The social and ethical implications of autonomous vehicles

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Declaration

This thesis has not been submitted in support of an application for another degree at this or any other university. It is the result of my own work and includes nothing that is the outcome of work done in collaboration except where specifically indicated. Many of the ideas in this thesis were the product of discussion with my supervisors Nick Dunn, Daniel Richards and Paul Coulton.
Excerpts of this thesis have been published in the following conference manuscripts and academic publications:

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Abstract

The current discourse surrounding vehicle autonomy focuses on the safe decision making of these machines, and the optimisation of traffic flow. It seems unquestionable that driverless vehicles will have far reaching effects on the way we live our lives yet to date, the social and ethical implications of driverless technologies on the user have largely been ignored. Using a multimethods approach incorporating speculative design and qualitative methods, this thesis explores the social and ethical implications of autonomous technologies on everyday life.

Speculative design methods were used to question the autonomous vehicle concepts published by manufacturers. This identified user groups who appear unlikely to adopt such technologies, due to infrastructural and logistical constraints. HGV drivers emerged as a pioneering user group, who by law, had been using early driverless technologies since November 2015 with mixed success. The views of HGV drivers were explored through qualitative methods, using semi-structured interviews. The findings indicate that the industries developing autonomous technologies are all too often focused on a single user, the urban commuter. As a result, HGV drivers felt that they were being burdened with technology which they see as imposed on them and which is unhelpful or even detrimental to their lives and working practices. This is leading to increased resistance and a questioning of the future role of the professional driver.

Building on the emerging field of data comics and using HGV drivers as a case study, this thesis proposes methods of visualising futures that could help designers and academics to explore, challenge and influence how we want emergent technologies to shape our daily lives in the future. This thesis highlights that the trajectory of autonomous technology development is not towards the experience of the driver or user but instead, is focused on the pursuit of the advancement of technology.

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List of Abbreviations and Acronyms

ABS	Anit-lock braking system
ACC	Adaptive cruise control
ADAS	Advanced driver assistance systems
AEBS	Autonomous emergency brake system
AI	Artificial intelligence
BBC	British Broadcasting Corporation
CAV	Connected autonomous vehicle
CEO	Chief executive officer
CPC	Certificate of professional competency
DVLA	Driver and Vehicle Licencing Agency
EAD	European Academy of Design
EBA	Emergency brake assist
EU	European Union
GDP	Gross domestic product
GDPR	General Data Protection Regulation
GM	General Motors
GVA	Gross value added
HGV	Heavy goods vehicle
HIE	Highlands and Islands Enterprise
HSE	Health Safety Executive
IBM	International Business Machines
ICT	Information and communications technology
ID	Identity
IoT	Internet of things
IT	Information technology
JIT	Just in time
LDW	Lane departure warning
LGV	Large goods vehicle
LICA	Lancaster Institute of contemporary Arts
PCP	Personal contract purchase

RAC	Royal Automobile Club
RDC	Regional distribution centre
RHA	Road Haulage Association
SAE	Society of Automotive Engineering
TFL	Transport for London
UK	United Kingdom
UN	United Nations
UNECE	United Nations Economic Commission for Europe
US	United States of America
VOSA	Vehicle and Operator Services Agency
WHO	World Health Organization

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Author Background

The author of this thesis, Richard, has a background in architecture having studied at the Manchester School of Architecture (MSA) to complete his BA in 2004, B.Arch in 2007 and MA in 2008. Since 2008, Richard worked as an associate lecturer at MSA, alongside his role in industry, specialising in security, satellite and mobile communication technologies. He completed this thesis while continuing his associate lecturer role and was appointed to his current role as a full-time senior lecturer at MSA in August 2019.

During his time in industry, Richard became interested in digital networks and the transformative nature that these technologies are having on our cities and their stakeholders. In his role as Development Director of an SME, his team were awarded funding to conduct research and product development by Satellite Applications Catapult and Highlands and Islands Enterprise. This work focused on the feasibility of using 3G and 4G platforms for the Emergency Services Network. The work explored the delivery of digital healthcare in the Highlands of Scotland, including working on the Satellite Ultrasound for Rural Stroke (SURS) project.

Richard continued this line of research with MSA, tutoring on both the Highlands and Islands Data Mapping project and the Data Mapping Cornwall project. The latter project was funded by Satellite Applications Catapult and the Cornwall, Isles of Scilly LEP to speculate on where increased digital connectivity may contribute to spatial and operational value.

In 2016, Richard applied for an EPSRC funded PhD position at Lancaster University to continue building on his research interests exploring potential and challenges that digital technologies will present to cities and their citizens. Through the early stages of this research it became clear that autonomous vehicles were being pitched as the ultimate embodiment of a digitally connected device, which if deliverable, would have a significant impact on all of our lives. Despite this potential, it became clear that visions and discourse surrounding autonomous vehicles were leaving some user groups behind, including those arguably most affected by their implementation; professional drivers.

1 Introduction

This chapter provides an introduction to the thesis; including the motivations behind the research question introduced in this section. The later stages of the introduction will then set out the current and historical context of the automobile and how we can use this history to question some of the future speculations of the automotive industries that we see today.

The way in which people move around our cities and towns is set to change. Technologies have changed the way we interact with the built environment's fabric and its users. The user however has always remained the decision maker, determining how and when they engage with the city (Preston, 1990). Cities are now on the cusp of another industrial revolution which will begin to slowly erode the day to day decision making of the citizen (Schwab, 2017). Autonomous vehicles will take the decisions about how citizens move, where they may go and who they may meet, out of their hands and into those of a third-party operators' protocols (Kelly 2016). It is important that real debate is held about how we want autonomous technologies to engage with our citizens and infrastructure. Yet, to date, the driverless discourse has largely been limited to evaluating the operational capability and efficiency of autonomous technologies.

The first generation of driver assistance systems such as adaptive cruise control and lane assist, the precursor to autonomous vehicles, are already on our roads. Designers must consider the impact, the level of human involvement and the transparency of these autonomous decision-making protocols. Without such oversight, there are social and ethical concerns about how individual users will be treated, and what decisions will be made on their behalf. Protocols are already playing a greater role in determining our actions through the interpretation of live data (McBride, 2014). The ability for city stakeholders to interact with these protocols is limited and as such, it is unclear whether users can trust the information they provide. Autonomous vehicles present a real opportunity to improve efficiency, experience, and ultimately, even social mobility (Firnkorn & Müller, 2015). Without the ability for all users of autonomous systems to challenge, influence and observe the decisions being made, there is a real risk that such technologies will be for the benefit of the operators and not the users. We should, as a collective group of stakeholders begin to understand the role of the driver in a world of autonomous vehicles. This thesis will argue that these challenges are already emerging as we see increasing levels of automation in vehicles on the road today, changing the lives of the people who engage with these technologies.

1.1 Research question

What are the social and ethical implications of increased vehicle automation?

This thesis will focus on understanding how and where social and ethical implications are likely to occur as a result of increases in vehicles automation. Secondly the thesis will put forward methods to engage stakeholders in the design of emergent technologies. The thesis will consider a user group which has already begun to engage with the introduction of automated vehicle technologies name HGV drivers.

In chapter one, the social and ethical implications of these emerging technologies will be considered through an overview of the historical, technological, social, and political context in which autonomous vehicles are being introduced. Chapter two outlines the current autonomous vehicle discourse, focusing on current technologies, manufacturers' future projections and the ethical implications of machine decision making. Building on the knowledge acquired in the literature review, chapter three will use speculative design to investigate the potential social and ethical implications of autonomous vehicles on end users. Additionally, this chapter will explore how increases in machine decision making will challenge current infrastructure and behavioural habits. Building on the questions raised in the first three chapters, chapter four uses qualitative methods to understand the issues that are already arising as a result of increased machine decision making. Finally, in chapter five, participatory data comics will be put forward as a method to help designers involve all stakeholders in the development and implementation of emergent technologies, with the ultimate aim of generating more equitable futures.

To drive this research towards the primary research question, the following questions will be addressed:

- What is the current thinking about autonomous vehicles among stakeholders?
- How have driver assistance technologies impacted on users' lives?
- Where may opportunity and resistance to future autonomous technologies lie?
- How can designers work with stakeholders to develop collective goals?

1.2 Autonomous vehicles

Before going on to understand how the history of the automobile is relevant today, it is necessary to introduce what is meant by the terms used to describe different levels of vehicle automation and the context in which they are being discussed.

The literature surrounding the future of mobilities is awash with the terms driverless, self-driving, autonomous, automated and assisted. These terms are often used in an interchangeable way, but it is not strictly correct to do so. These terms are perhaps best understood through the level of input the vehicle requires from the human driver. Kornhausr (2017) sets this out in perhaps the clearest way. Both the terms self-driving and automated can be used to describe the same thing, that is; a vehicle that can drive itself but requires human oversight to take over the responsibility of driving when the vehicle is no longer capable. This type of vehicle would be categorised as Society of Automotive Engineers (SAE) Level III (SAE International, 2019) (See Table 2.1). Both the terms autonomous and driverless are again interchangeable and are used to describe a vehicle which is capable of making all decisions while travelling to the extent that the vehicle can perform all tasks either with or without a human present. In this case all responsibility for decisions fall on the vehicle's control algorithms. This type of vehicle would be defined as SAE Level IV or V (SAE International, 2019) (See Table 2.1).

Currently there is much hype and optimism within the media and the transport industry about the prospect of autonomous, driverless technologies. These types of technologies are being put forward by some as the solution to congestion, pollution and to some extent, the social and infrastructural issues which plague cities (Tettamanti et al., 2017). Much of the rhetoric is based on a few common predictions:

- We will no longer individually own vehicles; reducing the infrastructural storage capacity required for vehicles when not in use.
- Autonomous vehicles will have the capability to optimise the use of any current infrastructure and so reduce pollution and traffic.
- Autonomous vehicles will massively reduce accidents and road deaths.
- Users will be able to perform tasks other than driving, making travelling more productive and rewarding, enabling an increase in productivity or leisure time.

These predictions are however based on a number of assumptions about the technology:

- All vehicles will become driverless (SAE Level IV or V; see Table 2.1) (SAE International, 2019).
- Autonomous vehicles will be electric.
- Autonomous vehicles will be safer and more efficient.
- All vehicles will be capable of being SAE Level IV or V in all environments (SAE International, 2019).
- The communication infrastructure will have the capability to allow vehicles to remain connected at all times.

All of the above statements are at this stage hypothetical and as such, developers of driverless technologies will have to overcome a lot of barriers for full autonomy to be a realistic opportunity for the future. There is a general consensus to try and enable the development of driverless technologies. Tech giants, manufacturers, local government, central government and some consumers all seem to be pushing hard to make driverless vehicles a reality (GOV.UK, 2019; Demaitre, 2019). With the future visions of driverless vehicles, being presented by those financially invested, it is hard to see where the friction and opportunities in these technologies lie. The visions shown in Figure 1.1 communicate a world where vehicles are seen whisking their way through clear city streets, not having to stop at any point, while the user is entertained in an environment which is more akin to first class airline travel (Nissan Online Newsroom, 2017).

Figure 1.1. Screenshots from Nissan's IDS concept video. The images show how Nissan portray the future of autonomous vehicles. It is worth noting the lack of people and traffic. (Source: Nissan, 2019).

These futures depict seamless engagement between vehicles users and other modes of transportation, creating a 'frictionless world', embedded into all kinds of city infrastructure (Kelly, 2016). While it is entirely possible that one day technology, policy, cities and the infrastructure will be capable of delivering these futures, there are many social and ethical concerns that manufacturers, and others engaged in the development of these technologies will have to overcome (Mcbride, 2016).

Driver aids and self-driving technologies have been in use for less than half a decade, with vehicles which can brake, monitor the steering, and monitor other road users. As of the 1st of November 2015, all Euro VI HGVs have been fitted with emergency braking technologies which will stop the vehicle if an incident is detected ahead. The vehicle will also maintain a distance to the vehicle ahead, monitor the vehicle's lane position and detect if another vehicle is in the driver's blind spot (Commercial fleet, 2015). These kinds of technologies are what SAE would determine as a level I or II automated vehicle (SAE International, 2019). In these cases, the driver retains full responsibility for the vehicle. Consequently, if a SAE level I or II vehicle performs an emergency stop due to a fault in the systems protocols causing an accident, it is currently the fault of the driver for not having oversight and preventing the incident (Hevelke & Nida-Rümelin, 2014). These types of systems are beginning to raise both social and ethical concerns which to date, have been rarely raised in the driverless vehicle discourse.

1.3 Technology, policy and vehicle development

This section will outline the technological, social and political history of the automobile and draw a parallel with the manufacturers' projected concepts of the future we see today.

There are parallels that can be drawn between the hard-fought introduction of self-propelled vehicles from the 1860s through to the 1960s, and today's introduction of driverless vehicles. This section (1.3) will discuss how we can learn from the events that have led to the cities we see today. This section will focus on the ever-developing vehicle technologies and the visions of the future that have shaped our cities through both successes and failures.

1.3.1 The introduction of the horseless carriage

Since 1860 and the introduction of the Rickett carriage (Figure 1.2) (Freund & Martin, 1993), vehicles have rapidly developed into the high-tech, hi speed, well-engineered vehicles we see today. The introduction of these vehicles was not a seamless transition with a singular route of development. In fact, development of the cars has been a long, hard-fought development of political change, failed solutions, technology and innovation (Vannini et al., 2012).

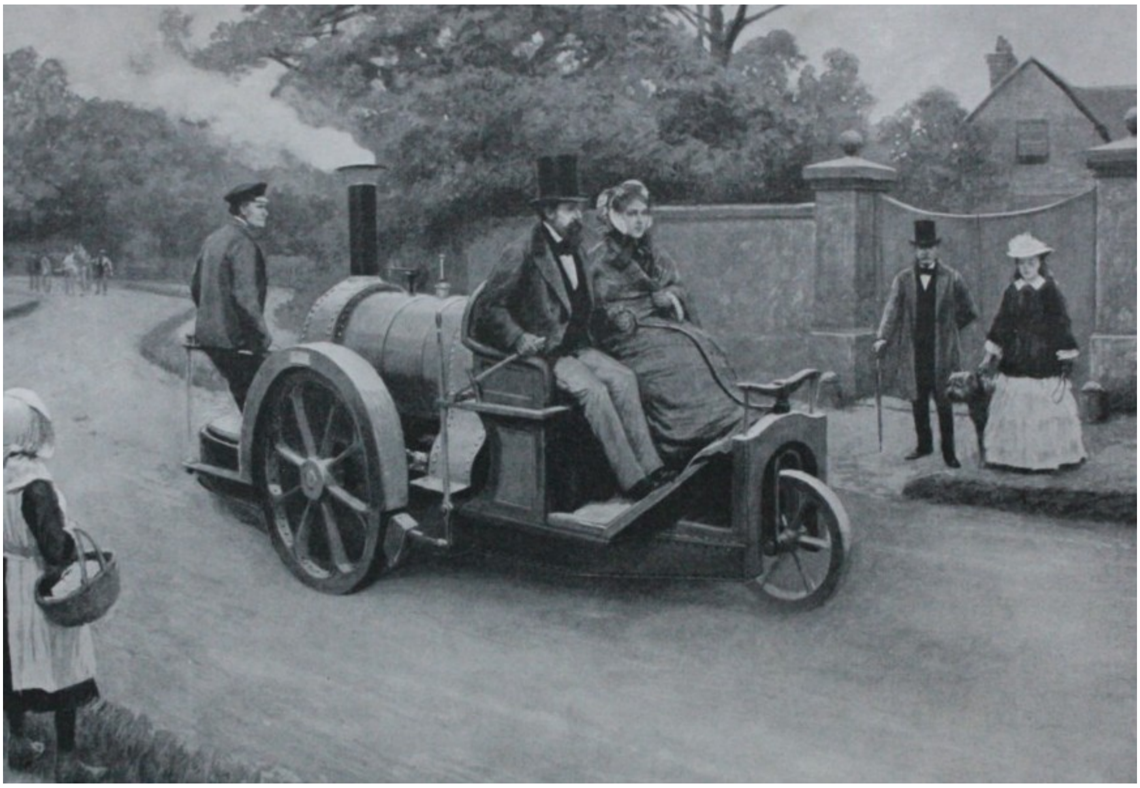


Figure 1.2. A Rickett carriage. The image highlights how dramatically different early motorised vehicles were when compared to today's technology. It is worth noting the need for an operator to stoke the fire (Source. ageofsteam.com).

During the early years of the horseless carriage, there was much dispute and challenge as to the appropriacy of such vehicles. This led to parliament discussing the matter during the 1860s and introducing acts of parliament to define in law the operation of these new vehicles. Perhaps the most significant of these was the Highways Act of 1865, otherwise known as the Red Flag Act (Locomotive Act 1865, 2018). This was an

Act which imposed very strict rules and regulations on all self-propelled vehicles. The act stated that any self-propelled vehicle must have at least a crew of three plus an additional person to wave a red flag at 60 yards in front of the vehicle. Vehicles were also restricted to 2 mph in town and 4 mph in the countryside. There was a belief that this act was introduced for two reasons. Firstly, it was argued in Parliament that these new vehicles presented a risk to members of the public due to the fact that it was unknown, just how dangerous and controllable these vehicles would be in the real-world (a situation perhaps similar to today's autonomous vehicles) (Bird, 1969). Secondly, it was thought that the Act was imposed as a result of the pressure imposed on government by both the well-established horse and cart and railroad industries, who thought that this new mode of transport could undermine their business (Bird, 1969). We now know, that their fears were valid. To date, there has been little opposition to the driverless vehicle.

As time moved on and the confidence grew in these new machines, the Red Flag Act was amended and eventually replaced with the 1878 act which relaxed the law regarding the carrying of a red flag to just 20 yards in front of the moving vehicle (Locomotive on Highway Act, 1878). This 1878 act also had a more technical focus which related to road damage. In order to reduce damage to unpaved roads, vehicles now had to have defined wheel sizes and types, the legislations also covered how the cost of road repairs would be met. This is a piece of legislation which, in a form, still exists today, regulating the maximum permissible weight of an axle in an effort to minimise road damage. This trend of continual legal amendments and new act to the law continued well into the 20th century, as confidence and complexity of the technology in automobiles grew.

Today we are seeing similar discussions taking place surrounding the subject of autonomous vehicles. Governments around the world are slowly allowing more and more testing of early autonomous vehicles. At the moment we are still politically somewhere around the Red Flag Act as the risks of fully driverless vehicles remain unknown from a road and cyber safety point of view (Ramanujam, 2017). The UK government is attempting to lead the way, revising its Code of Practice for Automated

Vehicle Trialling in 2019. However, this code, effectively only provides three limiting legal factors for developers to consider (Centre for Connected and Autonomous Vehicles, 2019, P.8):

- A driver is present, in or out of the vehicle, who is ready, able, and willing to resume control of the vehicle.
- The vehicle is roadworthy.
- Appropriate insurance is in place.

1.3.2 1885-1900

By 1886, the highly restrictive acts of 1865 and 1878 were lifted by the Locomotives on Highways Act 1896 (Locomotive on Highway Act, 1896). This is a point in history celebrated to this day by the London to Brighton run, in which cars built before 1905 attempt to drive from Hyde Park to Brighton within one day. Perhaps one day in the future there may be an event like the London to Brighton which marks the legislative approval of the fully driverless vehicle. The 1896 Highway Act finally paved the way for the future of the automobile. Self-propelled vehicles could now travel with just a single operator/driver but were allowed to travel at speeds of up to 14mph which is interestingly, the same speed of a horse at a two-beat trot (Freund & Martin, 1993). The way was set for the automobile to become a mode of transport which could compete with other transport modes of the age, paving the way for the car to be a viable future technology.

During this period, it was not just the legislation, which was developing rapidly, but the vehicles themselves. These early vehicles had a lot of variation in the design and manufacturing process compared to vehicles on the road today (Mom, 2014), but not when compared to the autonomous concepts produced by manufacturers (see Figure 2.5). These early cars were operated through a range of control methods, such as tillers, rudders and steering wheels. The throttles were operated by levers, hand controls and pedals. They even had very different sources of propulsion, which included the internal combustion engine, steam engines, electric motors and even hybrid systems. The race was on to develop the formula for the future and at this stage the winning formula was about whichever solution provided the most practicality and usability. Early motor vehicles were extremely difficult to drive, slow, unreliable and as such, needed constant maintenance and oversight. Regardless of how usable vehicle technologies were at this stage, the supporting infrastructure did not yet have the capacity or capability to support motorised vehicles (Bird, 1969). It is likely that early autonomous vehicles will face the same issues, being limited to operate in areas where both physical and digital infrastructure is capable of supporting them (Fagnant & Kockelman, 2015).

