nazelle et al., 2011; Saunders et al., 2013). Active travel has therefore been encouraged by transport planners and activists. But how can CAV technology supplement active travel in the transport system, if not discourage it, requires more research.

More agnostics made their statements. “It could go either way- it depends on how joined-up strategy on the purpose and use of DCs ends up being.” “Technology itself is neutral. How it will be used matters.”
Professor Lyons stopped the conversation and introduced a morning exercise, called ‘Plausible utopia/dystopia in 2025.’ This exercise was designed for participants to generate a characterisation of ‘what 2050 could plausibly look like in terms of a mobility system with a significant presence of DCs.’ Among all four groups, two were assigned the task of creating ‘plausible utopia’ and the other two groups ‘plausible dystopia’. This structured exercise aimed to distinguish where possible between first and second-order positive/negative effects. My group was assigned the ‘plausible utopia’ which echoed my preference but not the professor’s. She raised her hand and asked Professor Lyons, “I’m critical about DCs but I’m assigned to the utopia one. Is it how it supposed to work- no matter what your starting position was?”

“Yes! But later, all of you will be transferred to another group and do the opposite task.”

I glanced at her indetectable sadden face. ‘Maybe that is the whole point’, I thought, ‘giving participants the chance to discuss why they initially agree/disagree with DCs’
prospects and then leave the comfort zone to think from the opposite. That’s how imaginaries go dynamic!’

Our table quickly came up with over ten utopian futures such as better-designed cities with more green space, well-connected rural areas, and organised tourist visits. Linking the recent forest fire in Australia\textsuperscript{53}, I added, “DCs can save fire without risking human firefighters’ lives!” The scene of a robot car saving lives was acknowledged by my peers. All of us were highly engaged in the discussion and to my surprise, it was the professor who considered herself a radical opponent, came up with the most plausible utopias.

We sometimes underestimate our ability to imagine the unknown and the opposite. Johnson found that imagination is central to cognition. It is “central to human meaning and rationality for the simple reason that what we can experience and cognize as meaningful, and how we can reason about it, are both dependent on structures of imagination that make our experience what it is” (Johnson, 1987: 172). With conscious effort, we can use imagination- the future-oriented ability- to become an “intentional arc” as Merleau-Ponty (1962: 136) described, that “projects round about us our past, our future, our human setting, our physical, ideological and moral situation” and leads us to the life of consciousness. Imaginaries help to explore the uses of technology. For instance, a vacuum cleaner was invented after somebody imagines reversing the airflow of a hairdryer. And the imaginary of storing ice inspired the change of a vacuum cup into an ice bucket. Our CAV imaginaries might also discover and inspire new uses.

\textsuperscript{53} 2019–20 Australian bushfire season, also known as the black summer. 
https://en.wikipedia.org/wiki/2019%E2%80%9320_Australian_bushfire_season
We were then assigned to different groups to discuss the opposite aspects. My new team nailed the task by generating many ‘black mirror’ style scenarios where humanity suffers under robots’ domination. In fear of losing human control, these dystopian imaginaries echo the terminology findings in the previous chapter.

This session helped us to see various possibilities and challenges. Below are some utopian/dystopian 2050 scenarios that impressed me in particular.

**Utopian imaginaries:**

1. Travel time being part of (extended) working time, which might be paid. It offers people more free time for themselves.
2. DC depots for cleaning, maintenance and recharge have replaced dealership showrooms.

**Dystopian imaginaries:**

1. Fear of being watched by the Big Brother.
2. DCs are susceptible to cyberattacks.
3. DCs are privately owned and OEMs determine the vehicle control systems in operation.

In reflecting upon descriptions of the scenarios generated, some key overarching messages emerged (Lyons, 2020): “First, dystopic thinking comes easily. Second, many of the utopian scenarios were predicted upon an assumption of strong governance. Third, DCs should be considered in a wider context of mobility and society.

---

54 A British dystopian science fiction anthology television series launched in 2011.
And finally, scenarios, whether utopian or dystopian, were founded upon assumptions.”

These findings enrich an understanding of what to improve apart from the technology itself. CAVs/DCs were imagined as a tool to potentially expand freedom and human rights (better housing and locations, extra payments for commuting hours, etc.). Meanwhile, the imaginaries of ‘being watched’ and ‘(cyber-)attacked’ implied a desire for socio-political transparency and stronger governance. Some of the CAV imaginaries were very specific and many were not previously mentioned by the planners.

After more discussions and a coffee break, we were invited to revisit the core position of the initiative- ‘DCs are a great opportunity for society.’ I did not change my position (agree), which made me one of the ‘stubborn’ majority. Notwithstanding the same position, I wouldn’t deny the richness this event offered me. One participant changed his position towards ‘strongly agree’ while six participants moved towards ‘strongly disagree’.

Why participants became more negative about the DC opportunity after this workshop and tend to imagine dystopian futures?

Some participants shared their opinions. “It’s clear that the risks are high so unfortunately I am less optimistic now.” “I still believe DCs could be either be a good opportunity or a big threat, but the ‘big threat’ is more likely than the ‘big opportunity’.” The one that became more positive said, “It seems that the ‘driverless emulsion’ is establishing wider principles for mobility in which DCs can play a significant positive
If participants’ perception changes within a few hours, I wonder how it might be shifting in the following years? Due to time limits to my research, I could not offer an answer but this event suggests a quick change in the public perception of technology. I encourage researchers to compare the perceptions of CAV in the next 3, 5, and 10 years.

Although being an evangelist myself, I value opponents’ views and appreciate the chance for myself to think from the opposite. Resistance to new technologies is concluded as ‘part of an interactive process of sociotechnical change’ (Bauer, 1995: 3), which as a common means, encourages negotiation among producers, mediators, and users. Beyond resistance/acceptance, it is important to think about why technologies cause different responses, which leads to further thought about not just the technology itself, but its possible rollouts in the socio-political environment and the impacts it may create on different people’s lives. We also see that the imaginaries, whether utopian or dystopian, are still very abstract. This is partially because the questions such as ‘how will this technology affect society in 30 or 50 years’ are broad at a high level. In the following two events, imaginaries are more contextual, relating to the individual’s commuting expectations and concerns.

1.2 The CAV Forth Workshop
Two months before the DC Emulsion (12 September 2019), I assisted a 4-sessions workshop organised by Innovation Manager Steven Russell at Stagecoach for the CAV Forth project. The workshop aimed to engage local residents in Edinburgh, especially potential users who commute between Edinburgh Park and Fife and tried to
understand their expectations about the forthcoming services. In doing so, an understanding of people’s needs and concerns can be developed before the actual trials and Stagecoach along with other stakeholders can (re-)shape the service accordingly. To follow the project, see what do planners do, and listen to residents’ opinions on CAVs, I volunteered to facilitate the workshop.

The workshop was held in Edinburgh Premier Inn near the Edinburgh Park. The location was selected on purpose in the hope that people who live or work nearby can attend the workshop and share their views or, at least, put forward some questions. The workshop information was posted on the Stagecoach website, advertised on Eventbrite, and circulated through emails to attract different groups of people. All sessions had the same settings of presentation. Each session lasted one hour and fifteen minutes with four to seven participants involved. Most participants are Edinburgh residents and a few live in Fife, crossing the bridge. They need to commute between Edinburgh and Fife on a daily basis. These participants wanted to know if and how this new service- autonomous buses running between these two places- can potentially benefit their daily journey. Apart from those who have ‘practical’ questions and expectations, transport insiders, consultants from WSP, and curious residents came along the workshop.

Steven played a 5 minutes-long video of the CAV trial in Manchester- it was a Stagecoach autonomous vehicle running in a bus depot. The bus successfully turned around and went to the parking place. It was a small-scale trial with the same type of vehicle that is expected to be running between Edinburgh and Fife in the following year. This video aroused many questions not about the technology itself but the driver on board. "Why is there a driver sitting there when it is autonomous? What is his role?" “In
the real services, will we also see the human driver?”

One participant commented, “I understand it is good to have a human driver on board. Human drivers might offer safety when the computer system fails to handle emergencies. But it feels weird to have a driver there. Especially when passengers and pedestrians can’t really see whether the driver touches the wheels or not, it is so confusing who is actually driving.” He was concerned that the role of ‘safety driver’ may not be virtually demonstrated to the public and cause confusion about this technology.

Another participant jumped in the conversation and suggested, ‘perhaps the driver can walk in the corridor from time to time, checking passengers as a conductor instead of sitting there during the whole journey.’ Although many participants doubted the human driver’s role, one female participant showed appreciation for having a human driver on board. “It makes me feel safer, especially in the evening time. Also, it’s important to have staff members’ support when it’s needed.”

Her words explicated two good points: first, social safety is essential, which should be assured especially to female passengers, the poor, the old, the disabled, and ethnic minorities. It echoed the concern about social issues from some previous participants. We will discuss these concerns and imaginaries related to social issues later with some interviewees. Her second point centres around the human-robot relation, similar to her viewpoint, many believe that human interactions can never be replaced by robotic reactions. As discussed in chapter 2, more types of human-and-machine relations might be unfolded through tech innovation.
Through a 10-minute presentation, Steven presented the project’s partners and the estimated duration. He then showed a map of the service route, elucidating the stops, speed of the bus, and frequency of the service. The plan was not fixed though—based on Edinburgh Napier University’s research and the engagement with the public, changes could be made. Steven and I asked each participant to share their biggest expectation and concern. Safety turned out to be the biggest shared concern. Unlike the Driverless Car Emulsion, this workshop placed a specific focus on the CAV Forth project. The participants, therefore, tended to pose practical questions and imagine the near future with autonomous buses running across the Forth bridge.

“What about the fare? Do we need to pay more or less for autonomous buses than normal buses?”

“Can anyone access it? Any space and facility for disabled people?”

“How does an autonomous bus follow the traffic rule? Is it the same?” … “When it encounters other road users, how will it act? Will it always slow down and let others pass?”

“Oh, that would be annoying. Other road users may manipulate the autonomous car system, knowing that an autonomous car would prioritise safety and stop, so, others may take advantage of it…”
“Right, in that case, would anyone form new rules to regulate it? And… I really want to know if things go wrong who will take the blame? Although I know CAV Forth is about public buses but what if one day we own autonomous cars and, at that point, there are just so many things to discuss.”

“Yes, like insurance!”

“And whether an autonomous vehicle can decide who to kill in an unstoppable crash. Have you all heard about the trolley problem? It is a moral debate…” Interestingly, people brought various aspects that interest me as a researcher. Thought experiments such as the Trolley Problem (see chapter 6) are often discussed by philosophers, ethicists, and experts in the field (see Lin, 2016; Goodall, 2014; Millar et al., 2017), so I did not expect it to be mentioned at the workshop. Accessibility, affordability, responsibility, ethics and many other aspects came along the dialogue but due to the time limit, we did not dig the details.

Andy, one retired participant who used to work in a transport organization said, “what they (customers) care about is the RELIABILITY of the service. If the service promotes their commuting experience and makes them trust the service, then it doesn’t matter whether it’s driven by people or AI.”

Technical questions were not left. For example, ‘when sensors collapse, how can an autonomous bus diagnose its’ issues and drive itself to get fixed?’ It suggests an
awareness that technology can never be perfect and that once autonomous vehicles collapse, back-up plans are expected.

When asked if an autonomous bus looks different from traditional buses, disagreements appeared. Three male participants from the same session agreed that the technological element is unnecessary to be emphasised.

“Technology is always there, but people usually don’t think about it. They simply use or don’t use it. There’s no point emphasising the bus is AUTONOMOUS to the public. Also, the term may scare off some people, right?” “Exactly, just run it, don’t advertise it as an autonomous bus.”

“Don’t you want some futuristic favour in its design? What would you say the future cars should look like?” I pushed.

Two hesitated and one suggested that how to design a vehicle is car manufacturers’ responsibility and freedom. Since CAVs are new to society, he preferred the CAV Forth bus with no distinguishable features. “Looking normal, and I would use it.”

One participant who brought her nine-year-old son to the workshop disagreed, “no, it is the bus company’s duty to tell other people that it is an autonomous bus and let people decide whether to use it or avoid it. Otherwise, it’s not responsible. The public needs to know.” In her opinion, transparency of information is a necessary premise for any legal and ethical decision-making. It implies that for the public, despite their limited
knowledge of technology, a transparent political environment/system that can explain how this technology works and ensure responsibility could generate positive perception and enhance trust.

Participants’ biggest expectation echoed their biggest concern- they hope the technology will be feasible enough to lead to a “zero crash” future. Other expectations include “having enough space for cyclists (to store bikes) on the bus”, “have a smart ticketing system”, “combine automation technology with EV (electric vehicles) so that it’s good for the environment”, “design an App for this specific service” and more. These expectations and suggestions may inspire Stagecoach in terms of designing and operating at the following time.

As mentioned, the CAV imaginaries drawn from the CAV Forth workshop are more related to the participants’ commuting experiences and directly reveal some needs and wants while the imaginaries shown at the DC Emulsion are comparatively abstract. The reason is that the DC Emulsion only intends to explore big scenarios but the CAV Forth workshop aims to understand people’s expectations for a specific project. As a result, though not contradictory to the high-level and abstract imaginaries at the DC Emulsion, imaginaries at the CAV Forth workshop are very detailed, with personal touch such as the stops’ distance to their home and offices and the service frequency. To collect more public imaginaries, I ran a self-driving car meetup event in London, where I also conducted fieldwork due to its various opportunities for accessing CAV projects.

1.3 The Meetup Group
Continuing my investigation in the CAV imaginaries, I established a meetup group
called “Smart Transport: London Self-Driving Cars Meetup Group” in early January 2020 for the following reasons: first, as mentioned above, I wanted to expand the public pool and the free online event can quickly and widely attract them. Second, I selected Londoners because, at that time, more CAV events/trials had happened in London than Edinburgh (same as today), meaning the public awareness of this technology might be different, which further affects the CAV imaginaries. Third, as mentioned in methodology, by organising my own workshop, I would be able to use it as an anticipatory method (Macnaghten, 2021), control the framing and ask questions that are directly related to my research.

I used the word “Self-driving” rather than “autonomous” because based on my terminology survey, I found the majority of the public are more familiar with the term “self-driving cars”. I thus adopted it to attract participants.

I started introducing myself and the group by saying:

“Hi, I'm a PhD student in social anthropology. I'm looking at the social impacts and integration of self-driving/ autonomous vehicles. (The trials have been happening in London!!!) If you are interested in self-driving cars or would like to discuss the future afforded by self-driving technology along with how it could affect your daily commuting experience, you are more than welcome to join the group. Remember, you don’t need to be an expert to talk about it! All you need is imagination! Come along to the events and I'd appreciate your insights.”

The group link was also shared on my Facebook, Twitter, and LinkedIn. In two weeks, 39 members registered in the group. On the Wednesday evening of 26th February, we
had the meetup event called “Driverless Hope & Fear and Beyond” in a theatre hall at the University College London (UCL).

I arrived early and posted the event outline on the wall along with two other handmade posters: a table of the SAE automation level and a poster with three questions: (1) how much knowledge do you have about self-driving cars? Participants can mark their positions between ‘no knowledge’ and ‘expert’; (2) how do you feel about self-driving cars? Similarly, participants can mark a place between ‘negative’ and ‘positive’ on the line; and (3) would you like to use this vehicle/try in public demos? Two endpoints are ‘no, thanks’ and ‘yes, I would love to have a try’. Attendees came in from 6.55 pm. I met the first two attendees in the corridor when sticking a sign of our meetup group. Sidney, who conducts user research in the AV domain, and his friend, who ‘confessed’ that she has no knowledge about self-driving cars nor a driver’s licence. She was willing to explore the possibility of being driven by a car itself. Later, more attendees came in and I asked them to grab some snacks and have a look at the posters. Attitudes towards self-driving cars vary hugely between ‘positive’ and ‘negative’ but most of the participants show interest in learning more and experiencing it by themselves.
At 7.10 pm, we had eight attendees, me excluded. It was better than I expected since it takes commitments to join meetup events on a Wednesday evening. We had a dynamic group of attendees.

The first session was an ice-breaker. I introduced myself, followed by Anna and Damian from Eloy\textsuperscript{55}, a car tech start-up. I met them ten days ago in the tech hub. Damian drives in London while Anna uses public transport. They found pain points in transport and gaps in the car tech industry and co-founded Eloy to generate better services. Among participants, we also have Tugce, who is a UX researcher in the car industry.

\textsuperscript{55} Eloy is a car tech start-up in London. \url{https://www.eloy.co.uk/}
industry, Atul, who is a science fiction fan, and Peter, a retired electric engineer who has recently bought a Tesla Model S. He said he had been enjoying the Tesla autopilot and looked forward to seeing how the self-driving technology goes. We also have Obi, whose PhD focuses on the interactions between autonomous vehicles and pedestrians and other road users.

I asked them, “what advantages do you think self-driving cars can bring to you or society?”

“Apart from safety benefits, I would say, it gives us more freedom. Sitting in a self-driving car is just like sitting on a bus or a train where you could read, work or take a nap.” Peter said.

Tugce challenged, “but the technology may not be that feasible and you need to pay attention to the roads, then it’s not the same as sitting on a bus because you get nervous in a self-driving car, right?”

“We haven’t reached there but I think one day we will have full automation!” Peter showed confidence in this technology. I cut in and said, “I also look forward to full automation, but my concern is, there will be a certain point where self-driving cars and traditional cars run together on the roads. Many scary scenarios just crossed my mind, for example, human drivers cut in front of self-driving cars to manipulate the self-driving code/rules, and it could be chaotic…”
“It’s really about understanding the interaction. How people need to adapt to new technological trends and adjust their driving habits. And the regulation of such interactions also has a big role to play.” Said Obi.

“Back to its advantage…” Atul said, “I think it’s good for reducing pollution.”

“By reducing vehicle numbers?”

“Right, the sharing services.”

“But we’ve already had Zipcar.”

“And Uber.”

“Yes, Uber as well. So, that’s all about shared mobility. What has it to do with self-driving cars?”

It seems like my participants were not sure about how CAVs and shared mobility can walk hand in hand, how the existing shared mobility model and CAV can further innovate each other. Tie back to the planners’ SEAV assumption (see the previous chapter), it reveals another perception difference of the future possibility/social deployment of CAVs.

The discussion last for another 10 minutes and attendees mentioned other advantages such as mobility for the disabled, efficient parking and long-distance drive. “Delivery as well.” Somebody said, “If the autonomous pods or small vehicles are well designed and can run through streets and alleys, then it could be more efficient than people because people take time to find the place and they don’t work after 6 pm or on Sundays.”
But Anna disagreed with this idea. “No, there’s no control then. What if somebody else takes your stuff?”

“One U.S company, I forgot the name, anyway, a start-up from MIT designed a delivery pod and it has lockers. The consumer has to type the pin to take the items.” Atul said.

“See, then you need to wait for the parcel at home.” Anna continued.

“Exactly, if machines can do the delivery, you need people to sign it. And if it is a delivery to your company, the self-driving pod cannot communicate with the receptionist, right? You need people to do that part of the job.”

“Great. It naturally goes to the opposite aspect.” I posed the second question, “What disadvantages do you think self-driving cars may bring to you or society?”

Free debates became more intense when it came to the negative side.

“Loss of jobs.”

“Not really, it takes out some jobs but creates others.”

This argument frequently appears in academic debates. Some scholars share a
concern that automation will kill many types of jobs (Wajcman, 2017; Arntz et al., 2017) while others think alternative opportunities will be generated (Bessen, 2017). Some participants agree that automation might create new jobs, however, they are more likely to require more technical skills or higher educational backgrounds in different areas. It could thus widen the wealth gap by depriving jobs of those who are currently doing labour work that requires less knowledge or techniques.

“Loss of meanings then.”

“What do you mean by that?”

“Say, when we use shared self-driving vehicles, things are different. A car is not just a tool, a service to us. For me, I have children and I drive. I store family items in my car. It’s an extended family space. You can’t do that when you share it with others.”

The automobile was first invented to travel long distances, but throughout time, people have been adding not only physical functions (speed, safety innovation) but also social functions (car sports gathering, family trip), morality (feminism movements in a drag race), economic and political meanings (national and international car firms and oil industry), and cultural elements (car sub-cultures around the world), which I have discussed in the introduction. CAV technology does not make the car a brand new invention, rather, with connected and automated technology added upon, it is entitled to, at least, more physical functions. If the technical change detaches the richness of many of those socio-cultural meanings, people may rebalance its worthiness. On the contrary, if CAV technology both empowers a physical body and encourages socio-cultural features, for instance, extra family space for gathering and fun, it could open up more positive imaginaries and smooth integration into society.
A critical aspect put forward by Sidney was, “self-driving cars give more power to the government to control—control the cars, the roads, the infrastructures and your data.”

“Another thing I was thinking was that,” Obi said, “automated cars, whether shared or addressing last mile issues like pods, sort of discouraging active travel. People stop walking or cycling and the downside I see is the illness that might be caused.”

It reminded me of a critique coming from the Driverless Car Emulsion that automation makes people fat and lazy. I added another downside of the discouragement of active travel, “apart from physical issues, it causes mental illness and loneliness.”

“Totally! Less active travel will cause stress and anxiety. If the automated technology deprives us of our happy journeys, then what’s the point of having it?” Anna said. She continued, “I don’t see the benefits of adding more automation in public transport. DLR is automated, which is fine. But I can’t imagine the upside of autonomous buses. For me, a female passenger, if no one is regulating on-board behaviours, I fear sitting on the bus with creepy strangers and feeling unsafe. Plus, human interaction— a chat with the driver might actually be what people want.”

Commuting is not just about functionally travelling from A to B. It can also be ‘psychogeography’ (Richardson, 2015) and the ‘Flaneur’, enriching experience of the space we live in (Tester, 2014). The concept of joyful journeys was created (Harmer et al., 2019) to highlight positive feelings and wellbeing while travelling. Apart from
accessing mobility, people use transport to interact with others and reduce social isolation (Kunur and Gheerawo, 2007), as discussed in the introduction and suggested by my participant Anna. However, technology may negatively affect it. Sociologist Sherry Turkle (2011) described the phenomenon of the millennials paying increased attention to the internet while decreasing face-to-face communication as ‘being alone together’. Imagine if we use CAVs to achieve only efficient travels, ‘alone together’ will become the norm in automated pods or private-owned CAVs.

I asked them, “based on your day-to-day commuting experience in London, how would you like to use self-driving vehicles or services to improve your experience?”

“Back to the point I mentioned earlier, I want a fully automated car and I want to be set free from the driving task.” Peter said, “but then again, as Sidney said before, people ended up working more and more in the vehicle rather than focus on themselves and create a healthier life.”

At the end of the event, I passed around a diagram where I wrote aspects that are associated with self-driving cars, including ‘safety’, ‘interaction’, ‘trust’, ‘design’, ‘education and public demo’, ‘regulation’, ‘policy’, ‘ethics’, ‘cost’, ‘space-sharing’, ‘insurance’, ‘accessibility’, ‘well-being’ and ‘responsibility’. I asked each of them to select two that interest them the most. It turned out that their interests were widespread- almost all aspects of the diagram were marked, however, the most favoured ones were ‘safety’, ‘insurance’ and ‘ethics’. They suggest growing attention to how to transform CAV technology from labs to a society where complexity is embedded. Due to the COVID-19 pandemic, we did not have a following-up workshop.
as planned. But the highly engaged and curious participants continued online discussions on our platform and some of them emailed me about their commuting struggles and asked me how CAV technology can solve their problems. I did not have clear answers for them but was intrigued by their personal commuting experiences and saw the importance of investigating the day-to-day commuting issues.

2. Imagine CAVs in Everyday Life

The public’s problem-focused CAV imaginaries lead me to investigate their everyday commuting experiences, through which, an understanding of why they want to use CAV in certain ways can be formed. Besides, it can further reveal CAV possibilities in very contextual environments. In the Festival Mobility and Transportation Project, the transport issues during the Edinburgh Fringe festival are explicated, which, though not representing pain points in all transport systems, reveals some common issues such as congestion, illegal parking, and the overlap of transport services. The exposure to these issues formed some Edinburghers’ critical attitudes towards the CAV technology as they suspect it can ever address these on-the-ground issues. The personal commuting stories show more various social problems, beyond which, the interviewees imagined how CAV technology can fit into their daily journey and help solve some of the issues. Hence, the public’s engagement with CAV imaginaries contributes to understanding the current problems as well as foreseeing the possibilities.