Historically steam cars needed to be continually topped up with fuel, coal and water; resources which were available, but difficult to store and transport. Early electric vehicles needed to be recharged for long periods and there was very little access to electricity at the time. Combustion engine vehicles need to be regularly supplied with petrol and there were very few petrol stations, but petrol could be carried on the vehicle. All of the technologies and designs of the time had their advantages and disadvantages and each manufacturer undoubtedly thought that they had the correct solution for the future. Time however dictated that not all of them did and for this reason, only five car manufacturers of that period still exist today. This could be seen as an analogy for the disparate technologies that we are seeing emerge within the growing autonomous vehicle industry.

1.3.3 1900-1945

Much of this period between the 1900 and 1945 is recognised as the Brass Era which represents vehicles made from the turn of the century up until the start of the First World War (Dluhy, 2013). Once again as confidence grew in automobile capability, speed limits were again increased by the Motor Car Act 1903 from 14mph to 20mph (Harmsworth, 1904). The Act also introduced laws about the conduct of drivers, including making reckless driving an offence and put in law the need for all vehicles to be registered. By 1930, the capability of vehicles had somewhat exceeded the still in force 20mph speed limit. As a result, parliament debated the issue and decided that speed limits should be removed altogether, due to a complete disregard of them. As a result, the Road Traffic act 1930 (Road Traffic Act, 1930) was enacted, repealing the

1865, 1895 and 1903 Acts. However, the 1930 act did not last long as a result of an increase in road fatalities. As a direct consequence, the Road Traffic Act 1934 (Road Traffic Act 1934) was introduced and speed limits were reintroduced in built up areas where they were set at 30mph. It was not until 1965 that speed limits as we recognise them today were introduced.

In 1931 the Highway Code was introduced, which defined and setup in law, the rules that all road users must adhere to. The Highway Code has of course been revised many times to take into account new infrastructure and vehicle technologies. To date The Highway Code has not been updated to take account of the emerging driverless technologies. In general, this Brass Era represents a time when government and its associated bodies had to develop a knowledge about the risks and relationships that existed between the car and humans. These relationships had to be controlled through the introduction of rules. The relationships that will exist between autonomous vehicles and their users are today far from understood as demonstrated from the wide range of manufacturers' concepts. Regulatory documents such as The Highway Code will inevitably be inadequate in their current state for the introduction of autonomous vehicles.

It was during the Brass Era that we began to see the initial emergence of the vehicles and road infrastructures which we would recognise today. This recognisable format is the reason we see many of the later manufacturers of this period dominate today's marketplace; these were the companies that pioneered the formula for the vehicles we see today (Freund & Martin, 1993). This started with the 1908 Model T (Figure 1.3), not because of the car per se, or because of the common misconception that is was the first mass produced car; that honour goes to the Oldsmobile Curved Dash.

Figure 1.3. With its standard colour and simple design, the Ford Model T brought the car to the masses (Source. Mitch Taylor)

The reason the Model T was so important was because the demographic of the people who could buy cars changed (Womack et al., 2007). Before the Model T, car ownership was an exclusive club for the rich, where cars were hand crafted to the owner's specification, the stripped down, simple mass-produced Ford sold in its thousands across the world to the now rising middle classes (Womack et al., 2007). It defined a philosophy and target audience which is still as relevant today as it was in 1905 and has in fact defined the automotive industry as a mass manufacturing sector. The second piece of car technology that changed the vehicles we drive today was invented by Charles Kettering, with Henry Leland, the latter being the founder of the Cadillac and Lincoln car companies. Their invention, the electric starter for combustion engines is often attributed to the demise of the steam car (Baker, 1988). The starter transformed the experience of starting a car from one which was dangerous and physical to the mere press of a button. This development in technology continued to change how the automobile was socially perceived.

Before the Model T and the development of electric starters, the automobile was not only a toy of the upper classes, but also required staff such as a driver to maintain and operate the vehicle, something that vehicle manufacturers had a desire to change in an effort to sell more cars and establish themselves as a relevant technology for the future. Today, this desire for increased convenience and value is continuing. Millennials see cars as expensive and a burden on their urban lives (Schwartz & Rossen, 2015). Autonomous vehicle developers are playing into this changing view of the car, by demonstrating the driverless car through an Uber style shared ownership model, where the user is not singularly burdened with the cost of ownership and maintenance (Waymo,2019).

This pattern of manufacturers developing technology as a means to establish a marketplace has continued until today. As a result, many of the early manufacturers and technologies such as steam would come and go throughout the Brass era. During the early 1900s, the automotive industry begun to find its feet as a real prospect, although it had not yet quite established the car as the most reliable method of transport (Baker, 1988). As a result, during the war, the horse was still seen as the superior method of transport. This sadly resulted in the death of around 8 million horses (Cooper, 2000). The automotive industry had not quite established their credentials among the military generals, however the automobile continued to be developed in the background. It is likely that the development of autonomous vehicles will be a similarly drawn out process, before consumers see them as a viable alternative to current vehicles. After the First World War, the development and sales of the automobile again began to ramp up, with Britain producing its own version of the Model T; the Austin 7 (Figure 1.4), which gained a global presence being manufactured by BMW in Germany and Nissan in Japan (Womack et al., 2007).

Figure 1.4. The 1934 Austin 7 was one of the world's first global cars (Source. Charlski at English Wikipedia).

By this stage the automobile was no longer just about new experimental technologies but was beginning to be established through notions of usability, capability, reliability and comfort and particularly in America, ideas of style and modernity with manufacturers like Cadillac (Bonsall, 2004).

By the 1930s and during the Second World War the automobile had established itself not just as a reliable mode of transport but one which was could enable both the economic and military objectives of a nation. The now established design of pneumatic tyres and the internal combustion engine was no longer just the basis for passenger vehicles, but was also being used to move trade around through the use of trucks. This was perhaps most evident in Germany where in the early 1920s, there was a realisation of the economic potential vehicles had to offer, sparking the investment of the Autobahns or Kraftfahrstraße as it was known at the time (Zeller, 2010). The Kraftfahrstraße was a project which attempted to realise the economic growth which would come from the increased movement of people, as a result these early roads were focused around personal vehicle movement. In 1933 Adolf Hitler criticised the project, stating that only the rich would benefit from these new roads. As a result, in 1934 Hilter tasked Ferdinand Porsche with designing a car which could be used and be afforded by ordinary Germans. By 1938, the Volkswagen Beetle, as we know it today, was born (Womack et al., 2007).

The car exclusivity of the autobahns did not last long as by 1939, the Nazi Party had realised the military capability and potential that the autobahns had to offer in moving equipment personal and goods quickly around its territory as it prepared for its "lightning war" (Zeller, 2010). The realities however did not play out as planned. With a shortage in Germany of petrol and the realities of moving tanks down paved surfaces, movement of the equipment and personnel fell to the train network to act as the backbone of Germany's military effort. This resulted in sections of Autobahn being paved over to be used as landing strips for aircraft. As the Second World War took grip of Europe and further afield, manufacturers who were once building private cars were seconded to the war effort. The need for private vehicles had fallen to near nothing and any road construction was stopped, as men and machines were moved to military duties. The automobile and its infrastructure had come to a halt while the war was fought, but during this time the motor vehicle, the motor bike and truck had all established themselves as indispensable pieces of equipment that the world could no longer do without. By the time the Second World War had finished, much of the world was near bankruptcy and returning soldiers had few prospects back at home (Wils, 2007). Governments around the world had to act and the idea that Germany had begun back in 1930s with its Autobahns posed a real opportunity for employment and growth to nations around the world (Zeller, 2010).

This idea of building roads to connect cities was vividly portrayed by Norman Bel Geddes and General Motors for the 1939 World's Fair in New York. Futurama as depicted in Figure 1.5 was a diorama, which visualised a city supported by major highway infrastructure (Bel Geddes, 2009).

Figure 1.5. A photograph of visitors viewing Bel Geddes' Futurama model with its depiction of futuristic cities, interlaced with highways (Source. Angela Ndalianis).

These new highways employed four principles; safety, comfort, speed and economy, which generated a Corbusian like quality of symmetry and standardisation. The accuracy and detail of the diorama created a convincing argument that highways, cars and suburbia represented a positive view of urban modernity. As a result, Futurama is often attributed to convincing a generation that cars and highways represented the future (Maffei, 2012). The power of well thought through and considered future visions had begun to be established as a tool to explore the future.

1.3.4 1945-2000

Cities and societies in the post war era saw the biggest impacts as a result of the automobile, this could be primarily attributed to a number of factors. The Second World War had completely changed global economics and society forever (Wills, 2007). Manufacturers could no longer rely on selling high end bespoke motors to the very wealthy, but now had to target everyone. The idea that everyone could and should own a car began to infiltrate itself into every aspect of human expectation and urban design. This meant that not only would automotive manufacturers change the way in which people would live their lives, but they would also change our cities, towns and villages. They would change the way we shopped and what we would expect to buy. The automotive industry would from 1945 changed almost every aspect of our lives and not necessarily for the better (Jacobs, 2016).

The war had already begun to change the expectations of a generation. Previously, people had grown up in small communities, even within cities and often worked for the same employers that their parents, siblings and friends did. The war had displaced people around the world and had broken down the community and labour patterns that existed before (Wills, 2007). Many people now wanted to change how they had lived their lives and wanted to move to the newly built suburbs. This new suburban model was not just about living in a cleaner environment with bigger houses but was about the motor car and the wide access to a new network of work and leisure activities that this model offered (Clapson, 1998). Today we are also reaching another period of change, as society becomes more digitally connected and environmentally aware (Urry, 2016). The car is increasingly meeting criticism for its inefficiency and harmful environmental impacts (Schwartz & Rossen, 2015).

Early post war vehicles were often based on the technology that the motor industry had used during the war years. The now post-war Volkswagen Beetle started production in an effort to get the German economy back on its feet but was quickly followed by other cheap utilitarian vehicles from around the world. This included the 1945 civilian version of the Willis Jeep, the CJ-2A, in 1948 the Citroën 2CV and in the same year, Land Rover's own answer to the Jeep, the Series 1 (Womack et al., 2007).

These smaller vehicles, were also accompanied by a boom in the development of trucks, targeted at farms and heavy industry to move their goods to a wider marketplace. The origins of the 1940s economic model of trade can still be seen today, with many hauliers' websites stating that they started the business from a farming background. Many of the post war truck manufacturers developed their technology through the war years. With peace, manufacturers such as Mercedes and Mack had to find new marketplaces for their war time equipment and with the agricultural industry needing to become ever more productive, farmers became the perfect clients.

As these early post war vehicles were increasing in numbers and importance to the economy of countries, there was an increasing demand for the development of more road infrastructure to support these vehicles. Many nations around the world, set about committing to large infrastructural projects to support and improve the efficiency of vehicles (Bird, 1969). This meant that during the 1950s onwards, major road building projects were being instigated around the world, but especially in West Germany, Great Britain and the US. In West Germany the Autobahns were being repaired and new stretches were being constructed (Zeller, 2010). Over in the UK, the 'Special Roads Act 1949' was getting underway with the construction of the M1, which was not complete until 1959 (Special Roads Act 1949, 1949). The Preston Bypass beat the M1 to be the first motorway in the UK to be completed, having been opened a year earlier in 1958 (Figure 1.6).

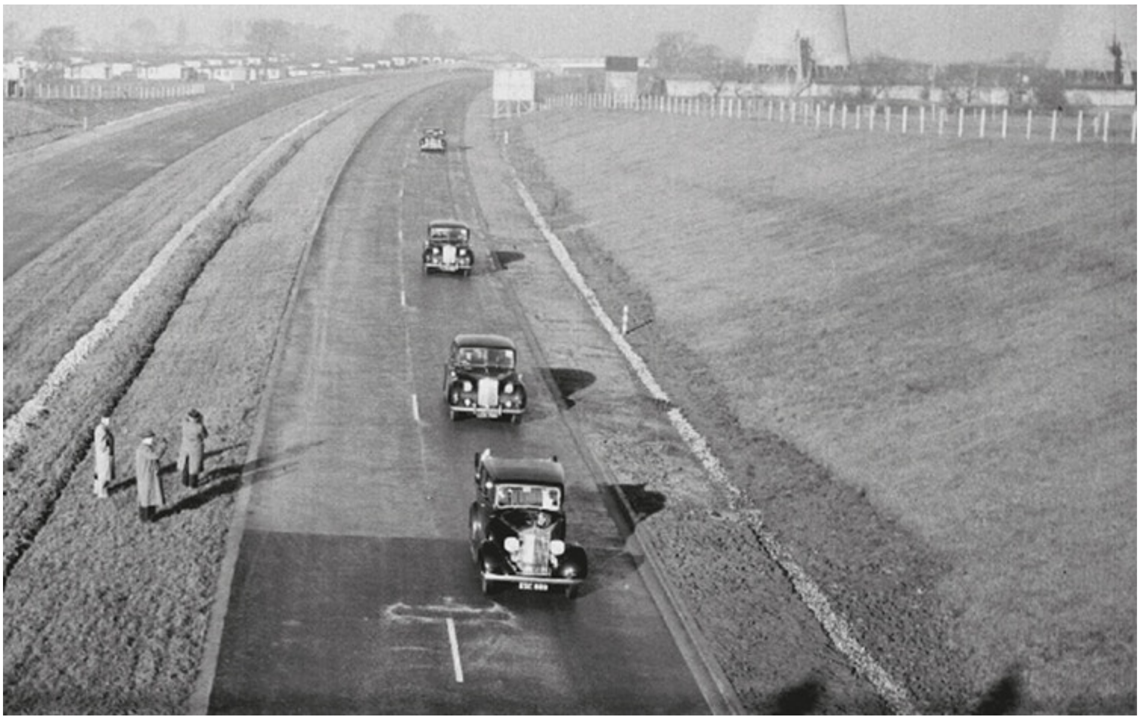


Figure 1.6. An image of Preston Bypass with spectators standing on the verges enjoying the vehicles speeding by (Source. theoldie.co.uk).

Over in the US, in 1956 a little behind Europe, President Eisenhower signed the Federal Aid Highway Act. This started the construction of the 'National System of Interstate and Defence Highway'. These highways were again partially predicated on war, but this time it was the Cold War that was being prepared for. While these Interstates were considered essential to connecting the cities of modern America, these roads were also constructed for the slightly more chilling prospect that it would allow for the mass evacuation of major cities if ever needed (Garrett, 2014). As with the Autobahns and motorways, the interstates were designed to strict design codes, which meant that these new roads were designed around speed. These new roads considered by some to be at the height of fashion and modernity, led to a new generation of vehicles.

With both the Autobahns and motorways having no speed limits and the Interstates having a limit of 55mph, cars had to develop quickly to keep pace with these new highspeed networks. As a result, the 1960s and 1970s saw a period of perhaps the biggest change in motor vehicles. The vehicles that were produced during this time became the blueprint for the vehicles that we see today.

The early 1960s brought about significant changes to the vehicles people drove. In Europe and America speed and style became the key selling point. With a new network of roads built to high standards, consumers were demanding vehicles that could extract the full potential of these roads and manufacturers were happy to supply and demonstrate these vehicles. In Europe this period generated some of the most desirable vehicles ever built, with examples like the Ferrari 250GTO, Aston Martin DB5 (‘the James Bond car’), Mini Cooper and the Jaguar E Type.

All of these road production cars could be seen in various race series around the world and later, the Jaguar could regularly be seen being driven up and down the M1 at 120 mph during testing. In 1964, a Mini won the Monte Carlo Rally, AC Motors were caught testing their Le Mans entry doing speeds of up to 180 mph up and down the M1 (Merriman, 2008). The motorway had become a glamourous place of speed; in 1964, services were a celebrity haunt for rock stars and the restaurant often had a waiting list for a table (Merriman, 2008). This was especially true at the Blue Boar in Watford Gap services (Figure 1.7).

Figure 1.7. This photo of Keith Richards at the Blue Boar (Watford Gap services) documents the glamour and appeal of the new motorway network and its associated infrastructure (Source. CoventryLive).

This European trend for speed also existed in America, perhaps a little later, but was particularly evidenced with the rise of the muscle car. Cars like the 1964 Pontiac GTO, 1968 Dodge Charger and the 69 Mustang and Camaro. By the late 1960s, there was a gradual shift away from speed as public opinion began to shift towards more regulation to slow the roads as the death toll continued to rise (Hagenzieker, Commandeur & Bijleveld, 2014). This shift began with the introduction of regulations and technologies that we take for granted today. In 1966, the British Isles passed a law that no road would have a speed limit above 70 mph. By 1968, the United States passed a Bill requiring all new cars to be fitted with lap belts, but it was not until 1970 in Australia before seat belts became mandatory. These regulations of technology and use would over the years become globally accepted as the norm.

The 1970s forced a lot of changed on the automotive industry. With increasing concerns about safety and reliability, manufacturers were already having to compete differently to win customers. The biggest shock to date came to the automotive industry in 1973 with the oil crisis. With Japan, the Netherlands, United Kingdom, Canada and the United States all subject to oil embargos, change had to take place ("Energy Crisis (1973)", n.d.). As an initial attempt to stem the use and dependency on oil, countries such as Switzerland banned the use of vehicles on a Sunday. The UK reduced speed limits nationally to 50 mph in an attempt to reduce fuel usage. Consumers were now paying more to run their cars and as a result, there was a consumer push for the manufacturers to produce smaller, more economical vehicles. In Europe, this led to a new style of vehicle, the hatchback and cars like the Vauxhall Astra, Ford Fiesta and the Volkswagen Golf (Freund & Martin, 1993). This was a formula which is as relevant today as it was in the 1970s. Across the Atlantic, the move towards more economical cars was also beginning to take hold. Nissan, Toyota and Honda all with their smaller, more economical and arguably more reliable cars, made massive inroads into what was once a marketplace made up entirely of US domestic manufacturers (Womack et al., 2007).

This changing trend of consumer expectations and the attempted repositioning by manufacturers, meant that the 1970s became a challenging time for many automotive manufacturers leading to nationalisation within Europe. The social and political atmosphere of the time also meant that many manufacturers in both America and Europe ceased operating, failing to adapt to the challenges of the 1970s (Womack et al., 2007).

The 1980s and the 1990s was a period when consumers slowly began to no longer see driving as a pleasurable activity, but one which was marred with the stress of traffic and increasing cost of ownership. During this time, manufacturers often looked to sell cars to consumers by appealing to the more socially responsible owner (Schwartz & Rossen, 2015). As a result, car manufacturers have focused on certain aspects with companies such as Volvo and Renault in the 90s marketing cars almost exclusively through their safety credentials (Womack et al., 2007). As greenhouses gases and global warming became widely understood, many manufacturers shifted their technologies to sell cars, producing examples like the hybrid Toyota Prius, which was launched in 1997. The 1980s and 1990s represented the start of a change to the industry where the auto manufacturers were being tasked, partially with managing issues created as a result of their own success in the 60s and 70s (Schwartz & Rossen, 2015). More than this, manufacturers in the 90s, caused generations of children to turn their backs on the car.

1.3.5 2000-today

Since the early 2000s, we have seen the automotive manufacturers battle to find their place in the world as we did at the turn of the twentieth century. This started around the millennium, with manufacturers exploring what we have now termed as alternative fuels. Initially auto manufacturers began to release hybrid cars which combined a small petrol engine with a small amount of electrical power stored in lithium batteries, which could be used with an electric motor to provide drive. Hybrid technologies require no charging, as they use regenerative braking. This works by using the motor as an alternator to recharge the batteries, providing the vehicle with braking and electricity (Toyota UK, 2019). With Toyota releasing this form of technology in

1997 and Honda soon after in 1999, it did not take long before another manufacturer took electric technologies further. In 2003, a new start-up, Tesla Motors founded by Martin Eberhard and Marc Tarpenning in Palo Alto California, set out to build vehicles powered by electricity only. By 2009, Tesla had delivered around 500 of its rather unsuccessful Roadsters. Tesla had however provided a proof of concept that there was an alternative to petrol and diesel (Ramey, 2017).

Today, just ten years after the Roadster, there are approximately 38 manufacturers making electric vehicles, from global players like BMW to new start-ups like Sion, making up around 2.1 million vehicles sold globally in 2018. Currently electric vehicles have been limited to small cars and vans, however there are also larger vehicles including HGVs in development, with manufacturers including Tesla and new companies entering the industry, including Siemens and the start-up Emoss. Hydrogen has also been proposed and developed as an alternative to battery powered vehicles, with some significant advantages including the speed to refill/recharge time and life expectancy. However, this technology has not gained the same momentum that electric technologies have and so is currently without the necessary infrastructure. Currently only Toyota and Hyundai offer hydrogen vehicles and many others have halted development to focus on electric technologies, despite some of the advantages of hydrogen as a fuel.

Perhaps the potentially more transformative and disruptive technology to emerge in the 21st century is the connected and autonomous vehicle (CAV). Nearly every vehicle manufacturer, technology giant, systems supplier and start up seems to have an interest in the connected world. At the heart of this connected world appears to be the CAV (McConky & Rungta, 2019). What is unique is that developers of self-driving vehicles are working across all modes of transportation, including mass transit, trucks, cars and personal transportation. It seems as if the goal is no longer to develop and sell driving vehicles, but to develop and sell the technology. The vehicle has just becoming another device in the digital world (McConky & Rungta, 2019). Manufacturers are increasingly eager to find their place in the future; a place that re-engages the disinterested millennial by challenging what the car is and can be.

1.4 The changing automotive world

Vehicles are becoming ever more connected with an increasing ability to make decisions. We are seeing technologies, futurists and designers exploring what this may mean for our cities and that of the citizens that live and work within them. The driverless hype has been perpetuated by manufacturers, futurists and governments alike as a method of managing the issues of mobility and climate change that our cities face (Glazebrook & Newman, 2018).

As with the 20th century, mobilities and the environment remain major concerns today. The impact and success of the motor vehicle is also its downfall, resulting in a lot of technologies and manufacturers coming and going. In the 21st century, we as a society are being faced with some of the same issues that were presented at the turn of the 20th century. Our cities are just as polluted, no longer with manure, but now due to the burning of fossil fuels. Interestingly, travel speeds in cities are similar to that of the turn of the 20th Century, around 16.8 mph in London despite the advances in technology (TFL, 2018).

The automotive industry is attempting to fight back at the lack of value consumers now place on cars. They are today heavily competing amongst themselves and other modes of transport on price and particularly ownership models, such as lease, PCP and hire purchase. This is even extending into short term leases, such as pay per mile or by the hour. Manufacturers are also attempting to mark themselves out by defining themselves and their vehicles with certain characteristics, whether it is about performance, comfort, safety or economy; today all manufacturers need a unique selling point to move cars in such a competitive marketplace. As a result, in 2018 and 2019, we have seen a global downturn in the sale of new cars particularly diesels which saw a 42% sales decline in September 2018 (Monaghan, 2019). This can mainly be attributed to the fall in consumer confidence, particularly surrounding engine technologies.

Globally, governments have ruled that diesel cars are too polluting due to their NOx emissions and that petrol vehicles represent a cleaner alternative. However, electric vehicles are being promoted as the preferred option via tax incentives, due to the vehicle itself producing zero emissions. This has confused consumers (RAC, 2018), since up until around 2017, diesel was the preferred option among governments due to its lower CO_2 emissions when compared to petrol. Petrol vehicles are now the preferred option as the agenda has shifted away from decreasing greenhouse emissions towards public health through the lowering of NOx emissions (The Independent, 2018a). The fact remains that for many, diesel cars represent the most cost effective and practical option due to their higher miles per gallon. Petrol vehicles are typically more expensive to run for high mileage drivers and electric vehicles currently fail to offer the range (the distance a vehicle can travel) or support infrastructure. These unclear messages are causing a lack of confidence in the electric vehicles, exemplified by the phenomenon known as ‘range anxiety’ (RAC, 2018).

As manufacturers and designers continue to look towards future technologies as an attempt to become responsive to current issues, we are finding that a wider spectrum of ideas and technologies are beginning to emerge. Automation however is something that most manufacturers view as a valid technology to address the issues of modernity that we face today. What is clear is that the situation of the past 100 years, with its divergent technologies competing to be the frontrunner, echoes the situation we see with autonomous vehicles today. It is currently unclear whether driverless cars will become yet another failed technology, or one which could revolutionise the way mobilities of the future operate.

1.5 The social and physical impact of the automobile

The automobile has arguably had more impact on society than any other technology. It has changed where and how we live and work, reshaped our cities and countryside and influenced our art, architecture and fashion. Since the turn of the 20^{th} Century, the automobile has undoubtedly affected the lives of nearly everyone on the planet and shaped the world around us (Bajpai, 2016). The mass building of roads around the globe has changed our expectations as citizens both from the perspective of how we can move and how goods can move (Urry, 2007). Today, most people can expect to be able to jump in a car or bus and travel around 500 miles in a day. Using a 19th Century stagecoach, travellers were limited to around 70-80 miles per day, meaning it would take over six days to travel the same distance. Our increased mobility has resulted in the displacement of communities; people can now travel large distances to work and sustain social networks on a global scale (Urry, 2007).

Mobility has also changed consumer habits; when shoppers enter a supermarket, they expect all-year-round availability of seasonal produce. These products have to be transported by lorry across Europe to ensure that they are fresh for us to eat. It is not just consumers, but industry too that expects goods from across Europe and the globe to be delivered on demand, 365 days a year. Just-in-time (JIT) has become an operating model for high-end manufacturing across the globe and is entirely dependent on the efficient and timely movement of goods (Halevi, 2001). Without trucks and roads, it would be impossible for businesses to operate in this way. Without JIT, factories would have to consume more land and be more expensive to operate.

There are however negative consequences to increased vehicle mobilities. Pollution has always been a major issue of our cities, whether it was sewage in the 19th Century, soot in the 20th, or CO_2 and NOx in the 21st Century particularly for vehicle which are not Euro VI, there is no doubt that cars have become a major contributor to the health issues of urban citizens and more widely, global warming (Degraeuwe et al., 2017). While manufacturers and governments are attempting to reduce pollution, the reality is that we are a long way from achieving clean air in our cities. Roads are major pieces of infrastructure and as such have had a physical consequence on both the urban and rural.

Roads, particularly high-speed ones have cut through communities, segregating one side form the other. By the very nature of the car, designers have attempted to remove pedestrians from these major roads, particularly motorways which are impossible to penetrate without bridges or subways (Plowden, 1972). As a result, roads have actually made walking and cycling more difficult as shown in Figure 1.8.

Figure 1.8. A satellite image showing how the M602 in Manchester cuts through the Victorian housing, creating a barrier to once connected communities (Source: Googlemaps.com).

Traffic jams have also been a result of the success of the automobile. While traffic jams existed at the turn of the 20th Century as horses and carriages blocked the roads, there is no doubt that traffic today is worse than it ever was. In 2017 the average driver in London spent 72 hours stuck in traffic a year (BBC.co.uk, 2019). This undermines the convenience and speed that cars once commanded and also contributes to increased levels of pollution.

Despite the issues associated with vehicles, they have had a huge influence on art, architecture and fashion. Some would argue the resulting design of many cars such as the Jaguar E Type are pure art and that its designer, Malcolm Sayer, is indeed an artist. As an art form, many cars are coveted and desired by their owners and appreciators. As evidence to the art of these cars, there are many museums and galleries around the world which are dedicated to the exhibition of cars and bikes. Vehicles over the years, have had the ability to get under of skin and for some, we treat them like a member of the family, taking great care of them during ownership and grieving their loss. Whether it is the vehicle itself, or the memories it has given us, there is no doubt that vehicles have a staggering impact on some of our lives.

Vehicles have had a profound impact on the architecture of our cities. This is perhaps most true when the function of cars and buildings collide, forming a kind of "carcitecture" (Bell, 2001). This is perhaps most embodied in the US, where throughout the 20th Century, buildings have been designed around the principles of car ownership. One of the most striking exemplars of this is the Marina City in Chicago by Bertrand Goldberg, a 65-storey cylindrical apartment building, of which the first 19 floors are parking. The building completed in 1967, was seen at the time as a model for inner city residential development and has been used as a typology across the globe (Figure 1.9) (Bell, 2001).

Figure 1.9. Marina City in Chicago is one of the most iconic examples of "carcitecture" where there has been a deliberate attempt to seamlessly integrate the automobile into the design of the building (Source. Nicolas Janberg - structurae.net, 2015).

The Middle East in particular has adopted this model, attempting to seamlessly integrate cars into the buildings program, but it has certainly not been without its consequences. Cities such as Doha (Qatar), are extremely difficult to navigate without a car and impossible by foot. This has led to a deeply divisive city between the wealthy citizens who own cars and the poor who don't (Ali et al., 2014). There has also been a worrying trend which has emerged globally from car dependant cities. In both American cities and in Doha, there has been a measurable downward trend in the health and fitness of the population (Ali et al., 2014). Today much of the world has started to wake up to the consequences of car dependence through good examples like Portland Oregon, but this does not mean that we have stopped building cities designed around the car (Schwartz & Rossen, 2015). We now have a long legacy of "carcitecture". If autonomous vehicles develop as the manufacturers predict, then what will happen to these buildings and infrastructures? Also, how will the next generation of architects respond to the changing relationship between cities, users and buildings? Will we see the rise of a new architectural typology?

Perhaps a more ironic example of so called "carcitecture" resides in Detroit, the home of the once vast US motor industry. Positioned in the heart of the city, the Michigan Theatre stands decaying with remnants of its once illustrious interiors although there are proposals to restore the building. The theatre and cinema designed by Rapp and Rapp was built in 1926, with no expense spared. The construction was reported to have cost $5 million, the Italian renaissance styled theatre with its 4,050 seating capacity and 4 storey gilded lobby, demonstrated the wealth that the automotive industry in Detroit was generating at the time. By the 1960s, the theatre was slowing falling into decline and the ballroom became a venue for the up and coming Detroit rock scene. By the 1970s, not even the well-established rock scene could save the building and so it closed its doors (Austin, 2019). The solution was extreme; converting the building into a carpark was the only way for the structure to remain financially viable.

Another emergent architectural typology derived from car use is the service station, and perhaps one of the most striking of these original structures remaining today is

Forton Services on the M6 near Lancaster built in 1965. Created by the architects T.P. Bennett and Sons, the building is readable at motorway speeds, yet the experience of its spaces re-connects drivers visually with the environment, as shown in Figure 1.10. In this case, the views are back towards the picturesque Morecombe Bay and Trafford Bowland (Crowe, 1960).

Figure 1.10. The UFO-like structure of Forton Services acts as a landmark against the backdrop of the monotonous motorway network. The platform allows visitors to stop and reconnect with the surrounding landscape (Source: fortonservices.webs.com).

When motorway services such as Forton were built, they were beacons of modernity, popularised by rock bands, so much so that you had to make a booking to use the restaurant. This did not however last long and by the 1970s, they had already turned in locations which sold terrible overpriced food and no longer met the needs of their customers (Moran,2010). Services had very quickly become a place for people who were desperate for the toilet or food and worse still, a prison for those regulated to stop and rest, such as truck drivers. These places had quickly become a place of social separation, this was not helped by the accessibility of services and the motorway network. Without a suitable vehicle, it is impossible to access or leave a motorway and its services, this means that those regulated to stop have no ability to leave and likewise, those stuck outside have no ability to access the services.

In response to this national parking crisis, truck cabs are becoming ever more equipped in an attempt to provide some form of suitable living conditions. Trucks now have heating, cooling, power, microwaves and fridges, but in Europe they nearly never have toilets. The conditions of living on the side of a road or out of services is described as very poor and unacceptable (Marston, 2019). There is in fact a more extreme version of this beginning to emerge. In places like London and California, people are choosing to live out of their cars. This is primarily for one reason, the cost of living is so high that people cannot afford to live there, sparking the safe parking programme in the US ("Safe Parking® Manual", 2019). People tend to live out of the boot of an estate car, but over the years, there have been manufacturers who have suggested that their vehicles may be ideal for such lifestyles. In the 1980s, Renault launched their Espace, demonstrating in the literature how the interior could be modified to provide a home away from home, providing sleeping and dining at a table with others. There are of course serious ethical implications of such trends and Renault are now speculating on how their Symbioz concept car could be at the centre of the home (Figure 1.11) ("SYMBIOZ Concept", 2019).

Figure 1.11. Renault's SYMBIOZ Concept explores the connection between a highly digitised vehicle and our domestic living space (Source. Renault, 2017).

Such is the power that automotive brands hold, that many fashion designers have connected their own brands with that of auto manufacturers. Ferrari has been particularly happy to connect their brand to others. Both Tod's and Puma make Ferrari branded footwear which they market as a driving shoe. These brands are perhaps attempting to conjure notions that the shoe provides some of the experience of driving a supercar. Ferrari are not alone, with other companies like Mercedes and BMW all selling lifestyle products, dual branded with fashion and in particular golf designers. This demonstrates that for some, cars are still regarded as status symbols; something to be aspired to. This is something that will perhaps always remain with the exclusivity that high end brands such as Ferrari, Bugatti and Rolls Royce have, for the rest of the industry however, cars are often just seen as something to get you from A-B, because there is no better alternative.

The automobile has had a profound effect on our lives, influencing every aspect of our cities, art and culture. Autonomous vehicles are set to be the next revolution of this transformative technology. The impacts of these driverless vehicles will once again affect everyone, challenging, society, cities, policy, design and every aspect of the way we will live in the future. History has taught us that without proper management and forethought, the future these technologies will create may not be of our choosing, as we have seen through the last 100 years of the automobile.

2 Literature review

Driverless vehicles; the ethics of the mundane

This chapter explores the literature surrounding the development and implementations of autonomous transportation and the potential opportunities and challenges that these technologies present to the urban fabric and its users. While much of the work conducted by industry and academics to date focuses upon how machines will make driving decisions, 'should the vehicle swerve left, or right?' This work will consider the often-overlooked ethical aspects of autonomy; the way in which autonomous vehicles will influence and shape the more mundane aspects of our everyday decision making.

The review will first consider the context in which driver assistance systems are being applied today (2.1 and 2.2). Sections 2.3 and 2.4 look at the literature surrounding the future of driverless cars through exploring manufacturer concepts and the potential for driverless cars both spatially and in terms of the experiences we value today.

The latter sections of this review (2.5 - 2.11), explore literature which questions how both digital and physical infrastructure will challenge us as citizens both socially and ethically.

2.1 Future Mobility

Mobility has always been a fundamental part of our cities, arising as a result of social practices, including work, entertainment, consumption and health. It is therefore unfeasible that these activities will cease, but how we perform them may change (Castells, 2007). Globally, we now move in the pursuit of social practices more than we ever have (Urry, 2007). This could be primarily attributed to our increased accessibility to modes of transport, for example, cars, buses, planes, ships and even digital forms of mobility such as email, phones and video chat (Urry, 2007). As a global population, the world has never had as greater access to mobilities as they have today, and the world is only becoming more connected (Urry, 2007). This revolution is not without its consequences. As a result of these opportunities, people are travelling greater distances than ever before, bringing both social and environmental impacts.

In the UK, the total vehicle miles travelled across the population has risen from 37 billion in 1951 to 311 billion in 2014. However, in 2008 and 2009, the total number of road traffic miles travelled declined for the first time. This reduction can however be attributed to the economic downturn, as the number increased again as GDP rose in 2014 (Department for Transport, 2016). Despite this it is hard to believe that digital capability did not contribute in some way to this decline. While we may still prefer and value face to face contact over the alternative methods of communication that platforms such as Skype offer, there is no doubt that digital connectivity does at time present an alternative to traditional methods of social exchange (Gentina & Chen, 2018). The digital world has given people the option to reduce the frequency of physical travel, instead, opting to work from home, or have their food and goods delivered through business models like Amazon and Ocado (Urry, 2016). In fact, government findings show that the number of people working from home has risen from 1.3 million in 1998 to 4.2 million in 2014 (Office for National Statistics, 2014).

With citizens becoming ever more digitally engaged, it was inevitable that vehicles would become increasingly digital to support our connected lives and cities. Driving still currently acts as a barrier to our digital desires. Legislations, safety and practicality prevent us from remaining submerged in the digital content that our smartphones endlessly deliver (Burns, 2013). This is however slowly changing, connected vehicles are being rolled out across a wide variety of manufacturers including BMW and Mercedes, while many others are using proprietary systems such as Apple Carplay or Android Auto. Both these proprietary and manufacturer embedded systems are intended to make the car an extension of our smartphone. These systems allow constant access to applications such as Google maps, Whatsapp, Spotify and calendars, all integrated and ready to be used whilst driving.

Figure 2.1. Apple Carplay, with its integrated applications, already keeps users connected to the world while travelling.

Connected vehicles are however, not just about streaming content to the user but are being developed for their ability to share data with others, enabling them to be developed as prototypes for connected autonomous vehicles (CAV) (Burns, 2013). Connected vehicles are today already streaming and receiving real time data, informing drivers of traffic and incidents ahead, rerouting journeys often without the need for any human intervention. Connected vehicles also stream real time information about traffic conditions, vehicle performance and any maintenance issues that may be developing, allowing the manufacturer to intervene and perform remote diagnostics if required. Beyond this, manufacturers such as BMW are also currently working on integrating IoT devices to their connected cars, enabling the driver to turn the lights on at home or adjust the heating while travelling down the road (Boeriu, 2019). While the value of being able to adjust the heating from a place some distance from your current location remains questionable, the end objective and the societal contribution of these developments remain unclear (Sterling, 2014; Zuboff, 2019). It could be assumed that data being shared at a vehicle to vehicle level and a vehicle to city level, develops a trajectory towards achieving the technical capability through which future smart city objectives could be achieved. This development is important when you consider that many of the future visions of smart driverless mobilities are based upon a premise that all vehicles and road infrastructure can communicate, enabling the seamless movement of vehicles through intersections and the wider city (Ratti & Biderman, 2017). As a result, autonomous vehicles could be viewed as packets of data moving through a digital network of routers and switches. Without ubiquitous connectivity through which all devices, infrastructure, vehicles and users can be tracked and given prioritised routes through our cities, it is hard to imagine how seamless exchanges as demonstrated in Figure 2.2 could take place.

Figure 2.2. A still image from Black Sheep's video of what an autonomous intersection may look like. This was created using a scripted sequence of actions performed by actors; producing a visual representation of an autonomous future (Source. Black Sheep Production, 2014).

While much of the literature and focus of the media is based on mass transit and personal transportation, trucks are perhaps the most connected and overlooked vehicles on the road today. There is a need for research which takes into account the role that trucks and their drivers have on society and how new technology is changing the lives and working practices of these drivers.

Truck, lorry, wagon, heavy good vehicle (HGV) or large goods vehicle (LGV) are terms commonly used interchangeably to describe vehicles weighing over 3.5 tonnes designed for the carrying goods and equipment (Wallace School, 2019). The latest versions of these vehicles are capable of streaming and receiving all of the data that cars can, while also acting as an essential tool to manage fleet operations and since 2015, have become a test bed for autonomous technologies (The European Parliament, 2009). Today's trucks can stream data about the driver's performance, the truck's performance, its location and anticipated arrival time, enabling customers to see when deliveries will be made. They can also manage and live stream data such as, cameras, tachograph records, speed and weight of the vehicle with many operators sharing this information with regulatory bodies such as Vehicle and Operator Service Agency (VOSA) in the UK. This means that such bodies do not need to stop a vehicle to perform checks, but can assess compliance remotely using digital records. Since 2015 and the introduction of Euro VI regulations, HGVs have been legislated to use driver assistance systems (The European Parliament, 2009). These systems include emergency brake assist (EBA), lane departure warning (LDW) and adaptive cruise control (ACC) to name but a few. See figures, 2.2, 2.3 and 2.4 for a more detailed breakdown.

The introduction of driver assistance systems has been predicated on the increase in safety that they will allegedly introduce (Bajpai, 2016). However, to date there have only been a few studies that have sought to quantify the real-world impact on drivers of such technologies (Navarro et al., 2016). This area is emerging as both a fertile and overlooked subject for research. This is perhaps due to the fact that a great deal of the research into autonomous technology assumes a level of capability where the driver is removed, the messy interim periods where machines and humans will have to work together appears to be have been studied less. The arguments for the increased safety that the introduction of autonomous systems will deliver are still unclear. Early data demonstrates that these systems have reduced the kind of accidents that they have been introduced to prevent (Seehan, 2019; Thatcham, 2019a). However, the results of these studies do not conclusively show whether the technology has been the cause of these reductions, or if other factors could be at play.