2.1 The current pain points
I worked with the Edinburgh Living Lab on the project “Festival Mobility and Transportation”\(^56\). As pilot research of my PhD project, it enriched my understanding of

\(^{56}\) Festival Mobility and Transportation Project: https://www.edinburghlivinglab.org/projects/festival-mobility-and-
the transport system in Edinburgh, the transport issues during and beyond the festival, and different groups of people’s expectations of mobility. The project aimed to compile a body of information about mobility and transportation issues during the Festival from the perspective of different groups of people, including stakeholders, residents, and tourists. The team consisted of social researchers and data scientists from both academia and industry. My work as a social researcher involved interviews with different parties and participant observation of the traffic during the festival. The team tried to identify pain points around the city, identify machine-readable data that can provide insight into what happened, and explore possible solutions.

Below are some extracted findings from the interviews, showing the transport issues and the participants’ expectations.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Issues noticed/experienced</th>
<th>Solutions adopted</th>
<th>Expectation/suggestion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resident M</td>
<td>- Buses are packed and sometimes can’t get on; - negative impact on mental health; - “I’m commuting such a long way and sometimes not getting back until 9 pm. I find my anxiety levels going up and up” (delayed/packed buses and trains between Edinburgh and Glasgow)</td>
<td>- “I find myself altering my hours” (leave work at half-past six instead of five)</td>
<td>- more capacity - put on more double-decker buses -alternative modes: bike/on foot/rickshaws</td>
</tr>
<tr>
<td>Resident E</td>
<td>-difficult for cycling: “During the Fringe, I have a genuine</td>
<td>/</td>
<td>-less tourist driving</td>
</tr>
</tbody>
</table>
| Resident S | Illegal parking: “the whole Pleasance Road was blocked because of illegal car parking. Very annoying”  
- buses are not tourist-friendly (no clear audio reminder, no smart pay methods) | - smart pay methods/ weekly bus card  
- eco-friendly buses | Escape Edinburgh in August |
| Participant in Transport Charity | Affect schools. “There’re a lot of private schools near the city centre and Murrayfield, the parents have to travel quite a distance and spend longer time on roads.”  
- “I tend to avoid cycling because it’s really busy.” | E-cargo bikes to ship equipment between venues  
- personally change routes and avoid cycling | - less tourist driving  
- encourage walking and cycling |
| Participant in the catering business | “George Square becomes pedestrianized. It’s mostly manageable as they do allow some business vehicles in. The contractors who set up the venues take up the whole area and stop all traffic from entering”  
- “People come via taxi which creates congestion. There isn’t a really system for somewhere for them to pull in.” | “park further away and transport our deliveries on trollies to the venues” (hard for large orders) | - give areas for delivery; better communication to the contractors and security to allow for other businesses into the area  
- better provisions for taxi pick up and drop off |
| Participant from Lothian | “pavement space which already at a premium is put under significant | partnership with the Fringe to ensure buses | - always try to identify the busiest time of day/week |
I conclude six highly-recognized issues in the below diagram. As we discussed before, expectation relies on the past experience. These pain points demonstrate people’s struggles during the festival and their desires for better mobility from various aspects.
I briefly asked some of them if adding automated technologies would be helpful? One middle-aged resident laughed with his strong Scottish accent, “Ahaha, you mean putting more autonomous pods on the street?” Clearly, he had no faith in CAV’s potential contribution to less congestion (assumed by the planners in Chapter3).

A 20-ish female resident desperately replied, “Nope. It wouldn’t help. The population is doubled or tripled in summer and that’s the problem- there’s no space! Unless we have some of those flying vehicles to disperse the tourist flow.”

I recall a taxi manager’s words, ‘Identifying the issues first, like what you’re doing in this project and then think about how to use those enchanting technologies to solve them- this is always better than throwing technologies in the (transport) systems and say “okay, it’s done!”’.
This linear thinking was criticised by Urry (2004: 25) in *Automobilities* that we focus on the technical fix and try to improve cars while the real challenge is ‘how to move to a different pattern involving a more or less complete break with the current car system’. When we think about CAV or other vehicle technologies, we need to consider the transport system and further, the urban environments they are embedded in, and question ‘can such technology really be integrated into the system and solve such transport issue in everyday life?’

It implies that technological prospects and possibilities do not always meet people’s current needs. Whereas the CAV technology can potentially add value to safety, the environment, and the economy and these prospects are appreciated by the public, what’s more important for them is to solve the existing problems that disturb their day-to-day activities. In the next section, I study people’s expectations of using CAVs in their journeys.

**2.2 Shaping commuting experiences with CAV**

Expectation is recognised as a conservative teleology because of its reliance on the past (Bryant and Knight, 2019: 58). However, I appreciate its dependence on the past (especially the frustrating experience) because it awakens an awareness of “what it ought to be” (ibid.) while stimulating the imagination of “what it could be”. Having been inspired by the pilot research, I conducted more one-on-one, in-depth interviews to study people’s commuting stories. Only by knowing their daily travelling experiences—especially what kind of problems do they encounter—can I understand why certain CAV concerns and expectations are formed. Below I share commuting stories from three UK residents.
Jane, a 24-year-old student, moved to Edinburgh in late 2018. As an exchange student in history, she has few classes every week, which leaves her plenty of time to explore the art and culture of this city. The most used travelling model for her is walk. “It’s cheap and healthy, very practical” Jane enjoys walking around this walkable city and occasionally takes Lothian buses to the Portobello beach since that is an over 30-minute long walk on foot.

“I don’t think a massive use of the autonomous vehicles will happen in the next five years.” Jane said, “at least, I don’t see myself using it in five years. Not that I am extremely suspicious about the technology, but… do you remember the massive accident (Chinese high-speed railway) in Wenzhou in 2011? It caused 40 people’s deaths and injured over 150 people. The technology was not feasible at that time, I don’t know, or maybe the infrastructure didn’t match the new vehicles. Anyway, the government introduced the reduction of speed. I think it takes time for any transport technology to function well in society. So I would say, to avoid a similar tragedy, autonomous vehicles should be fully tested before the large-scale operation.”

After highlighting her safety concern, Jane continued imagining the 2030 or 2040 scenarios, where she can completely relax in the vehicle.

“When technology is mature, it will be a piece of excellent news for me as I don’t drive. At that time, I will just relax in my car without getting anxious about the road situation. So I hope autonomous cars will have more entertaining facilities. Mini theatres or even foot massage would be grand!”
I asked her if she would completely place trust in CAVs by then and would never learn how to drive. She replied, “Nope. Even it’s claimed to be 100% safe, I think I still will learn and apply for a driver’s licence. Who knows if someday I need to back up? It might just be a psychological comfort, knowing that you can come back to control.” Jane expects CAVs to allow human backup. It echoes the discussions in the previous workshops as well as the terminology investigation in Chapter 2: Human Control will certainly always be wanted.

Jad, a 27-year-old postdoc in physics, has been living in London for five years. Tubes and buses are normally what he takes to commute between home and laboratory. Uber sometimes has a role to play in his daily journey. Jad is satisfied with the wide links of transport services in London though the fare is expensive. Generally happy with the transport services, he recalled two traumatic experiences.

“I was standing on the platform and waiting for the underground. An old white guy came to me and started shouting at me. I didn’t know him and had no idea why he picked up a fight with me. His words were full of insulting racial discrimination (Jad is Asian). I was frozen there. Thankfully he walked away when others started staring at him. Although this kind of thing may happen everywhere- restaurant, bar, gym- but imagine if that was on a tube or a train and you stuck there with that person. If it goes really bad, you can’t even leave right away.”

“Another time, I was waiting for the bus to O2. 40 minutes later, the bus still did not come and I was anxious. I asked several passersby and found this bus stop was
temporarily banned. Residents nearby seem to be informed, and maybe there’s an online announcement. But I didn’t see any sign at the stop, which is weird and irresponsible.”

Apart from reliable, intelligent traffic information, Jad longs for equal and safe travelling environments. He believes that CAVs will be safer than normal cars in terms of lower accident rates. However, improving social safety on public transport, suggested by Jad, is more challenging than improving technological feasibility. Apart from racial discrimination during commutes, some other social concerns were brought up by another interviewee.

Shelly, a 34-year-old resident in Belfast, is a design thinker by profession. When she moved to Belfast, she cycled, took buses, and sometimes used black cabs as an alternative. In 2019, she bought a Golf, Volkswagen and began driving to work. Among all the travelling modes she used, she likes driving the most. But she highlights that it is not because she enjoys driving, but the freedom and convenience it provides. She believes that CAVs can further enhance that freedom.

“It would be handy to have a self-driving car. It’s good for the long-distance drive and I can just chill out in the car on my way to Dublin (Shelly is originally from Ireland) on a Friday evening after a long tiring week.” Similar to Jane, Shelly wants to be entertained in a CAV. “I can perhaps have a massage in the car, right? Or if I can get my fingernails’ done or get waxed while commuting, that will save me a lot of time. A lifesaver it would be!”
But she showed concerns about some unexpected incidents and safety issues.

“It was quite a few times where there was trouble on the buses (in West Belfast) like one day somebody threw a rock at the bus and the windows were totally smashed. We had to stop and get off the bus and get onto another one. Another day the bus driver actually nearly had a heart attack, because he was screaming so much at a woman in the car. I was so pissed off with that mad driver. It annoyed many of us, but at least, some will always say something.”

“Also, it was just funny like one day I remember I was running for the bus. The road was slippery and I fell. There’s me, two bags of mine, and a rolling broccoli on the wide ground. The busman stopped and looked at me and then he just got back to the bus and drove off. OMG. Everyone on the bus was looking at me and perhaps the rolling broccoli.”

With a reflexive mind as an anthropologist, she added, “But I wouldn’t say the bus experience is terrible. It's interesting because of the socio-economic area that I’m travelling within- you see very different, dynamic ways drivers and passengers interact. So I have concerns about getting everything automated. When unexpected social incidents occur, what would an autonomous car do? Probably just nothing, right?”

I suggested that there will be remote control and people watching the onboard behaviour through cameras. She disagreed.
“Even though somebody is watching through the camera, what happens if somebody on the bus has a heart attack or other emergent situations? And my point is, a human response is always more positive than a robotic response to humans experiencing strange events.” Shelly highlights the importance of having human support and interaction. In her eyes, automation can never have the empathy as humans do. It resonates with some participants’ views in Chapter 2 and we will discuss CAV’s lack of human intelligence/empathy in Chapter 5.

The interviewees projected their day-to-day commuting challenges onto their CAV imaginaries, in other words, when they explored the possibilities with CAV technology, a bottom-up approach that reflects existing or potential problems was adopted. The following section will further unfold the problem-focused imaginaries.

3. Problem-Focused Imaginaries: something old and something new

Influenced by the past commuting experiences and shaped by the current social realities, CAV imaginaries transcend us into various possible scenarios of future mobility. The participants see the opportunities that a CAV may bring to their everyday life and discover new uses and features through utopian imaginaries. At the same time, they concern about the issues this technology may cause, including emerging new issues and long-existed ones. The dystopian imaginaries, in particular, explicate the existed or potential issues and thus help reflect the technological and socio-political challenges we are facing.

Technology causes new types of vulnerabilities, as Jasanoff summarised three types
brought by digital technology (Jasanoff, 2016: 156): the first one refers to issues of individual autonomy. Data sets can be grouped to build a big picture of a person’s ‘identity, preference, and behaviour and thus access to a person’s thought and intention’. The second type of vulnerability is about data privacy. When people share data on the Internet, they become potential ‘subjects for surveillance, commerce, and experimentation’. The third issue regards the duration of digital data as it can last forever, outliving the human owner. Such new issues in the digital time, therefore, raise debates about ethics and law-making.

The new issues raised by CAV technology, named by the participants, are associated with its technological feasibility, data privacy, cybersecurity, new traffic rules and regulation, trust between humans and machines, and the many unknowns and uncertainties. CAV imaginaries also encourage new questions- by removing a driver out of a vehicle (who was a fundamentality of the driving task), it would be interesting to see how will masculinities and control, which have long been attached to the driver’s position, be reconfigured? And how a driver’s power will be reassigned to engineers and computer scientists (Balkmar and Mellstrom, 2018)? How will policymakers and lawyers come up with new rules to accommodate the new technologies? In the following chapters, I will study how some of these issues, especially about safety, regulation, and ethics, are considered and addressed through institutional efforts.

Apart from the new issues, the participants also brought attention back to some of the old that have long existed, marking the legal, political, and ethical holes in our social systems. To name but a few, the inequity of distribution and unaffordability of transport services, the discouragement of active travel which further arises physical and mental problems (Section 1.3), congestion, the incapacity of public transport, illegal parking
(Section 2.1), delayed services, lack of transparency around traffic information, and unsafe travel environments (Section 2.2).

I recall Jad’s unhappy experience at the tube station where he received racial discrimination and highlight the vulnerability of certain social groups when accessing transport services, which include the ethnic minority, the old, the disabled, and women (Ferreira and Batey, 2007; Martens, 2012; Lansing and Hendricks, 1967; Lopata, 1980; Rodrigue, 2016). My interviewee Shelly also mentioned her conscious resistance to Uber POOL (the ridesharing service) as it appears unsafe and risky to travel with male strangers. Sexual harassment of female passengers on rail services, for instance, was brought to light (Fisch, 2018). Gender and racial discrimination in a taxi (Hughes and MacKenzie, 2016), Uber, and Lyft network has also been acknowledged. For instance, some drivers take female passengers for longer and more expensive rides and cancel trips against passengers with African American-sounding names (Ge et al., 2016). Safety in mobility thus refers to more than travelling without collision but also travelling in a safe social environment.

One female participant who works at a technology company is frustrated with the gender gap reflected in the vehicle commercial design. The driver’s seat, she said, is designed according to the average male’s weight and height. Female drivers who are normally shorter need to adjust the seat and position themselves closer to the wheel, the dashboard, and the pedal. That means, if the airbag is triggered in an accident, female drivers face more pressure and higher risks than male drivers. The worst part is, this issue has been ignored by the industry for ages. She doubts by merely adding automated technologies or any fancy technologies that such issues will go away.
Unfortunately, she is correct about the design bias that places women in a risky position. Researchers found that men are more likely than women to be involved in car accidents, however, when a woman is involved in a car accident, “she is 47% more likely to be seriously injured than a man, and 71% more likely to be moderately injured” and “she is 17% more likely to die” (Perez, 2019: 186). Since the early 1980s, researchers had argued for an inclusive car design for women. Before 2011, however, a standard crash-test-dummy was ‘177 cm by height, 76 kg by weight’, and contained ‘male muscle-mass proportions’ (ibid.). Apart from the driver’s seat, the seat-belt design also ignored the difference of a female’s body, let alone a pregnant female’s body.

Many participants share such concerns because automated technologies will not automatically solve social problems. As scholar David Nye said, no technology ‘is, has been, or will be a natural force’ nor will any technology by itself ‘break down cultural barriers and bring world peace’ (Nye, 2007: 19). A CAV is not a one-size-fits-all solution to our transport system. We need to understand what technologies can do and what technologies cannot do (alone). And we need to explore how to better integrate CAVs into the social environment where they can bring new opportunities and address old issues at the same time. And the latter task often requires adding socio-political values and morality onto the technological invention by means of policy, law, and education to encourage and perform equality and inclusivity.

So far, my investigation of the CAV’s social integration has mapped out various prospects, challenges, possibilities, and problems from the socio-political discourses with the planners (Chapter 3) and the imaginative effects generated by the public (Chapter 2 and 4). It contributes to a presentation of how an abstract idea of technology
is imagined, discussed, and negotiated, where important aspects such as
technological feasibility, equity, social safety, regulation, and ethics come to the surface.
It also paves the way for my investigation of the institutional forces of the CAV rollout
in the second half of this thesis where the technology itself and its practical use in society are studied.

4. Conclusion

In this chapter, I joined, facilitated, and organised workshops to engage the public and
study their CAV imaginaries. It was found that the bottom-up imaginaries are (1) detail-
oriented, (2) everyday experience-based, and (3) problem-focused, though also
reflecting hope and expectations for potential prospects. The participants at the DC
Emulsion put forward both utopian and dystopian scenarios with CAV’s presence.
Some of the utopian scenarios were similar to the planners’ prospect-driven visions
where CAVs can improve road safety, mobility, and the environment whereas the
dystopian scenarios crossed over aspects such as data privacy, cybersecurity, and
insurance that were not previously discussed with the planners. At the CAV Forth
workshop, the imaginaries became more detailed and they were tied closely with the
potential users’ expectations for the autonomous bus service in Edinburgh. Apart from
technological feasibility, the participants’ imaginaries were mainly concentrated on the
accessibility and reliability of the transport service. This finding might help the planners
to step back, think and re-think about the deployment of CAV from a people-centric
approach instead of a technology-centric one that results in a chase for technical
features, functions, and prospects. Together with participants from the London meetup
group, they gradually revealed various potential problems of CAV’s social deployment,
including but were not limited to the unequal distribution of transport services, design
basis, and unclear or less updated regulatory policy and insurance.
The specific, on-the-ground, and problem-focused imaginaries thus led to a close look at people’s commuting experiences where pain points of the transport system shed light on the CAV’s potentials to address some of them, at the same time, it suggested that CAV is not a one-size-fits-all solution to all transport problems. Notwithstanding that it may bring new challenges such as data privacy and cybersecurity, the problem-focused imaginaries were rooted in concerns about the existing social problems such as gender inequity, sexual harassment, and racial discrimination during commutes. Hope the findings from the bottom-up imaginaries can encourage the top-down thinkers to enrich their visions and plans for public good.

The planners’ prospect-driven, top-down thinking in the previous chapter and the public’s problem-focused, bottom-up imaginaries in this chapter, together, form a full range of possibilities afforded by CAVs. Through an open exploration of CAV imaginaries about ‘how a CAV is perceived and imagined’, and ‘how its users are imagined and (re)configured’ (Balkmar and Mellstrom, 2018: 50), I pointed out not only the current gap between the top-down and the bottom-up approaches but also potentials about people’s sense of ‘what they can do with the technology in novel and unpredictable ways’ (Jasanoff, 2016: 144), which enables a collective, critical, and creative CAV social deployment.

Having studied how the CAV technology is understood, perceived, and imagined by different social groups, in the following parts of the thesis, we will explore how it is practically integrated into society, especially focusing on how are the institutional efforts pushing forward the CAV social deployment. In other words, it will study how CAV is politically presented (Bijker, Hughes, and Pinch, 1987) and collectively imagined and
(re)configured (Balkmar and Mellstrom, 2018) with a strong focus on some of the most important practical aspects of the CAV deployment such as safety, responsibility, and operational engagements.
Chapter 5 CAV Feasibility: the conceptualization and development of safety

After exploring the CAV imaginaries and analysing the involved fundamental topics such as trust, human-and-machine relationship, and possibilities of the tech future, from this chapter, the thesis dives into the institutional efforts on integrating this technology into society. Since safety has been the most raised topic in the CAV discourses, this chapter examines how CAV safety is conceptualised and built, with a strong focus on its technological feasibility but not excluding other perspectives. Based on the interviews and documentation of safety cases, it deconstructs safety into two dimensions: (1) functional safety that refers to the CAV technological feasibility, and (2) socio-political safety that refers to a transparent system that can explain the CAV operation and ensure responsibility, as well as a sense of safety for passengers who share automated rides with strangers and cannot immediately reach out to human authorities when encountering emergencies such as racial discrimination and sexual harassment onboard.

Chapter 5 firstly uses historical events to discuss different types of risks. Apart from technological infeasibility, faulty operation and regulation may also raise risks and lead to disasters. Safety of technologies thus refers to not only functional feasibility but also socio-political safety as mentioned above. The sketch of the automobile history then reveals people’s different and changing perceptions of risk and/or safety, which suggests difficulty in forming a CAV safety standard. Secondly, the chapter studies how do CAV planners conceptualise safety by asking a fundamental question of ‘how safe is safe (enough) for a CAV?’ While placing much effort in improving its functional safety by testing and building safety cases, the planners point out the complexity of this
question from a socio-political standpoint that improving CAV’s operation in a safe and transparent social environment also constitutes its success. Though mainly investigating functional safety, these findings pave the way for further research on how do the planners consolidate the CAV’s social safety through legislation and regulation in the following chapter. Thirdly, Chapter 5 analytically presents the dialogues with technicians and OEMs that are centred around technological feasibility and demonstrates a safety case of the CAV’s simulated test. In doing so, it elucidates the current incapability and technological challenges that are underestimated by the majority. Specifically, the current machine intelligence is not equivalent to human intelligence in terms of abilities of improvisation, flexibility, and empathy. In a short term, CAVs can only reach level 4 automation and run in the Operational Design Domain (ODD) under strict supervision. Finally, through the public’s voice, it brings attention back to the non-technical risks such as the lack of social safety and political transparency where the public’s trust in the CAV social deployment is discussed, which again, lays a foundation for the study of ethics in Chapter 6.

1. Technological Disasters and Risks

On 26 April 1942, over 15,000 people died in a gas explosion at China’s Honkeiko coal mine, making it the worst mining disaster in history. On 16 April 1947, nearly 600 deaths attributed to an explosion at a pier in Texas City during the loading of fertilizer onto the freighter. On 28 January 1986, seven crew members lost their lives with the Space Shuttle Challenger flew apart in flight near the coast of Florida. Later that year, about 60 people died in the Chernobyl nuclear accident on 26 April, with up to 200,000 unverified reported deaths as a result of the radiation in the years that followed. These tragedies are only the epitome of disasters that arise from the wide use and operation of technology. Opposed to natural disasters such as earthquakes, storms, or
pandemics, Sheila Jasanoff suggests (2016: 34) that technological disasters stand for more than failure and loss but technological governance and ‘morality tales about carelessness and overreaching’. In other words, beyond technological infeasibility, socio-political and moral factors also impact risks and/or people’s perception of risks.

Among investigations in technological disasters, Charles Perrow’s *Normal Accidents* (1984) is one of the most significant work, where catastrophic cases of nuclear power plants, chemical plants, aircraft and air traffic control, ships, dams, nuclear weapons, space missions, and genetic engineering are demonstrated and analysed.

“*Most high-risk systems have some special characteristics, beyond their toxic or explosive or genetic dangers, that make accidents in them inevitable, even "normal." This has to do with the way failures can interact and the way the system is tied together [...] Risk will never be eliminated from high-risk systems, and we will never eliminate more than a few systems at best. At the very least, however, we might stop blaming the wrong people and the wrong factors, and stop trying to fix the systems in ways that only make them riskier.*” (Perrow, 1984: 4)

The interactive complexity and interactions of multiple failures explain the uncontrollable and unavoidable accidents, and according to Perrow, the more complex the technological system is, the more likely accidents will occur. Perrow starts the book with a close look at the Three Mile Island (TMI) accident in Harrisburg, Pennsylvania in 1979. It said that Unit 2 Nuclear plant at TMI had a hard time getting underway in late 1978 because “the system is so complex, and the technology so new. Many processes are still not well understood, and the tolerances are frightfully small for some
components” (ibid.: 16). In early 1979, the Unit 2 cooling system and the polisher system started showing problems: the new reactor exhausted the conventional and old supporting systems, which were the non-nuclear secondary ones. After the shutdown of one plant, a stuck-open pilot-operated relief valve in the primary system caused a large amount of loss of nuclear reactor coolant. Later on, the chaotic operations in the control room mistakenly caused the steam pressure release. The massive radiation leak that occurred on 28 March 1979 was rated a five out of seven on the International Nuclear Event Scale and it was considered the most significant accident in the commercial nuclear industry in the U.S.

Perrow concluded this accident as a consequence of the system’s immense complexity and believed such accidents are unavoidable due to the modern high-risk technological systems. He divided the modern high-risk systems into three categories (1984: 304): (1) the hopeless systems such as nuclear weapons/power that should be abandoned because the risks outweigh benefits; (2) those we rely on and could be made less risky such as marine transport, or those worthy of taking some risks for its significant potential benefits, such as DNA research; and (3) those capable of self-correcting and could be further improved, such as highway and automobile safety. Perrow held a very optimistic opinion that the automobile is capable of self-correction and improvement. In fact, in comparison to air crashes and nuclear station explosions, automobiles caused more deaths and the death toll of road accidents has kept increasing. Despite the progress brought by the use of safe innovations (see introduction), the improvement of road infrastructures and the introduction to traffic rules, accidents occur due to higher speed and increased volume of traffic. According to the Global Status Report on Road Safety launched by the World Health Organization (WHO, 2018: 4), ‘road traffic deaths continue to rise, with an annual 1.35 million fatalities. Road traffic injuries are now the leading killer of children and young people aged 5-29 years. This
is an unacceptable price to pay for mobility.’ In other words, automobile technology contains more risks than Perrow considered.