To date, no study has conclusively determined if driver assistance technologies are introducing other issues that were perhaps unforeseen. Thatcham have produced a report that shows that third party insurance claims against the Mark VII Golf with EBA were 45% lower than the equivalent Mark VII golf without EBA (Thatcham, 2019a). While these figures demonstrate a stark difference, there are factors which could have contributed towards their findings. For one, owners who opted to pay extra for the Golf with EBA could be more safety minded and thus drive with more care. The figures also do not also show the kind of accidents that the different vehicles were having. For example, while there was a reduction in the number of claims made by a Golf with EBA, we do not know the severity of those accidents and what the contributing factors were. As a result, consumers are having to trust the claims of safety published by manufacturers in their marketing material, as shown in Figure 2.1.

Figure 2.3. MAN's marketing literature for emergency brake assist claims to increase safety by considerably reducing the risk of a road traffic accident (Source.www.truck.man.eu).

The increased automation of vehicles is a trajectory that today seems unavoidable, as the digital and physical worlds become ever more entwined. Despite this, to date there is a lack of research, which explores the realities and impacts, socially and ethically that such technologies may have on our cities and their citizens. This gap in research could be attributed towards the changing views on humans as drivers. Increasingly, humans are being seen as poor decision makers and ultimately bad drivers (Bajpai, 2016). Secondly there is a growing movement among younger citizens who no longer value driving (Schwartz and Rosen, 2015). These facts appear to be creating a growth in research which seeks to remove humans from the task of driving, to be completely replaced by machines.

2.2 Driverless vehicles - Automation or autonomy?

To understand the context of driverless vehicles, we must understand the difference between automation and autonomy. Automation is perhaps the most commonly used and understood term, partly because automated machines and devices have been used for hundreds of years. Automation is defined by de Visser, Pak and Shaw (2018, p.1409) as A *"conventional automated system designed to carry out a limited set of pre-programmed supervised tasks on behalf of the user."* Today we use automation in lots of devices such as vending machines, doors and especially in vehicles with, wipers, chokes and gear boxes, all designed to reduce the workload of humans.

Autonomy could be viewed as a higher level of automation, which demands a higher-level of computing. According to de Visser, Pak and Shaw, autonomous systems (2018, p.1409) *"are distinguished by their capability to learn and change over time, dynamically setting its own goals, and the ability to adapt to local conditions via external sensor information or updated input data."*

While both terms have similar connotations, they are terms which clearly define different stages of development. Putting the terms into the context of vehicles, we already have cars and trucks on our roads today with automated driving systems. Driverless trains have had automated systems for some time. These are systems which operate within isolated or restricted environment, monitoring known variables through sensors and switches. Current automated vehicle systems such as adaptive cruise control operate in the same way as the train, although sometimes, to humans they have the appearance of being autonomous, but this is not true and raises concerns for shared decision making (Dickie & Boyle, 2009).

Adaptive cruise control operates by using radars mounting on the front of the vehicle. These radars scan the road ahead looking for an obstruction. Very rapidly, within milliseconds, the radar system can determine the speed of the obstacle and then a simple algorithmic calculation is carried out, determining how quickly to decelerate in order to avoid the obstruction. The system is then designed to follow the obstruction, in the case of another vehicle, at a set distance determined by the user. The system is clearly automated, and its limitations can be demonstrated by some simple examples. This type of system is unable to operate unless the system makes an assumption that the road is straight. This is because the system has no information about the layout of lanes, or curvatures to the road. Secondly the system cannot make any judgements about other road users, for example, it could not slow to allow an indicating vehicle to change lanes. The system has no ability to observe a turn signal and take appropriate action.

It is therefore the case that automated systems can only operate in limited environments such as, within the confines of a motorway, while requiring continual monitoring from a human to manage situations outside of the system's operating parameters. Using automation alone to control a vehicle, means that it is unlikely that a vehicle could ever exceed SAE Level III (SAE International, 2019).

Autonomous systems by contrast are very different and are theoretically capable of performing as well as a human, or arguably even better. However, whether an autonomous system would be able to act appropriately among human drivers as opposed to other machines, remains very much unknown (Sparrow & Howard, 2017). Autonomous systems rely on accurate, real-time data about all other road users and the infrastructure which governs their movement. This is why, the connected vehicle becomes an extremely important prospect for the future. A connected vehicle is able to communicate with other vehicles, road users, and in fact the road network itself. This means that a vehicle travelling down a road, knows when the traffic lights are going to change, or when another vehicle is going to change lanes.

If all vehicles were operating on a common platform, or with a common language, every vehicle could operate autonomously without a human (Talebpour & Mahmassani, 2016). Through this kind of system, it is possible to achieve a transport network which operates at SAE Level V (SAE International, 2019). However, there is a question about how a human would operate within this kind of network, as humans are unable to reliably transmit their actions to other machines. Additionally, humans are well known for their indecision, characteristics which machines struggle to accommodate.

2.3 What is a driverless, autonomous, self-driving and driver assisted vehicle?

Autonomous, driverless, self-driving and driver assisted are all terms we hear regularly within the media, but we rarely hear them defined. This is perhaps why people erroneously use them interchangeably. Perhaps the Society of Automotive Engineers (SAE) puts the most widely recognised and used definitions forward. The system proposes a hierarchical framework in which the level of autonomy performed by the vehicles ranges from level 0 which represent human only input, up to level 5, where the system is entirely autonomous (Snyder, 2016, p.25). Table 2.1 provides a brief definition of all 6 levels of autonomy.

Table 2.1. SAE levels of autonomy (Snyder, 2016, p.25).

SAE Level	Definition	Human Role	Example
Level 0	No automation Human driver does everything.	Human must conduct all driving tasks.	Most human driven cars on the road today.
Level 1	Driver assistance Vehicle assists with some parts of driving.	Human is the driver.	Adaptive cruise control, parking assist.
Level 2	Driver assistance Vehicle does some of the driving, while human and driver monitors	Human is the both the driver and observer.	Mercedes-Benz intelligent drive, Tesla Autopilot.

	the driving environment and performs the rest of the driving.		
Level 3	Self-driving Vehicle conducts parts of the driving and sometimes monitors the driving environment, but the human must drive when the system requests.	Human is the observer and when requested the driver.	No current examples.
Level 4	Conditionally driverless or autonomous The vehicle drives and monitors the driving environment, while the human does not need control, but the vehicle can only operate in certain environments and under certain conditions.	Human driver in never needed within defined environments.	No current examples.
Level 5	Driverless or autonomous The automated system performs all the driving tasks.	Human driver is never needed.	No current examples.

It could be argued that there are concepts that explore a level of autonomy, beyond the SAE document. This could be viewed as where all decision-making, navigation, timing, destination selection and engagement with others is removed from the driver and vehicle and placed centrally in a third-party operator's hands. These concepts place all decision making about our mobility, and day to day routines under the control of a third-party operator in an attempt to make our day to day lives seamless (Mitchell et al., 2015). This decision making, will not just concern the control of vehicles but the city, having implications for many aspects of our lives. This will mean cars, mobility, infrastructure and our lives could become part of this holistic system of operation (Simoudis, 2017). But at what cost to citizens ability to make their own decisions or deviate from the norm?

Today, as of early 2019 it appears that we are currently some way off achieving driverless vehicles. Manufacturers such as Ford state that level 3 vehicles should be widely available from 2021, operating within geo fenced areas, but the realities of achieving level 4 and above appear some way off. Ford's CEO Jim Hackett stated that they had "overestimated" the arrival of autonomous vehicles by not fully understanding the complexities of the problem (Marshall et al., 2019). As of early 2019, driver assistance systems are in common use with HGVs, but still remain a new introduction or an option in many cars. What complicates the situation is that driver assistance technologies are being introduced with different names and vastly different capabilities. Without an in-depth knowledge and information on the exact vehicles specification it is extremely difficult to know how the driver assistance systems will behave. Tables 2.2, 2.3 and 2.4 show the range of names used to describe the systems in use today. This problem is exacerbated by the fact that manufacturers typically advertise their most capable technologies. The reality of the vehicles being delivered is that few have had the most advanced systems fitted, as nearly all manufacturers sell these systems as expensive upgrades. While the tables below show many manufacturers offering high speed AEBS systems and active lane departure warning systems, few vehicles leave the factory with such capabilities. This is creating public tension between manufacturers such as Mercedes, Audi, GM and BMW who believe that future development should be done incrementally and manufacturers like Ford and Jaguar who believe that it is dangerous to gradually increase active driverless technologies until they are fully capable and tested to work without human oversight (Ft.com, 2019).

To date there is no real legislation or training governing the use of these systems and their introduction. The UN's Economic Commission for Europe has as of the 28th January 2019, drafted a document for the basis of an Approved UN Regulation, which will provide a process for system approval. The regulation seeks to define the operation and testing of such systems but does not include any aspect of training or information provided to end users (UNECE, 2019). To date this is still a draft document and through discussions held with other regulatory, operating and training bodies there appears to be little other research or regulation being invested into the area of increased driver automation.

The following three tables show the names and types of driver assistance systems offered by manufacturers. All information was sourced from the manufacturers' website or the owners' manuals. Note: The following charts are based on vehicles sold in Europe and list the manufacturers most capable systems

Table 2.2. Manufacturers names for EBA or AEBS systems

EBA (emergency brake assistance) Or AEBS (advanced emergency braking system) System characteristics - Detects objects in the vehicles path. Provides alert to the driver before applying the brakes and bringing the vehicle to a stop. Typically, there are two types of systems. (1) Low-speed systems focused at city driving. (2) High-speed systems, which perform at both city and highway speeds.
Audi - Pre sense front – High speed
BMW – Drive Assist – High speed
Citroen - Active safety brake - Low speed
Chrysler - Active braking - High speed
DAF Trucks - Advanced emergency braking assistance - High speed
Fiat - City brake assist - Low speed
Ford - Pre collision assist - Low speed
GM - Automatic braking and Super cruise - High speed
Jaguar Land Rover - Autonomous emergency braking - High speed
Jeep - Automatic emergency braking - High speed
Kia - Autonomous emergency braking - High speed
Peugeot - Automatic emergency braking system - Low speed
Honda - Collison mitigation braking system - Not stated
Hyundai - Autonomous emergency braking - Low speed
MAN Trucks - Brakematic - High speed
Mazda - Forward obstruction warning - High speed
Mercedes - Active braking assist - High Speed

Mercedes Trucks - Active brake assist 4 - High speed
Nissan - Intelligent forward collision warning - High speed
Renault - Active emergency brake system - High speed
Renault Trucks - Automatic emergency brake system - High speed
Scania - Advanced emergency braking system- High speed
Suzuki - Dual sensor brake support - High speed
Tesla - Automatic emergency braking - High speed
Toyota - Pre-collision system - High speed
Vauxhall Opel - Forward collision alert with automatic city emergency braking **-** Low speed
Volkswagen - Front Assist - High speed
Volvo - City safety - High Speed
Volvo Trucks - Collison warning with emergency brake - High speed

Table 2.3. Manufacturers names for lane departure warning systems

Lane departure warning **System Characteristics – Lane departure warning is designed to alert the driver if the vehicle unintentionally begins to change lanes due to cross wind, or as the result of a lack of attention on behalf of the driver. There are typically two systems. (1) Passive systems, which provide an audible warning. (2) Active systems, which provide steering corrections.**
Audi - Active lane assist - Active
BMW - Steering and lane control assistance - Active
Citroen - Lane departure warning - Active
Chrysler - Lane departure warning with lane assist - Active
DAF Trucks - Lane departure warning - Passive
Fiat - Lane sense - Active
Ford - Lane keeping system - Active
GM - Lane keeping assist with lane departure warning - Active
Jaguar Land Rover - Lane keeping assist with lane departure warning - Active
Jeep - Lane sense - Active

Kia - Lane keeping assist line with lane departure warning - Active
Peugeot - Lane departure warning with active lane keeping assist - Active
Honda - Lane departure warning with active lane keeping assist - Active
Hyundai - Lane departure warning with lane keeping system - Active
MAN Trucks - Lane guard system and lane return assist - Active
Mazda - lane departure warning and lane keep assist - Active
Mercedes - Lane departure waring and active lane keeping assist - Active
Mercedes Trucks - Lane departure waring and active lane keeping assist - Active
Nissan - Lane departure warning and intelligent lane intervention - Active
Renault - Lane departure warning - Passive
Renault Trucks - Lane departure waring - Passive
Scania - Lane departure warning - Passive
Suzuki - Lane departure warning - Active
Tesla - Auto steer plus - Active
Toyota - Lane departure alert with steering assist - Active
Vauxhall Opel - Active lane keep assist - Active
Volkswagen - Lane assist - Active
Volvo - Pilot assist and lane assist - Active
Volvo Trucks - Dynamic steering and lane keeping assist - Active

Table 2.4. Manufacturers names for semi-autonomous systems

Semi-autonomous systems **System Characteristics – Often incorrectly referred to as hands off systems. The reality is that while the vehicle can sometimes drive itself the driver must remain continually vigilant and with their hands on the wheel ready to take over without warning. These systems can be categorised as (1) High speed systems which can be used at all road speeds (2) Low speed systems that are designed to work in traffic jams only.**
Audi - AI semi-autonomous traffic jam assist - Low speed
BMW - Traffic jam assist - Low speed
Citroen - Not available

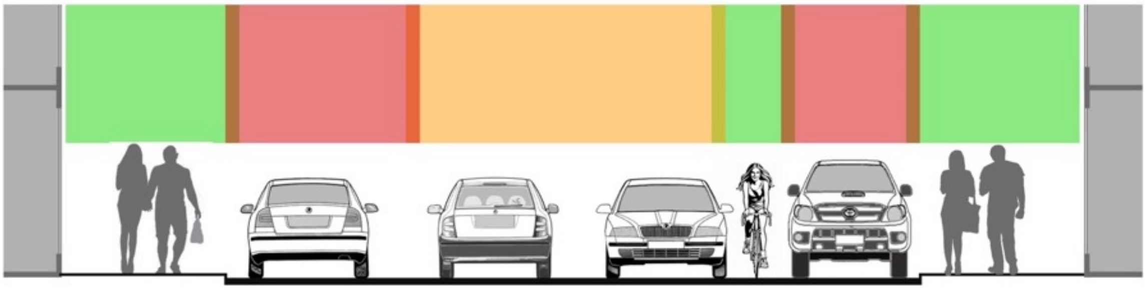
Chrysler - Not available
Daf Trucks - Not available
Fiat - Not available
Ford - Not available
GM - Super cruise - High speed
Jaguar Land Rover - Not available
Jeep - Not available
Kia - Not available
Peugeot - Not available
Honda - Not available
Hyundai - Not available
MAN Trucks - Not available
Mazda - Not available
Mercedes - Driver assistance package - High speed
Mercedes Trucks - Highway pilot - High speed (July 2019)
Nissan - Pro pilot - High speed
Renault - Not available
Renault Trucks - Not available
Scania - Not available
Suzuki - Not available
Tesla - Autopilot - High speed
Toyota - DRCC - High speed
Vauxhall Opel - Not available
Volkswagen - Not available
Volvo - Pilot assist - High speed
Volvo Trucks - Mine tests in Norway

2.4 The drive for vehicle autonomy

Since the 1950s, cars have become integral to our cities. This ‘50 Year Mistake’ as Schwartz and Rosen (2015) have defined it, has continued through to the 21st Century. It has built and shaped our cities and towns. It has produced a landscape, which is often difficult, occasionally impossible to navigate without a car. It has left a public transport system devoid of investment for decades. It has built suburban sprawl, which is without the density to be walkable, or efficiently supported by mass transit (Schwartz and Rosen, 2015). Despite this, there has been a change; not a political, or a social change, but a generational one. The so-called ‘millennials’, those born between the mid 1980s and early 2000s have an entirely different relationship with cars than their parents and grandparents. Their grandparents aspired to car ownership. Their parents felt they must have a car. Millennials neither love nor feel the need for a car; in fact, they see them as a burden. They see them for what the data shows them to be, inefficient, expensive and unproductive (Schwartz and Rosen, 2015).

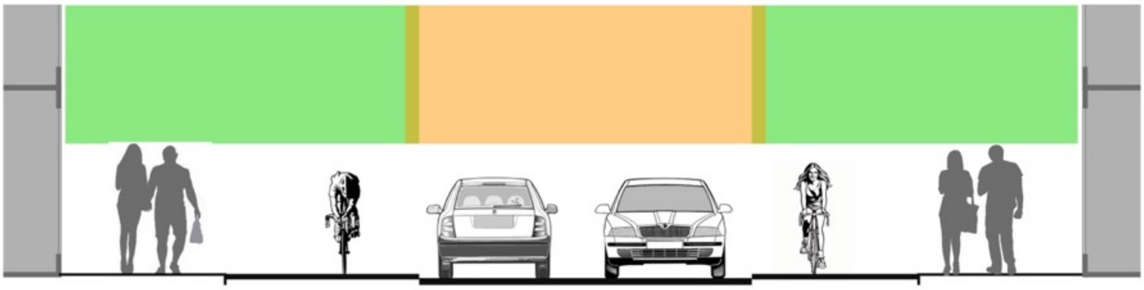
The car has its place and if used in the right situations can be efficient and productive. In cities however, the car is the least efficient mode of transport due to the space required for them to operate and as such, does not respond to the millennial generation, who predominantly locate themselves in urban centres. Despite their inefficiency, business models that rely on cars (e.g. Uber), are at their most profitable in cities due to the density of users (Cox, 2016). There are two ways of making the car efficient; speed and capacity. High speed is something at odds with the city’s makeup; to have high speed roads, they need to be wide and separated from pedestrians and cycles, acting as barriers to movement and impacting the urban cohesion. This is not the case in low-density environments where high-speed roads can be routed past urban centres. For medium length journeys that pass-through medium to low density areas, where high speeds can be maintained, the car can be highly efficient. Efficiency can be further optimised by carrying more passengers. A car with multiple passengers requires no more road infrastructure to be consumed than a car carrying a single occupant (Skeete, 2018). The reason why the car works so well in this example, is twofold. The car is not frequency dependent; meaning that users do not have to wait for the next one; it is ready when you are. The car is also door-to-door and so efficient in direct-routing. If the distance is long enough, the car becomes less efficient than for example, the train. This is because both the frequency and direct nature of the car is overshadowed by the speed and capacity of the train over a longer distance (Global street design guide, 2016). Driverless cars and changing habits of mobility ultimately offer the possibility for cities to re-strategise urban space that was once consumed by vehicle infrastructure. Figure 2.4 demonstrates how technology could produce different mixes of mobilities and alternative street-scapes with varying degrees of permeability.

On-street parking



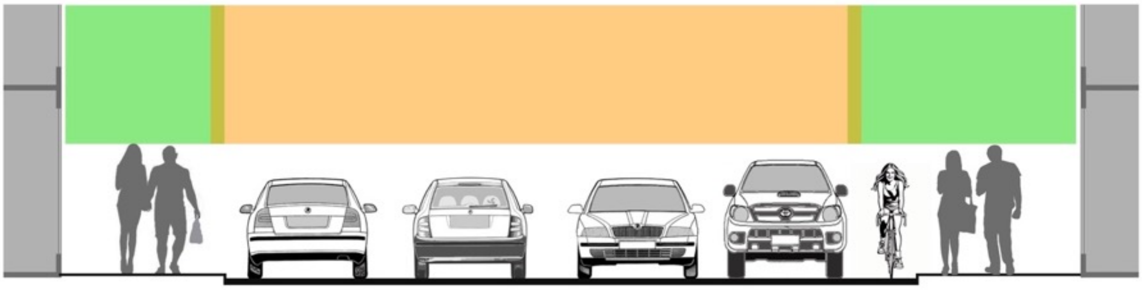
- A situation seen across all UK cities.
- Pavements are confined and narrow.
- Cars are parked on the inside lane with little productive value to the city, while restricting traffic flow.
- Cycles are pushed into the traffic.
- Traffic flow is restricted and disconnected from the city's streets.

On-street parking is removed



- Pavements can grow, creating a visual connection across the road.
- Cyclists can have a dedicated lane offering safety to riders, engaging them with the street.
- Traffic flow remains unchanged from a situation with street parking.
- The experience is improved.

All lanes running



- This is again a situation seen throughout UK cities in an attempt to maximise traffic flow.
- Pavements are confined and narrow.
- Cycles are pushed into the gutters.
- All lanes are dedicated to vehicle movement.
- There is evidence to suggest this has little

impact with buses and vehicles stopping on the inside, restricting flow causing a stop-start scenario.

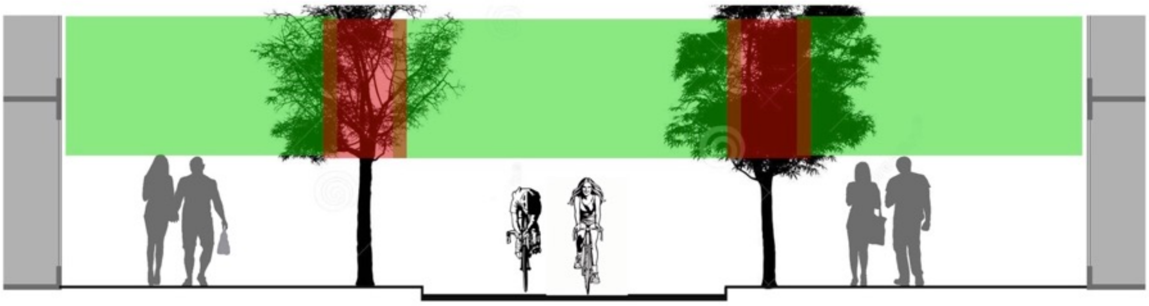
Personal transportation

- A situation rarely seen in the UK.
- Pavements are given lots of space for activity to take place.
- Cycles are given dedicated space and are separated from pedestrians.
- The street can move high levels of traffic at relatively low speed encouraging engagement with the city and between its users.

Mass Transit

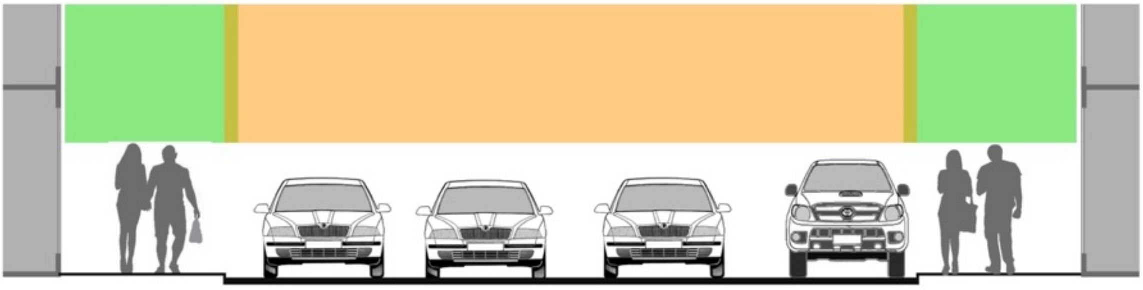
- Pavements can grow for activity to engage with street fronts.
- Cyclists can have a dedicated lane offering safety to riders and engaging them with the street.
- Mass transit is brought into the city streets offering speed and efficiency, away from congested vehicle routes.

Personal transport and green space



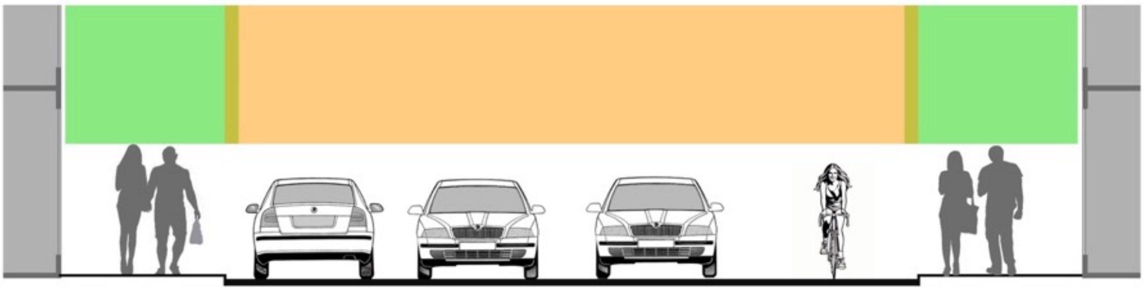
- This is a situation rarely seen in UK cities.
- Pavements are given lots of space for activity to take place.
- Cycles are given dedicated space and are separated from pedestrians.
- Some unproductive space is given up to the experience of the street, maximising the environment and quality of the space.

Swarm intelligence scenario 1



- Still focused around the car but with divided space. Traffic routing and lanes are changed by needs, to maximise the infrastructure available.
- This relies on technology enabled vehicles. Pedestrians are still restricted and minimised in the pursuit of vehicle efficiency.
- This is the kind of model that Audi is working on as part of their driverless world.

Swarm intelligence scenario 2



- This is more adaptive than scenario 1. Vehicles are again routed according to needs, however examples such as cycles can be cloud mapped in real time to offer dedicated space around each cyclist.
- Pedestrians are still restricted and minimised in the pursuit of vehicle efficiency.
- This is entirely reliant on all vehicles communicating through the same platform.

Swarm intelligence scenario 3

- This is the most adaptive of all the scenarios. Space is not defined for any user. All users are cloud mapped and traffic is routed accordingly. Space that is for a few seconds used as a road can then become a cycle way or footpath.
- This requires all users to be mapped and routes processed through AI technologies. It has the potential to offer a rewarding user experience, but the technology is a long way off.

Figure 2.4. Visualises how street-scapes could be re-strategised as a result of autonomous vehicles (Global street design guide, 2016).

Currently when driving, it is near impossible to become immersed in any other tasks as the act of driving consumes all of our operational capacity. As a result, drivers cannot be either economically productive, by performing work tasks, or socially productive, such as when using Facebook or Twitter (Dennis and Urry, 2010). The experience that millennials had as children could also be a contributory factor. This was a generation that had to sit in the back of cars, in traffic, asking 'are we there yet?', while mum and dad cursed at other drivers, road works and each other, all in pursuit of leisure (Schwartz and Rosen, 2015). Driverless technologies have the potential to change the millennials' relationship with the car and other transport modes. Competing with public transportation by being cost and time-efficient, while remaining door-to-door and on-demand, driverless vehicles potentially retain the best elements of the car while addressing its current failings (Firnkorn & Müller, 2015).

While there is no doubt that the city and its users should be regarded as the stakeholders of driverless cars, the reality of the situation is more complex. Even the UK government has a vested interest in driverless cars. Driverless technologies have been highlighted as an opportunity to benefit industry and develop economic growth. KPMG have highlighted that, the UK government is investing £200 million into the research and development of driverless vehicles, an industry it believes will create 320,000 jobs and benefit the economy by £51 billion by 2030 (2014). Throughout the development of driverless cars, we must keep a watchful eye on the motives of governments, tech companies, operators and manufacturers. We are at the cusp of a fourth Industrial Revolution, and as a result there are huge opportunities for governments, and industry alike. If we are not careful the opportunities, needs and experiences of the user will be lost to make way for commercial gain (Schwab, 2017).

2.5 Developers of driverless vehicles and their concepts

The automotive industry has produced a wide range of concepts exploring the future of autonomous vehicles. Figure 2.5 demonstrates the different approaches taken by the main automotive and technology companies. This research was conducted primarily using the websites of the companies in question. Literature, videos, images and websites were analysed against 22 factors, generated through a combination of future visions. The chart shows whether the manufacturer or technology company demonstrated any of the factors identified.

Manufacturers future concepts

Figure 2.5 shows the future concepts published by manufacturers as of early 2017. Two companies, Jaguar Land Rover (JLR) and Porsche previously stated that they did not intend to produce fully autonomous vehicles where the driver was removed (Wade, 2015; BBC.co.uk, 2016), although JLR are now working on autonomous vehicles as of late 2018 (Tovey, 2018). Apple has pulled its driverless projects (Autocar, 2017), while all other major technology companies see driverless technologies as the future. However, there is a split between those that are developing augmented technologies and those developing fully autonomous technologies.

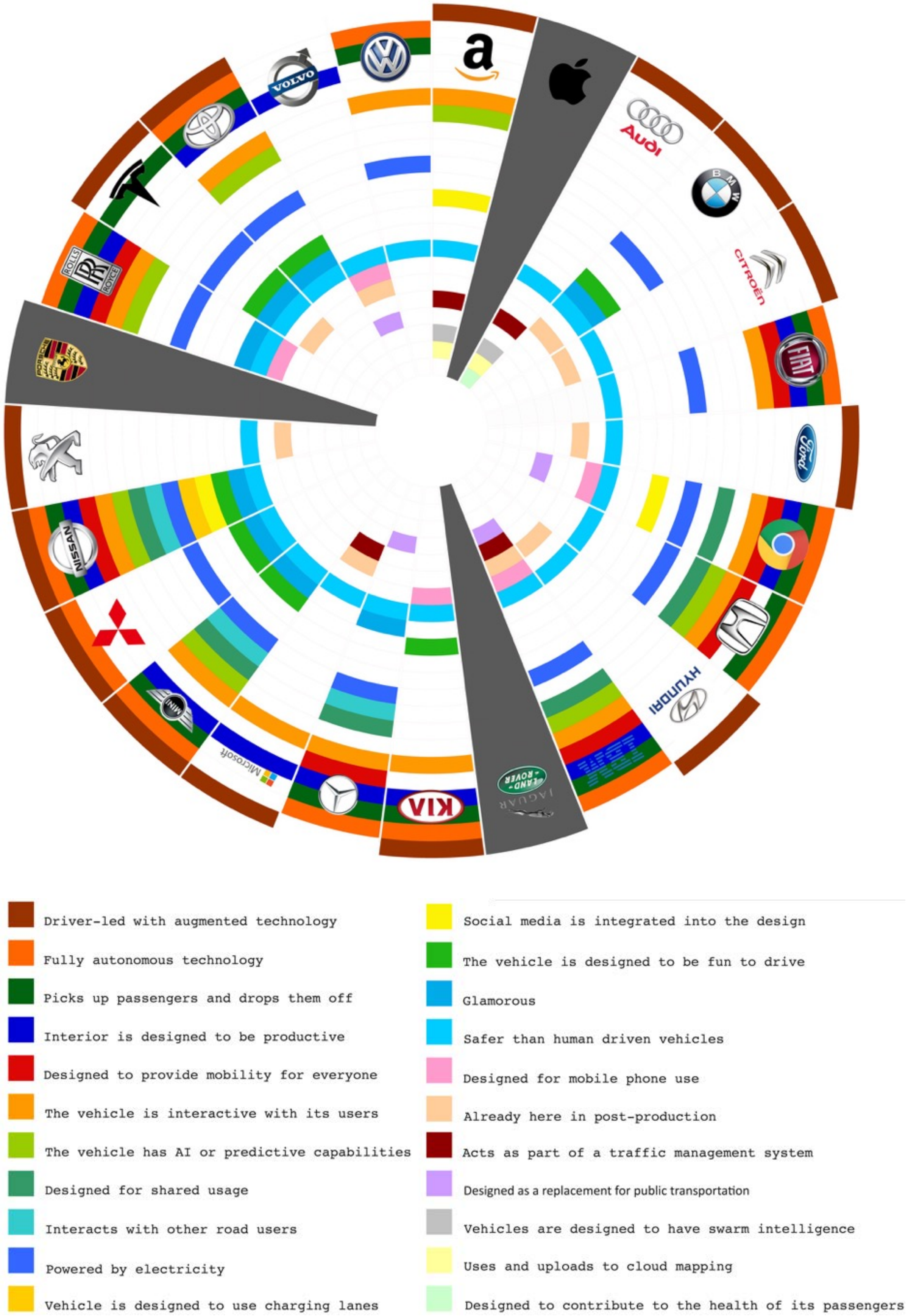


Figure 2.5. Show the developers of driverless technologies and their conceptual visons of the future.

What becomes evident from the manufacturers concepts is that there is little consensus on what the future of driverless vehicles will be. While some concepts, such as Mercedes' F015, could be seen as an opportunity to challenge the current position of personal transportation (mercedes-benz.com, 2017), others are taking a more current view of driverless vehicles as a digital technical exercise. Tesla is one of the companies, which are basing their future visions on current vehicles, and technologies which are in principle available today on some high-end cars (Tesla.com, 2017). They are based around reducing the demand on the driver, with the driver remaining at the center of control, ready to take over if needed. Currently these augmented technologies are not designed to completely self-drive, limiting vehicle movements without a driver to parking only. As a result, they do not challenge our current conceptualisations of a car, nor do they truly fall under the title of 'autonomous'.

Most manufacturers and corporations are developing autonomous concepts, which are focused on more projective future technologies. The concepts of Tesla are less likely to change the relationship cars have with humans and the city, as the human remains the decision maker (Tesla.com, 2017). Manufacturers such as Rolls Royce, and their associated partners, are all developing cars, which are fully autonomous and as such, the driver has no input. These vehicles are intended to drive fully autonomously and as such, the space inside is not focused around the task of driving (Rolls-roycemotorcars.com, 2017). Based on the future visions currently marketed by these manufacturers, one thing is common to their concepts. They are all attempting to sell a first-class mode of public transport, something akin to the experience of travelling on a private jet. The experience they portray is based on socialising with friends, digitally or physically, in seats, which face fellow travellers. Nearly all surfaces are embedded with digital interfaces, allowing users to engage digital with the world while the algorithms stream marketing and information, but perhaps more simply they allow us to simply sit back and look out of the windows. While these concepts embrace the best elements of public transport, they are clearly trying to address the negative aspects such modes have (Snyder, 2016). Through 'Smart', AI and predictive technologies, these manufacturers are showing that their cars are always there, always present, they are predictive to our needs and wants. They are marketed as our new smartphone (Nissan Online Newsroom, 2017).

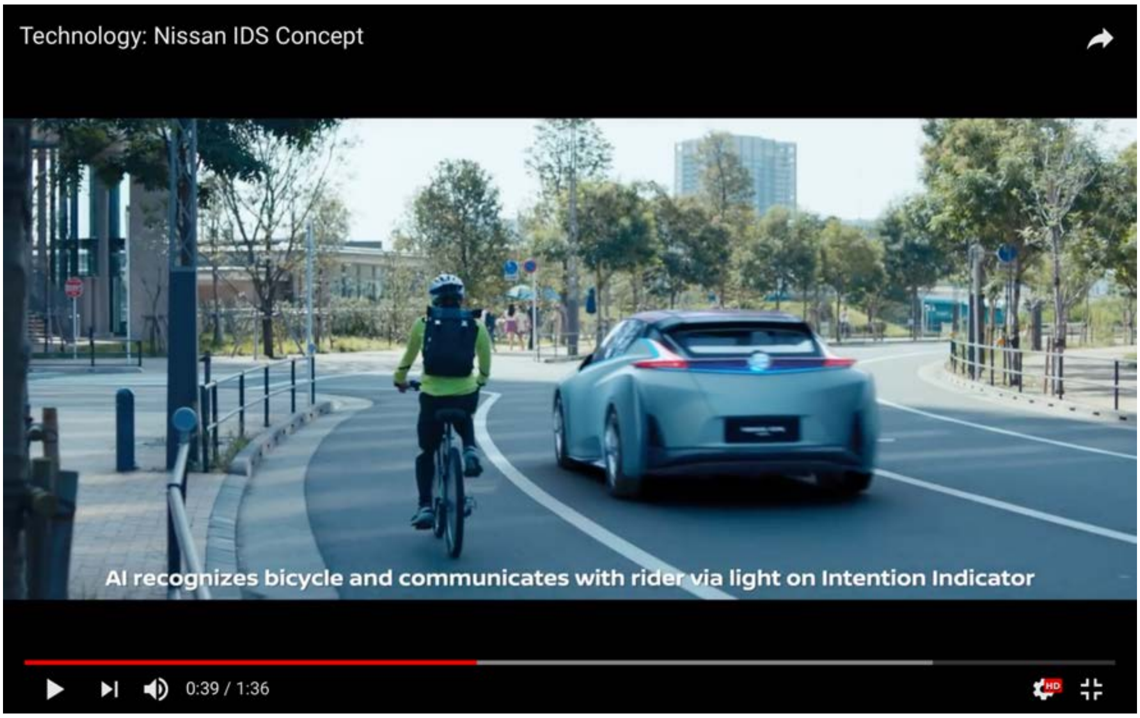


Figure 2.6. Nissan's IDS concept again shows an image which is devoid of the usual hustle and bustle of an urban area. Instead, Nissan choose to depict the vehicle communicating with a lone cyclist (Source. 日産自動車株式会社 www.youtube.com. 2015).

The current visions produced by all the vehicle manufacturers and technology corporations raise a few interesting questions. Most concepts project a vision of empty cities, which have become adapted to our needs. They depict a positive relationship with the city in which there is no congestion, the car is always only a few metres away and yet the background depicts high-density urban centers. This unoccupied infrastructure is only encumbered by the occasional cyclist or pedestrian, with whom the vehicle politely interacts, as seen in Nissan's IDS concept (Nissan Online Newsroom, 2017). The only manufacturer, which demonstrates a concept which considers the issue of congestion, is Audi, who briefly demonstrate swarm technologies and cloud mapping as a potential future concept (Audi MediaCenter, 2017). To date, as is often the case with concepts designed to grab the attention of end users, autonomous vehicle concepts lack the detail to explain how their systems will cope with the complexities of humans and the cities in which they will operate.

2.6 Autonomy in the past

Aramis was a rapid personal transport system designed to individually transport commuters across Paris which began in 1969. It has been described as the first autonomous transport system, but it did not have to engage with a dynamic environment nor its users; it acted in complete isolation to the city, within a highly-constrained set of parameters, with no engagement or adaptability to its context (Latour, 2002). Aramis was the subject of Latour's book, "Aramis or the Love of Technology" in which he attempts to dissect the causes of its failure, through "Actor Network Theory." In his book, Latour identifies various mechanisms for the failure of Aramis. There are two points to which Latour attributes this failure, which this review will now consider. The first point to reflect on, is how Latour describes the Aramis vehicles as Leibniz's "monads"; objects which do not respond to their users or environments; early prototype of the vehicles did not even have windows. While perhaps more importantly, they were completely governed, and controlled by their programming, they were unable to make decisions for themselves; to respond in an unexpected way. This is what Latour describes as Aramis's biggest failure. The conclusion to this appears to be that Aramis needed more autonomy. It needed the ability to stop responding to its creators and start making decisions based on interactions with other vehicles, people and the city (Latour 1996). Latour's thinking here was very much ahead of his time. His ideas are far more representative of the autonomous concepts we see today, some twenty years later. At the time, Aramis was highly limited by the technology of the day. Early incarnations of the system would have had very limited computing capability. To put this in perspective, an iPhone 6 is approximately 32,600 times faster than the IBM System/360 computer that put man on the moon (Marin et al., 2016). Latour's point is highly relevant today, as we move ever closer to having the technology and computing to theoretically deliver contextually responsive autonomous vehicles.

There is however, a second issue surrounding tech firms, which Latour raises, as a barrier to the delivery of a socially engaging and responsive transportation network (Latour, 1993). This discussion predominantly revolves around the agendas of technology corporations and who they consider to be the stakeholders of transportation, a position reinforced by the likes of Bruce Sterling (2014). In the case of Aramis, some argue that the project was simply a way of reappropriating a redundant workforce, after the successful moon landings. A less sceptical opinion could be that Aramis presented an opportunity to explore space technologies, in a more social and publicly beneficial landscape (Latour, 1993). Regardless of opinion, what becomes unavoidable, is the reality that corporations, such as Engins Mantra, a company, which while working on personal rail transportation, was a major French armaments company developing spacecraft and intercontinental missiles (Flight 1060). With engineers tasked with the design of missiles and public transport, it is no surprise that early prototypes for Aramis did not have windows. With Mantra overseeing the project, it was likely that the Aramis would be driven from a technological perspective, without addressing the social ramifications of these solutions. With such major infrastructural projects being driven by publicly limited companies, the stakeholder of these projects becomes unclear. It is hard to imagine that companies such as Mantra were considering the city and its users as the stakeholders. With these projects being considered as a technical resolution to a problem, it is unsurprising that the autonomy of these vehicles to behave as “actants” rather than isolated objects is lost (Latour, 1996).

Today it is easy to imagine with the likes of Waymo’s early protoypes as seen in figure 2.7, that driverless vehicles are being developed as a technical exercise, as opposed to a socially responsive one. If driverless vehicles are to achieve the social and environmental change that it is believed they are able to, then we must learn from failures such as Aramis ensuring that concept are responsive to both their users and the environments in which they will operate.

Figure 2.7. Google's Waymo concept lacked the visual appeal of automotive manufacturers' designs; focusing on a more current technical solution rather than more futuristic concepts (Source. www. 9to5google.com).