Automobile history tells us that people’s perception of ‘what is safe’, ‘what is risky’, and how they play the ‘blame game’ can change dramatically (Vanlaar and Yannis, 2006) due to differences in cultures and traffic regulations (Hayakawa et al., 2000), which will be explained in the following writings. Regardless of approval or disapproval voices, after the mass production, car ownership soared. More cars on roads lead to more accidents. However, the freedom, convenience, and various symbolic meanings brought by a car (see introduction) did not stop people’s pursuit of using and owning them. As a result, critiques and ownership of automobiles increased at the same time. What had been changed was that people criticised careless driving more than the technology itself. American historian Peter Norton studied the evolution of traffic safety in the 21st century United States. He divided the history into four paradigms to explore ‘what is safe traffic? Whom do we protect from road accidents, and how do we protect them? Whom do we imagine when we hear about “accident victims,” and whom (or what) do we hold responsible?’ (Norton, 2015: 320-321). The first paradigm refers to the period between the 1900s and 1920s when cars were perceived as dangerous inventions and bad drivers bore most of the responsibilities. A surprising fact at that time was that the public tended to accept a very high accident rate (Eastman, 1984: 118) as a normal cost for mobility. They put blame on the technological invention rather than the use of it and enjoyed the popularity of cars in their everyday life. The indifferent attitude was criticised by scholars such as JW Eastman and lawyers such as Ralph Nader (see introduction) who pushed education and regulation forward for road safety in the following paradigms. In their views, irresponsible driving is more of the problem.
The second paradigm started from the 1920s and ended in the 1960s and was dominated by the ‘Three Es’: (highway) Engineering, Education, and Enforcement (ibid.: 326). During which, ‘control’ for highway safety became the mainstream and it required efforts from multiple parties, including infrastructure engineers, car manufacturers, policymakers, drivers, pedestrians, cyclists and other road users. In other words, cars and drivers were no longer the only ones with liability for road accidents but also OEMs and insurers. It also marked the beginning of public trust-building in broad traffic systems. The crashworthiness paradigm last from the 1960s to the 1980s. It was a rebellion against the preceding paradigm: although paying attention to safe speed and accident prevention, the ‘control’ failed to decrease the annual road accident rate in the mid-60s. The ‘crashworthiness’ paradigm reflected the driver-restraint systems (ibid.: 328) where “passive restraints” such as seat belts and airbags are a must. Traffic education and the use of seat belts became mandatory in the fourth paradigm that began in the 1980s and last until the present. Responsibility has been highlighted more than ever before. Drivers, in particular, have been assigned heavy responsibilities for themselves, passengers, and other road users.

As Norton concluded, the four paradigms reflected a constant interest in road safety that were expressed in very distinctive ways. From normalizing accidents as a consequence of car technology to reconfiguring the meanings of control and responsibility, efforts in improving technological feasibility and regulating traffic systems started walking hand in hand.

From a technical standpoint, we have witnessed and experienced safety innovations such as belts, brakes, advanced driver-assistance systems (ADAS), autopilot systems, and electrification. Today, connected and automated vehicles are considered an
important part of future mobility by the British planners because they could largely reduce road accidents, boost the economy, and benefit the environment (if combined with shared mobility and electrification). At that same time, concerns about its technological feasibility emerge. Though not as risky as nuclear power, a CAV is a complex system: any dysfunctional components such as sensors and ADS software can cause big trouble. Nevertheless, a CAV is expected to be connected to other vehicles, infrastructures, and personal devices like smartphones, being part of a bigger complex system, which contains risks of cyberattacks, data invasion and massive multiple car crashes. In terms of responsibility, a devolution from drivers to cars is raising new forms of ‘who to blame’ questions and many legal and ethical concerns. In order to explore these aspects in detail and understand whether a CAV is safe or not, above all, we need to study how CAV safety is conceptualized and (planned to be) built.

2. How Safe is Safe Enough?

Improving the safety of technology and its operation has long been wanted by policymakers, technicians, researchers, and the public. To nail the task, vital methods are proposed, including but not limited to examining the new field of risk assessment and the field of decision-making, also, examining the organizational dilemmas inherent in high-risk technological systems (Perrow, 1984: 305). From Charles Perrow’s point of view, the level of safety (or risk) of technology is associated with technology, policy, and politics, and to ‘sensibly live with’ risky technological systems, we need to be open to the public opinions and understand the political nature of risk assessment. therefore, above all, we explore the fundamental question of ‘How safe is safe enough?’ as it goes beyond the search for a safe zone where a CAV can demonstrate its technological feasibility, but leads to political questions such as ‘what is the standard of safety for a CAV? Who decides it?’ In this section, I interpret and analyse planners’
views on ‘safety’ that are extracted from my interviews and the second-hand publicly open ones. As a top priority, safety has been explored and implemented by them through discussions, experimental tests and case building to not only build robustness for its operation but also to prove it and, therefore, increase public trust and acceptance. Different kinds of challenges of setting safety standards are also explained.

**Camilla Fowler**, Principal Risk Management Consultant and **David Hynd**, Chief Scientist at TRL, a global centre for innovation in transport and mobility, shared their views (secondary interview material, see footnote 57):

---

**David**: It sounds like a simple question but it’s actually a really big, difficult question to answer. In terms of the comparison with human drivers, you could say it (a CAV) is going to be at least as safe as very good, alert human drivers who are paying attention to the driving tasks. Think about the current collisions that involve a human component, for instance, drunk driving or speeding, a CAV automatically doesn’t have any of those things. Actually, that’s a minimum and a CAV got to be a lot better than human drivers.

**Camilla**: There are two elements to it- What is safe enough or how can we demonstrate that a vehicle is safe enough to take the safety driver out? And a future question that the vehicles got to be able to demonstrate that it can actually deal with the scenarios that are likely to come across in standard driving.

But the key question for me at the moment is how safe is the trial and testing during this development phase. In other words, how can you demonstrate that your trial or your tests are safe enough to be on the UK network right now? And that’s sort of where safety cases come in, where you have that sort of structured argument and supporting evidence that says ‘yes, we’ve done this testing, this is what we’re going to be doing.

---

57 “How Safe is Safe Enough?” Interview with Camilla Fowler and David Hynd at TRL. 29 April 2020. [https://www.youtube.com/watch?time_continue=22&v=BaRCKELuRx0&feature=emb_logo](https://www.youtube.com/watch?time_continue=22&v=BaRCKELuRx0&feature=emb_logo)
How safe is safe enough? In their opinion, it is not a black-and-white mathematic question. It is hard to finalise a standard, nevertheless, they critically thought about how to assure the public that it is tested and that it is safe.

The shared expectation is that a CAV has to be way much safer than human drivers. Critically, that margin was not described. Perhaps, as they suggested, it is difficult to measure and prove ‘being safer’ or ‘safe enough’. It was also implied that in different phases- the development phase and the real operation phase, the safety standards vary.

Jessica Ugguccioni, Lead Lawyer at the Law Commission of England and Wales who is working on Automated Vehicles Reviews, shared her insights. She agreed that a CAV has to be much safer than human drivers, which is a basic standard, and pointed out that the margin of ‘being safer than human drivers’ is a key political question that needs further exploration.

Me: “Many people are debating how safe is safe, what is the standards of safety? Who's going to decide the standards?”

Jessica: “In terms of how safe is safe enough, I think the agreed, basic standard is to ensure that you’re at least as safe as the current parameter of a competent and careful human driver. That’s the absolute baseline."
“But meeting that standard would not be enough, CAVs have to be a lot safer and that margin ought to be part of the conversation, that is something that needs to be debated as a political question. This is a question of how much risk people are willing to accept from this new technology. I think most people agree it shouldn’t make safety worse.”

Jessica made a good point that ‘being safe enough’ is about finding out the level of risks that people can accept from this new technology. An additional challenge was that the accidents caused by a CAV might be different from the traditional ones. Specifically, although CAVs may reduce the overall number of accidents, people might not accept the new risks that they are not familiar with or not easy to understand:

Jessica: “Today we have things like drunk driving or drowsiness, and accidents that people understand what happened. But if the accidents caused by automated vehicles were very different and occurred in circumstances which current human drivers are not drunk or drowsy, people might struggle to accept it, even if the likelihood of it occurring is much lower.”

Jessica’s views on CAV’s having a higher safety margin and avoiding typical human mistakes, in fact, resonate with many interviewee’s expectations. It reflects that people tend to show empathy for human mistakes while having zero or very little tolerance for machine failure. In fact, an experiment\textsuperscript{58} conducted by the University of Wisconsin confirmed that people more easily forgive mistakes made by humans than AI and such

tendency is highlighted by more scholars (Chen et al., 2021). Anthropologists and psychologists provided explanations for tendency: to err is human and showing empathy to each other’s mistakes is in order to achieve harmony as empathy is critical for social functioning and recognition (Zaki and Cikara, 2015; Thompson, 2005). But some anthropologists also pointed out that the trend of anthropomorphising technology will lead to more empathic attachments to robots (Glaskin, 2012). In the case of CAV, empathy is currently rather exclusive for human mistakes but this area requires more research to constantly study the potential change in people’s attitudes and perceptions.

New risks caused by CAV technology include but are not limited to losing car control due to software shutdowns or hackings and cyberattacks and personal data invasion, which may decrease public acceptance and trust. To date, the rare cases of CAV-involved crashes are sensationaly reported in the presses like BBC and NBC News. People can normalise numerous traditional car crashes that are typically caused by human error while are far from accepting mistakes done by machines, even though they are radically less likely to happen. This is associated with trust and how to (re-)distribute responsibility. In a traditional car crash, people can typically identify a driver’s fault. But when the driver is removed and things go wrong, ‘whose fault’ is not always crystal clear. We will discuss trust in the final section of this chapter and explore ethics and responsibility from some ‘who is responsible?’ scenarios in the next one.

Defining concepts around CAVs’ safety or risks is a struggle for law-making because the law does not typically deal with statistics, said Jessica. The law asks whether

---

59 BBC and NBC reports on the self-driving car crash. 16 September 2020. Uber’s self-driving operator charged over fatal crash - BBC News. 9 Nov 2019. Self-driving Uber car that hit and killed woman did not recognize that pedestrians jaywalk (nbcnews.com)
should the accident have happened and what is the standard that has been held to. But it does not say, for example, you were driving for this many million miles and how many incidents happened- that's not how the law usually works and not how lawyers usually think about these things. She thinks it a challenge to translate the statistical approach, which seems to be the way that developers use to measure the quality and successes of technology, compared to the more normative approach that the law usually takes. We will explore the legal perspective in the following chapter, but from here, we realise that safety has different meanings, connotations, and therefore, approaches in different disciplines, which hinders from answering the fundamental question ‘How safe is safe enough?’ in any simple fashion.

Camila and David shared further thoughts on the importance of defining and proving ‘safety’ in the CAV context, focusing on its trials and tests.

Camila: I think it's important in terms of trials, testing, and the development of vehicles and it's important to have a very consistent way of showing, or demonstrating that there is a level of safety prior to testing on the road network. For which we have PAS 1881\(^\text{60}\)- it sets out the minimum requirements for a safety case. If you meet those requirements, and you build a robust safety case to demonstrate that there is a level of safety associated with your trial, stakeholders, landowners or insurers or road authorities will then give the permission.

David: I think it's important to think about the end goal as well. With the deployment of automated vehicles on the roads, one of the key expected benefits is a big improvement in road safety. So you could aim for automated vehicles having a very close to zero-risk of causing a collision or causing an injury or fatality, but that will take a very long time to develop systems to that level, and it will take a very long time to

prove that they're at that level. It is a balance to be made because if you wait that long, a lot of people will have been injured and killed in the meantime. So part of the idea is to find a good balance between what you're really aiming for the long term and being able to save lives and serious injuries already along the way as you go on that journey.

A safety case is a structured argument supported by evidence that demonstrates that a system or a product is safe. TRL helps to set safety standards and build safety cases for OEMs or CAV operators to demonstrate that they have a functionally and systematically safe vehicle and that it is safe within the environment they are embedded in. For trials and testing, TRL generally starts with a risk assessment, identify things that could go wrong, and then they identify controls (safety drivers at the moment) along with management controls in order to manage the risk.

It was said that when TRL first started conducting CAV trials and testing, they face the challenge of that there isn't any standard or regulation whilst they need to ensure that they meet the needs of research and basic road safety, and that is how safety case framework was created. TRL developed a safety case framework for the GATEWay trials in 2018, which has been subsequently developed and used in other CAV trials. Today, UK bodies such as Zenzic and Smart Mobility Living Lab (led by TRL) are uniting industry, government and academia to provide testbeds, run trials, and build safety cases. Setting standards and building safety cases thus help accumulate knowledge in this field and consolidate CAV safety in the long term.

A critical question is: “who evaluates such bodies?” Especially considering that their projects are funded by or joint with governments, industry partners, and academia.
Researchers show concern that companies who test ADS to report disengagement rate ("the frequency with which the ADS disengages and hands back control to the human safety driver") may game with it by "driving only in the safest possible areas to improve their figures and could discourage safety drivers from taking back control in dangerous situations" (Burke, 2020: 329). So how can we know it is safe when somebody, even authority, says it is safe? I put forward such questions in hope of continuous research across multiple disciplines.

3. Technological (in-)feasibility

Technological feasibility also refers to functional safety. It is a discipline foundational to advanced driving system (ADS) development in which a safety critical system is designed, assessed, and validated in a highly structured process so that the desired level of performance is met for each safety function. In an attempt to understand whether CAVs are technically safe to use and where are we now on this journey towards autonomous driving, I spoke to leading engineers in the field. Most of them expressed that the engineering challenges to develop a robust CAV have been highly underestimated and that such underestimation often leads to high expectations, false anticipations, and empty promises. Apart from the obvious challenges of building robust CAVs, many have been revealed from day-to-day activities where complexity cannot be easily translated into the tech language. It, therefore, implies the importance to realise and tackle complexity. We also learn from technicians that even facing tough challenges and technological uncertainty, progresses have been made and more CAVs have been tested in dynamic controlled environments.

Regarding the question 'where are we now on the journey of developing CAVs?' Experts at TRL said:
Camila: There has been a lot of focus on the development of the technology and focus on increasing safety cases of trials and testing. But there are still a lot of building blocks that need to be put in place to further that journey. There’s a big question of how to remove the safety driver and how to use simulation to demonstrate that a vehicle is safe. But there’s also the sort of elements that go around it – so how do you licence a vehicle? How do you demonstrate that it is safe to put passengers in that vehicle? […] In short, there are a lot of things that need to be smoothed out at the moment. Another tech challenge is if you have an automated vehicle that has been modified or a system that is updated regularly in terms of increasing capabilities or changing the scope of what it can do, then how to keep assuring that system and approving that system.

David: Going back maybe five years, there was a lot of talk about having automated vehicles by 2020. We’re in 2020, and they’re far from widespread. So I think there’s a realisation that technologically it’s a harder problem than was originally thought, and particularly the last few percent of the problem is exponentially hard and challenging.

Camila and David suggest that the technical development of CAVs faces many challenges and that those challenges are harder than expected. I decided to dig deeper to see what exactly the technical challenges are.

In Chapter 1, I briefly introduced the AI Perception-Action loop. For a CAV, there are three components to supporting its operation: perception/sensing the environment, planning/decision-making, and acting.
Pic. 5.1: How does a CAV operate 1 (by the author)

In the perception layer, a CAV needs to understand two things: (1) ‘Where am I?’ which normally requires techniques of localization and HD Mapping, and (2) ‘What’s around me?’ It needs the vehicle to understand, for instance, ‘if there is a tree or a curb or a pedestrian nearby?’ ‘How far are they?’ ‘Are they moving and how am I going to interact?’ through the uses of multiple sensors. A large amount of data will then be transferred to the AI-empowered software to help it make a decision, in other words, planning the path. Finally, the robust body act accordingly on the real roads. Each layer combines many specific techniques and so, risks and challenges.
At a PAVE webinar in early 2020, technicians demonstrated how does a CAV see the world and explicated some of the main challenges of AV perception. PAVE stands for Partners for Automated Vehicle Education, it is a campaign started in the U.S. in 2019. As a coalition of industry, non-profits and academics, PAVE aims to bring the conversation about automated vehicles (AVs) to the public. The online webinars connected many people during the COVID-19 lockdown and provided the latest insights into the field. And they helped me deconstruct CAV technology and see risks in different layers from technicians’ perspectives.

**Sam Anthony**, Co-founder and CTO of Perceptive Automata, shared his view in the webinar. He said that driving is in fact, a very complicated task: as human drivers, we take in huge amounts of information as driving down the road and we are used to that
process that we do not think about breaking the task down but when it comes to sensors like Lidar or radar, obviously there’s more than one single task that’s going on. The complexity of breaking down the driving task and tackling them with different techniques is underestimated.

Sam: We as humans don’t even realise how much we’re doing (when we drive). There’s a concept of robotics called Moravec’s paradox (Moravec, 1988), which is that the things that are hard for humans to do are easy for computers while the things that are easy for humans are hard for computers. For example, as a human, if I look out my window, in 250 milliseconds, I can tell you thousands of things about that environment. It’s not just about, oh, there’s a pedestrian out there and there’s a road sign and a mailbox and what kind of weather we have. I can tell how traffic moving and much richer than that, I could make guesses about what does that pedestrian want to do next, whether crossing the street or walking along the street or stop and I can understand how might that person want to interact with me, in what way and how am I going to change my way to correspond. So there’s this incredible richness of things and as humans, we are so good at seeing and understanding and reacting so naturally and effortlessly. But AVs don’t yet have this ability to see and to understand the environment as we do. (See footnote 61)

That says, even being equipped with the most advanced sensors, if vehicles don’t have a semantic understanding of things such as this is what pedestrians do and this is how cyclists behave, then it could be problematic for that vehicle to operate in the real world, let alone there exist bugs of detecting and recognising in the first place.

As many AI scientists who work on computer vision said, the current AI perception is immature and we need to realise that ‘to see doesn’t mean to understand’. A

---

62 Fei Fei Li. 2015 TED Talk “How we’re teaching computers to understand pictures”. March 2015. [https://www.ted.com/talks/fei_fei_li_how_we_re_teaching_computers_to_understand_pictures?language=en](https://www.ted.com/talks/fei_fei_li_how_we_re_teaching_computers_to_understand_pictures?language=en)
connected and automated vehicle can capture the winking, nodding, and other gestures from a pedestrian yet are far from being able to understand the meanings of those winks and nods. Besides, the meanings of these gestures could vary in different cultures and contexts. In the UK, for example, pedestrians and drivers share eye contact: pedestrians look at drivers and most of the time, drivers will then give a nod or a hand gesture to let pedestrians pass first. In India, however, pedestrians often walk across the streets without eye contacts with drivers because if they do, that means they prefer the vehicles to pass first.

To see, understand, and interact with improvisation requires a high level of intelligence that is beyond our current reach. For example, a CAV might be confused by a ball bouncing at it, followed by a child running after the ball in violation of traffic rules. Or, if there is a truck breaking down in the middle of the road, the CAV might just park behind it rather than divert around. These are very normal situations in our everyday life and we could imagine trickier scenarios. Can a CAV recognise a pedestrian who is in her dinosaur-style Halloween costume like most people do? If not, will a CAV divert around another vehicle in a potential collision and choose to run over the ‘dinosaur’ instead?
As Sam said that we have made signs of progress in terms of improving maps and cameras and various techniques and they contribute to the CAV’s perception of roads. However, human consciousness is irreplaceable by these technological improvements.

**Sam:** Unlike traditional maps or GPS, HD maps start recognising a whole bunch of different layers of the world. As one component that helps the vehicle to perceive and understand the road network and think about what to do next, it also includes the smartness as human drivers who learn from experience, like how to assess pavement conditions and how to respond. However, sensors and localization and other sorts of technologies still can’t empower AVs with our consciousness, memory and intuition. So we are facing many technical challenges of AV perception.

Human consciousness on roads often reflects on an ability to improvise, which creates space for flexibility and empathy. When people drive, they may break some traffic rules to show empathy and kindness without raising big troubles. For example, some ignore red lights and speed up in order to send a person in danger to the emergency room. Will a CAV do the same? Or will it stick to traffic rules only? It is important to be law-abiding yet under some circumstances, empathetic and humanised decision-making is expected and appreciated.

At a transport conference, an engineer mentioned some tricky scenarios and urged the development of smart sensors that are able to tell some nuances. He said, as we see in downtowns and on motorways, many advertising boards contain car images- will the

---

car image on advertising boards confuse automated vehicles? Possible. Also, he reminded us that sensors on CAVs are very expensive. What if a CAV drives itself to a traditional car wash station and the rough cleaning damages the sensitive and expensive sensors? Despite tricky scenarios, the harsh reality is that self-driving cars can be fooled by unclear and inconsistent white lines on the road. In one experiment (the video is not open to the public), researchers drew a big white circle on the ground. When the automated car entered the circle, it kept driving around without getting out of the circle. The devil is in the detail—daily and unexpected details. As we think more about day-to-day activities, we can name trickier challenges for CAVs running through CBDs or our neighbourhoods.

From the perception layer to the planning layer, artificial intelligence (AI) plays a bigger role. It is often in the form of deep convolutional neural networks that interprets multiple sensors’ outputs. There are debates among technicians that we do not have the ‘real’ AI in CAVs yet, what we use is rather advanced machine learning (ML). Apart from the technical debate, there also exist philosophical discussions about ‘what is AI?’, but here, I do not explore the philosophical definition or connotation of AI or ML. I asked Tom Webster, Chief Technologist at CPC, to distinguish AI and ML in the simplest fashion.

Tom: “AI is a very broad term. Machine learning is one branch of AI relating to a software algorithm that is trained to perform a task by learning through experience. Data processing in an ADS (Autonomous Driving System) broadly fits in two top-level tasks (a) Object/event detection (b) Path planning.”
“ML is generally accepted as state of the art and necessary for various ‘perception’ tasks involved in object/event detection, such as identifying and categorising objects from image data.

“For path planning, some developers are also advocating ML approach for this, although others are using more conventional software programming and it is debated whether this part of the system should be regulated to conventional techniques so the system relating to the control decisions made by the ADS can be formally verified.”

In this layer, Tom said, no matter they use ML or traditional approaches, it is extremely difficult. It’s a challenge about seeing all the possibilities and managing complexity that involves many factors. Developing ADS to plan smart paths is thus considered as a challenge of taking complexity as standard by many tech firms, especially software-focused AV firms.

I asked Tom to explain the difference between automation levels, which I found confusing.

Me: “Some tech firms and car manufactures claimed that they’ve already reached automation level 4 while some suggest we are merely at level 3 even 2. The definition of automation level seems blurred. I’m wondering what’s level 3 and what’s level 4? And where are we now?”
Tom: “Regarding level 3 and level 4 the difference as defined in SAE (J3016) is that for level 3 a human is responsible for being ready to fulfil fallback whereas for level 4 the system is responsible for fallback. So if a deployment involves a human monitoring the real-time driving task and ready to intervene for safety reasons etc., then the deployment is not Level 4.

“This issue becomes confused by the technology companies’ PR/marketing it as level 4 to boost investor confidence whereas in reality they don’t have the technical enabling regulations/maturity/confidence/insurance to deploy without some human responsibility for the driving task.

“As far as I am aware true level 4 has only been deliberately executed in controlled environments and not on open public roads – Waymo is still using a remote supervisor.”

SAE J3061 as he mentioned, was launched in 2019 after the first deployed graphic in 2016 because the Technical Standard Committee saw the need to further explain the features at each automation level. Compared with the initial version, it clarified humans’ responsibility at each level with examples. In line with this explanation, we are somewhere between level 3 and level 4 because these two levels share many common features but level 3 CAVs require a human to drive and at the moment (2019-2020), we cannot remove safety driver’s input, either technologically or by law. In other words, level 4 CAVs exist only in specific operational design domains (ODD).
Having combined Tom’s explanation with the SAE definition, I interpret the automation levels in a simple fashion: from a human driver’s perspective, how s/he plays a role in driving:

**Assisted driving:**

- Level 0: human driver is in full charge of the vehicle;
- Level 1-2: human driver drives, assisted with either/both steering or/and speed; attention on roads is a necessity;

---

Automated driving:

- Level 3: human driver doesn’t drive, but might be asked to drive to maintain safety; attention on roads is required;
- Level 4: human driver doesn’t drive, but might be asked to back up; attention on roads is required;
- Level 5: human driver doesn’t drive, the vehicle is in charge and attention on roads is not required.

Technicians critically pointed out the challenge of misleading advertisements and promotions. They believe it is dangerous when advanced driver-assistance systems (ADAS) are branded as self-driving and that automation level 3 is branded as level 4 or even higher. The risk thus does not only reside in the technological infeasibility but also the overestimation and bragging in commercialization.

In terms of the execution layer, CAVs are tested in two ways- on the real roads or through simulation. I was fascinated with simulation technology when I watched videos about the simulated cities and how these environments can help CAVs do constant ‘road training’.
One case is that Five is digitalising London for safety tests with simulation. They spend a long time collecting knowledge of traffic domains on London streets, for instance, what do different pedestrians look like and how do they behave. The vehicle captures images from the real world and starts building an understanding of how the world works. But real road tests have limitations in terms of how many miles can be driven, for example. Simulation is thus used as a supplement to testing CAVs and enhancing technological feasibility. This is an ambitious project while building digital replicas of the capital city itself is a difficult and time-consuming task.