2.7 Autonomy today

Are developers of today's autonomous vehicles making the same mistakes today that caused Aramis to fail in the past? Traditionally, the car industry was a marketplace entirely dominated by the global car manufacturers (Stewart et al., 2017). Today there are no sizeable domestic automotive manufacturers in the UK. In fact, most major vehicle manufacturers now operate as part of group structures, in order to optimise design, development and manufacturing costs. So why has this model changed? As of 2016 there were only 23 vehicles manufacturers that produced over one million cars per year, yet in the last 10 years the number of companies developing driverless vehicles has risen to nearly 263 established and start-up companies (Statista, 2017). While many of these companies are part of consortiums with established vehicle manufacturers, others are in consortiums not with vehicle manufacturers, but with technology companies. Currently there are 44 companies with driverless test vehicles.

This is made up of 30 consortiums and of those consortiums just over half of them do not have a vehicle manufacturer involved at all (CB Insights Research, 2017). This expansion in companies, especially technology companies, cannot be attributed to a sudden interest in cars and personal transportation, nor is it that they have suddenly become interested in supporting cities and their users, by the prospect of developing more efficient mobilities.

Bruce Sterling (2014) in his book, 'The Epic Struggle for the Internet of Things', begins to explore the reasons behind these changes. Google is a big investor in autonomous technologies, through its purchase of companies such as Deep Mind and the development of its Waymo project. Companies such as Google are corporations which have motivations that are difficult to unravel. At some point in the formation of Google, the company started to realise that the true value of their operations, lay not solely in marketing through their search platforms, but in the data acquired through these systems (Sterling 2014). While users of their search engine saw Google as a superb tool to finally un-tap the wealth of knowledge that was being uploaded to the web, there was little notion of this ulterior motive. Most Google users of the early 2000s, thought that the only charge for this service, was to be exposed to advertising whilst browsing online. In fact, it turned out, that the revenue stream Google were most interested in was the data that they could collect (Sterling 2014). The hunger for data is also evident in Google's investment in applications, such as their mapping tools. These applications not only provide Google with detailed information about our cities and the physical infrastructure that exists, but also, through the tracking of individual devices they know how users move, stop and engage with the city. This is not just done at a city level, but at a user level through the tracking of personal devices (Kelly, 2016).

This business model exhibited by companies, such as Google has been predicated on the development of personal digital devices, such as laptops, tablets and more importantly smartphones, the latter of which UK citizens utilise to access online content for an average of nearly two hours per day (Ofcom, 2017). It is these personal devices and the data that can be captured from them that are the real reward to the 'big five' Amazon, Apple, Facebook, Google and Microsoft (Sterling 2014). To put the scale of this opportunity into perspective, in 2016 Apple made a revenue of $8.8 billion from its App Store. This equates to a total spend in the App Store of just under $30 billion, netting the developer community over $20 billion (Forbes.com, 2017). With falling sales revenue in handsets and increasing sales in the App Store, there is no doubt that the digital content and applications contribute substantially to Apple's profits and there is no way of truly understanding the value placed on the data being extracted through these platforms and applications (Forbes.com, 2017). The autonomous car has the opportunity to become a highly connect device, which is partly why technology companies and auto manufacturers have invested an estimated $80 billion between August 2014 and June 2017 into their development (TheHill. 2017). The race is on to be the operator of the algorithms that will control autonomous vehicles.

2.8 The drive for efficiency

The selling point marketed by the creators of driverless technologies is the belief that autonomous cars can dramatically increase the efficiency and mobility of people and goods. There has been a series of studies which explore the realities of driverless vehicles as the answer to future mobility. These studies predominantly focus on road safety, traffic congestion, mobility and environmental impact as a measure of success (Bajpai, 2016). Of these studies, there are two main differences in the modelling that has taken place. This difference revolves around the ownership of driverless vehicles. As mentioned earlier, one vision of the future is that we will no longer own personal vehicles. Instead, the user will rent a vehicle for a single journey. At the end of the rent, the vehicle will move on and be rented by another user. Vehicles can also be used for ride sharing, where a singular journey may be linked up to carry two or more people who would not have shared a journey, through a ride share platform such as Uber (Knight, 2016). This is the model that Volvo and Uber are currently jointly developing. Indeed, Uber has recently committed to buying 24,000 self-driving Volvos (Gibbs, 2017). The second model is based upon how we own cars today, whereby vehicles are owned and operated by a single individual, for example, a husband and wife may share the vehicle, but any sharing is typically limited to within a single household (Nissan Online Newsroom, 2017).

Road safety is a serious issue, with over 1.2 million annual deaths globally on roads (World Health Organization, 2015). It is estimated in the US, that 90% of road accidents are caused by driver error (U.S. Department of Transportation, 2015a). Accidents are not just measured in term of the number of deaths, but the impact on economies. When accidents occur, it is inevitable that the operation of the road network is compromised, leading to increased journey times. In the US, road accidents cost the economy $563 billion due to loss of property, medical expenses and goods/passengers being delayed (U.S. Department of Transportation, 2015b).

There is a huge opportunity, through the introduction of autonomous technologies, to save economies $100s of billions a year (NHTSA, 2015). It is however noteworthy that the regions of the world which could benefit most readily from autonomous technologies are not necessarily the areas in which driverless car developers are operating and aiming to target. This is because according to the World Health Organisation, lower and middle-income economies have by far the highest number of road fatalities. Middle-income economies such as India, China and Brazil represent 80% of the world's road fatalities. This equates to 20.1 deaths per one hundred thousand people (World Health Organization, 2015). Currently there has been little development of autonomous vehicles in these regions, with the exception of China (Bajpai, 2016). High income economies such as North America and most of Europe only equate to 8% of global road deaths (World Health Organization, 2015), yet represent the areas where the majority of driverless testing is being conducted. These figures highlight an inequality between the wealthiest and poorest regions of the world, the latter of which would benefit most greatly from driverless cars (Bajpai, 2016).

The second major efficiency benefit being pushed by the developers of driverless technologies, is that of road congestion. Again, as mentioned earlier, reductions in road accidents will have a major impact in reducing traffic delays (NHTSA, 2015). Currently in Great Britain, local road networks have approximately 46 seconds of delays for every mile travelled, rising to approximately 100 seconds in London, according to the Department for Transport. This equates to costing the UK economy around £9 billion per year in lost earnings, fuel and additional emissions (Department for Transport, 2017).

Research has suggested that one of the biggest opportunities to reduce emissions and optimise road infrastructure is through the deployment of both platooning and connected vehicles (Fernandes, 2012; Malasek, 2016). With vehicles being able to talk to one another and connected through a cloud type platform, vehicles can act as one; braking and accelerating simultaneously, to maintain a continuous distance. Modelling of this type of system has shown that road capacity can be increased by up to 500% (Fernandes, 2012). Similar to platooning, road capacity could also be increased through intelligently controlled intersections, merging and junctions, etc. With vehicles that can talk to each other, it is entirely possible that free space on roads could be minimised through the seamless blending of traffic streams and minimal gaps between vehicles, resulting in optimised flow through traditional pinch points. This type of technology may also mean that in an entirely autonomous network, signalling, such as traffic lights and road signs would no longer be required (Dresner, & Stone 2005). But how would pedestrians cross the road?

Accessibility to mobility has long been an issue of socio-economics, and the affordability of travel has allowed wealthier economic groups greater access to jobs (Bajpai, 2016). Research by the Metropolitan Washington Council of Government has indicated that in the Washington area, jobs accessible within 45 minutes of car travel averaged around 918,000, yet by mass transit systems, jobs accessible within 45 minutes travel time, totalled just 398,000. With car mobility being one of the most expensive modes of transport, this places poorer income households without a car at a disadvantage in terms of access to employment (Metropolitan Washington Council of Governments, 2015). Autonomous cars have the ability to challenge this deficit through two methods: shared transportation models such as Uber and car sharing fleets such as Car2go. Currently the main difference between the two models is who drives. Uber's model is that the car is driven by a hired driver, making it door-to-door.

Car2go, relies on the rentee being the driver; therefore, the vehicle needs to be picked up from a parking lot (Firnkorn, 2014). The two models are in fact very similar when driverless technologies are applied, the only difference is that the Uber model has been designed to be capable of linking up journeys, reducing the number of vehicles required. Currently, cars are on average only on the move for 4% of the time (Bates & Leibling 2012). These models mean that vehicles are better utilised, therefore having a lower operational cost to the user (Firnkorn, 2014). Shared journeys can lower the cost even further, increasing the possibility for greater social mobility among less affluent communities.

The potential environmental benefit is also central to the pitch for autonomous vehicles, as a result of the methods of increasing efficiency mentioned above. Interestingly, this is not a new argument by automotive manufacturers. Early proponents of the car argued for its public health benefits. Cities were becoming consumed with the pollutants from horses and the automobile was seen as a clean alternative, although it was thought that it would never fully replace the horse (The Lancet, 1896). The irony of this is that today we are faced with the same discussion. Cars in the city are become a major public health concern. Today it is estimated that there are 29,000 premature deaths per year as a result of vehicle pollution (Boseley, 2017). Developers of driverless vehicles are advocating their technology as the answer, based on the opinion that driverless cars will completely replace driven cars.

Autonomous technology is not the only future concepts of mobility that is being viewed as a core development area and a method of responding to the issues which cities today face. As indicated in chapter 2.5, most of the future concepts of mobility are based on fuelling vehicles on electricity, which is held within the vehicles using lithium batteries. This will be covered in more detail in chapter 4 ‘Smart’ Autonomous vehicles in cities of the future, but the literature review will look to highlight how current policy making is not always clearly understood in context to the real world.

2.9 The ethics of autonomy

Smart city projects have faced criticism over issues of ownership, reward and opportunity (McBride, 2014; Sterling, 2014). Sterling and others have long been vocal critics of IoT and the smart city agenda, for one very simple reason - for whom does the opportunity exist? Google is a corporation which since its creation in the early days of the Internet, we have seen its business transform and evolve into one of the biggest gatherers of data. As a result, people like Sterling (2014) are more cautious and critical about the agenda of these corporations (Rosati & Conti, 2016). In the early days of the Internet when Google was a mere search engine, users believed that the revenue stream for the service which Google provided was provided through advertising being posted on the pages that users viewed. This however rapidly evolved and advertising became only part of the opportunity of Google. Its customers and the corporation have entered into a deeply entwined relationship which has allowed Google to not only to understand our search habits but has made users into developers and testers for their systems and platforms (Kelly, 2016). The end game objective of the companies investing in autonomous vehicles will only ever become truly clear through the passage of time. What is clear is that connected vehicles are beginning to be seen as the new smartphone where data will be the valuable commodity as opposed to the product itself. This point is underpinned by the expansion in data services and cloud services that manufacturers such as Ford are entering into (Business Wire, 2019).

For some, access to digital technology and ultimately digitally connected vehicles has become the urban equivalent of a highway, gate, fence or river which divides economic groups and communities from the social elite. Digital connectivity empowers those that are already the most powerful, the most educated and therefore the most capable of using digital potential. It is not universally liberating (Swyngedouw, 1993). This becomes a chicken and the egg argument as what is the cause of this digital divide? Is it Graham's (2016a) theory of digital unevenness or Swyngdouw's (1993) theory that the unevenness of skills and education causes the digital divide we see today? Or simply does it matter - the two are so intertwined, is it even possible to unravelling the two theories? What become abundantly evident though is that connected vehicles and the smart cities in which they operate should become citizen centric (Paulin, 2016). Without autonomous decision-making being open to view and led by the city's citizens, machine protocols which are already taking a greater role in determining our actions will be entirely led and for the benefit of its operators and not for its users. This will present serious social and ethical implications for end users and will perhaps again lead to the kind of social, ethical and environment challenges that the car and its manufacturers created in the 1950s and 60s (McBride, 2014).

To date the ethical decision making of autonomous vehicles has been widely discussed, though primarily this discourse focuses on decision making in emergency situations. The ethical scenario often presented is the 'tunnel problem' (Millar, 2016). This is where an autonomous car is presented with an impossible decision. Does the vehicle "swerve left and strike an eight-year-old girl, or swerve right and strike an 80-year old grandmother" (Lin, 2015, p.69). While there is no doubt that this is an important discussion and crash avoidance will always be the objective of autonomous system designers, vehicles will be faced with the reality, that sometimes accidents will become unavoidable as a matter of physics, especially during the transitional period between driverless and driven vehicles (Lin, 2015). This means that the on-road decision making of autonomous vehicles will of course be prominent in the ethical debate. There is however, a subtler ethical issue about the more mundane aspects of decision-making under full autonomy, such as the route, the mode transport, and what we see along the way to work.

Autonomous concepts of the driverless car, such as Nissan's IDS concept (Nissan Online Newsroom, 2017) and 'Ben's Journey' (Deloitte, 2016), demonstrate a decision-making process without any input from the user, attempting to demonstrate seamless mobility. Ben's Journey portrays the user stepping out of their front door on the way to work and the vehicle is already waiting outside. The user has not requested the vehicle; the system has learnt through data, their routines and behaviours to predict what the user wants and when. The user steps into the car. It knows where to go, it decides the route though algorithms designed into the system architecture to optimise the route. It takes the user to their destination and disappears from their context without the need to worry about parking or charging the vehicle (Cox, 2016). This concept leaves the user out of the decision-making loop, as the decisions are being made on so many factors and datasets, that it would be impossible for a human to make an informed decision, never mind achieve the levels of efficiency being aspired to (Bratton, 2016). None of these concepts and technology solutions show how humans will find their role and place within the technology, to participate and observe in the decision-making process. McBride (2014), has the opinion that fully autonomous transport has no value or role without human interactions, as they will be isolated objects. There is little evidence to suggest that the role of the user is anything other than the developer, tester of these future technologies (Kelly 2017).

Autonomous vehicles must learn from the lessons of Aramis, by incorporating users in the protocols that will take decisions about our mundane futures. For humans to be involved, we must find a way of bringing order to a seemingly disorderly technology (Galloway, 2006). Filtering of this disorderly technology is something, which needs to be considered, as the digital content grows more complex. Kelly (2016) argues that filtering is an inevitable and essential part of the future. We need the ability to control and filter what we see. Through mass data acquisition from the likes of Google's 'Deep Mind', there is a belief that the development of AI is a real possibility. AI has the potential to allow the development of a more intuitive and intelligently filtered environment, completely attuned to us. It is such developments that will help us to question and oversee the algorithms that will determine our future mobility (Kelly, 2016).

2.10 The shape of the network

The digital age is made up of software and hardware, both of which have a physical presence. ICT and particularly the Internet has been marketed as a value free panacea of instant, limitless and geographically void opportunity. Cyberspace as it has become known is not cyberspace singular but cyberspaces physical plural (Graham, 1998). Is any of this true today? Cyberspace is not invisible or magical. It is real with a physical presence and the Internet is not free (Sterling, 2014). Cities historically had clearly defined hubs, centres and borders. Digital technologies are blurring these spaces and as a result, our cities are becoming increasingly complex and challenging to understand as technology drives the size, scale, shape and relationship of the city (Luque-Ayala & Marvin, 2015). For example, a moving train with its digital capability can become a centre for commerce or a street corner can become a hub for Uber.

The projected concepts of driverless cars are based around the vehicle itself and as discussed earlier, it is not the steel and leather which will make the decisions, nor is it likely to be the human passenger. The decisions will take place through as Bratton (2016) suggests, a stack of digital, physical and social layers. This means that a vehicle travelling down the street, will be linked to a cloud-based system, where decisions and information will be processed, based on the operator's algorithms. The autonomous vehicle will not just be controlled by a singular notion of traffic as some suggest, but a complex interwoven logic of algorithms, based on historic and live data. For example, destinations may be chosen according to where your friends are right now or have eaten in the past. This could be informed through platforms such as Facebook, while Google may assist in knowing if there are seats available. The route will be informed by live data about traffic and accidents from cloud mapping, but the route may also be informed by personal preferences or even charged premium services, such as first-class zones through the city, which would be charged for by the operator of the vehicle (Bratton, 2016). While much of the research is based around the driverless vehicle's actions when being used by the consumer, the autonomous vehicle does not stop or remain in a state of hibernation until called. Indeed, Bratton's stack (2016) could be used to explore the vehicle's actions and behaviours when not in use. When a vehicle is not being rented or used, it will need to find a space to store itself and charge its batteries. This again will be driven by a complex relationship of protocols to understand where parking spaces are available, the status of the energy grid and when demand for journeys is likely to occur. Through this cross referencing of datasets, vehicles can be optimised to meet demand and wider city systems, to help meet the challenges of increasing population and mobility, whilst delivering on tightening environmental requirements.

While Bratton's stack theory (2016) will help to meet the demands and challenges of an autonomous future, through delivering vehicles which act as actants and not objects, the theory is not without its problems. Galloway (2006), in his book 'Protocol: How Control Exists After Decentralization', highlights some of the issues which exist around digital systems. Firstly, there is no doubt that autonomous vehicles will exist as highly tuned digital devices moving through our city streets. The latest cars today, already have embedded applications, tracking, streaming and displaying data on Android and Apple in-car operating systems. This will only advance as vehicles and cities, buildings and infrastructure are embedded with more and more sensors, all streaming their activities and talking to each other. The question is, who is listening, who can listen and who is using the data? Today, very little of this data is in the public domain and there are various reasons for this. Firstly, the availability of data is so great that a clearly defined question is needed to make sense of it; otherwise it is completely unmanageable even to personal computing, never mind a human. This means that data needs to be filtered to become manageable, but by who and for whom (Kelly, 1994)? Such responsibilities are open to abuse and mishandling as came to light in 2017 with Cambridge Analytica's alleged interference into the Brexit vote and the US elections (Cadwalladr, 2019).

Filtering information presents the second major issue. Who is filtering the information and what is being omitted? Data is typically held by corporations and governments. In the case of corporations such as tech firms, the data that they collect has cost them money and is perceived to offer a commercial advantage over their competitors and as a result, is seen to have a commercial value. Corporations often avoid sharing their data in any way that could be commercially or operationally useful to a competitor (Kelly, 2016). Governments are huge collectors of data and are starting to share what they hold, although there are data protection restrictions to which they must comply. Data protection laws such as the General Data Protection Regulation (GDPR) are set up to protect individuals and groups of users from having their personal information shared. This is because personal data has value and can be used for criminal intent, but this means that any data released from governments and associated bodies cannot be used to find out anything that may be considered personal to individuals and specific groups of people. This means that once again, data has been filtered and manipulated to prevent this from happening. As a result, the data has lost much of its usefulness and the data is often not live to ensure that no personal information can be extracted (McBride, 2014).

The final and often most common issue of using data in the operation of a 'stack' is that there are so many parties collecting, storing and transmitting data over different networks, that collecting and collating this data into one source is a commercial and operational challenge. The challenge does not even stop there; if this data could in fact be brought together, it is all operating within different protocols. The interpretation and integration of these data sources mean that it is near impossible for an individual to interoperate and use this in any meaningful way. Only the big tech firms have the capability to unravel these masses of data (Galloway 2006). This perhaps explains why most of the manufacturers developing driverless technologies are already partnered with technology companies (Autotech 2017).

2.11 The shape of the city

For centuries, cities have been regarded by architects and designers as chaotic places which require control and order through imposing geometric form to create idealised utopian spaces (Jacobs 2011). Historically, few voices have critiqued this way of thinking, Jane Jacobs (2011) being one of the few. More recently, the introduction of digital technologies, has allowed us to re-evaluate perceptions of space. The order within these so-called disorderly spaces was not overtly readable without the development of digital methodologies (Batty 2005). Digital technologies have not only challenged the view of how our cities operate but to some extent, have increased transparency, allowing academics, local authorities and governments to untangle the human role within the complex city (Reades & Smith, 2014). Cities and their users have embraced digital networks and technology, which in turn, has challenged to limits of the city through increased mobility. Through history, we have never been more mobile, both physically and digitally and this is changing how we build, live, socialise, work and access services (Urry, 2007). Coupled with the distinct economic boundaries, which exist in and around cities, technology is reshaping where we live and work. To reflect on this point, the following three figures are visuals produced as a result of a brief study which document how a typical British residential street may have looked in 1930 compared with today, while speculating on how it may look in 2050, thinking about changes in mobility, living and working practices.

Figure 2.8. A suburban past where vehicles on driveways are not yet the norm. As a result, there is more space for children to play without traffic.

Figure 2.9. The suburban present is a scene that we are all familiar with. Gardens have been removed to make way for parked cars. Pavements are squeezed to provide more room for parking and roads are busy with vehicles moving up and down.

Figure 2.10. A possible suburban future. The image explores how autonomous vehicles could have a positive impact on our lives; freeing up space currently used by parked vehicles for recreation and allowing the road to become a shared space due to dramatic increases in safety.

London is a city, which on average is 263% more expensive than the rest of the UK (Rightmove.co.uk, 2017). This high cost of housing has driven people to explore and test where the extremities of the city lie. Via virtual hot-desking and cheap travel (by plane, train, or car), some people are off-setting the cost of living in places like London by living in cheaper regions and spending the savings on travel. This has led to the rise of the so called ‘super-commuter’; people who travel more than 90 miles each way to work, meaning that cities like London are becoming part of a physical pan-European network (Budden, 2017). There are people who now live in the French countryside where prices are low, while commuting to work by plane in London for two or three days per week. While the economics of the situation make this possible, the reality is that it is the digitally productive capacity, which makes it feasible. Three days a week you can work from home, with access to office resources such as, databases and workflows. Cheap flights and travel can be booked from our smartphone at the press of a button. Cheap spare capacity space in London can be found through online applications, such as Airbnb. Cafes, hotels and designated workspaces such as Regus office can be used for client face-to-face meetings.

While the technology allows this to happen, it is the experience, which causes people to make the choice to become a super-commuter. It allows them to live in an area, which they claim to be beautiful with superior weather, yet they can tap into a marketplace, which offers greater job opportunities (BBC.com, 2017). This is no doubt an extreme example, which will not appeal to everyone, but it does begin to touch on some of the ways driverless cars will change our mobility habits and how we will live and engage with cities of the future. It is unlikely that driverless cars will be challenging the super-commuter, but with people already commuting an average of a 54-minute (Worley, 2017) per day, what if during that time, users could perform their job? Could that additional travel time then be paid for and does this then challenge the acceptable time that people are willing to commute, creating a larger radius from which people travel on a daily basis? What would happen if through the sale of your data and the manipulation of your journey to maximise marketing opportunities your journey was free; would users be willing to travel further?

What if we were to consider the space within the vehicle; could this again challenge the shape of the city? Current cars are entirely focused around the act of driving, but what if the space in the vehicle was a bedroom? Could the vehicle become more like a studio, offering a more transient style of life, where you could work in a different city every day of the week (Rolls-roycemotorcars.com, 2017)? This makes the prospect of being a driverless super-commuter a feasible scenario. The user could get into the car in Paris on Sunday night and arrive at work in London on Monday morning, rested and refreshed. The user could then spend a full day in the office and return to car to sleep in a designated area of the city. The possibility exists to make the world more global and more connected through the appropriation of the vehicle as additional domestic space.

While driverless cars are still limited by the physical structure of the city, there are vehicles in development, which are not restricted in the same way. Aerial vehicles are currently in development and being tested by companies such as Ehang. These vehicles offer the possibility to move freely around cities, without the need for major physical infrastructure (Ehang.com, 2017). Sci-fi and Cyberpunk have long explored the possibilities of how the urban fabric of our cities may be adapted and changed through the exploration of vertically accessible architecture (Graham, 2016a). 'The Fifth Element' by Luc Besson highlights how flying technologies may engage with the exploration of vertical cities and the social implications that may exist (The Fifth Element, 1996). The visions that Luc Besson portrays do not differ greatly from the academic position of Graham (2016b). In the film, the central character Corban Dalas, a taxi driver, resides in an apartment appearing to exist kilometres above ground. The main entrance to the apartment is not to an internal circulation space, but is entered and exited by a flying taxi, which docks directly into the apartment. The film also depicts a food delivery by docking directly into the apartment (The Fifth Element, 1996). What becomes interesting is how Benson explores two other spaces in the film. These spaces demonstrate how social hierarchy may exist in the vertical city, which are a play on already existing conditions today. The wealthy evil villain, the owner of an interstellar technology company Zorg, has his offices at the very top of one of the city's mega towers, overlooking the entire city below. By contrast to this space, when Corban is trying to avoid the police, he descends through the city, through a thick layer of pollution to a down-trodden underworld of rubbish and street-scapes in disrepair (The Fifth Element, 1996). While today the social elite often seeks to live in the highest spaces in our cities, they still value and need ready access to ground-level infrastructure (Graham, 2016a). Aerial vehicles could challenge this, leaving the street-level as the realm of those who cannot afford to fly.

The growth and success of the digital world has drawn the attention of not just its 3.2 billion users but of some of the biggest companies in the world (Kelly, 2016). Yet the rate of progression has left many behind. At one time it was considered that the elderly were being left behind by technology (Vaportzis et al., 2017), which is still partly true, but there have been many developments to address this issue. Tablet computers, with their simplified operating systems and touch functionality, have made everyday digital interaction possible for users with the most basic IT skills. Ironically groups such as the Police, IT companies, communities and end users face different but equally challenging access issues (Bratton, 2016). The geopolitical boundaries in which these users operate are unclear and blurred. For example, where does a digital event (e.g. crime, discussion on a forum) take place within the global geoscape of the Internet and what physical political boundary does it take place within? While we as users, communities and authorities may be blind to see the inter-relationship between the digital and physical world, this is not true of the ‘big 5’ (Google, Apple, Facebook, Microsoft and Amazon). Through the mass data acquisition of their users’ information, it could be argued that these corporations are in the strongest position to understand, change and influence how the city operates through their user developers.

2.12 Smart Cities

Smart technologies are emerging as highly transformative to the way in which we understand the geographical boundaries and spatial operation of the contemporary city and as such, they occupy the core of contemporary city discourse. The appetite to build smart cities has driven an agenda of smart frameworks in cities globally, yet it is a term which is widely used without a clear definition or understanding (Hollands, 2008; Neirotti et al., 2014). Before this thesis discusses the current and potential future impacts that smart technologies may have, we need to put in context what is meant by “smart” technologies in the geography in which they exist. So, what is a smart city? Söderström “et al” (2014) describe the smart city as the relationship between technology and society to optimise a system through the identification of a problem. This broad definition offers insight but fails to clarification what defines a smart city project. As a result of this lack of clarity, it is hard to imagine that the many actions we conduct today in the developed world do not fit within this definition of smart. Simply commuting to work in the morning now encompasses many of the technology relationships that could be classified as part of the smart city, but yet these are not technologies typically deemed as such. For example: when getting in the car, satellite navigation downloads the traffic on route and automatically directs us according to the fastest route, or if selected, the most economical one. Our phone or car can direct us to the nearest vacant parking spaces. If we need to move around the city, a car can be called to our location and without any requirement to interact with another human, it can take us to the destination and bill us based on the demand for the service we have taken. Yet none of these actions are categorised as projects of a smart city but are in fact classified as smart technologies. Cities, governments and major corporations are slow to react and capitalise on new technologies and so they have been doing what they know and trust, with the addition of digital add-ons (Malecki, 2014). This will surely have to change as we see more and more the impact that digital technologies can have on cities, their economies and citizens.

Smart city projects can be divided into two types of projects. The first of these areas is the official, authorised smart city projects, which are often provided with financial backing and authorisation of the local government and have a large corporation at the centre of the contract. IBM's smart city structure is based upon existing city management structures and based on systems theory (Chadwick, 2013). This method can be traced to the origins of the smart city agenda and primarily starts with IBM. The concept dates back to 2008 when IBM launched its Smarter Planet® Project. By October 2011, IBM was granted the Trademark Smarter City® and soon after the Smarter Cities Challenge® began. The challenge was an IBM venture, to carry out pro-bono consultancy work, to investigate what smart projects could offer 100 individual cities around the globe (Chadwick, 2013). This loss-leading consultancy was developed to yield returns, and for IBM it paid off, globally establishing the smart city concept as the buzzword for contemporary cities (Söderström et al., 2014). To date IBM owns a host of trademarks including: Smart Traffic®, Smarter Analytics®, Smarter Banking®, Smarter Cities®,Smarter Cities Challenge®, Smarter Commerce®, Smarter Energy®, Smarter Healthcare®, Smarter Oil®, Smarter Planet®, Smarter Public Safety®, Smarter Traffic®, Smarter Water®, Smartmodels® (Ibm.com, 2019). To put the scale of the smart city projects into perspective, in 2017 these contract generated revenue of $25 billion for the vendors of these projects (Abiresearch.com, 2018).

The system theory approach that the likes of IBM have established is generating a marketability of “Smart” as a brand. Vanolo (2015) has discussed how Turin had used the concept of the smart city as a brand through the slogan “Smartness will save Turin”. At the time, Turin was at the height of the financial crash, like much of the world (Vanolo, 2015). It was seen and marketed by the city and the corporations behind the initiative, that smartness would bring prosperity and would also make the city more productive and provide economic stability (Vanolo, 2015). This marketing approach is unsurprising when you begin to look at the typical process of the smart city. To begin with, corporations installed a host of platforms, monitors and sensors around the city. This enables a level of data gathering that has never been seen before in our cities. This big data did not just reveal how cities operate, but began to reveal how individual groups live and work within the city (Vanolo, 2015). This is what Sterling refers to as the real value of smart projects to the corporations who manage them - our data (Sterling, 2014). Data is not the only commodity of value to corporations such as IBM. This big data highlights where systems and infrastructure are falling short of their potential, allowing the corporations to identify problems and opportunities and then sell the city and its users a proposed solution, such as autonomous vehicles. This completes the cycle; more data results in more city modelling which provides more problems to fix. The branding of smartness gets the stakeholders on-board by convincing us that through engaging with these bits of technology the world will get better, a point which is still up for debate. Autonomous vehicles are currently the prime example of this and are being marketed as the saviour to our cities and social mobility (Bajpai, 2016). The autonomous vehicle represents the ultimate smart city project, a seamless system of users, city and technology, but its application and viability, are still unknown.

The second part to discuss is smart technologies, which are rather more difficult to understand and predict, and have arguably been far more transformative and contentious than smart city projects. This smart technology method is at odds with the system theory utilised by the likes of IBM and is often developed through the identification of a single problem or business model. There is little consideration from the beginning to act as part of a system. In fact, the business model is often intended to be disruptive to existing systems in an attempt to find customers and partners through an increase in productivity.

This method of smart technology consumerism has created the rise of business models such as Airbnb and Uber, both of which have had profound effects on our cities

(Meredith, 2016). Technologies such as Uber have the ability to rapidly transform the city through one major difference to the traditional system theory smart city projects in that they require no heavy infrastructure (Meredith, 2016). This means that they can move rapidly deploy their systems, often before the city and its stakeholders have been involved in consultation or legislation. In the case of Ubers operation in London, when legislation attempted to regulate them, they had become such an accepted norm with a loyal customer base who valued the service they provided that when Uber had their right to operate revoked, their customers' spoke out and advocated for Uber to remain operation (The Independent, 2017). Despite the issues Uber reportedly has with working practices and safety, the scale of the customer's response was recorded in a petition, which received over 500,000 signatures in 24 hours (The Independent, 2017). Uber has demonstrated the speed and effectiveness that smart technologies can have at disrupting existing systems. The question remains whether this disruption is a good thing and whether smart technologies be controlled and led by the stakeholders of the city.

2.13 Conclusions

Autonomous vehicles represent an exciting future, which is potentially full of opportunities. While there is an abundance of work speculating on what these opportunities may be, the literature is not as clear about who may benefit from these emergent technologies. Today, it is difficult to understand who the beneficiary of autonomous technologies will be. The only beneficiary whose role can be clearly seen is that of the operator of the autonomous system. It is for this reason that the race is on to be the first company to develop an operational autonomous car. The algorithms that support these autonomous vehicles will define the basis of how these vehicles will engage with cites and what impact they may have. Today, we can only speculate on this future, but this speculation is not without its value. For these algorithms to truly serve all stakeholders, there needs to be transparency, and the ability for all components (technology, stakeholders and the city) to have a meaningful stake. This does not necessarily mean an equal share; the reality of the situation is that most users of the city (e.g. commuters and shoppers) may be willing to have a degree of decision-making removed from them, in exchange for one less thing ‘to do’. For example, most people do not want to have to research the best way to get home. There is an appeal in having these decisions made for us; the question in such cases is where does the balance in decision-making lie?

What becomes essential is that the user has the ability to intervene and observe the decisions being made and influence them if desired. It is only through this kind of discourse that the user can begin to trust the decisions being made. This discourse should not just exist between users and the developers of driverless vehicles but must all also include the city and its occupants. If vehicles are to start platooning on our city streets, how would a pedestrian cross the road? For fully autonomous vehicles to operate efficiently, there must be a discourse taking place between all actants in the city.

There appears to be little work to date on how stakeholders, other than the operators of the protocols, will be involved in this decision-making. Work needs to be carried out as to how users can understand the data on which decisions are based and what the impact to the wider system may be. The action of one component within a networked system, could have implication for all other users. Similarly, a protocol could disadvantage an entire group of people without oversight. There is a balance to be struck within this system; users must not be overburdened, but the owner, operators of these protocols must not go unchallenged in the decisions they make. The development of a method that can visualise the protocols governing the actions of driverless vehicles is not currently part of the commentary surrounding autonomous decision making. To have any realistic opportunity of delivering an equitable transport infrastructure, this work needs to be a priority.

3 Methods and Methodology

This chapter outlines the methods and methodology used to explore the potential impact of autonomous vehicles on decision making and working practices. The research focused primarily on professional drivers using driver assistance systems, for whom driving forms an essential part of their livelihood. This work used data collected through a series of interconnected studies to investigate how participants view and engage with driver assistance systems and the associated connected technologies, such as navigation and driver dispatch systems. The chapter will then go on to outline how the findings could be used to conduct iterative design, through the use of both speculative design and data comics. Finally, the chapter will consider research rigour, ethics and safety.

3.1 Outline

Chapter one presented the historical context in which autonomous vehicles are emerging. The literature review presented in chapter two, discusses the technologies being put forward by automotive manufacturers. These two sections combined have help to inform the research questions and subsequent work. The research was broken down into three phases presented in chapters five and six. In phase one, users of a haulage internet forum TruckNet were asked to engage in discussions about how they currently used their vehicles and how they imagined these activities would change as a result of an increasing number of autonomous technologies. The data gathered from phase one was explored using qualitative research methods, resulting in the identification of codes and preliminary themes for further exploration. The findings of phase one were then used to inform the questioning used in more in-depth face-to-face interviews as part of phase two.

The data recorded from both phases one and two was combined to form one qualitative dataset, which was subjected to thematic analysis. The findings of this analysis are presented in chapter five of this thesis.

Phase three (described in chapter 6) used the finding from the first two phases to discuss how we could use a combination of data comics and speculative design to explore methods of engaging all stakeholders in iteratively designing the future of emerging technologies.

3.2 Research objectives

The study of autonomous vehicles comprises a diverse range of subjects, including safety, environment, IoT, computing, AI, ethics, mobilities and future cities. It was therefore considered important to first identify the scope of the research. While many researchers are looking at driverless technologies from the perspective of how autonomous control algorithms will make decisions, this study differed in that it focused upon the social and ethical implications of driverless technologies as discussed in chapter two. Specifically, how these emergent technologies are beginning to have an impact on drivers.

3.3 Literature review

The literature review was conducted by pooling information from four main secondary source areas:

1. Books and journals

Relevant books were identified by searching online library catalogues held by Lancaster University, Manchester Metropolitan University and the University of Manchester. This was accompanied by a search of Amazon.co.uk due to the rapid rate at which literature on driverless vehicles is being released. It is worth noting that on occasions, books had to be accessed through Kindle, as they had not yet been released in paper format.

Journals were searched using the Scopus, Web of Science and Lancaster One electronic databases. Search terms were selected according to four main keyword areas:

- Cars with driver assistance, driverless, autonomous technologies focusing on the social and ethics
- HGV, trucks, driver assistance, driverless, autonomous
- connected vehicles, connected autonomous vehicles, CAV
- smart cities, social, ethical, mobilities

A database was created listing the papers found in each of the thematic areas to ensure consistency and manage overlap. This also meant that reoccurring authors could be quickly identified.

2. Manufacturers websites, motoring press, motoring websites

The motoring press became a key resource when looking at future concepts and automotive technologies in use today. Although the motoring press, magazines and websites such as Whatcar, Autocar, etc can provide insight and direction for further investigation, they lack the depth to be a reliable source in their own right. The manufacturers themselves do provide material on their own websites but again, there is a lack of depth in the information provided. One of the most valuable resources was found to be the vehicle operating manuals. These manuals included more detail than the manufacturers websites, about the operating limitations and how users engage with the systems.

3. Policy and regulatory documents

Policy and regulatory documents proved valuable in understanding the context in which new technologies currently operate. The research focused on both UK and US documentation primarily due to the language barrier which exists in European documentation. UK documentation currently aligns with EU documentation due its current membership of this union.

4. Government websites and datasets

Databases and government sources were primarily used to explore and understand the scale of the issues being raised.

The findings of the literature review were used to perform a series of speculative studies to question and test the realities of the rhetoric around autonomous vehicles. These studies used speculative design (Auger, 2013) as a methodology to question future scenarios put forward by manufacturers, governments and industry and is set out in chapter four.

3.4 Rationale

Early observations, personal experiences and the literature review established the idea that people were not using vehicles to simply drive from one place to another but were conducting a range of activities other than driving. In fact, research shows that most cars spend far more time stationary than they do moving. According to the RAC Foundation's (2012) Spaced Out Report, the average car in UK is parked away from the home for just 16% of the time. While the vehicle is being driven for only 4% of the time, this equates to the vehicle being driven for just 6 hours 43 minutes per week (Bates & Leibling, 2012). By contrast, users whose livelihoods depend on their vehicles such as HGV drivers, on average drive for 48 hours per week due to regulations. However, based on a 5-day working week, this means that HGV drivers are living from the cab of their truck for up to 120 hours per week, 72 hours of which they are not driving, but parked in lay-bys, lorry parks and services (GOV.UK, 2018). Equally there are many other types of drivers whose livelihoods depend on their vehicles and who spend vast amounts of time in their vehicles such as; delivery drivers, taxi drivers and maintenance vehicle drivers.

People who drive for a living and the social and ethical issues that autonomy may create are not the focus of current research, while being typically overlooked by manufacturers and designers (McBride, 2014). Most autonomous research is instead focusing on the commuter, or social user, who use their vehicles for just 4% of the time. With cars making up approximately 82% of vehicles, HGVs making up just over 1% and LGVs making up around 10% (Department for Transport, 2018b), it is not a surprise that the car driver has become the focus for manufacturers. Yet, it is this group of working drivers, the 11%, where current driver assistance technologies are being most widely used. This research takes the position that autonomous technologies will not simply integrate into our lives, cities and work places without any impact, challenges or ethical consequences. It is the complexities of the implementation of driver assistance systems and the impact on drivers' lives that this research will aim to unpack.

In order to answer the research question, this work has used a series of interconnected studies using complementary methodologies. Initially a series of speculative design studies were conducted to test some of the futures being proposed in literature (chapter 4). The research then moved to involving participants in phases one and two, to document and analyse the perspectives of drivers (chapter 5). The thesis then explored design methods in phase three, which are intended to get stakeholders to think about the future they may want to see, by presenting methods of producing data comics and engaging stakeholders in future scenarios (chapter 6).

3.5 Methodological approach

This study has embraced a theoretical position that a single methodology is not broad enough yet not focused enough to appropriately respond to the methods at various stages of the research process. This is the result of a research question which hinges on an emergent technology. Yet autonomous technologies are widely becoming a topic of conversation and concern for many and are therefore, speculatively producing social data. It is for these reasons that this research was carried out as a series of complementary studies which were brought together to utilise the best methodology for the research task at hand. Throughout the research there was an ongoing focus to always consider and value the opinion of the individual user (Coffey and Atkinson, 1996); in this case, the professional driver.

The multimethod approach incorporated qualitative, ethnographic, user centered design and speculative design approaches. It is through this multimethod approach that this research incorporated both social and autonomous vehicle technology agendas. To achieve this, the study was broken down into three phases. The principle behind this was that these complementary phases used different methodologies to build knowledge. This allowed for a pragmatic approach as to how data was captured, investigated and used (Creswell, 2009). This allowed the researcher to address the research problem with the best methodology for the task, as opposed to responding to the pursuit of a singular methodological practice (Rosseman & Wilson, 1985).