**Case: Building digital replicas of London**

By Team Five

“Think of simulation, and the images your mind conjures up will likely have been shaped by simulations in popular culture, from video games to innovative virtual reality experiences. These tend to be high-fidelity, realistic worlds that excite the mind precisely because they’re copied from life as we know it. This kind of photoreal simulation has an important application in the development of autonomous vehicles,

---


principally for the development and testing of ‘perception’ — how our car ‘sees’.

“Let’s take a moment to circle back to the ‘why’ that drives all this. Within a simulation, we can run a scenario a billion times, taking all possible movements and interactions into account, so the car’s ability to perform safely is rigorously tested. It would be impossible to do this in the real world — it would take decades, damage the environment, and might put road users at risk. Meanwhile, we can simulate an entire day of driving in just one minute.” (Team Five, 2019, see footnote 66)

From testing through simulation, FiveAI moves to test tracks and then runs road tests in London and other areas in the UK. Their team members suggest that there are certainly things that they have discovered or encountered on public roads in London, which they might have not encountered in those prior environments. London is a dense urban environment where behaviours of other road users become incredibly relevant. Safety is the priority of developing CAVs, but they said that adopting a very, very cautious or defensive driving style is not always compatible with keeping up the traffic

---

67 Same as above.
flow in places like London. For instance, if a CAV drives in such a cautious way in London and try to leave a large distance from the vehicle in front of it, then typically other drivers will choose to cut in to step into that space. Manipulation of CAVs is another risk that is associated with ethics and regulation, which will be discussed in detail in the next chapter. The ‘cut-in’ behaviours bring challenges that a CAV may not necessarily encounter in the simulated environments. In other words, simulation cannot replace but only support CAV road safety testing.

In general, we can currently test CAVs in ODD with safety drivers’ presence and we face many technical challenges that turned out to be harder than we thought. And as the exploration went deeper, technicians specified more issues and challenges and encountered new ones. As robot scientist Chris Urmson, who heads Aurora Technology, a San Francisco startup developing a robotic driving system for commercial vehicles and passenger cars, concluded:

> Chris: Unlike developing a web application or even a consumer electronics product, we have to tackle everything from the optimal electronics with the sensors, the electronics for radar and the high-speed computing and networking that happens in the vehicles through the software infrastructure that allows us to implement sufficiently real-time systems. The complexity of taking the signal coming back to the sensors, interpreting that, generating a model of the world, predicting how that model is going to evolve over the next few seconds, figuring out based on how the world evolves, how do we pick a safe path through it, translating that into something the vehicle can understand of how it moves through the world. And then adding on top of that the fact that we’re driving a multi-cam thing through the world. We need to be doing all that at a very high level of reliability, robustness, and safety.

---

The CAV infeasibility brings questions about safety and creates new types of risks. Apart from technical challenges though, we also came across some socio-political ones, such as the inaccurate understanding and exaggerated commercial promotion. In the next section, we will have a close look at some of the social aspects of CAV’s safety that affect the public’s trust.

4. Socio-Political Safety Concerns and the Public Trust

In this section, we look at the socio-political safety of CAVs with the public and study how could the potential safety issues impact on people’s trust level. Trust is a complex and elusive concept that is affected by many factors such as subject and context. Among all considerations, sexual harassment, racial discrimination, and the lack of transparency in (black box) data processing consist the public’s major socio-political safety concerns. Below, we discuss these aspects in detail.

Considering that level 5 automation will not be achieved soon, human-automation coordination is expected for level 3 or level 4 automated vehicles to mitigate human biases (bad decision-making, drunkenness, drowsiness, etc.) and monitor autonomous driving once encountering emergency (system collapses, for instance). This process requires additional trust concerning micro interactions between human users and automated vehicles as well as macro interactions on public roads that are associated with people’s perception and acceptance. Underlying these topics is trust, which is also tied with and affected by the ‘sense of control’ and ‘human-and-machine relations’ as discussed in chapter 2.
Trust is a complex, philosophical, multi-faceted concept, operating at “timescales of seconds to years and mediates how people rely on, accept, and tolerate technology” (Lee, 2020: 67). Largely driven by commercialization, research on trust emerged in explaining how people adopt new technologies in diverse domains (automation, e-commerce, sharing economy, etc., see Cunningham and Regan, 2019). It was found that human responses to humans are parallel to their responses to technologies (Reeves and Nass, 1996) and it was easier to win trust by designing anthropomorphized technologies such as humanoid robots (Robertson, 2007). These findings further opened the discovery of human-and-technology trust. Having critically built upon studies of human-and-human and human-and-technology trust, Lee and See (2004: 54) defined trust between humans and automation as “the attitude that an agent will help achieve an individual’s goals in a situation characterized by uncertainty and vulnerability”. It emphasises technology’s functional ability to meet humans’ needs and wants. A recent focus is ‘how accessible that functionality is?’ (Lee, 2020: 84) and it highlights an urgency of building trustworthy automation. Trustworthy automation, in Lee’s eyes, deserves trust for its reliable technology and its accessible and equal services for the public. Trustworthiness and ethical implications of technologies (Etzioni & Etzioni, 2016) thus started raising research attention.

In the domain of CAVs, trust and its relations to various social factors are studied under the exploration of public acceptance. Some researchers justified their concentration on this area, ‘unless there is societal acceptance of CAVs, the potential benefits will not be achieved’ (Horberry et al., 2018). There is a confusing logic here: ‘which comes first? Public acceptance or technological benefits?’ Putting aside my doubt about setting an end-goal of improving public acceptance so that CAVs can benefit society, research on
creating trustworthy CAVs is undeveloped. Creating trustworthy automation, as I believe, should be the end-goal while an increase of social acceptance as a natural result. As mentioned above, trust is a complex concept and it is affected by different factors and contexts. I remember discussing this with a middle-aged interviewee who works in a wine shop. He asked me if I trust using CAVs myself? I expressed my positive attitudes toward technology and my willingness to try CAV services. He challenged me by asking whether I feel equally comfortable to leave my grandma (who does not drive) alone in that same vehicle? He saw my hesitation and said, “I know it’s tricky, right? You might want to change your answer, especially when it comes to family members who are either old or very young. Say, I am a parent to two boys- eleven and nine- I’m very blessed. So, even though I’m happy to try technology as much as you do, I’d have concerns if school decides to use autonomous buses next month.”

Another participant expressed a similar view. She said that parents of small babies may have different feelings of relinquishing control. For drivers who normally have a responsibility towards other passengers, the shifting of power and control from themselves to vehicles may cause anxiety and mistrust. Especially if they are owners of the automated vehicle, even if they didn’t drive, whatever happened could still be on their conscience. Hence, trust is closely tied to the contexts.

Age, gender, and culture all affect public acceptance and trust of CAVs. Males are found to be less concerned about CAV-related issues than females (Schoettle and Sivak, 2014) and young people are found to be more open to CAV technology than the old (Becker and Axhausen, 2017). A further study suggested that old people tend to trust their experienced driving skills while having limited knowledge of new technologies (Abraham et al., 2017), which explains the different acceptance between
the young and the old. People’s acceptance also varies from culture to culture. For example, Schoettle and Sivak (2014) compared the different concerns about CAVs between UK and U.S. residents. UK residents tend to raise concerns about cybersecurity and question interactions between CAV and pedestrians/cyclists while U.S. residents show more concerns about data privacy and interactions between CAVs and traditional cars. Among the UK dialogues happening in meetings and conferences, I indeed noticed more attention centred around cybersecurity risks and potential solutions rather than data privacy. Such differences can further shape policies with a different focus- it deserves further and continuous research, however, it is not my main concern in the chapter. Apart from these factors, Lee (2006) and Norman (2004) spotted how people’s emotional attachment to vehicle brands affects their trust in CAVs.

Trials and demos are important ways to engage the public and enhance their trust in this technology but there are limitations. David Hynd, Chief Scientist at TRL expressed that since most people won’t have the opportunity to engage directly in the trials or demos, there is a communication challenge to make sure that people are reassured that a reasonable robust process has been carried out in evaluating the safety of the vehicles. He thus emphasised the importance of having a rigorous approval process. David’s colleague Camilla Fowler, Principal Risk Management Consultant at TRL, added that making this approval process transparent will help build public trust in CAV trials and testing and further deployment.

TRL’s view made good points: improving public trust is about addressing fears. There are fears around technological safety and security, and there are concerns about the transparency of the CAV testing approval process. As the participants emphasised, using CAVs to travel in a safe social environment is by no means less important than
improving its physical robustness. We have also discussed this highly recognised risk in Chapter 3. The participants have trust issues partially because the lack of human supervision in automated vehicles may worsen bad travel behaviours such as racial discrimination and sexual harassment. This concern has been mentioned by many participants in my fieldwork.

Anna: “If we share an autonomous taxi or an autonomous pod that has smaller space, other passengers’ behaviours affect us more. Personally, that social factor worries me a lot. Even that I trust the technology of self-driving, it can’t assure me of travelling safely in a safe and comfortable environment.”

Anisha: “You see George Floyd’s tragedy raised more attention these days and there’re powerful protests happening globally. Some people say it’s too much. I say, if they are fed up with racism news, then imagine those who experience racism every single day, perhaps during their commuting to work. When that happens, human drivers on buses, for example, may stand out and say something. But if there’re only passengers there on an autonomous bus, they may not necessarily be willing to intervene because they don’t have the duty to stop those behaviours. Or simply because they feel they aren’t in the position to do so, not like a staff member on board, you know? So it’s risky without regulation and intervention right away.”

Peter: “I don’t trust cameras or the so-called remote control for autonomous cars in a

---

69 The police’s killing of George Floyd, an African-American man, opened up the Black Lives Matter movement and global protests against racism since 25 May 2020. [https://blacklivesmatter.com/about/](https://blacklivesmatter.com/about/)
way that they can’t really help when there’s an emergency. Also, what if somebody sabotages the software or spray something on the camera?”

Apart from technological feasibility, the concept of safety in the CAV context also includes broad aspects such as whether the in-vehicle travelling environment is safe, whether passengers’ personal data is safe, whether there is a clear boundary of responsibility-sharing when encountering incidents, and so much more to explore.

Most public members I interviewed have no CAV-ride experiences or professional knowledge about CAV technology. I asked if they can give some suggestions to carmakers or tech firms in terms of how to present CAVs to the public and ensuring them that the vehicles are technologically safe? Shelly, a 34-years-old Belfast resident, insisted that CAVs should be set with a speed limit that is lower than the traditional cars.

Shelly: “It is essential because the speed limit is closely tied to responsibility. When they slow down the speed of self-driving cars, my level of trust in those cars would increase.”

In her opinion, the lack of speed regulation increases the risks of road accidents caused by potential technological failures. It is fascinating that she tended to assume that CAVs would be faster than normal vehicles though she can hardly explain why she had this imagined higher speed. Her trust for the use of CAVs largely depends on the technical regulation and governance. Opposite to her opinion on the speed limit, Jad, a 27-year-old London resident, suggested that CAVs should go as fast as they can
once they are approved feasible to run on the roads.

_Jad:_ “As fast as possible- isn’t efficiency one of the end goals?” But he highlighted that the promise is technological safety. _“With more precise navigation techniques and better brakes, CAVs should drive themselves up to the max safe speed limit.”_

I asked him what is the max safe speed in his eyes? He said, this is what he expected carmakers to set well for CAVs.

_Jad:_ “The majority don’t know much about the specific technologies behind self-driving cars, nor traditional cars. But what we have now is some readable safety factors, for instance, if you want to buy a car, you compare several cars by looking at the numbers that tell you the capability of engines and the distance it takes to stop at a certain speed. With CAVs, more data need to be visualised for users to understand. And then we will know more and trust more.”

Whether it is setting speed limits or measurable CAV safety factors, Shelly and Jad expressed a wish to quantify safety risks and make technological feasibility easy to understand, moreover, to see transparency in its operation and regulation. The risks they recognise reside in both the technology and its operational systems where socio-political complexity is intertwined. And it is the interaction of these complexities, as Perrow (1984) said, increases risks and causes technological disasters. Other commonly raised types of risks that affect the participants’ perception and trust are associated with data regulation and identification of responsibilities in CAV accidents.
Jad admitted that technology brings various risks and challenges but, at the same time, technology could help come up with solutions. ‘It is a shame that we haven’t used many good technological ways to address issues.’ As mentioned before, Jad proposed to quantify CAV’s feasibility and set safety factors that could be measured and easy to understand. However, as some researchers (Burke, 2020: 329) pointed out, in this stage, “due to the rarity of fatal crashes in terms of kilometres traveled (despite the large overall number of deaths), it is difficult to convincingly demonstrate that automated vehicles are safer without traveling a prohibitive distance”. I agree that from a technical standpoint, Jad’s idea of quantifying safety makes sense, but based on our discussions so far, we understand that many socio-political and ethical parts of safety as well as people’s different perceptions of it are difficult to be measured. CAV safety, after all, is not just a technological challenge.

Jad believed that CAV-related data, despite the highly sensitive commercial ones, should be inclusively shared in a transparent system. One example he gave is that people started placing trust in digital money such as bitcoin because there is a transparent platform- the Blockchain network-where everyone plays a role in regulating and protecting everyone’s legal rights. Jad believes we need similar regulatory platforms for CAV’s eco-system.

_Jad: “When somebody violates the traffic rule or you meet frauds finding fault with you, you take a picture and upload it to the platform where everyone can see it. It’s for the public to identify bad behaviours, enhance awareness for self-protection, and it is evidence for the authority to investigate. The authorities should also have open digital platforms for people to report and complain and the whole process should be_
The ‘Black Box’ worries many participants. For instance, Shelly said it could be a technology that is open to being manipulated.

Shelly: “It is not clear to the public what kind of data will be collected and how will they be processed. Imagine in an incident, if the black box information is not on an insurer’s side and they manipulate it for premium… or they manipulate data in a way that protects VIP users. Unlike a smartphone or a 3D printer, an autonomous vehicle is something that may bring people in dangerous situations where they could be facing a huge financial penalty and even jail time. The risks and repercussions are higher. If there’re no clear and transparent solutions to the black box issue, I doubt many would ever trust AVs.”

Black box data is only one factor that affects the CAV incident’s investigation and the purpose of such investigation is to find out the responsible party. I asked many of my interviewees about their opinions on the CAV crash and who should be responsible- their various opinions and ideas unfold some fundamental legal and ethical questions. When imagining a CAV crash that inevitably will collide with a pedestrian or another road user, many participants find it difficult to make the decision on whom to avoid and whom not to because of the morality involved. Philosophers and psychologists designed and conducted many ethical thought experiments in the CAV context and we will have a close look at some of them in the next chapter. One participant, Jane, emphasised that it is unethical to let anyone make such decisions.
Jane: “I don’t think anyone has the right to make that big ethical choice, not policymakers, not software programmers, not ethicists, because when they choose to avoid one party in a collision, they basically give a death penalty to the other party— that’s the type of power that decides life and death and it terrifies me if a car firm, for instance, has the say for that circumstance.”

It goes back to the political question of ‘who decides’ that has been constantly put forward by different parties throughout this study. I asked Jane, putting aside the ethical decision, if the collision happens, who should take the responsibility?

Jane: “It’s hard to say. I think it depends on the specific occasion, say, first, we need to confirm whether the car is on the self-driving mode or being driven by a person. Then perhaps check who else is involved—pedestrians, cyclists, other cars, or if the self-driving car just collides with some infrastructure by itself? But these circumstances can be tricky because the technology is just new to us and the regulation is lagged behind, I think. The car has risks in terms of technological maturity and the holes in the legal systems could amplify that risk and pose different threats like insurance disputes.”

Shelly also has a concern about CAV insurance: “Traditionally, an individual is insured. But who is insured in the context of autonomous cars? The ‘driver’? The user? or the car itself?”

Jad believes that the car company has a major responsibility. I asked him why so and why not the software firm or other technology partners?

He replied: “When the car company decides to cooperate with a certain tech firm, the products or services must pass the safety tests set by the tech department of the car
firm before getting manufactured. Eventually, it’s the car company that combines techniques and go marketing, being known to the customers with their brands, like BMW or Volvo. Think about Toyota’s car recall in 2009, the accelerator got stuck. Whether the accelerators are directly made by Toyota or outsourced by others, it is Toyota facing the public blame and dealing with the incident. So I think it’s the same for self-driving cars, if things go wrong, the car firm needs to take a big part of the responsibilities.”

Though believing it is the car firms to blame, Jad mentioned that other parties may also take small proportions of responsibilities, and that the proportions need to be re-measured and re-set by policymakers and lawmakers in the new context. Overall, non-technical risks raised by the interaction between technology, morality, and socio-political environments encourage thinking about how does legal institutes react to this technology’s social deployment. Apart from CAVs, emerging technologies such as drones also bring ethical issues and risks about ‘privacy, safety, enforceability, crime, nuisance and professionalism’ and underlying most of these themes is trust (Nelson and Gorichanaz, 2019: 101131). Governance and regulation of such technologies are considered as solutions to these potential issues and enhance public trust and acceptance. Because researchers (Gutteling et al., 2006) found that with higher levels of trust in governance, people place more trust in applications of technology and are more likely to accept and use them. Transparent and democratic governance of technology is thus called (Jones and Salter, 2003) to provide the availability of information and engage the public in decision-making. We will further explore some of the ethical and legal challenges of CAVs as well as how do planners address them through governance and regulation.
Conclusion

Let me briefly summarise the key findings in this chapter. First, through historical events of technological disasters, we found that safety is conceptualised from not only a technical perspective but also socio-political and ethical ones that are often associated with the technology’s operation and regulation. Besides, people’s perceptions of safety/risks shift throughout time in the auto industry. CAV safety building is thus more of an ethical work when it comes to social integration into people’s everyday life. Although it is difficult to answer the political-oriented question of ‘how safe is safe (enough)?’ and set a safety standard, the planners have been exploring this field with a focus on the CAV’s functional safety as well as the socio-political environment where it is embedded. Second, in terms of technological feasibility, we found that the various technical challenges have been underestimated by the majority. After discussions with the technicians and the study of a safety case, we found that, aiming to reach level 4 automation, the current CAVs show incapability of improvisation, flexibility, and empathy. This is because machine/AI intelligence is not yet equivalent to human intelligence. In a short term, only a fleet of CAV service can be expected to run in the Operational Design Domain (ODD) under human supervision. Third, some socio-political safety concerns were elucidated by the public in specific scenarios. Underlying their different perceptions of the CAV safety/risks are trust issues that are complex and contextual. For instance, even some people feel confident in trying out this technology, it does not mean they feel equally confident to use a CAV on a daily basis to pick up kids from school. A recent survey supports this view as it found that 85% of participants were at least concerned when asked if they ‘would allow your child to ride in the [fully-automated] car by themselves?’ (Cunningham et al., 2019). Such concern also encourages us to question what roles would legal institutes play in ensuring the non-technical dimensions of CAV safety in its social deployment? In the
next chapter, we will mainly look at the legal and ethical aspects of the CAV social deployment.

Despite my initial attempt to deeply engage with technicians in this part of my technography and draw out insights into CAV’s technical feasibility from different perspectives, my biggest finding in this chapter is to explicate the vital but underdeveloped aspect of CAV’s social safety.

As I explained earlier, safety in mobility refers to more than ‘zero collision’ but also social safety. The elderly, the disabled, and women were most vulnerable due to the poor transit service and lack of automobile ownership (Lansing and Hendricks, 1967; Lopata, 1980; Rodrigue, 2016). For instance, sexual harassment has long been a threat for females to use public transport (Fisch, 2018) and ride-sharing services. Discrimination against females, the old, the disabled, and ethnic minorities create an unsafe feeling among them and an unhealthy social environment for all transport users. Such problems will not be solved with the development and improvement of CAV technical feasibility alone but require more efforts to improve commuting environments and social equity overall. In other words, as I argued, CAV is not a one-size-fits-all solution to problems in the current transport system.

The findings in this chapter further led me to question how planners ensure both technical and social safety, ethic, and responsibility through a legal approach. In the following chapter, I discuss these aspects in detail.
Chapter 6 CAV Ethics and Legislation: beyond the Trolley Problem

In this chapter, I explore institutional efforts in the CAV ethics and legislation. Before diving into the legal approach to the CAV ethics, first, I reveal four major institutional forces that affect the ethical settings. These four forces consist of technicians, academic researchers, industry stakeholders and insurers, and policymakers. Alongside analysis of their values and priorities, I discuss a power re-distribution between the tech firms and the regulatory institutes. Since CAVs have no human driver but a ‘black box’, policing and regulating require data access and knowledge to process it. My lawyer interviewees confirm such challenges. Due to an ethical demand for a CAV UK legal framework, lawyers who either are policymakers or advise policymakers prioritise ‘knowledge update’ through training and collaboration and highlight the importance of improving explainability of CAV-related investigation and regulation.

Second, I introduce Zigon’s (2007) notion of a ‘moral breakdown’, which highlights a conscious reflection and/or decision-making for ethical practice. It paves the way to an understanding of the CAV deployment’s ethical demand for legislation and regulation. To explicate morality-focused debates and ethics-focused practice in the CAV context, I demonstrate two thought experiments- the Trolley problem and the Molly problem. The former thought experiment opens up discussions about who to spare in a car collision while the latter one focuses on receiving answers to specific questions that can help build and regulate CAVs, for example, it studies the public’s expectations about the self-driving software recall ability. After analysing the various responses to the Trolley problem, on the one hand, I acknowledge its theoretical contribution to studying sociocultural diversity, though it can hardly guide the CAV ethics-building. The
Molly problem, on the other hand, helps the planners to narrow down an ethical focus onto the explainability of the vehicle’s behaviour. It also implies the public’s expectation for clarification of responsibility and transparency in the investigation and communication process.

Finally, I study the ongoing process of the CAV legislation with the Law Commission of England and Wales and the Scottish Law Commission. Their ambitious three-year (2018-2021) project contains three consultation papers, which, similar to the Molly problem, aim at studying specific and practical aspects such as civil and criminal liability. For example, ‘HARPS’ (highly automated road passenger services), as their newly proposed legal concept, represents an effort to differentiate responsibilities between the CAV operators (who hold a licence) and users/passengers. Such ethical practice helps eliminate or reduce the possibility of taking human users as a scapegoat when a collision happens. However, the lawmakers suggest challenges to implementing a single national system for the CAV operation. Specifically, Northern Ireland is not yet included in this dialogue for historical and political reasons and local authorities such as Transport for London disagree with the Law Commission’s proposal. Although such political tension is not the main focus in this chapter, it reflects various barriers to the CAV ethics and legislation, suggesting that this ongoing process requires continuous studies.

1. Who Sets the Ethical Settings?

Before diving into legal efforts in making the CAV ethics, we need to look at who are involved in this dialogue and set the ethical settings for autonomous driving? What
are their ethical considerations and what do they value? How might their choices affect the CAV ethics and legislation? In this section, I explicate four major institutional forces in this field along with their ethical considerations and/or priorities.

Technicians such as software programmers seem to have direct control and dominant power of ‘coding’ ethics into CAVs. But based on my fieldwork, it is clear that the field of CAV/machine ethics has been affected by at least four institutional forces: first, builders and developers who have technical backgrounds; second, academic researchers, especially ethicists and social scientists; third, industry stakeholders; and fourth, policymakers. Though having a common ground—emphasising safety as the highest priority—these four institutional forces address safety from different approaches and weigh different sub considerations over the others.

First, the CAV builders and developers who have technical backgrounds aim to minimise the harm that is reflected in both scope and number and the ultimate goal is ‘zero accident’. Apart from improving algorithms, they build overall feasibility, for example, by developing sensors that have a better capacity for lane recognition and advanced machine learning that process data at a higher speed for motion planning. I mentioned the Trolley Problem to four technicians during the fieldwork and they were all familiar with this thought experiment. Either over the phone or from face-to-face meetings, I can sense their disdain for this cliché, though to a different degree. ‘It’s an interesting moral debate but also a distraction to what we do… and it’s funny. Why do we have to programme who to KILL (by prioritising one party’s life not the other’s, this action is considered by Alan as to sentence the other party to death)?’ Alan, CAV technologist, said, ‘What we focus on are CAV’s safety and robustness
and what we do is improving and assuring safety rather than playing any thought
experiments.’ Agreed by an engineer from Toyota, who I encountered at a transport
conference, ‘Philosophers spend decades on those imagined scenarios but they
don’t have an answer, do they? Don’t get me wrong, I’m not saying that the
philosophical debates are not important. But that’s not our expertise. We have a
straightforward task: we need to put safer and safer cars on roads.’ These findings
suggest that the group of technicians are not very much involved nor willing to be
involved in the non-tech focused debates. Rather, they value and focus on
developing technology’s feasibility (functional safety).

The second institutional force refers to ethicists and academic researchers who have
created various scenarios such as the Trolley problem to discuss ethics and morality.
Beyond drawing attention to morality, another distinctive contribution is that they
stress the importance of the socio-technical transition to highlight equity, fairness,
transparency and other social value (Holstein et al., 2018; Boeglin, 2015; Sylvester
and Raff, 2018). Social researchers have long reminded us that offsetting
technology’s alluring promises, there exist three problems: risk, inequality, and value
of nature (Jasanoff, 2016). None of these social problems are new, but technology
may trigger new vulnerabilities and amplify some of the problems. For instance,
digital technology brings issues of individual autonomy as sufficient personal data
could allow picturing an individual’s behaviour, identity, and even mind, and digital
information can last long. Besides, while using data from the internet, people become
subjects for surveillance (ibid.: 156). In the CAV domain, we have discussed some of
the social issues based on my empirical data and literature (see Chapters 3 and 4).
Through the lens of ethics, some researchers analysed responsibility and political
transparency in particular.
For instance, studying policy and ethical implications of AI systems, Cultural Anthropologist Madeleine Clare Elish (2019) introduced the concept of a ‘moral crumple zone’. It was used to describe how ‘responsibility for an action may be misattributed to a human actor who had limited control over the behaviour of an automated or autonomous system’ (Elish, 2019: 40). Before applying it to the AV context, Elish gave an example of the crash of Air France Flight 447 where blame was put on the pilot despite many other factors that may cause the crash. In this case, due to the lack of certification process that recognises the autopilot’s malfunction, the human pilot became the ‘moral crumple zone’. The Volvo-manufactured self-driving Uber car’s crash in Arizona in 2018 was analysed as another example, showing that “intelligent and autonomous systems in every form have the possibility to generate moral crumple zones because they distribute control, often in obfuscated ways, among multiple actors across space and time” (ibid.: 54).

The flaw of the autonomous driving system as well as the absent-minded safety driver both attributed to the crash. However, after a quick investigation, the initial response from the police was that the human driver should retain all responsibility. This event caught much attention through media: researchers in and outside of this field and concerned citizens joined the investigation by collecting reports, comparing footages, conducting interviews, and pushing authorities to give the truth. Two months after the crash, the U.S. National Transportation Safety Board (NTSB) released a preliminary report, detailing the technological failure and concluding that it lacks a federal standard for autonomous driving systems. NTSB’s attitude towards self-driving crashes has been constantly passive- punishing the human safety drivers on all auto-control modes. Often raised by industry stakeholders to protect the

---

institution’s benefits (eg. reputation and finance), such constant blame on human actors has been identified and mocked as “a common feature of self-driving car innovation” (Stilgoe, 2018: 41). These studies call for a clear distribution of responsibility between humans and machines, and between multiple human parties in a transparent system. The group of scholars and researchers have thus been trying to draw other parties’ attention back to social responsibility and transparency and open up more discussions.

The third institutional force consists of industry stakeholders and insurers. During the fieldwork, I have heard representatives from insurance companies giving presentations at transport conferences. They emphasised that offering new packages of insurance policy in the CAV context is a new challenge and promised to work closely with tech firms, car manufacturers, policymakers as well as the police (for collaborative investigation of car accidents). The new insurance package was not explained nor was ‘HOW’ they are going to accommodate CAV technology with the insurance policy. I tried to reach out to insurance companies. The only one who replied to my request played tai-chi: ‘it’s a quite new and complex area. We are working closely with policymakers and technicians on this to make sure that we offer the best insurance services to our customers. At this stage, we cannot give you a clear answer because we have gaps in knowledge of this technology… and I cannot share commercial information.’ It was frustrating to not directly access useful data from the insurance industry, especially knowing that they play an important role in shaping the CAV ethics. It is also hard to tell whether the rejections to my research request are due to the sensitivity of commercial data or the insurance companies’ incapability of making the CAV ethics.
Sociologist Zelizer (1979) has long emphasised that insurance reflected social values and had an impact on them. Among marine, fire, and life insurance, she particularly focused on changes in life insurance’s popularity in the U.S. The sale of life insurance in the U.S. began in the 1760s but only till the mid-19th century did it achieve success. Zelier (1979: 2) thus asked, “what explains the strong and prolonged resistance of Americans to buying life insurance and what accounts for its unusually rapid success in the 1840s?” Apart from the economic growth that largely changed Americans’ consuming behaviour, she pointed out a fundamental transformation in American values. Life insurance was once considered as a betray of God’s wisdom but the liberal theology that emerged in the 1840s acknowledged its participatory role in managing life and death, which changed people’s perception, attitudes, and acceptance, and revealed its nature- ‘management of death’. The sanctification of life insurance encouraged its commercialization. Life insurance promoters took this opportunity to emphasise that life insurance can provide human control of life affairs. Fatalism was thus, to some degree, conquered by the set of values of having control over one’s own life through the purchase of life insurance. Besides, through the lens of children’s insurance along with the compensation for the wrongful death of children, Zelizer (1994) discussed the transformation in the economic and sentimental value of American children. Child labour was prevalent before the 19th century. However, a change was noticed between 1870 and 1930 that children were seen as an object of sentiment rather than an object of utility, especially by the growing middle class. The adoption of children insurance reflected not only changes in morality and societal value, but its close tie to the economy, which stimulated its popularity and the later set of trust funds for children. Managing different kinds of risks, insurance as a tool, mirrors socio-economic changes and affects social value, morality, and decision-making.
One of my participants stressed the power of insurance and this industry: (in the CAV context) ‘If the law says that under such and such circumstances, you can be “hands-off” and let the autopilot drive, even if the car crashes, it’s not your fault. Fine. But if the insurance company says, without backing up under that circumstance and the car crashes, you lose all your compensation. Well, that means, even by law, you can do this, out of financial considerations (fear of losing compensation), you will do the opposite. It drives people’s choices and that is the power of insurance!’ I appreciate his point and agree that insurance is playing a big role in the CAV deployment. The implication is that facing conflicts or inconsistency between law and insurance, people may seek grey areas or even break the law/rules consciously if the financial benefits outweigh legal consequences. This finding suggests collaboration between policymakers and insurers and further clarification on law/rules.

The lack of access to insurers led me to reach out to the last institutional force: policymakers, especially those who directly work on the CAV legislation (lawyers who are either policymakers or who advise on the CAV legislation). In doing so, I form an understanding of legal efforts of the CAV social deployment. Legal Anthropologist Laura Nader (2002) who revealed the erosion of plaintiff’s power in the U.S. judicial system in contrast to the increasing dominance of large business corporations and the prominence of neoliberal ideology, showed the role of law in struggle for socioeconomic justice. She urges anthropologists, lawmakers, and other social scientists to recognise the centrality of law in social change. I acknowledge the centrality of law and decide to study lawyers’ values and approaches to setting an ethical code. Their views and values directly affect the legal framework and thus have a powerful and long-lasting influence on the CAV ethics. Before that, I explain the CAV ethics and point out an important shift regarding the planners’ focus.
2. The ‘Moral Breakdown’ in the CAV Domain and the Shifted Focus

The terms of morality and ethics seem interchangeable in everyday use and the meanings contained by them appear similar on the surface. Within the field of Anthropology, there has been a debate about whether to make a distinction between ethics and morality. In this chapter, I do not wish to dive into this debate but rather to explore the ‘moral breakdown’ (Zigon, 2007) in the CAV context. Specifically, in this section, I explain the CAV-related ethical dilemmas in two thought experiments and unfold the planners’ shifted focus, which implies their current and forthcoming effort to integrate the CAV technology into society.

The moral breakdown, as Zigon (2007: 133) explained, refers to a moment that needs to ‘consciously consider or reason what to do’ and it ‘shakes one out of the everydayness of being moral’. It implied a disconnection, tension, and even contradiction between everyday morality and ethical choice. In Zigon’s ethnography of the moral breakdown of a Muscovite woman, the participant skipped a long queue and got onto the train without a ticket. As a good Christian, this action was against her value but she made this hard choice to ensure herself on board on time to visit her aunt. Another time, her husband who had left her and their son for ages came back for money. She hated that man but acted against what she would have chosen to do. She eventually lent him money to embody God’s morality as a good Christian. Zigon captured her ambivalence and self-contradiction and further suggested that the ‘moral breakdown is able to isolate moral conceptions and ethical tactics for analysis’ (ibid.: 147). Zigon considered the moral breakdown to be similar to the Foucauldian notion of problematization, which refers to a conscious practice of freedom to
question and reason oneself. That says, the moral breakdown contains a ‘freedom that allows ethics’ (ibid.: 137) to make a decision. In other words, the moral breakdown is made based on certain socio-cultural values and possibilities but is not limited by them.

Zigon (2007, 2010) also discussed the ethical demand for action, performance, and keeping things going. It is this demand that drives the moral breakdown as a tactic decision-making and returns it to the unreflective everyday life as a practical code or guidance. In the domain of CAV, the planners are facing this ethical demand to legislate and regulate the CAV operation. Its moral breakdown started with a study of the public’s morality and values in a car collision scenario, which is also known as the Trolley Problem thought experiment, but the planners’ focus shifted onto ensuring responsibilities, which was reflected by another thought experiment called the Molly Problem. Below I first fully explain these two thought experiments, their differences, and analyse the planners’ focus.

2.1 The Trolley Problem
The Trolley Problem was a famous thought experiment put forward in the 1960s (Foot, 1967). Since then, it had been extensively analysed in the following decades (Thomson et al., 1976; Kamm, 1989; Unger et al., 1996). The initial scenario of the trolley problem is: a running trolley is about to run over five people tied-up on the main track. You happen to stand next to the lever that controls a switch. If you pull the lever, the trolley will be redirected onto a side track so that those five people will be saved. However, a single person is lying on the side track. You are facing a moral choice: would you sacrifice one person to save five people?
With the rapid development of artificial intelligence and automated machines, this thought experiment has been widely applied to discussing how automated vehicles make moral decisions since 2010 as one of the latest instantiations of Latour’s (Latour and Venn, 2002) cases of delegating morality to technological artefacts. The most raised questions include: in an unavoidable accident, who will an automated vehicle run over? Will it sacrifice in-vehicle passengers to save pedestrians or vice versa? Will it divert around a mother with a newborn baby and hit an old man instead? Will it sacrifice one person to avoid killing a group of five?

Before autonomous driving, human drivers also need to make a decision about who to spare (and who not to) in an unavoidable crash. Such ethical questions did not raise as much as attention like today. Normally, human drivers try their best to minimise harm. As my interviewee Jad commented on this, ‘You try not to hurt

71 Picture of the Trolley Problem: The new coronavirus pandemic cannot be seen as a moral dilemma of the 'trolley problem' for public management – Admethics
anyone, then whatever happens, just “顺其自然” (let it be).’ However, the introduction
of the CAV technology recasts people’s appreciation of ethical dilemmas that
question: what decisions will an automated car make under such circumstances?
How does it make such decisions? What kind of criterion does it hold? Does a CAV
evaluate the number of people that are involved in the event and prioritise a bigger-
sized group? Or does it put age, gender, race, class, and other factors into
consideration?

From my perspective, beyond the appreciation of ethics, the prevalent discussions of
‘who will a self-driving car kill in the Trolley Problem scenario?’ reflect two things: (1)
people’s eager to understand ‘once handing in power and control to an automated
vehicle, how will it make decisions?’, and it further implies low trust in technology
compared to human control; and (2) people’s wish for clarification on socio-political
aspects, such as who sets the ethical settings (eg. programmers or policymakers)
and what do they value? Fundamentally, they want to know how will the changes
brought by the CAV technology affect their life.

Based on the trolley problem, MIT Media Lab launched the ‘Moral Machine’ survey in
2014 and completed it in 2018. This moral machine experiment is an ambitious
project as ‘no research has previously attempted to measure moral preferences
using a nine-dimensional experimental design in more than 200 countries’ (Awad et
al., 2018: 63). The nine dimensions refer to sparing humans (versus pets), staying on
course (versus swerving), more lives (versus fewer lives), men (versus women), the
young (versus the old), pedestrians who cross legally (versus jaywalking), the fit
(versus the less fit), those with higher social status (versus lower social status),
characters who are included in some scenarios (eg. criminals, pregnant women or
doctors) versus those who are not included. A total of 40 million decisions were collected and analysed at four levels: (1) global preferences, (2) individual variations, (3) culture clusters, and (4) country-level predictors. The results suggested the difficulty of reaching a universal agreement: ‘even the strongest preferences expressed through the Moral Machine showed substantial cultural variations in ethical judgements’, therefore, aligning machine ethics with human values is challenging as humans often experience ‘inner conflict, interpersonal disagreements, and cultural dissimilarities in the moral domain’ (ibid.)

Critiques of such thought experiments kept emerging. For example, Julian De Frietas, a researcher at Harvard University, acknowledged the trolley problem’s theoretical contribution to psychology but not policy. He said that the limitation of thought experiments is that they force people to make a moral decision between one or two predetermined choices. But when De Frietas and his team asked people directly, “Do you endorse the idea of programming vehicles like these to make decisions on whom to kill based on these sort of factors?”, and less than 20% of people think that’s a good idea.” I partially agree with De Frietas that such thought experiments contribute little to policymaking. The predetermined choices, in his eyes, limited the public’s freedom to make a moral decision. But from my perspective, they entitled the planners with the freedom to make ethical decisions and build the CAV ethics and/or its legal guidance, which is reflected in the Molly Problem thought experiment.

2.2 The Molly Problem
In the past two years or so, the Trolley Problem was out of favour among the planners while the Molly Problem received more attention. There are two major
differences between the Trolley Problem and the Molly Problem: first, unlike the Trolley Problem that was initially set in a broad context to discuss ethical dilemmas, the Molly Problem was designed in the specific CAV context to explore how to ensure responsibility. Second, the Trolley Problem mainly makes theoretical contributions to ethics while the Molly Problem has practical ones that push forward the CAV social deployment. The planners’ shifted focus from the Trolley problem to the Molly problem thus shows the institutional effort of the CAV practice.

The Molly problem was generated from a 2020 discussion in the ITU group. ITU stands for the International Telecommunication Union- it is the United Nations specialised agency for information and communication technologies, consisting of top engineers and computer scientists. Although the Molly problem has been conceptualised as an alternative thought experiment to the trolley problem, unlike the trolley problem which only aims at theoretical discussions, its mission is to practically serve the OEMs and policymakers: the findings from the Molly problem survey are expected to support and facilitate the identification of requirements for the data and metrics to help shape global regulatory frameworks and safety standards for self-driving software\textsuperscript{72}.

So far, the preliminary results based on about 300 responses (ITU, 2020) have been launched. Below, we discuss the scenario, the findings, and how do they serve the planners to shape the CAV ethics.

**The Molly Problem**

\textsuperscript{72} Introduction to The Molly Problem: [https://www.itu.int/en/ITU-T/focusgroups/ai4ad/Pages/MollyProblem.aspx](https://www.itu.int/en/ITU-T/focusgroups/ai4ad/Pages/MollyProblem.aspx)
**Scenario:** “A young girl called Molly is crossing the road alone and is hit by an unoccupied self-driving vehicle. There are no eye-witnesses. What should happen next?”

<table>
<thead>
<tr>
<th>Questions</th>
<th>Yes</th>
<th>No</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Would you expect the self-driving software to be aware of the collision?</td>
<td>97%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>2. Would you expect the self-driving software to stop at the collision site?</td>
<td>94%</td>
<td>2%</td>
<td>4%</td>
</tr>
<tr>
<td>3. Would you expect the self-driving software to indicate a hazard to other drivers?</td>
<td>97%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>4. Would you expect the self-driving software to alert the emergency services?</td>
<td>94%</td>
<td>1%</td>
<td>5%</td>
</tr>
<tr>
<td>5. Would you expect the self-driving software to recall the time of the collision?</td>
<td>99%</td>
<td>1%</td>
<td>/</td>
</tr>
<tr>
<td>6. Would you expect the self-driving software to recall the location of the collision?</td>
<td>99%</td>
<td>1%</td>
<td>/</td>
</tr>
<tr>
<td>7. Would you expect the self-driving software to recall when the collision risk was identified?</td>
<td>93%</td>
<td>1%</td>
<td>6%</td>
</tr>
<tr>
<td>8. Would you expect the self-driving software to recall if Molly was detected?</td>
<td>96%</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>8. Would you expect the self-driving software to recall if Molly was detected as a human?</td>
<td>91%</td>
<td>3%</td>
<td>6%</td>
</tr>
<tr>
<td>9. Would you expect the self-driving software to recall when Molly was detected as a human?</td>
<td>90%</td>
<td>3%</td>
<td>7%</td>
</tr>
<tr>
<td>10. Would you expect the self-driving software to recall whether mitigating action was taken?</td>
<td>98%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>11. Would you expect the self-driving software to recall when mitigating action was taken?</td>
<td>97%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>12. Would you expect the self-driving software to recall what mitigating action was taken?</td>
<td>96%</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>13. Would you expect similar recall abilities for near-miss events?</td>
<td>88%</td>
<td>7%</td>
<td>5%</td>
</tr>
<tr>
<td>14. Would you expect driving to be prohibited for software</td>
<td>73%</td>
<td>12%</td>
<td>15%</td>
</tr>
</tbody>
</table>
In the paper ‘moral breakdown and the ethical demand’, Zigon (2007: 148) expressed that ‘we not only witness how individuals and social groups respond to the breakdown but, perhaps more importantly, we are better able to see the ways in which the moral dispositions themselves are shaped and reshaped’. Similarly, here, instead of analysing the public responses, I would like to draw attention to how did the ITU design this survey to serve practical purposes. The questions in the Molly problem survey show a strong focus on the self-driving software’s recall ability in both collision and near-miss events. In other words, explainability-develop the software’s capability of explaining situations to the public and make the process transparent-is considered by the planners as key criteria. It is interesting that all questions received a dominant ‘yes’ response and the ‘yes’ responses were highlighted in the publication as if they proved the planners’ hypothesis of these practical questions that can help decide to what extent to develop the software’s recall ability, or rather, to what extent to regulate it if not meeting the expectation. Echoing the second difference from the Trolley Problem (mentioned at the beginning of the section), the Molly Problem was well-designed/consciously designed to solve problems in the CAV context. The questions thus have a strong intention to test people’s agreement level on improving the software’s recall ability to ensure responsibility. In other words, the Molly Problem can also be seen as a breakdown of a ‘moral breakdown’ that is very specific and straightforward.

The ITU Group said that the findings will be considered by OEMs, insurers, standard bodies, and regulators (ITU, 2020). On 2 March 2021, a collaborative webinar was set among them to discuss the Molly problem and how to build a regulatory
framework for automated driving that can ensure a transparent and no-blame culture. We do not know to what degree the findings from the Molly problem survey will be eventually considered but it suggests that the planners have certain freedom to make the final ethical decision based on both the public’s responses to the moral breakdown and their expertise. As an early effort in building a legal framework, we do not yet see specific codes or concrete ethical settings, but the planners have reached a point as they believe the automated driving systems should be designed in ways that enable their decisions to be explained. In the webinar, the planners, especially the policymakers explained the challenges of introducing new technology into existing legal frameworks and the opportunities created through domestic (the UK) legal reform.

3. Ensure Responsibility: who to blame?

Since the planners’ focus has been narrowed down onto ensuring responsibility, in this section, I explore ‘who to blame’ in a CAV accident with an influential lawyer in this field to show the current issues, challenges, and efforts that have been placed to address the issues.

Alex Glassbrook, who works at the Temple Garden Chambers in London, is a barrister and writer on Law of Driverless Cars (Glassbrook, 2017). He has been working with the Law Commission of England and Wales and advising policymakers on the CAV legislation. Before taking my interview, he kindly gave me an introduction to the legal background of automobiles in the UK. He said it had been a controversial issue for many decades before the British law was brought in to require anybody who

73 Recorded webinar ‘A Regulatory Framework for Automated Driving: the Value of in-use Data for Creating a no-blame Culture of Safety’: https://www.youtube.com/watch?v=8ZNh_XipR4Y
uses a motor car on a public road or in a public place in the UK to be insured against the risks of injury and damage to the third parties. Because the insurance industry was uncomfortable with the idea that it would have to provide insurance cover, as a matter of law. It was eventually enacted in the first of the road traffic acts in the 1930s (Merkin and Stuart-Smith, 2004), which clarifies that the central part of British tort law on cars is compulsory third party motor insurance because it means that anybody who is injured by the fault of a human driver is more or less guaranteed compensation.

I realised a problem: all of the tort law including insurance law is based upon a human fault because it is the fault of the driver whereas in a CAV, the driver is removed. From what we have discussed above, cases that involve advanced technology often find programmers or human operators at fault. I thus raised questions of 'in a CAV-involved crash, in the first place, is it a human fault or robot fault? How to evaluate it? If the cause of the accident is associated with human parties, who is responsible? Can users of a CAV receive (full) compensation by law?'

3.1 The AEVA 2018
Alex mentioned the Automated and Electric Vehicles Act (AEVA) 201874 as the very first stepping stone to address these questions- Part 1 of the 2018 Act is designed to provide compulsory insurance for that situation and at the heart of it is civil liability (Part 2 mainly focuses on issues related to electric chargers). Its importance is highlighted because the act is not only about motor insurance but an attempt to answer the fundamental question “who is liable for a car?” It starts to explore

essentials in the CAV context, for instance, the circumstances in which cars will be the liable object and the vicarious liability for that car. It also starts to set out the causation conditions of the payment of compensation and deals with the defence of contributory negligence. Hence, although AEVA 2018 is a very high-end piece of legislation, it shows legal efforts into accommodating new technology.

“The conceptual problem is that at level four and five, the human driver isn't involved anymore. It's a decision by the sensors, the software and the hardware of the car based on what we might call artificial intelligence. So, the law hits the problem immediately—how do you legislate for robot responsibility?

“When the 2018 Act was going through Parliament, this was the central problem. Broadly, two solutions were available. One was to make it a question of product liability. That's to say, a question of whether the car was a defective product. And the other was to extend, somehow, our existing system of compulsory third party motor insurance based on human fault to robot actions. The solution that became the 2018 Act was the extension of the existing regime of compulsory third party motor insurance against human fault to robot actions. The reason it was chosen legally is that product liability presented many difficult problems.”

The problems Alex talked about include two: first, British modern product liability law does not regard software as a product. So software that's downloaded over the air,

---

75 When the UK law to embody the European Community directive (1985) was enacted, software was not made explicitly exempt, but 'product' was defined in such a way that it is not clear whether or not software was included. Resources from OpenLearn on software and the law. See on 9 June 2020.
https://www.open.edu/openlearn/science-maths-technology/software-and-the-law/content-section-6.4
as every piece of CAV software and every piece of ADAS software is likely to be, is not a product within the legislation. The second problem of product liability as the basis for compensation is practical. Because product liability is a much more expensive piece of litigation than regular litigation about road traffic accidents. It is technical and highly dependent on experts and the costs of it can be enormous. Insurance companies would have no real underwriting data upon which to measure the risks and potential costs of road traffic accident litigation brought on a product liability basis. And the victims of automated road traffic accidents would very often lack the financial means to investigate and pursue product liability claims for injury. Due to such legal and economic reasons, the solution was to avoid the product liability approach and instead to extend compulsory third party motor insurance for human fault into robot action.

The interesting phrase “robot action” caught my attention. I always find lawyers meticulous and precise at expressions, so I assume Alex must have good reasons for using this term. I asked Alex why he used “robot action” rather than “robot fault” in contrast to the use of “human fault”? He explained that he does not use “robot fault” because the 2018 Act does not really talk about fault. Instead, it talks about accidents that are, at least, partly caused by an automated vehicle when driving itself at level four and five, when it does not need to be monitored by an individual.

“I think is quite significant that the Act does not talk about fault in relation to primary liability (the situation is different in relation to contributory negligence, where the Act seems to introduce the fiction of a human driver).
“On primary liability, the Act talks about causation. Here we hit one of the major conceptual questions - not just a legal concept but a philosophical concept - behind automated vehicles, because the vehicle will drive according to its algorithm. Unless there is a defect, (for example one of the sensors says it’s not working properly because of a fault in the equipment, or there’s a software problem in its programming). These cars will do what they’re programmed to do. So they won’t probably be any question of it being at fault. If there’s a fault, it would be the fault of the programmer or the manufacturer. But that would be the question you’d be asking in a product liability case. So the question is, in what we call a regular liability case, how will the courts translate what have always up until now in questions of human fault into questions of robot actions. I’m not convinced that the word ‘fault’ crosses over from the human area into the robots.”

In Alex’s eyes, the Artificial intelligence we have today is not sophisticated enough to make decisions, so it would not be able to make mistakes (the so-called robot fault). If things go wrong, the cause resides in the algorithms programmed by people or the robust body manufactured by people. It means that robots take actions accordingly, which could passively lead to problems and that human parties retain legal responsibilities. The human and robot areas are thus distinguished. Alex’s emphasis suggests an attempt to avoid a ‘moral crumple zone’ (Elish, 2019) as well as his value of enabling explainability and transparency in the process of judging and evaluating a CAV’s action. It still needs exploration to clarify, though, which human party/parties to blame in specific scenarios. If we review the self-driving Uber crash in Arizona in 2018, the hardest task is to identify whether tech firms, programmers,
manufacturers, or safety drivers cause this human fault? Till 2021, it remains one of the most challenging tasks.

Alex used the concept of contributory negligence as an example and shared his insights. This concept, he said, in its modern form is still quite new. Applied to road traffic accidents, it goes back to the 1930s.

“It’s a difficult subject when applied towards automated vehicles because again you come across this having to bridge the difficult conceptual gap between human responsibility on one hand and robot actions on the other. We humans are able to adjudicate human ethical questions, even though ethical questions are often very difficult, because there is a great deal of emotional and instinctive response behind that. So we don’t find ethics a difficult area to comment on.

“By contrast, commenting upon whether a computer or a robot has followed its programming is a highly technical and difficult area. It’s not helped by the fact that laws have to describe these things in words. Laws break these ethical questions into pieces that can be used by judges when giving judgments, and by lawyers when making arguments. It’s also challenging for a draftsperson writing the language of a statute. For example, the language in the section on contributory negligence is not easy at all. That’s not a criticism at all: it’s language facing a set of serious philosophical questions.”

Breaking fundamental ethical and philosophical questions into measurable pieces in the language of law appears a big challenge. What the 2018 Act is doing, for
instance, is to make the insurance company or the owner strictly liable for the acts of the automated vehicle, which is considered by policymakers as the first step. Second, in the exercise of comparing the fault of a victim and faulted robot, what the Act does is to introduce a legal fiction that the robot is actually another human driver. However, it is not immediately clear as a very dense piece of wording.

Me: “Could you tell me a bit more about legal fiction? Is it often used?”

Alex: “In order to make the dispute comprehensible and capable of resolution, the law occasionally uses substituted approaches when it hits difficult problems.”

Me: “Any example?”

Alex: “The example I used in my paper for the Law Commission is, how does the law resolve the problem of causation in medically very complex cases where the precise cause of disease simply isn’t known. And one of those examples is mesothelioma, where you cannot tell which fibre, the inhaled industrial material caused the injury. You can’t tell because the science isn’t available. And in that situation, what happens is the traditional test of causation is adjusted. And those sorts of adjustments I think are probably how the law is going to cope with this.”

It implies that the legal institute needs to decide when to process new regulatory policy and make adjustments according to the availability and development of technology. The relationship between technology and law has been discussed by
many scholars. For instance, Law Professor Ralph D. Clifford (2012: 2) said that the creation of new machines and improvements of tools have always been ‘a motivating force of change in law’ so that when a new technology transforms society, there would be responsive rules. But the law is often claimed to fail to keep up with new technology, especially in the regime of digital technologies (Jones, 2018) and in face of the intensification of nonhuman intelligence (Hildebrandt, 2015) such as the personal digital assistant that affects fundamentality of personhood, privacy, and individual autonomy. These technological changes thus bring unfamiliar challenges to the law and make it lags behind. And it is true in the case of the 2018 Act: to date (interview with Alex in May 2020), the AEVA 2018 act has not been activated after appearing on the statute book in July 2018. Because it is waiting for the described technology (level 4) to appear. It means that the Act will be brought into force when Level 4 is reached. This fact explicates this relationship and from a legal perspective, it is also a strong piece of evidence against the commercial claims made years ago that ‘we’ve already had level 4 automated vehicles’!76

3.2 “Black Box”: policing and insuring
Although the 2018 Act addressed important civil liability aspects in the CAV context, I am curious about some other critical questions associated with the CAV ethics. Centred around the ‘black box’, these questions are actually raised by my participants from the public: What kind of data will be collected in the first place? Will it cause personal data invasion? How would such data help CAV-crash investigation? Technology is controlled by the big players and data could be manipulated, what if insurance companies or tech firms change it for their benefits? These questions reflect common concerns about the transparency of the investigation process and

---

76 Due to interruptions of the COVID-19 pandemic, the CAV tests have been delayed and thus affected the legislation process. The Act has not been in force to date (10 May 2021).
imply the power redistribution between tech firms and law and enforcement.

Law and enforcement used to have dominant power on roads in terms of regulating and investigating accidents. Policing on the public American road in the 20th century was criticised for its abuse and penetration of such dominant power into citizens’ daily driving experiences not only to drivers but also to those who were in the car. Sarah A. Seo, a legal historian of criminal law, identifies the “automobile paradox” that the modern symbol of freedom offered by the automobile also represents “the most policed aspects of everyday life” (Seo, 2019: 301).

“Traffic laws, and the power of ordinary police officers to intervene in citizens’ lives, have been shaped not only by law enforcement and lawmakers and judges, but also by prejudice and fear and hatred. Traffic policing has had enormous consequences for everything from our expectations about order, to our capacity to move through space without harassment.” (ibid.: 300)

She pointed out that by law, to search a citizen’s property such as a house, the police need a warrant. However, when they stop a car on road, though the car being a citizen’s property, normally the police ask for the driver’s and sometimes the passengers’ ID and then, perhaps, search the car without a warrant. Seo also stressed the fact that the police tend to implement their power to certain groups of people, for instance, black people and the working class who normally drive cheap cars. Such discretionary policing disrupts the meaning of freedom and raises social problems that are related to class, race, and gender. Her critiques reflect some important social problems in the traffic regulatory system and explicate the power of
With the development and deployment of the CAV technology, power has been re-distributed between tech firms and law and enforcement. First, in the future, road regulators may stop a car without any humans on board. In that case, it is impossible for them to play hard and do the traditional searching or policing. Second, road regulators and lawmakers without a technical background or relevant training may not understand the information stored in the ‘black box’, thus not being able to make clear judgements on road situations. Let alone they may not have (full) access to the black box data in the first place. Road regulators can no longer perform traditional regulation and the new form of policing in the CAV context is thus data surveillance and data access controlled by the tech firms/OEMs.

This change poses new risks such as data invasion, cyberattack, and data manipulation that are out of traditional regulators’ hands. Putting aside these potential issues, I wonder how would law and enforcement cope with the change and address all sorts of new risks. I sought legal approaches from lawyers Alex and Jessica.

Me: “what kind of data and whose data will be collected? Who has access?”

Alex: “In terms of black box data and who controls the black box data, this is quite an interesting issue because Data Protection Law tends to approach these questions from first ‘who is the subject’? If the subject is the driver, then arguably it’s their data.”
But if the subject is something else, the car for example, then the answer might be slightly different. My inclination is to think that the law will tend to adopt an expansive interpretation of that. There is potential for arguments about the rules for disclosure and evidential arguments surrounding black box data. For example, it’s in the insurance company’s interests, as the company liable under the Act, to have full disclosure of this information. Transparency might also be in the manufacturers’ interest.”

Jessica: “The insurance companies are very much leading in this field because they will need a lot of data in order to be able to reallocate the responsibilities that they will be under the 2018 Act. So there will be a lot of pressure from the insurance companies to have access to information. We’re in discussions with police and the kinds of powers that they have in terms of accessing information, but there’s going to be a really interesting point about what information gets recorded in the first place in the black box, which it’s referred to as the event detection recorders (EDR) now. These conversations are happening very much at the international level.

“Depending on what happens with that then there’s a question of who has access to this information, and we think it’s a very important question to ask at a domestic level-who should have access to the information? And that is something we’re going to be looking at in our next paper (referring to the consultation papers, which we will discuss later).”

I showed concerns about CAV builders or insurers holding and/or manipulating data. Alex said that his concern would not be so much that there are conspiracies on the
commercial side, but that court procedures and court rules as to disclosure keep up with the particular situation, and are able to police it, both in terms of law enforcement and in terms of court procedures.

“When I spoke at a conference about cybersecurity a few years ago, I made the point that at the moment, there’s a concern that police officers do not have adequate training and equipment to download information from cars at the scene. I think that's the capability that has to be looked at. Since then, the Home Office has actually said the need to train and equip police officers to gather evidence in those situations is something that they’re aware of.”

In Section 3, we found that the policymakers recognise their main challenges of the CAV ethics as having access to essential data from the tech firms/OEMs (power regain), being able to understand the technical information (knowledge update), and demonstrate a clear legal framework and transparent investigation process to the public (explainability). As discussed, these changes and challenges reflect a power re-distribution between the law and enforcement and the industry (tech firms). In order to trace data and ensure responsibility, the policymakers have been exploring these areas. For instance, the example of the Law Commission of England and Wales using consultant project to build a UK CAV legal framework is demonstrated in Section 4. Besides, it analyses the involved planners’ value, priority, and some of the achievements so far.

4. Building a UK CAV Legal Framework
Legal efforts are not merely shown in active discourses and the single *AEVA 2018*. In this section, I place my analytical attention on the consultation papers released by the Law Commission of England and Wales between 2018 and 2019. The consultation papers reflect collective wisdom from multiple parties who are directly or indirectly involved in the field of CAVs. As a milestone, it tries to deal with some fundamental questions as well as open up thought-provoking ones. Till the end of my fieldwork, two have been completed, leaving one to be finished by the end of 2021.

4.1 The consultation papers

The Centre for Connected and Autonomous Vehicles (CCAV) has asked the Law Commission of England and Wales and the Scottish Law Commission to undertake a review of the legal framework for automated vehicles and their use as part of public transport networks and on-demand passenger services. Holding three objectives: ‘(1) consider ways to assure safety both before and after the deployment of CAVs; (2) provide clear allocations of liability in both civil and criminal law; and (3) remove unnecessary blocks that might delay the benefits of driving automation to mobility and productivity’ 77, the law commission started this three-year project running from 2018 to 2021. It contains three rounds of consultation:

1. In November 2018 we launched our first three-month consultation on safety assurance and legal liability. We published an analysis of responses and interim findings in June 2019.

2. Our second consultation paper on highly automated road passenger services (HARPS) covers the regulation of remotely operated fleets of automated vehicles and their relationship with public transport. The second consultation paper was published

---

77 Consultation papers on automated vehicles (2018-2021), Law Commission of England and Wales: https://www.lawcom.gov.uk/project/automated-vehicles/
in October 2020. We published an analysis of responses and interim findings in May 2020.

3. Our third consultation, in 2020, will draw on responses to both previous papers to formulate overarching proposals on the way forward.

Final recommendations to be provided in 2021.

In this section, I do not discuss the consultation papers in detail, rather, I focus on why does the Law Commission adopt it and what do lawmakers want to learn or achieve from it? Jessica Uguccioni, the lead lawyer at the Law Commission of England and Wales, took my interview and shared her insights.

Me: “What’s the role of the law commission in this field?”

Jessica: “I think probably the most useful thing that we can try and do is to bring stakeholders from very different fields together. Because the OEMs are doing fantastic work in developing the technology, they’re doing a customer research and they’re being very focused on producing features and making sure that they work as best they can. But what we also need is to have a lot of input from broader society and from regulators about their expectations, and make sure that there is a full dialogue in that direction which isn’t just bilateral (regulators and OEMs). It has other players who are interested, like insurance companies, road safety groups, vulnerable road user groups, and disability groups, all these different constituents. All these different points of view are going to be really important in shaping what the future looks like and for it to be a successful integration. And we need to make sure that the
introduction is as positive as possible and actually helping make the mobility options for people work better.”

Me: “How do you differentiate work done by the law commission from those done by organizations such as TRL, BSI Group, and Zenzic?”

Jessica: “The law commission obviously focuses on the law, we have a perspective that is very much based on regulatory structures and legal obligations. Standards bodies, they determine the near content of the rules that need to be complied with and actual substantive metrics for assessing this technology, which is absolutely crucial. But we’re looking at a different part of the system- we’re looking at the legal framework that then can support everything else. We need that legal structure to support the standards and industry like Zenzic. They’re like looking at the sort of business and innovation angle. We’re looking at the structure in which everything sits, and how in a long-term view, we can ensure the UK is ready to help these businesses and these technologies to flourish as part of a transparent and workable flexible framework. That’s the ambition.”

To provide a positive introduction to this technology, and the deployment and regulation of it, the law commission needs to assure safety. As discussed in Chapter 5, it goes back to the challenge of ‘how to prove it is safe’ that is subordinate to the fundamental one of ‘how safe is safe (enough)?’ The consultation addressed it by dividing the question into two parts: it considered how safety can be assured before automated vehicles are placed on the market, as well as ongoing monitoring and maintenance requirements once they are on the road. Based on discussions about
the existing type approvals, it tentatively proposed that the UK should set up a new safety assurance scheme for automated driving systems that are installed either as modifications to registered vehicles or in vehicles manufactured in limited numbers. In terms of assuring safety on road, the paper focused on (1) How to communicate with consumers (what information to provide?) (2) How to conduct market surveillance and recalls? (3) How to deliver trustworthy road tests? And (4) how to investigate road accidents? It also proposed to train drivers in the new context. These aspects were explicated while constant and in-depth research is necessary.

During the period between November 2018 and June 2019, the law commission received nearly 180 written responses to the preliminary consultation paper in addition to the input they received from conferences and meetings. The responses came from individuals, transport researchers, car manufacturers, safety and disability groups, insurers, the police, local authorities, lawyers and academics were centred around safety assurance and a national safety assurance scheme for automated driving systems was overwhelmingly supported.

As Jessica said, the law commission is bringing different perspectives and gathering wisdom to solve difficult questions. The consultation thus consists of open discussions, proposed solutions, and questions. The questions at the end of the paper are very thought-provoking. For instance, the first consultation paper also considered issues of transparency and ethics, especially focusing on “machine factors” to reflect broader questions raised by artificial intelligence in the context of driving. One interesting question is: Should automated vehicles ever exceed speed limits? In chapter 5, I mentioned that CAVs could be considered as less flexible and less empathic if they cannot speed up in emergent cases where humans would do.
The consultation paper pointed out that:

“Guidelines issued by National Police Chiefs Council 48 stress that the police have discretion about how to enforce speed limits. In broad terms, the guidelines indicate that a fixed penalty notice is only appropriate when the speed exceeds the limit by at least 10% plus 2 miles per hour.” (Law Commission of England and Wales, Scottish Law Commission, 2019: 30)

The question was thus ‘whether the “10%+2” tolerance should also apply to automated vehicles?’ Can people tolerate CAV speeding up at all? If so, where is the margin? These questions are not yet answered, and again, they require more research and discussion before being addressed in law documents or on courts.

4.2 HARPS and the Operator Licencing
The second consultation paper focused on the regulation of highly automated road passenger services (HARPS). I am particularly interested in the introduction to this new concept. I asked Jessica what is HARPS and why did they build this concept? What kind of problems did the law commission want to address? How did they implement this ethical practice?

Jessica: “We were trying to capture HARPS, the most ambitious use case for the technology which is what people imagine is in hopping into a self-driving vehicle and being whisked off to their destination without having any responsibility or input into the mechanics of how the vehicle actually gets in there. Like looking at the passenger in a purely passive role and this, of course, is wonderful for all those that are unable
to drive. We were trying to look at what kind of regulatory structure would support that use case, how can we make sure that that is part of the ambition that we’re getting to, how can the law support that.”

The term HARPS was coined by lawmakers to encapsulate the idea of a new service that uses highly automated vehicles to supply road journeys to passengers without a human driver (referred to as the “user-in-charge” in the consultation papers). Since the highly automated vehicle only has passenger on board or travels empty, no person in the vehicle takes legal responsibility for its safety. As such, it is the type of vehicle that people want to hop in without any burden.

Jessica continued, “We, therefore, looked at the current transport modes, the ways that passengers are transported today, and the existing regulatory frameworks, which, however, often rely heavily on human drivers to do a lot of important functions. We looked at what can we draw from those frameworks and how can we learn and base our idea of regulation and established principles, like the operatorlicencing, which is very effective. So how could we modify them in a way that took into account the unique challenges that technology such as self-driving vehicles has, for instance, not having a human agent as of necessity in the vehicle. We wanted to make sure we enabled that and so we looked at things like supervision. That was the idea behind HARPS.”

The creation of this concept is a typical ethical practice made by the law institute: once the HARPS operators are registered, it sets a clear line between who is responsible for the vehicle’s operation and who is not. The moral crumple zone as
discussed before or the possibility of taking human operators as a scapegoat can thus be eliminated. By explicating and highlighting the licence’s holders’ legal responsibility, the Law Commission improved the explainability and transparency of the CAV ethics for the public.

Jessica also suggested that the ‘expense and technical challenges of safely operating passenger-only vehicles make it less likely that many individuals will own them for private use, at least initially’, but CAV for private use was still discussed in the paper. Concentrating on the public use (for passenger transport rather than goods deliveries at the moment), the law commission discussed how to increase accessibility for the old and the disabled people and how to integrate CAVs with public transport.

To implement HARPS, the law commission has been considering a national operator licensing scheme. Most responses to the second consultation paper supported national licensing for HARPS operators. Though it could be three national systems for each of Scotland, England and Wales. I would like to highlight several important and critical questions: would the law institute decide to build and roll out a single national system? How would they implement their ethical decision despite the differences between nations and/or regions?

Me: “I saw the majority of responses agreed to a single national system. But there’re challenges related to the unique positions of Scotland and Northern Ireland. What’s your opinion on it and how can we build a single national system?”
Jessica: “We are making recommendations for England, Wales and Scotland. We very much welcome input from Northern Ireland, but they’ve got their own system. So it will be absolutely for Northern Ireland to determine whether they feel that the system that we suggest is something that they would wish to also adopt.

“The idea would probably be to set up a scheme, which we call a national scheme, but it could be no different nation, you could have a Welsh, England, and Scottish scheme. Also, we would try to have as much cooperation as possible between the nations but respecting that devolutionary settlement.”

Me: “When a national or general system is set, would regional differences affect its implementation?”

Alex: “In terms of general guidance, the Highway Code in a sort of soft law way gives general guidance as to the use of advanced systems already. On the final point of our local byelaws, this is really interesting because in London boroughs, for example, you do come across subtle differences in traffic. Some boroughs allow motorcycles to use the bus lanes but others don’t. So motorcyclists who ride in a bus lane across several London boroughs will occasionally find themselves caught out and fined, because they were still in the bus lane in another borough and they were photographed.

“When you think about the practicalities of automated vehicles, that becomes immediately very interesting because it means that sort of difference is going to have to be built into the programme. It’s going to have to find its way into the instructions for the vehicles and there’s an interesting side question as to if the software updates
fail to take into account the local byelaw and the driver gets fined, and my strong suspicion is that it will become part of that contractual term of the use of that vehicle between driver and manufacturer.”

Jessica: “London, for instance, has many freestanding rules, we’ve suggested that we should adopt a national scheme for standards of safety and an operator licencing scheme at that level. Of course, Transport for London disagreed on the element in their response and they would very much wish to keep operator licencing as a local competence for them. And I think that basically just goes to the tension between going at a higher national level versus going at a local level.”

Jessica acknowledged TfL’s vast experience in regulating different modes of transport in London bringing together. In the consultation paper, the law commission highlighted that TfL could retain the existing power, including things like road pricing and regulation of the curbside. What she suggested is that local authorities indeed have more knowledge about some specific issues and so should have some autonomy to regulate the local situations. However, what is needed is a balance to ensure an implementation of a national level regulatory code and this balance is yet to be found.

“Even if you wrote licencing at a national level. There are essential elements of making the service work, which is local and means that any operator would have to engage and work with local authorities in order to actually deliver a service integrated units you want access to a hub, like a train station. Tube stations, bus stations, all those very crucial parts of the city are absolutely within the domain of local
authorities. So that's how we in the paper suggested that could be managed alongside road pricing which can be very nuanced and you can through that determine which types of vehicles you want to encourage on your streets, you can use traffic regulation orders to help you also just managesession roads and the use of space.”

Jessica suggested that the law commission will explore further in the next paper to try and ensure that they can better accommodate the important balance between local powers and powers that are administered at a more national level. Till the write-up of this chapter, collaborative efforts at such detailed levels have not been shown to the public. But it is clear that the tension and conflicts between the central and the local governments raised challenges to practise the CAV ethics and legislation.

5. Conclusion

After a closer look at the planners’ efforts in shaping the CAV ethics and legislation, the chapter firstly identified four institutional forces in the field and discussed their values and priorities. They included (1) technicians who prioritise technological feasibility, (2) academic researchers who argue for social safety and equity, (3) industry stakeholders and insurers who protect commercial data, and (4) lawmakers who shoulder responsibilities of building a UK legal framework for the CAV deployment.

Secondly, through a ‘moral breakdown’ (Zigon, 2007) exploration in two thought experiments- the Trolley problem and the Molly problem, it respectively demonstrated
the moral debates and the ethical practice in a CAV collision scenario. Focused on who to spare/who to protect in a car collision, the Trolley problem received various responses that were based on everyday morality and contributed to a theoretical understanding of sociocultural diversity. The Molly problem, on the contrary, asked specific questions about the public’s expectation for the self-driving software recall ability. The planners’ shifted focus from the Trolley Problem to the Molly problem suggested practical efforts of improving explainability of the technology/transparency in its operation and ensuring responsibility in the specific CAV context.

Finally, following questions posted in the previous chapters about the planners practical efforts in exploring and solving socio-political, ethical, and legal questions, I engaged with lawmakers in the UK who had been working on a CAV legal framework. It found that the policymakers value responsibility differentiation and explainability yet are facing challenges brought by this new technology. A power re-distribution between the traditional regulators and the tech firms was elucidated, which implied a demand for the law and enforcement to access data, update relevant knowledge, and plan for new, collaborative investigations. Although my research did not have space to dive into the relationship between technology and politics, it implied such necessity in the CAV domain.

Besides, it looked at the ongoing legislation process with the Law Commission of England and Wales and the Scottish Law Commission. Their newly proposed legal term ‘HARPS’- highly automated road passenger services- showed the progress of differentiating responsibilities between the CAV operators/licence holders and passengers. However, the study also revealed political challenges of implementing a single national system in the UK at all levels and such areas of the legal framework
building needs continuous research. Till the end of my research programme, the development of the CAV UK legal framework was still at an early stage, therefore, this part of the research left much space for further investigation and called for accumulated efforts in this area. Nevertheless, some critical questions generated from my exploration include: would the political tension between the central government and local transport authorities hinder the CAV legal framework-building? How would this tension shape its implementation after discourses and (re)negotiations? And how would the final deployment of legislated CAVs be perceived by the public and affect their everyday life?

In the next and final chapter, I mainly describe and analyse my performative participation in the CAV trials to draw out insights into embodiment, technology display and public engagement.
Chapter 7 CAV Public Trials: embodiment, engagement, and the technology display

Whereas the CAV technology is not feasible enough to be scaled up on public roads, trials in the controlled environments have been partially open to the public in various places in the UK. I conclude three reasons behind the CAV public demonstrations: First, technical insights can be drawn to build safety cases and further improve the vehicles’ functional safety. Second, the technology display launched by the planners—the industry and/or the government—as an output, engages the public and provides them with a platform where technology meets sociotechnical imaginaries. ‘To see is to believe’, embodied experience generated in such trials is a powerful tool to shorten the distance between new technology and people’s everyday life. In other words, the planners aim to enrich the public’s understanding of this technology, influence their perception, and enhance trust by opening up the CAV trials. Third, technology’s public demonstration is considered as a ‘public situated feedback channel’ (Hosio et al., 2014) through which, from a user’s perspective, the public comments on not only the technical functions/feasibility but also its design, accessibility, and engagement. For example, in a CAV showcase in London, the public brings back attention to socio-political safety and inspires human-centric design.

Explaining the last two reasons through two cases, the chapter draws upon the anthropology of embodiment to see how trust in technology is constructed and explicates how public engagement contributes to technology’s co-construction between the planners and the public. In the first case, I demonstrate my first CAV ride in Glasgow. Apart from descriptions of the performance of the automated bus and my feelings during the ride, I illustrate how do planners use this demo as an output to
enhance the public’s understanding of the CAV technology and in particular, the forthcoming automated bus services in Edinburgh. The other case is my shared ride in an automated pod in London and this case represents both the inputs (Hosio et al., 2014) and outputs (van Oudheusden, 2011) of a technology display. As researchers pointed out, technology displays help planners/agencies to gain the public’s trust in technology as well as their approaches to integrating the technology into society, also, it is an opportunity for the planners/agencies to reflect on their practice (Stilgoe et al., 2014). Specifically, on the one hand, it engages the public members. Even though the automated pod operates at a slow speed and only in a very controlled environment, its physical existence and fun of the ride eliminate some doubts and misunderstanding from the public and thus enhance their trust in the CAV technology. On the other hand, the project organisers collect the public’s feedback for further development and improvement. Socio-political safety, for example, how to commute in a safe shared space without human supervision, as a frequently raised point from the public catches the planners’ attention and leads to more research and discourses. Moreover, commonly raised points such as data privacy, insurance, responsibility, and equity in accessing the CAV services through public trials contribute to CAV’s legislation and social deployment from multiple aspects.

1. Jump on an Automated Bus!

I got up in pitch dark. It was cold and windy outside- a typical November morning in Scotland. I took one of the earliest buses at the Edinburgh bus station, heading to Glasgow. What dragged me out of my warm bed was not just the talks at the second CAV Scotland conference but the automated vehicle demos. As the UK’s first CAV
demo that is open to the public, anyone can register to the conference, join the conversation with planners from the government and the industry, and participate in the CAV trials. To include as many public members as possible in this technology display, the CAV rides are filmed and the videos are accessible on YouTube, which is similar to Tesla’s approach to engaging the public. Among all types of CAVs in the demo, the automated bus is operated the most times that day with a large amount of passengers. As the planners’ output to showcase the CAV technology and the forthcoming automated vehicle services, it generates interest among the public and forms an understanding of what CAVs are capable of and what are currently not through embodied experience. However, with the main focus on its ‘output’, feedback from the public is not asked for. From my narrative as a public participant, excitement exceeds all other feelings. Even though I have disappointment and concerns about the low operating speed and the controlled environment, the ride gives me faith in its future rollout.

I reached the car park at the Scottish Exhibition Centre (SEC) before 10 am. Four types of automated vehicles had already been scattered in the open space, including the Alexander Dennis full-size bus, the NAVYA autonomous electric shuttle, the StreetDrone Twizy, and a futuristic-looking car called KAR-GO. Delegates of the two-day conference can experience four live demonstrations of these vehicles. All of them were appealing and I could not wait to experience the rides. My main focus was the forthcoming trial of that single-decker bus, which was developed in the joint project CAV Forth between bus manufacturer Alexander Dennis, bus operator Stagecoach, Transport Scotland, tech firm Fusion Processing, Edinburgh Napier University, and Bristol Robotics Laboratory of the University of the West of England. In March 2019, extensive trials have taken place at a Stagecoach bus depot in Manchester. The trials were exclusive to the public and so I only followed the report and watched the edited
videos launched on YouTube. Today was different. It was the first time for this Europe’s first full-size automated bus to be showcased in Scotland and as a delegate of the CAV Scotland conference, I was invited to experience an automated bus!

Pic. 7.1 From left to right: Alexander Dennis bus, NAVYA shuttle, StreetDrone Twizy, KAR-GO

Groups of people gathered around the vehicles with the majority close to the Alexander Dennis bus. I saw Steven Russell, Stagecoach innovation manager, chatting with Jim Fleming, director of marketing at Fusion Processing. We made warm greetings to each other. They seemed to have been standing in the chilly wind for a while yet with excitement to embrace the public participants. It is clear to me that the planners highly value this opportunity to display their accomplishment and gain trust from the public both in the automated bus itself and their management skills to operate the bus service.

78 Pictures by CAV Scotland 2019. http://www.cavscotland.co.uk/
At 10.30am, a person near the bus waved hands and suggested us to get on. Delegates from the joint partners (manufactures, software builders etc.) started jumping on the bus one by one without hesitation. Followed by the media people then some passengers who were less recognisable to me. While I was thinking perhaps I should go for the second round, Steven came to me and encouraged me to give it a go. I was not supervised to see a smiling human driver when I stepped on the automated bus. Because all delegates were informed that a driver would remain on board for safety reasons.

I saw most passengers sitting at the back of the bus and only Jim Hutchinson, chief executive of Fusion Processing, Louise Simpson, Stagecoach Scotland East project manager, along with a cameraman standing in the front corridor.

“Is this a subconscious choice? Does it make any safer by sitting at the back of an automated bus? Or does it make safer to have human authority standing in the front corridor? Maybe all just psychological comfort, really… It seems that the passengers do have concerns, at least, not completely assured.”

Not having many options left, I sat down on a front seat. I thought I was always the brave, futuristic person who was ready to try any brand new technological applications without getting nervous. But the truth is, as a person who was facing something new and uncertain, my body betrayed me with a quick and slight shortness of breath and an accelerated pulse. Holly Molly!

The automated bus started moving in a cordoned-off section of the car park. I had a
glance at the rearview mirror: the safety driver indeed did not touch the wheel and the bus was driving itself.

Natural silence occurred in the first thirty seconds. I felt overwhelmed as the atmosphere on the bus became intense. Only when the bus successfully passed the first turn, people who sat at the back started chatting in a low voice. I turned back and counted the passengers roughly—there were over ten female passengers and twelve male passengers on board, aged between mid-twenties and fifties. I noticed two guys on my left hand grabbing smartphones. Any nervousness on board gave way to easiness after them taking a selfie. Many passengers followed the lead. A young man simply walked from the back to the front side and started filming the safety driver’s ‘hands not on the wheel’ scene. More joined the amateur photographing team and Louise had to kindly ask them to sit down. Other passengers’ interaction with the bus reflected their excitement and growing curiosity just like myself.

The bus went through the zigzagging traffic cones and then diverted around a parked trucked, smoothly, stably, and slowly. Jim still stood in the front corridor with a calm and big smile. I was not sure whether he was genuinely confident about the trial or simply wanted to provide psychological comfort to the passengers. Louise gave a brief demonstration with a macro on, “We hope you are excited. We understand that some of you may be skeptical and slightly fearful of the new technology, but that’s nothing new in the advancements in technology in general.” She also suggested that in the short term, by law, a safety driver will remain on board on public roads. This is an interesting way to assure and relax passengers and it suggests that the planners had thought about the potential concerns among the public.
Most passengers went back to their seats and I started paying more attention to the ‘road situations’. My feelings had been on a roller coaster: after the initial excitement mixed with nervousness, I was delighted with the successful first turn. Excitement soared when the bus diverted around a parked truck but disappointment soon occurred as I roughly eye-measured the controlled environment and rationally thought about its operation. The journey was short, the road condition settings were reasonably simple, and the bus operating speed was very slow.

Later, I confirmed with the safety driver. It turned out that today’s trial was very much controlled- the operation speed was 3 mph-ish. Considering that the trial in 2020 summertime (postponed to 2022 summertime due to the global Covid-19 pandemic) will be conducted on a motorway- the public road between Edinburgh park to Fife, and the speed will be set up to 50mph. That being said, the operating speed in the demo is far away from what it would be in the real condition. Therefore, after the faded-away excitement and a second thought, critiques crossed my mind. The demo in Glasgow was a success in many ways, but isn’t there a huge gap between this trial and the next one? Practically speaking, first, the next trial in 2020 aimed to operate in a less controlled environment where unexpected road situations could happen. In other words, apart from a few traffic cones and one parked truck, the bus will encounter other road users, for example, terrible drivers and cyclists who are in a rush. The automated bus will also face complex traffic signs and different weather conditions. How will these factors affect the automated bus running across the Forth Road Bridge? Second, the whole journey of the next trial is 14-miles long yet today’s demo last merely 5-minutes long. It was hard to tell whether the bus would consistently perform well in a longer journey. Third, speed-wise, the bus did a good job at 3mhp. The huge leap from 3mph to 50mph, however, carries many uncertainties and potential problems. Will the Alexander Dennis automated bus be
able to handle these challenges in the following couple of months? Or has it been technologically feasible yet just not showcased here today? The public does not know. They only saw the well-prepared display that demonstrated what the planners wanted to showcase.

From a positive side, although me and other passengers appeared very nervous at the beginning in silence, it might have to do with the lack of broadcast during the trial. Stagecoach suggested that they will include an audio introduction to the automated bus service and the journey, which could comfort passengers and enhance interactions between passengers and the vehicle. Engaging services, especially AI-companion services have been added to CAVs to generate situation awareness (De Salis et al., 2020), which in this case, refers to passengers’ perception of the elements (car, road situation, and other road users) in a CAV operation environment during the ride. With additional information and companionship, passengers are more likely to understand what is going on and what could happen next. I can imagine a simple audio service/companion making me less confused and worried while more at ease.

Before jumping off the bus, I approached the driver and said, “nice ‘drive’, mate! Really appreciated.” We both laughed. I asked him how did he feel about ‘driving’ the bus with his arms crossed during the whole journey, ‘Did you feel relaxed or did you concentrate more? Any moment you wanted to take over or just unconsciously wanted to touch the wheel?’ ‘Oh, I was very focused. I needed to consciously not to touch the wheel, you know, that was hard. I needed to stay very focused for passengers and be ready to control. After all, machines can be dysfunctional.’ The ride was thus both an interesting experience for passengers and the safety driver.
The ‘feet off, hands off, eyes off, and brain off’ scenario is still far, technically. But it did not stop the planners’ eager to display the technology or the public’s curiosity about possibilities afforded by the automated vehicle services. In the next section, I present another CAV experience where I had the chance to closely study reactions and perceptions from participants who are outside the field, for whom, CAV only existed in imaginaries and/or dialogues.

---

79 Autonomous bus demonstrated at SEC in Glasgow. 13 November 2019. CAV Scotland 2019. Video is available: https://www.youtube.com/watch?v=GKzvDwB1QhY
2. Look! Here’s a self-driving Pod!

It was a partially cloudy day on 14 March 2020 and the weather was mild. I commuted for more than one hour from west London to the Queen Elizabeth Olympic Park in the early morning to join the final trial of the Capri project\textsuperscript{80}. Unlike the Glasgow demo, this trial aims at ‘outputs’- demonstrating the CAV technology through public engagement as well as ‘inputs’- receiving feedback from the public to understand their perception and trust, and rethink the development and deployment of automated pods. First, by walking the pod, I saw its technical potentials to support delivering people and goods in controlled environments such as campuses, hospitals, and residential areas. Second, by taking the shared ride, I formed a better understanding of functional safety as well as social safety, and noticed that the latter concept is highly valued by other female passengers, too. Third, having doubts about safety in shared space, the embodied experience was nevertheless enjoyable due to the interactions among passengers and the interactions with the pod’s facilities. It showed me and other passengers that commuting by automated vehicles is not just about achieving greater functional safety and efficiency but also fun (Hassenzahl et al., 2017; Harvey and Knox, 2015) of the experience itself. The ride thus generated positive perceptions and trust and further encouraged us to imagine having CAVs in our everyday life. Finally, our feedback was collected in a survey that contains both open and closed questions that focused on improving technological feasibility and social display/deployment of automated pods. This case thus contributes to an understanding of the socio-political and technical aspects of CAVs as well as embodiment and engagement in its display.

\textsuperscript{80} The Capri is the first UK project to trial pods on public roads. \url{https://caprimobility.com/}
I arrived at the park around 10.45am. It took me a while before finding the trailing spot in the North Park. The unique shaped, orange-and-white pod caught my eyes at a distance of at least 50 meters. It was moving at a very low speed as three people nearby effortlessly escorted the pod. I took a picture of this funny scene and named it “walking the pod”.

Pic. 7.3 Walking the Pod (photo by the author)

I followed them for a few minutes until the pod stopped after slowly yet successfully turning around a corner. I approached the pod- no one was on board.

“Are you in charge of this pod?” I asked those people.
“Yes.” said the girl in a yellow coat, “we all work on this project but we are from different institutes. I’m from Cranfield University.”

“Are you all engineers or computer scientists?”

“Umm, no, my background is in mathematics. We have more teammates at the trial stops with different expertise.”

“Do we have many people coming to see the trial?”

“Yeah, it’s been a few days and we will continue the trial until the 20th. But today is the last day we have this open trial in the park. Tomorrow we will run private ones on the open but controlled roads.” Said the guy in a grey jacket, “You are lucky. You can have a final ride today!”

“Brilliant! When and where can I start?”

“Actually, we can walk back to the stop together- just about 10 minutes. Then you can hop on the pod with other passengers, if there’s any waiting there.” The girl said.

I was more than delighted to walk the pod back to the stop with them because it was a great opportunity to observe its operation from the outside and throw questions to the experts. The pod caught much attention on our way back. Two cyclists even turned around and asked us what it is. We walked the pod at the speed of 5mph due to speed restrictions in the park. The researchers told me that the pod was trialled at 10mph and even higher speeds. The pod’s perception was empowered by multi-sensors, including cameras, radar, and Lidar. The pod can detect objects three meters away from its front and one metre from its side- they call it ‘the safety distance’ of a CAV. I had no idea whether such programmed safety distances were safe or not. But what I saw was: the pod fully stopped when a child ran to the front side to pick up his football. I realised in hindsight that the girl had been carrying a red
controller and, at that moment, she was pushing the emergency stop button. She functioned as the ‘safety driver’ the whole time, though outside of the pod. It was hard to tell whether the pod made a decision and stopped itself on time, or it stopped only after she pressing the button. It thus left a huge question there: what if we move out the safety driver, will the automated pod slam the brakes on?

There were no speed bumps but some part of the road contained small slopes. The pod crawled with difficulty and stopped several times. It also got confused when driving too close to the bush. The researcher in the grey jacket told me that it was very difficult for the pod to recognise the bush. Sometimes when the bush goes 3cm taller, the pod mistakes it as a person and freezes there. “Sounds pretty dumb, right? It’s not easy though- a huge challenge in computer vision.” He sighed.

I met more researchers on the team at the stop. One asked me if I mind sharing the ride with three passengers. My eyes followed the direction he pointed and saw two women and one man waiting there. They all look like in their early thirties.

“Sure.” I said, “I saw two pods here. Which one should we take?” As I saw another one, the same shape and colour yet slightly bigger, parked in the stop. That one was the first generation they trialled in Bristol before.

“You guys get in this one.” A mid-aged man pointed at the pod I just walked (with). I felt a bit relieved since I just saw its stable performance and built some sort of rapport with it during the walk. How strange, ten minutes’ walk and I attached some feelings to an automated pod. As if this one will definitely outperform the other one that I was
not familiar with.

Four of us hesitated to hop on the pod. One researcher saw through our concern and took the red controller from the girl and announced, “It’s quite slow and I’ll walk beside you guys. Just relax, you’re all gonna be safe and sound. If not, just let you know, I can stop it anytime.”

I sat on the backward seat, next to one girl and facing the other two passengers. I knew they knew each other and would chat anyway, so it would be awkward if I do not talk in this tinny shared space. The “table-seat” design puts strangers in a position where you need to chat, especially when it is a long journey.

“Did any of you experience this before?” I tried to break the ice with other passengers.

“Nope.” They all shook heads and replied.

“First time for us to ride a self-driving pod…so excited and nervous.” The woman sat next to me said. “It’s like being in the black mirror… Oops, hope not81.”

“Don’t know what’s going to happen.” The man said and pulled the seat belt. The rest of us did not buckle up and somehow we shared an eye, “mocking” the only male passenger being so nervous.

Before our ride, the safety driver demonstrated the information screen, the

81 Black Mirror, the British sci-fi TV show, normally has disturbing, dystopian endings.
emergency stop button, and the horn on the wall. They were all on the side near the
guy. His triumphant face grew jealousy of the rest of us. The safety driver then closed
the door and wished us a happy journey. We kept chatting randomly for more or less
one minute before exploring the in-vehicle design. The guy pulled out a screen
between his seat and the next. It was like a dashboard that showed the passengers
the real-time front road situation. I and the woman next to me shouted at the same
time, “Ahhh, it’s not fair. You got everything!”

“We can switch the seats!”

“Cool, in a few minutes, let’s swap seats for different views.” The woman next to him
agreed.
The pod abruptly stopped. My butt left the seat and my body leaned in due to inertia. We all looked outside. There was no obstacle on road yet the pod slammed the brakes on very hard. This situation confused and discomforted us. I remember in the Tesla autopilot tests, the car also slammed on (many times) and the driver complained about how uncomfortable and unnatural they were. Research shows that driver’s/passengers’ (dis-)comfort is affected by “jerks and acceleration forces of the vehicle” (Radhakrishnan et al., 2020: 391) as high magnitude and frequency of jerks result in motion sickness (Martin and Litwhiler, 2008). For automated vehicles, researchers (Svensson and Eriksson, 2015) suggest acceleration and jerk values should be limited to under 2m/s² and 0.9 m/s³. To offer a clear sense of the limitation, an example of railway can be used for comparison: standard railway’s acceleration and jerk values are under 1.47 m/s² and 0.6 m/s³ (Bae et al., 2019). I and other passengers do not know what was the acceleration value at that moment, but it felt less steady than being on a rail.

The following two minutes went smoothly. We started taking pictures of the inside and outside views. It was chill and we changed seats as agreed. This time, I became the privileged one who has access to the information screen, the front-view-screen, all buttons on the wall, and a small video screen above me. This design positioned passengers unequally in an obscure way—some have more control thus power than others. So Who deserves that access and control? Who deserves to sit on that privileged seat? Will other passengers all be easy-going and swap seats like us easily? Did these questions ever cross the designers’ minds?
The woman who sat next to me checked the entertaining screen and played Lady Gaga’s song. She asked our opinions before starting this pod-party. Her friends did not fancy Lady Gaga but were okay with it. I felt the same. Imagine if the pod was packed with four strangers who appreciate different types of music and were not willing to compromise, the situation might be awkward. Perhaps when the pod serves as a public transport vehicle, no passenger should be entitled with the power to select music and play it out loud in the public space, just like on train or airplane.

Partially given credits to music, when the pod slammed on again, we did not feel as nervous as the previous time. We enjoyed the curious and envious faces of pedestrians and cyclists and happily waved at them.
“I bet he (the safety driver) is more nervous than us.” One woman said.

“Yes, of course.” We laughed.

“You should try the emergency button.” The guy said to me.

“No!” One of his friends disagreed immediately, “don’t mess around with it. We don’t know the tech. Don’t break it…”

“I was literally going to press it!” I said with a wry smile, “really tempting, isn’t it?”

“Yeah, maybe we should try? Not the stop button, but see what other functions do we have here?”

“Umm, let me check.” I saw speed, time, temperature on the information screen. It is touchable as I tried to turn on the ventilation. The ventilation system worked well at level 2 but noisy at level 3. I pretended to reach out the emergency stop button while peeking at them. Their widened eyes and dropping jaws stopped me on my halfway.

“Look! They have a camera there!” the woman next to me pointed to a tiny secure camera.

“Is it working?”

“Think so. See the red light’s on?”

“Oh shit, they are filming us.” The woman was a bit surprised but not offended. “Let’s wave and say hi!”

The female researcher told me during the walk that they set a camera in the pod to study passengers’ reactions and interactions. Apparently, the other three passengers
had no idea about it. Studying passengers’ in-vehicle behaviour is crucial for CAV’s deployment, but is it ethical filming passengers without a notice? What if some consider it a violation of their privacy or concern about the use of the footage? Abundant research and constant discussions on data privacy (Glancy, 2012; Bloom et al., 2017; Lim and Taeihagh, 2018; Liu et al., 2020) can be found everywhere, yet not practised everywhere.

The pod stopped again and this time it did not start moving right away as it used to. We all captured this upsetting signal and worse, the “error” in big font on the screen.

The safety driver opened the door and said to us, “Don’t worry, let me check.” He pressed the information screen and typed a long pin. There appeared a small issue with GPS and the pod cannot direct itself to further areas (the other side of the park). “It needs to be further diagnosed but shouldn’t be a big problem. Let’s shorten the journey a little bit anyway just in case. We don’t want to get lost, right? And the rest of the journey is basically the same. What do you think?”

The pin worked and the screen went back to its normal status. We nodded to the safety driver and agreed on a shorter ride. When the pod slowly moved again, we were more or less disturbed and unsure about what happened or what’s next.

“Did anyone know what just happened? So wired, I feel like a laboratory rat now.” said one woman.

“Ahhh, who knows. I wonder if the GPS thing happens a lot?” The guy answered,
“Maybe it’s just a connection issue with the internet?”

“Connectivity, not automation.” I sighed and murmured. As discussed and criticised before, “C” (connected) in CAV received much less attention than “A” (automated). But the often neglected, small issues such as map-loading or internet reception may often cause issues.

“Well, he said it’s not a big problem. Still, it’s annoying. Hope the rest of the journey will be fine.” The woman next to me crossed her fingers.

The serious chat was soon replaced by the pod-party because the rest of the journey (another five minutes) was a success- the pod presented a stable and smooth operation. While approaching the destination, I pressed the horn. It was loud.

“Yes!” “Bravo! Do it again!” Cheered by my ride-sharers. I pressed the horn two more times.

We hopped off the pod one by one and thanked the research team. Interestingly, we also received a round of applause from them for our participation and bravery. One researcher asked if we would like to take a survey so that they can improve the ride according to our feedback. This suggests that this research team appreciates inputs from the public and adopts collective wisdom for the CAV development. Four of us all followed him to a table to take the survey.

“How do you guys feel?” I asked the other three passengers.

“Great.”
“It was interesting. I’d love to try again.”

“Where would you like to use it?”

“Parks like this I guess. It was safe but not perfect. So I don’t think in the short term these pods will be permitted to run on main roads.” One woman said.

The other woman agreed, “Perhaps just on campuses or in airports.”

Before the ride, for these three passengers, autonomous driving is only an abstract concept. But it is clear that this embodied experience triggered their positive imaginaries about using this technology in specific everyday scenarios. In other words, the perception and understanding of the CAV technology are specified through interactions the trial (Merat et al., 2017). I had a glance at the survey and saw the question about where do we want to use the pod. Apart from the few locations other passengers mentioned before (campus, airport, hospital etc.), I also saw the predetermined choice of “shopping centre” and selected it.

The survey asked “how many times did the pod stop during the ride?” A small debate occurred when one woman said, “I don’t remember at all. Any idea?”

“Five times?” I hesitated.

“Ha, no way. I think it stopped at least 20 times.” The other woman laughed.

“Really? That much?” I was surprised and looked at the man who has not given his number, “to be honest, I did not count… but I would say perhaps 10 times?”

“Oh, this is funny now.” Said the first woman. “Did we really share the ride together!? That’s way too different.”
I closed my eyes and tried to recall all the small stops (about 3 seconds) and eventually wrote down “15” on the sheet. We also had different answers regarding the duration of the journey. I assume that our personal emotions in this embodied experience affected memory and so we wrote down very different answers to these questions. However, it might be simply because we did not pay enough attention and counted the stops.

“Oh dear, I really don’t know. Between 10 to 20 minutes?”

“Not that long. I don’t think we spent twenty minutes there.”

“Feels like that long though.”

“Fifteen-ish?” I said.

“It’s 20 minutes.” The researcher who handed us the survey replied.

“But we had a GSP error and cut off some journey. So it’s probably 15 minutes for us.” I said.

“Oh, I didn’t know that. What’s happened?” Asked the researcher.

“It stopped in the middle of driving. That guy (I pointed the safety driver) came and checked the facility and told us we need to return earlier. I don’t know much about the technical stuff but later the ride seemed okay.” The male passenger replied. The survey man did not comment on the incident.

Based on how much did we trust the automated pod we were asked to score from 1 (don’t trust) to 10 (trust). After putting down a “9”, I peeked at theirs’. Their answers
were between 7 and 9, which suggested not only high levels of trust in CAVs but an increase in trust. At the beginning, they all showed concerns and hesitated to hop on the automated pod and their behaviours implied a low level of trust. However, the high trust scores after the ride proved the importance of embodiment (Pink et al., 2020) and engagement (Stilgoe and Badstuber, 2019) in displaying technology to the public. I asked them why giving such high marks? How did they feel after the ride? What was the difference before and after?

“I was really nervous. But I'm so glad we did it. Now I know that it is safe to have autonomous low-speed rides in parks or maybe other places.” Said the man, “I will tell this to my pals.”

“Yeah, I wasn’t so sure. But the pod looks promising especially after the close engagement plus our discussion. Thinking about how it could help the disabled and patients in hospitals, well, it’s just exciting.” The woman who sat next to me continued.

“I didn’t even know we have this in the UK. And I had no expectation but nervousness when they encouraged me to join them.” The other woman said and looked at her friends. “The ride was nice, so happy we saw it and decided to jump on! (They were in the park and accidentally found the trial) It was quite slow and stable overall despite the unexpected jerks. Guess that’s (the slow speed) part of the reason I dared to try. I don’t know whether it would be safe to speed up. So if they have this ride on open roads outside the park today, running at 20 or 30 mph, I don’t think I would like to participate.”
She continued, “I think it is important to engage the public, people who might be nervous, in trials like this first. Step by step. Then if possible, gradually introduce us to the ride at a higher speed or more complex environments.”

After the ride, me and my ride-sharers believe the automated pod was fun and useful and we can foresee it being inserted into the existing transport systems. Our feelings are in accordance with the finding from a questionnaire of a Berlin automated shuttle bus trial (Nordhoff et al., 2018). 384 participants found the automated shuttle bus useful and enjoyable but had concerns about the technological feasibility to provide fast and efficient services. Interviews were conducted with 30 among them and the research team indicated riders’ unrealistic high expectations about the automation level and the operation speed (Nordhoff et al., 2019). The ‘high expectation’ might be unrealistic in line with the current technological status, however, they came from riders’ everyday use of traditional transport and/or their own driving experience. An average speed of 5 mph in those trials (eg., Glasgow automated bus trial, Capri pod trial, and Berlin shuttle bus trial) is, therefore, comparatively low, disappointing and generates further concerns.

In the comment section of the survey, I highlighted my concern about data privacy and expected the pod to run at 10mph, at least. Because if the pods operate at 5mph only, I would rather walk apart from rainy days or travelling with heavy luggage. I selected “moderately content” when asked about how did I feel sharing the ride with strangers. After a second thought, I realised that in general I did not like the idea of being in a small space with strangers. The inside space of a pod is no bigger than an average elevator but the ride is much longer than going from the ground floor to the
fifth or tenth. I also sensed this concerns from other passengers, especially female passengers and so wrote it down in the survey. Overall, I felt content with this shared ride simply for three reasons. First, the other three passengers were welcoming and easy-going, at least, during the shared journey; second, we were all intrigued with the pod and focused on the operation rather than other passengers; and third, we were aware of the ride being a short trial rather than an everyday service. In other words, everything just happened was in a testing environment with supervision from the research team and kindness/tolerance among passengers. One researcher later saw my written concern and suggested that it was raised by others, too. The research team explained that they will be working on this potential problem. This, again, emphasised the importance of social safety during the CAV ride and that the planners are aware of it.

If not the case, I am not sure about using a shared automated pod in the evenings in rural areas.

One of my ride-sharers said, “I am very comfortable about sharing it with you.” She looked at me and then her friends. They both nodded. I took the compliment and smiled back. I think she might also have concerns if none of the other passengers are her friends.

My ride-sharers handed in the survey and wished me luck with my research before leaving. I stayed and asked the researcher some questions.

“What is the difference between the two generations of pods?”
“The modes are different- the new, also the advanced one has double modes. But they are not hugely different. We are still working on coding and programming the new one.”

“Are they electric?”

“Yes, they are. We charge the pods in the evening and use them during the day.”

“So, the battery lasts for the whole day?”

“Umm, I wouldn’t say that. It depends on the tasks - some may require bigger usage. Normally we don’t allow operation when the battery drops under 40%.”

“Why so? Is it because when the battery is low, the ‘brain’ of the pod will collapse? Apologise for my expression, but you know what I mean, right? When it doesn’t have enough power, the pod sort of becomes dump and make mistakes?”

“That’s what we don’t want to see. It might be the case though.”

The Capri was the first CAV project where I saw automation, connectivity, and electrification really walked hand in hand, though in baby steps. I stayed longer for a chat with the team and understood their appreciation for the public’s feedback. They believe that more CAV trials will be open in the following months, and maybe in a larger scale, to bridge technology with the public.

3. Conclusion

In this chapter, I used two CAV trial cases- my CAV rides respectively in Glasgow and London- to present embodied experience and study the public engagement. Readers can draw insights into the technical operation of CAV, the interaction between
participant and vehicle, as well as (changes in) perception associated with trust, acceptance, understanding, and expectation.

Through the trials, we understand its capacity of running in the controlled environments and foresee possibilities of deploying this technology outside trial environments, such as campuses, hospitals, and shopping centres where convenience can be safely delivered. These exciting possibilities along with the safe rides enhance my and other people’s perception of this technology. That being said, the display of the CAV technology, as the planners’ output, provided the public with an opportunity to experience the technology and enhanced their trust in the CAV operation and its social deployment.

The public’s feedback, as an input for the planners to rethink and reshape the CAV deployment. As Stilgoe argues against the narrative that ‘diagnosed public acceptance a problem’, based on research, he suggests public engagement/dialogue as ‘social learning’, which helps frame the ‘state of technology and its future trajectories’ (Stilgoe and Cohen, 2021: 855). Studying and analysing the public engagement thought the lens of technology also contains political value as it ‘describes the process of stabilization of democratic orders’ and displays ‘alternative political arrangements’ (Laurent, 2011: 664), hence, it empowers critical reflection upon technology’s social deployment. Greater functional safety, convenience, and efficiency, though desired for, were not all what the public wanted. In other words, the public engagement revealed the importance of socio-political safety during (shared) automated rides, clarification on responsibility, and the fun experience itself. To further bridge automated vehicles with the public and practise the CAV social deployment, more public engagement in trials/demos are thus expected.
**Thesis Conclusion**

To answer my Ph.D. research questions: (1) ‘How is a CAV imagined?’ and (2) ‘How is a CAV integrated into society?’, which were inspired by both the sociotechnical imaginaries of vehicles and the practical effort of sociotechnical transition of vehicle technologies, I investigated the social integration process of this technology into the UK society. In doing so, I critically drew a holistic view of the ongoing process, unfolded the socio-political fabricated complexity, and shed light on possibilities afforded by the emerging CAV technology from different perspectives. Using technography as a framework to articulate top-down and bottom-up perspectives, theoretically, the thesis contributes a thick description of technology’s social integration in the CAV domain and it enriches an understanding of technology along with its socio-political attributes in everyday life through the lens of dynamic imaginaries and institutional practice. Practically, on the one hand, it explicates and discusses the most important socio-political and ethical aspects of the CAV technology, which encourages (re-)thinking and practical efforts to ensure social safety along with technical feasibility, equity, and responsibility separate from developing its technological feasibility. On the other hand, by looking at this technology as an anthropologist, my exploration of the tech future inspires further imaginaries and thoughts on fundamental questions such as human-and-machine relationships, trust, acceptance, morality, and embodiment engagement.

Apart from my pilot research in Edinburgh from April 2019 to July 2019, during the period between September 2019 and September 2020, I conducted my fieldwork in London and Edinburgh where CAV projects have been emerging. I interviewed over 20 planners from the UK Government, auto industry, research institutes, and the Law
Commissions; engaged over 60 public members through interviews and workshops, and conducted participant observation in two CAV trials. Below I summarise my key findings in this thesis.

First, based on my bibliometric review that shows a techno-centric bias in the CAV research domain, I pointed out the lack of in-depth qualitative studies of CAVs. As discussed before, the elderly, the disabled, and women were most vulnerable due to the poor transit service and lack of automobile ownership (Lansing and Hendricks, 1967; Lopata, 1980; Rodrigue, 2016). Inequity, gender gap, and social safety issues such as sexual harassment and discrimination during commutes (Balkmar and Mellstrom, 2018; Fisch, 2018) reflect the importance of acknowledging and solving socio-political problems while innovating transport technology. Therefore, I called for anthropological effort to unpack complexity in the CAV social deployment process and bring attention back to the richness in everyday life.

Second, my CAV terminology survey that studies people's preferences for related terms such as 'automated vehicle', 'autonomous vehicle', 'self-driving vehicle', 'driverless vehicle', and 'robot vehicle', as a conversation starter, revealed utopian and dystopian possibilities afforded by the CAV technology and implied people's current low trust on it as I consciously selected 'sociotechnical imaginaries' as the research lens for it suggests people's perception and trust of technology (Jasanoff, 2014) and explicates some commonly wanted features or aspects that the public care about CAVs, which forms 'collectively imagined forms of social life'(Jasanoff and Kim, 2009: 119) being afforded by the development and deployment of this technology. Additionally, it inspired thoughts of human-and-machine relationships in the future. My exploration of these terms with the CAV planners (policymakers,
industry stakeholders, technicians, and researchers) suggested that their inconsistent word use and different priorities were driven by various economic and socio-political purposes, for instance, some consciously use the well-known and easy-to-understand word 'self-driving' to familiarize the public with this technology while others use the technician-acknowledged term 'automated' to show knowledge and expertise. This finding resonated with a long-existing anthropology and STS argument that a technological invention is politically presented (Bijker, Hughes, and Pinch, 1987).

Third, it unpacked the planners' prospect-driven, top-down approach to imagining and envisioning the CAV technology. Specifically, though acknowledging challenges such as technological uncertainty, the lack of investment and political transparency in the CAV deployment, and the low public's trust, the planners' imaginaries and plans were mainly driven by CAV's potential contribution to safety (vehicle's functional safety), the environment, and the UK economy, and considered them as public good. It revealed how technology is 'institutionally stabilised'- envisioned and negotiated for 'desirable futures' (Jasanoff, 2015: 4). A critical question I posted here is: who define the 'desirable futures' and whom do the 'desirable futures' benefit? Furthermore, it identified and criticised a common vague assumption of the concept of SEAV (shared electric and automated vehicle) among the planners, elucidated the difficulty of integrating automation, electrification, and shared mobility model into society as a holistic innovation, and highlighted the importance of constant research in these areas.

Forth, it presented the public's problem-focused, bottom-up approach to the CAV imaginaries, which were closely related to their everyday commuting experiences. The
potential problems extracted from their imaginaries included emerging ones that were associated with the CAV technology, such as data privacy, cybersecurity, and technical feasibility, as well as long-existing socio-political ones. For example, the lack of transparency in technology’s operation, biases in the vehicle design, unclear legal responsibility, unequal distribution of transport services, and racial discrimination and sexual harassment in shared rides, which, different from technical safety, constitute the socio-political safety of CAVs. Through an open exploration of CAV imaginaries about ‘how a CAV is perceived and imagined’, and ‘how its users are imagined and (re)configured’ (Balkmar and Mellstrom, 2018: 50), I pointed out not only the current gap between the top-down and the bottom-up approaches but also potentials about people’s sense of ‘what they can do with the technology in novel and unpredictable ways’ (Jasanoff, 2016: 144), which enables a collective, critical, and creative CAV social deployment. My findings suggested that technological advancement alone is not a one-size-fits-all solution to transport problems. Notwithstanding potential issues from the technical and socio-political dimensions, the public’s CAV imaginaries revealed possibilities of using CAVs to improve accessibility, convenience, and fun experiences in commuting. Having explicated the differences between the planners’ and the public’s CAV imaginaries, it inspired thinking and rethinking on the CAV social deployment from different perspectives. Having tied findings from Chapter 4 back to Chapter 3, from different perspectives we saw how is CAV imagined, politically presented (Bijker, Hughes, and Pinch, 1987), and collectively (re)configured (Balkmar and Mellstrom, 2018), and in this ingoing process, socio-political issues such as equity, responsibility, and operational engagements were emphasised along with the technical feasibility.

Fifth, by studying what constitutes CAV safety and how it is conceptualised by
different social groups, I found and emphasised that safety in mobility refers to more than ‘no collision’ but also social safety. For instance, a safe commuting environment is, in particular, desired by females and ethnic minorities. In other words, while improving the technical feasibility of CAVs, social problems such as inequity (Rodrique, 2016), sexual harassment, abuse, and discrimination (Fisch, 2018) deserve more attention from the transport planners and policymakers, which further critically led to thoughts and questions about legislation, responsibility distribution, and ethics of CAVs.

Sixth, through a close look at two different thought experiments on CAV ethics, it revealed some of the key socio-political and ethical aspects that the planners care most. Among which, explainability of why CAVs did what they did along with the responsibility distribution in a CAV accident to the public drew most attention. To do so, it required a clear and transparent legal framework for the social integration of CAVs into UK society. Through my engagement with the Law Commission of England and Wales who had been working on a CAV legal framework, I explicated political tension between different authorities and put forward questions that could inspire thoughts on tech governance in the future: would the political tension between the central government and local transport authorities hinder the CAV legal framework-building? How would this tension shape its implementation after discourses and (re)negotiations? And how would the final deployment of legislated CAVs be perceived by the public and affect their everyday life?

Last, from two cases, it emphasised that on the one hand, the CAV trials, as a technology display, provided the public with a platform where technology encounters imaginaries, and that the fun embodied experience during an automated ride
generated positive perception among the public and enhanced trust. On the other hand, the CAV trials were used to gather the public’s feedback, which helped the planners to reflect and reshape the social deployment of this technology through ‘social learning’ (Stilgoe and Cohen, 2021: 855). Studying and analysing the public engagement thought the lens of technology also contains political value as it ‘describes the process of stabilization of democratic orders’ and displays ‘alternative political arrangements’ (Laurent, 2011: 664), hence, it empowers critical reflection upon technology’s social deployment.

Due to time limits, the thesis only drew a holistic view of the ongoing process of the CAV deployment (from April 2019 to August 2020) while not being able to dive into all important socio-political and technical aspects mentioned in the writings. Initially, the project also aimed to have a close look at the CAV Forth (automated bus) trials in Edinburgh. However, under the influence of the global COVID-19 pandemic, the trials were postponed twice to the summertime in 2022. As a result, the thesis cannot provide further insights into the CAV’s performance as well as the public’s engagement as planned. Nevertheless, it could be a good direction for future studies of the CAV social deployment and I hope more anthropologists, STS scholars, and sociologists can join this investigation.

**Epilogue**

I was fortunate to complete most of my fieldwork offline, especially participated in two CAV trials before the COVID-19 pandemic had widely spread in the UK. However, cancellations of research events came one after the other and directed into much
frustration and regret. After the ride on the Capri automated pod, I was mean to visit the Bristol Robotics Laboratory (BRL) to meet the engineering team on the Capri project. Apart from Capri, BRL is also active in other CAV projects such as Flourish and Robopilot\(^{82}\). At the beginning of March 2020, I got in touch with a professor in the laboratory who showed interest in my ethnographic study on their automated vehicles. I was excited about my visit and expected to gain more technographic insights from BRL.

The fast-moving COVID situation interrupted many events that were supposed to happen in late March and early April: I had to cancel my second meetup event to prioritise the safety and wellbeing of my participants. Right after this hard decision, I heard from Leeds University as they decided to postpone a CAV workshop that I was kindly invited to. Above all, I did not fly to Bristol. With regrets, I wrapped up my work in London and went back to Edinburgh.

I was fortunate to stay safe and sound and quickly adapted online research methods to continue the rest of my research. During the 2020 summertime, numerous webinars, online conferences, and Zoom interviews provided me with not only research data but also fun in life that kept me sane. The pandemic drove away some people from public transport but, at the same time, it encouraged them to think about future mobility and how to travel in the post-COVID period? It also affected some perceptions of technology. For instance, one participant pointed out that people are becoming more adaptive to technology. He said, “The pandemic pushes people to use digital platforms to continue their life and work. I’ve witnessed this transformation in my father. He was

---

\(^{82}\) Flourish and Robopilot, two CAV projects in the UK. See [http://www.flourishmobility.com/](http://www.flourishmobility.com/) and [https://www.apollovehiclesafety.co.uk/robopilot](https://www.apollovehiclesafety.co.uk/robopilot)
reluctant to online shopping but now he is the one who’s been introducing the convenience of online shopping and many kinds of shopping Apps to his friends over the phone. And that’s not just regarding digital tools but technology in general. I think it (the pandemic) makes people more open to all sorts of technologies.”

Since the lockdown, I have indeed asked some previous participants about their updated opinions on automated vehicles and future mobility. I found the ambivalence in their answers quite fascinating. One participant said that self-driving pods (for only one passenger) outweigh any other types of vehicles for three reasons: first, the small-sized pods are flexible to drive around and easy to park, second, they eradicate the chances of one passenger misbehave to another, third, they are in line with the social-distancing policy. But he quickly corrected himself, saying that public transport is still the most efficient and environmentally-friendly way to travel around in the long term. Another participant believed that electric vehicles and active travel will soon become the norm while shared mobility will only encounter bigger challenges in its rollout due to people’s fear of virus infection. This participant showed faith in automated vehicles in the long term but she emphasised the risk of R&D funding reduction in a shrinking economy. Among various interesting views on future mobility, people’s fear, anxiety, and concern about uncertainty form the biggest takeaway.

Uncertainty is perceived as ‘an increasingly prominent feature of existence, combined with imagined possible worlds of horror, fear and despair. However unwelcome and blamed for crisis, insecurity vulnerability and indecision, it is constant, ongoing and continual’ (Pink et al., 2018: 1). The industry often shows little tolerance for uncertainty as they keep launching reports that predict the future trend. For example, facing the pandemic challenges, the auto industry is seen to encounter a global demand drop
and capital shortage. But it anticipates the automated vehicles’ market consolidation in North America and the slow-down of CAV development with only level-4 highway pilots in Europe in 2025 (McKinsey Centre for Future Mobility, 2020). Nevertheless, many questions remain unsolved. For example, the demand for vehicles will keep decreasing due to the shrinking post-COVID economy but the pandemic drives away the public transport users at the same time, which may increase the use and purchase of private vehicles. Besides, the public’s opinions on future mobility also vary significantly. Some eager to get back to the office and travel again while others get used to the home office and have less desire for mobility. No reports have fully explained such contradictories but there constantly appeared attempts to ‘kill uncertainty’ and shed light on the future. I appreciate such efforts in unfolding the future trends, however, it is crucial to knowledge the unknown with an open mind and consider uncertainty as a technology for future exploration rather than an enemy.

Instead of closing doors to truth, uncertainty is considered by social researchers to open up ‘pathways of what might be’ and it ‘enables us to creatively and imaginatively inhabit such worlds with possibilities’ (Pink et al., 2018: 3). Uncertainty and possibility as theoretical concepts have thus been drawing more attention from anthropologists who seek creative ways to understand risks, crises, and the future.

In some fields, embracing the concept of uncertainty contributes to practical skills for governance and management. For instance, through studying preparedness for pandemic influenza in Israel, anthropologist Samimian-Darash explored how uncertainty is conceptualized and dealt with. He argues that in the field of security and

---

83 Roger Harrabin. “Coronavirus will transform UK work and travel, says AA”. BBC News. 3 April 2020.
Coronavirus will transform UK work and travel, says AA - BBC News
biosecurity, ‘uncertainty is an element of a governmental technology that allows a thorough discussion of problems’ (Samimian-Darash, 2013: 13) and appreciates its use for future management. In other cases, an empirical investigation and engagement of people’s perception of uncertainty acknowledges that we do not know what exactly will happen but proactively exploring the possibilities and prepare for them. Some of the recent responses to the COVID-19 pandemic also adopted social approaches to uncertainty. For instance, Brown highlighted the role of embracing uncertainty in the critical and creative thinking of risks around the pandemic, which ‘combines the rational and the magical into everyday policy practice’ (Brown, 2020: 15).

The pandemic does not add extra uncertainty to future mobility but explicates some of it in an unexpected way that reveals possibilities. The challenges brought by the pandemic push technological innovation and creative deployment of CAVs forward. During the lockdown, automated pods at Mayo Clinic in Florida played an important role in delivering medical supplies and test samples84, which shows opportunities of operating more CAV fleets on hospital campuses and other similar environments in a short term. This is a good example of practicing imagination in everyday life to tackle issues brought by uncertainty and it deserves future research efforts.

Although the pandemic affected some CAV trials and rollouts, I am grateful for it showing me new questions, possibilities and some potential future research directions.

---

Reference


Dennis, M.A., 2015. Our monsters, ourselves: Reimagining the problem of knowledge in Cold War America. *Dreamscapes of modernity: Sociotechnical imaginaries and the*
fabrication of power, pp.56-78.


Ebert, T.J., 2019. Data Privacy and Shared Mobility: Protecting the rights of the individual while improving shared mobility data collection practices.


Hornborg, A., 2014. Technology as fetish: Marx, Latour, and the cultural foundations of


Lin, P., 2016. Why ethics matters for autonomous cars. In *Autonomous driving* (pp. 69-


Marsden, G., Anable, J., Bray, J., Seagriff, E. and Spurling, N., 2019. Shared mobility—where now, where next?.


Perez, C.C., 2019. *Invisible Women: Exposing data bias in a world designed for men*. 

354
Random House.


Stilgoe, J., 2021. How can we know a self-driving car is safe?. Ethics and Information Technology, 23(4), pp.635-647.


Zon, N. and Ditta, S., 2016. Robot, take the wheel: Public policy for automated vehicles.
## Appendix: CAV Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Artificial Intelligence (AI)</strong></td>
<td>In computer science, AI is intelligence demonstrated by computers and machines, in contrast to the natural intelligence displayed by humans and animals. Generally, the term refers to machines or software which can mimic human cognition and perform advanced levels of tasks, perceive its environment, and take actions that maximise its chance of successfully achieving its goals.</td>
</tr>
<tr>
<td><strong>Advanced Driver Assistance System (ADAS)</strong></td>
<td>ASAD is an electronic system that aid a vehicle driver while driving. When designed with a safe human-machine interface, it is intended to increase car safety and more generally road safety.</td>
</tr>
<tr>
<td><strong>Connected and Automated Vehicle (CAV)</strong></td>
<td>A vehicle that does not require a driver, sometimes called a driverless car that is connected to other vehicles, infrastructure, or both.</td>
</tr>
<tr>
<td><strong>Light Detection and Ranging (Lidar)</strong></td>
<td>Lidar, (also known as LIDAR, LiDAR, and LADAR) is a surveying method that measures distance to a target by illuminating the target with pulsed laser light and measuring the reflected pulses with a sensor.</td>
</tr>
<tr>
<td><strong>Machine Learning (ML)</strong></td>
<td>Machine learning is the scientific study of algorithms and statistical models that computer systems use in order to perform a specific task effectively without using explicit instructions, relying on patterns and inference instead. It is seen as a subset of artificial intelligence.</td>
</tr>
<tr>
<td><strong>Shared Automated Vehicles (SAV)</strong></td>
<td>In this report the term shared automated vehicles refers to automated vehicles (of all forms and shapes) shared by multiple users either simultaneously or at different times.</td>
</tr>
<tr>
<td><strong>Vehicle to Vehicle (V2V)</strong></td>
<td>V2V refers to wireless systems within automobiles that allow vehicles to communicate with each other.</td>
</tr>
</tbody>
</table>

---

<p>| <strong>Vehicle to Infrastructure (V2I)</strong> | The wireless exchange of critical safety and operational data between vehicles and highway infrastructure, intended primarily to avoid or mitigate motor vehicle accidents but also to enable a wide range of other safety, mobility, and environmental benefits. |
| <strong>Vehicle to Everything (V2X)</strong> | The wireless communication of information from a vehicle to any entity that may affect the vehicle, and vice versa. |
| <strong>Operational Design Domain (ODD)</strong> | ODD refers to operating conditions under which a given driving automation system or feature thereof is specifically designed to function, including, but not limited to, environmental, geographical, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics. |
| <strong>Fallback</strong> | It refers to the process by which the full function of the dynamic driving task is delivered when a driving automation system or systems. |
| <strong>Handover</strong> | It refers to the process by which the sustained dynamic driving task function transitions either from a human driver to an automated driving system or from an automated driving system to a human driver. |
| <strong>Autonomous Driving System (ADS)</strong> | A complex combination of various components that can be defined as systems where perception, decision making, and operation of the automobile are performed by electronics and machinery instead of a human driver, and as introduction of automation into road traffic. |
| <strong>Safety Driver</strong> | Safety operator at the controls within an automated vehicle, observing the driving environment, enforcing the operational design domain, recognizing challenging situations, detecting deviations from expected behaviour and ready and able to deliver the full function of the dynamic driving task when needed in order to preserve safety during development, testing or trial activities, in accordance with the safety case. |</p>
<table>
<thead>
<tr>
<th><strong>Simulation</strong></th>
<th>A simulation is an approximate imitation of the operation of a process or system; that represents its operation over time.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>User-in-charge</strong></td>
<td>Human within or in line of sight of a vehicle who is qualified to drive it and in a position to operate the controls of the vehicle but is not actively controlling the vehicle due to it being under the control of its automated driving system.</td>
</tr>
<tr>
<td><strong>Highly Automated Road Passenger Service (HARPS)</strong></td>
<td>Business which carries passengers for hire or reward using automated vehicles on the road without the services of a human driver or user-in-charge.</td>
</tr>
<tr>
<td><strong>Mobility as a Service (MaaS)</strong></td>
<td>It describes a shift away from personally owned modes of transportation and towards mobility provided as a service.</td>
</tr>
<tr>
<td><strong>Adaptive Cruise Control (ACC)</strong></td>
<td>System that attempts to maintain the vehicle at a driver-selected target speed and following distance, using sensors and automation to regulate vehicle speed</td>
</tr>
<tr>
<td><strong>Automatic Emergency Braking (AEB)</strong></td>
<td>Vehicle system that uses sensors and computer processing to detect when the ego vehicle could collide with an object in its path and applies the brakes automatically attempting to mitigate or avoid the collision, even if the driver takes no action</td>
</tr>
</tbody>
</table>