It was thought that a multimethod approach allowed the researchers to create a more balanced point of view than could be achieved through a single methodological approach. This methodology also allowed the research to explore where realities may lie within the data captured. Skogan (1977) provides a good example of the strengths and power that a multimethod approach can have. When recording crime statistics, the police record reported crimes only, however, this typically leads to an under reporting of actual crime. To balance this, many policing authorities in the US, take a sample of the population and ask them how they have been affected by crime. While this still has the potential for under reporting, research has suggested that in fact, members of the public tend to over report (Brewer & Hunter 2006). This illustrates that combining methodologies may yield greater insights than a single methodology alone.

Through triangulation, this research planned to explore the potential realities of autonomous vehicles by addressing the research question from different methodological standpoints. Levine (1976) argued that it is impossibility that a single viewpoint is able to consistently produce an accurate view of reality. While these triangulations may be convergent or divergent with each other, the reality is that in either case, consensus can be found. Convergent methodologies support the results of a singular method when measured against one another, providing greater validity to the results (Skogan, 1977). Divergence between triangulated methodologies can also be reconciled through a middle ground position, which could not have been found through a singular methodology (Skogan, 1977).

The first stage was to conduct a literature review, which documented how driverless vehicles are being viewed by manufacturers, the media and academia. These findings are built upon in chapter three, through speculating on the potential areas where social and ethical concerns may lie, as raised in the literature review. The insights obtained from the literature review and chapter two, were triangulated with the findings of phases one and two. Phases one and two used thematic analysis to understand the way HGV drivers currently engage with their vehicles and the associated technologies, while scoping what their perceptions of the future were. Phase three used speculative design (Auger, 2013) and data comics (Bach, Riche, Carpendale & Pfister, 2017), to develop methods, which could be used through participatory engagement to further question the role of the driver in vehicles of the future. Phase three presents the design for a follow up study which could be used to further triangulate and build on the findings from phases one and two. Phase three will be discussed in greater detail in chapter six.

3.6 Ontology and Epistemology

Researchers and philosophers have argued, that all research should have a clear grounding in ontology and epistemological philosophy, which can be used as a grounding principal to clearly define where the research fits within a world view (Crotty, 1998). It has been argued that a multimethodology approach where ‘anything goes’ lacks a philosophical justification as it is at odds with a clear epistemological and ontological theory. This is because it is considered difficult to assign a coherent philosophical stance to multimethodology due to the differing world view of the methodologies used (Deetz, 1996). It is also considered that thematic analysis can be applied to a wide range of epistemological views of the world. It is however considered good practice for the researcher to clearly state their epistemological stance (Braun & Clarke, 2006). This study has as embraced a multimethodology but refrained from adopting an 'anything goes' mentality, which is fraught with critique from an epistemological stand point unless complementary methodologies are used (Coffey & Atkinson, 1996).

As a response to the critique of this 'anything goes' methodological approach, some have theorised that multimethodology research, should be based upon different ontologies and epistemologies, namely interpretive and positivist theory. However, Falconer and Mackey (1999) argued that this is not the right approach and in fact, such an approach undermines the value of multimethodologies. More recently in response to these differing opinions, Becker and Niehaves (2007) have proposed that a coherent epistemological stance can be achieved and benefit multimethod research. This position is argued by considering the epistemology and ontology used throughout the different methodologies. It is considered that methodologies should not be contradictory to one another but complementary. If this principal is applied, then a single epistemology and ontology can play an important role in providing a philosophical stance to all methods and the research in general. A clear philosophical approach also plays an important role in providing coherence to the researcher and guides how the findings are interpreted and presented across all phases (Becker & Niehaves, 2007).

This research has adopted a singular coherent epistemological and ontological stance. The research has fully embraced all aspects of a multimethodology in the pursuit of achieving triangulated results. By grounding all phases of the research in established methods, which have been considered for their epistemological and ontological coherence, the study has endeavoured to value and triangulate each method's own interpretation of the research findings (Coffey & Atkinson, 1996). Through the adoption of a relativist ontology and an interpretivist epistemology, this research has sought to allow flexibility within the research structure. This flexibility has been designed to take account of the unknown, creating a research philosophy which allows the research to explore new avenues of investigation (Carson et al., 2001). This positions the research within an epistemological view, that there are multiple perspectives to the people involved and that individual voices and realities have value within their social context (Green & Thorogood, 2014). This means that the research will promote new knowledge through placing value on individual opinions in an area of research where the individual is often lost or overlooked.

3.7 Study design

Phase one used a well-recognised internet forum, TruckNet, as the method of engagement. Permission was sought from the forum before any research was conducted. By contrast phase two used face to face interviews. Throughout phases one and two, it was considered important that participants were engaged with in their own environment and where possible within their own peer groups. It was also considered important that the interviewer could discuss matters with drivers at the same level. The interviewer has taken a HGV test, and for two years drove a goods vehicle extensively on tachograph, interacting with professional drivers during this period.

The research was conducted through ethnographic principles. Although none of the studies were strictly ethnographic, the study adopted a style of interviewing that embraced engagement within the participants', particular cultural, social and occupational setting (Brewer, 2008). While some earlier postmodern ethnographers argued, that ethnography could produce universally valid knowledge as to the nature of the social world (Clifford & Marcus, 1986), Demzin (1992) argued that in fact a universal social reality is meaningless. If ethnographers are in fact recording a thick social description of people and life through a lens, then that lens has a focus and a subject matter making the research directed, focused and not universal (Cassell, 2012). While it is understood that any research has limited universal validity, ethnographic methods do offer the research the potential to uncover a richer layer of data, something that this research wanted to focus on. The researcher aimed to create a stronger rapport with participants by questioning participants within their usual environments, surrounded by their peers, while being interviewed by a researcher who could talk and understand common issues. By using these ethnographic principals, it was believed that participants would be more likely to speak candidly about their current realities, as well as their future, revealing a level of detail which has not yet been commonly recorded.

Phase one was considered as a scoping exercise to initially allow the researcher to explore the topic of autonomous vehicles more widely. The data from this phase of the research underwent thematic analysis to help inform phase two of the research as discussed in chapter 3.8. As a result, in phase two, the researcher established more precise avenues of investigation, while outlining more closely the specific user groups to be interviewed. In order to approach a wider audience, phase one of the research was undertaken on a well-recognised online forum, TruckNet (www.trucknet.com). TruckNet was chosen due to its professionalism and the proactive nature of the forum's moderators when the research was discussed with them. This stage of the research focused on two user groups, which have been identified as groups whose livelihoods are intrinsically linked to their vehicle: 1) Heavy goods vehicle (HGV) drivers who live away and make multiple delivery drops, 2) operators and owners of haulage fleets.

3.7.1 Phase one

The forum provided a quick way of approaching a known and engaged user group using both the driver forum and operator forum on TruckNetUK. The forums proved an excellent way of engaging with the target demographic groups. This is something that the Internet has the capability to deliver in a more comprehensive way than any other media or platform, but it has both its strengths and weaknesses (Flick, 2009). Using forums was recognised as a limitation as it engaged an already proactive sub set of drivers. Despite this, with so little research having been conducted in the area, the decision to use forums seemed justified as a starting point. Using forums also meant that all discussions were automatically documented and so the research could engage with the participants as opposed to just recording what was being said. Forums are also noted for being a breeding ground for abuse and disruptive behaviour. To help reduce this problem, the study worked closely with the forum moderators. They provided legitimacy to the post by introducing the research and gradually opening up the posts to all members once discussions had started to pollinate constructive posts. This was done by the participant membership level, which was based on their engagement with posts in the past, in the end all members were free to contribute to the post.

Abuse and disruptive behaviour was not an issue, however there was a necessity to manage forum members' understanding of why this research was being conducted and why value should be placed on their opinions. Discussing a technology, which does not currently exist was challenged by participants as something, which is 'not currently affecting them'. The researchers had to inform participants of the value of engaging in discussion before the event has happened, 'as the time to inform the technologies is now'. Participants were reminded that once we have driverless vehicles rolling down the road, there is very little chance of informing their development.

Before phase one of the research was conducted, it was unknown how much drivers had thought about the implications of these driver assistance technologies and what their expectations and understanding of the technology might be. As a result, posting on TruckNetUK provided the opportunity to understand what drivers knew about driver assistance technologies and autonomous vehicles. This allowed the researchers to question whether drivers understand what this technology might mean for them, their current livelihoods and how they may travel in the future. These forums also become a good basis to gather knowledge about how people currently used their vehicles. However, this study was not just interested in the activities people conducted within vehicles, but the mechanisms that led to the activity. The forum was conducted by the researchers posting a question to stimulate a conversation, the researchers then engaged with the conversation online, enabling them to steer the conversation and elicit new understanding while posting new questions to move the subject forward.

3.7.2 Phase two

Phase two was conducted using face-to-face interviews and used guidance questions as seen in Appendix 1, developed as a result of the phase one analysis. Phase two again used thematic analysis, although this time combining data from both phases one and two.

Face to face interviews are not without their problems and challenges. Questionnaires are often a simpler method to gather a wide range of demographic groups and as a result high participant numbers. Achieving a large sample of participants and a representative demographic group is often much more challenging when engaging with participants face-to-face. Despite this, it was felt that an individual approach was more likely to achieve a more in-depth understanding of the research and as such, a reduced demographic spread was considered acceptable.

Phase two was conducted using semi-structured interviews which were audio recorded to enable the researcher to focus on the interview and not have to worry about making detailed notes. With the interviews being conducted in a café where the drivers had time to spare, the context and the environment made for a relaxed discussion in which all drivers approached were happy to be interviewed.

3.7.3 Phase three

Phase three explored how visualised futures could be used as both a way of recording the impact of emergent technologies and as a design tool to explore future developments. The methods proposed in phase 3 (chapter 6) discuss how designers could employ iterative design to overcome the conflicting agendas of different stakeholder groups, with the aim of establishing more equitable futures (as discussed in chapter six). To date there is very little evidence to suggest that HGV drivers have been involved in the development and design of new technologies (Bedinger et al., 2015). This lack of stakeholder involvement among drivers will be unpacked in chapter 5, however initial consultations with representatives from the industry when planning the research suggested that HGV drivers do not currently fit into the discussion around increased machine decision making and automation.

It was felt that the manufacturers of trucks were responding to the needs of fleet managers or large haulage firms. As a result, drivers have been excluded from the conversation and have had little ability to exercise their voices due to a challenging employment market and weak representation by unions. It was for this reason that phase 3 was considered as a way of developing methods to engage stakeholders in a common conversation where the opinions of all users can be taken into account through the use of data comics.

3.8 Qualitative methods, phases one and two

Qualitative methods were chosen as the most appropriate approach due to their ability to develop a rich and more complex understanding of new ideas, compared with quantitative methods (Braun & Clarke, 2014). It was believed that questionnaires would be neither exploratory enough, nor open enough to elicit new findings (Braun & Clarke, 2014). Methodologically, thematic analysis is considered to be an excellent method for uncovering new concepts within data (Boyatzis, 2008). Through employing methods of analysis, which are flexible at adapting to research requirements, thematic analysis is capable of embracing and capturing the unknown, yet through clear documentation, is considered to be methodologically sound (Braun & Clarke, 2006).

Participant interviews were conducted on both forums and in person. Phase one used unstructured questioning, while phase two used semi-structured interviews. During the interviews every effort was made not t0 lead participants. However, a careful balance had to be struck between getting the most out of the interview by eliciting debate without bias (for more detail see 3.11 qualitative rigour).

The thematic analysis was conducted using Braun and Clarke's (2006) step by step guide as a basis for the work. The analysis was undertaken through following six steps:

Step one: Familiarising yourself with your data

Step two: Generating initial codes

Step three: Searching for themes

Step four: Reviewing themes

Step five: Defining and naming themes

Step six: Producing the report in this case user centred design driven futures

3.8.1 Step 1

Step one of the data analysis was run concurrently alongside data collection. This was especially true in phase one of the research, where getting to understand the data informed both the research and the discussion with participants. As conversations were taking place on forums, the information was being regularly read and digested in terms of its meaning and themes. This meant that the researcher could reflect on the participants' responses before further questioning. By developing more structured themes and questions through phase one, this made the role of the researcher easier in phase two. Phase one questioning was highly exploratory, drawing understanding of the data as public participation was taking place. Phase two did not allow the researcher time to reflect in the same way. Phase two was semi-structured with questions being structured before the interview took place. Phase two data had to be transcribed from the audio recordings, unlike phase one where the conversations were already documented due to the modality of engagement being in written form in the first place. The transcribing of phase two data was the task of the researcher, which while an onerous task, did present two opportunities. Firstly, it was a good way for the researcher to become familiar with the data (Braun & Clark, 2006) and secondly, it provided opportunity to decide how the audio files would be transcribed. It is argued that the transcriptions should be transcribed in a way that communicate both the nuances of what is being said and the objectives of the analysis (Edwards, 1993).

3.8.2 Step 2

Step 2: Step two was conducted once all discussions had been transcribed and the researcher had familiarised themselves with the data. The first stage of step two was conducted by identifying codes. The codes were highlighted in the transcripts, as a form of data identification. The process of coding was a way of organising the transcribed data into categories which are both important to the participants and relevant to the research question (Tuckett, 2005). The study looked to identify as many themes as possible, which were identified as relevant to the research question. These codes can be extracted either manually, using pen and paper or by computer using software such as NVivo. This study adopted a physical approach, using manual pattern identification, by cutting up transcripts and placing them on a wall (Kelle 2004). The researchers felt that it allowed for a clearer overview of the data making it easier to understand the codes in context.

3.8.3 Step 3

Step 3 used the codes from step two, to begin forming themes. The codes were initially broadly grouped into themes. As the work progressed, codes were regrouped. At this early stage, as the themes were being developed, a brief description was written to outline what was meant by the theme and how codes fitted within the thematic areas. As the process continued, sub-themes were also considered to explore some of the larger themes. At this stage all codes and themes were not discarded from the analysis, until further development had taken place.

3.8.4 Step 4

Step 4 was a development of step three, in which both themes and codes were refined. Braun and Clarke (2006) suggest that stage four should be broken down into two processes. Firstly, all themes and codes were read and fully understood. Themes and codes were then challenged to understand whether they made sense in term of the research question. Any themes and codes which no longer made sense were incorporated into existing themes, or alternatively made into additional themes or subsets. The second process unlike in the previous steps, challenged both the codes and themes as to their relevancy to the research and whether the theme was supported by the codes. Themes and codes were at this stage discarded if they were not supported by enough data, or if they were deemed to add little importance to the research. At the end of this step, a clear thematic map was produced and used in step 5.

3.8.5 Step 5

Step 5 worked with the thematic map produced in step 4 as a tool to explore and refine the data. The principal of step 5 was to refine the names and meanings of the themes and sub-themes to place less emphasis on the codes. At the end of this step themes were given names which were concise and which gave the reader a sense of what was meant by the themes (Braun & Clarke, 2006). This consisted of writing a clear definition for the themes which included both the context and any implied understanding that the researcher had developed though the research process.

3.8.6 Step 6

Step 6 followed the procedures outlined by Braun and Clarke (2006) to document the findings through the production of a report. The findings of this conference paper were presented at European Academy of Design 2019 and the paper forms chapter five of the thesis.

3.9 Qualitative rigour

Qualitative rigour starts with good interviewing techniques. With the interviewer having a background in driving and conducting research into driverless vehicles it is inevitable that the researcher would start to form opinions about the topic. What is important is that during the interviews the interviewer did not transpose or impart those opinions onto the participant. The study design attempted to mitigate this concern by firstly recording the interviews; this gave the interviewer more time to think and reflect on what was being said as opposed to making notes. This meant that the interviewer had more time to use the interview schedule and think about how to phrase questions in a way that was not leading. For example, rather than saying; "do you think driver assistance systems are bad?", the interviewer would ask "what are your thoughts about driver assistance systems?" (Ryan, Coughlan & Cronin, 2009).

In order to conduct good quality qualitative research, the data must be understood well before coding. To do this, the researcher both read and listened to the interviews multiple times to get a grip of the nuances and full meaning of what was being said. The decision was made not to use qualitative analysis software such as NVivo, instead opting to work with paper and a large wall as seen in figure 3.1. It was felt that this physical approach allowed a greater ability to view the codes and thematic mapping in more context as the whole process was visible at any one time. This enabled the process to be checked for consistency between the data and how the analysis represents the data. It also allows for the checking of the narrative and that a singular point does not become sensationalised within the story (Braun & Clarke, 2006).

Figure 3.1. Codes and themes physically mapped on a wall during the analysis process

The final point to make is how the data is interpreted and reflected upon. Discussing the emerging themes from the analysis with others was found to be a valuable exercise from two perspectives. Firstly, it is very easy to become drawn in and focus on a single line of enquiry. Discussion with others allowed for the researcher undertaking the exercise to stop and reflect on the overall picture and reposition the process, ensuring that the research question remains focused. The final point is that by discussing the qualitative phase of the research, particularly within an interdisciplinary group, these discussions can create opportunities to elicit new understandings and avenues of investigation that would not have been observed without sharing.

3.10 Participatory data comics phase three

‘The objective of all visual communication is to effect a change in the public’s knowledge attitudes and behaviour. For such a change to happen, the communication must be detectable, discriminable, attractive, understandable and convincing’ (Frascara, 1997). Thematic analysis was essential in creating new findings, however the realities of communicating these findings to both the public and stakeholders could be developed into a stronger method of communication. It was for this reason that this stage of the research was developed to communicate the narratives and context in which the findings existed. As such this stage employed speculative design (Auger, 2013) and data comics (Bach et al., 2017) as a method to play out and test, future scenarios and contexts.

Data comics were chosen as a method to communicate and build on the research findings of phases one and two through speculatively designing, projected futures, concept futures and alternative futures. This process has been shortened from the example of Endsley and Jones (2004) as this research is only interested in testing scenarios to record responses, as opposed to the commercialisation of a product. The objectives of this process were to explore methods which could communicate and engage stakeholders, with the data collected from phases one and two. Additionally, the methods explored how designers could speculate on scaling up the introduction of current concepts and the exploration of alternative futures. Through the use of data comics, the methods explored how stakeholders could respond to the futures generated, by providing reaction and opinions as to where they believed both opportunities and challenges lie through emerging technologies such autonomous vehicles.

3.11 Recruitment, phase one and phase two

Phase one participants were recruited through TruckNet's forums and so no active recruitment took place other than to explain the research and the subsequent posting of research questions.

The method of recruiting participants into the phase two study was carefully considered. Approaching participants who were currently under time pressures was considered inappropriate due to the length of time required to realistically undertake an interview. Additionally, drivers could not be approached while they were within a vehicle. Potential participants such as those driving HGVs spend a lot of time waiting, which causes them to gravitate towards common spaces. These are typically spaces where they can go to the toilet, get a drink, grab something to eat and park for free. As a result, these user groups are more readily approachable for two reasons; they congregate in known places and have free time to talk. As a result, it was decided that drivers should be approached in the evening at a truck stop, after work but before they typically go to bed. As such the interviews were conducted by approaching drivers in Haywood truck stop cafe while they were watching TV or had finished dinner and were sitting with little to do. This approach made recruitment easier than approaching drivers who were currently working, and on occasions, the social exchange was even welcomed. Although interviews were designed to take 15-20 minutes, all lasted over an hour at the request of the participant. Permission was sought from the owners of Haywood trucks stop and approved and given.

The interview started with a quick discussion and a more general chat about how their day had been, what was on the TV or anything in the news. The intention of this was to put both the researcher and participant at ease, before consent was sought and the questioning started. Informed consent was undertaken by firstly providing the participant with a participant information sheet (see ethics 3.13) which outlined the study and provided both complaint and withdrawal procedures. Before the interview started the researcher read a verbal consent statement (See ethics 3.13). If consent was given to both conduct an interview and audio-record it, then the audio device was started, and consent was audio-recorded. The questioning only began when the consent procedure had taken place.

3.12 Participant sample

As discussed in previous sections, participants recruited as part of phases one and two were drawn from two sources; Trucknet and Haywood truck stop. It is possible that use of these two recruitment sources may have affected the study findings due to the likely characteristics of drivers using these services. Although the recruitment of drivers at truck stops provided the researcher with a safe location to approach drivers (compared with lay bys or other stopping locations which are less monitored), it is likely that drivers accessing these services were employees of particularly responsible operators, i.e. those willing to cover the fee for their visit. The views of these individuals may be more likely to be positive compared to those whose employers did not cover these costs. Additionally, the selection of a single site could be deemed to produce a sample with particular opinions and similar experiences. However, this was deemed unlikely due to the nature of the industry where drivers typically travel long distances and rest in on-route locations. Therefore, it was not believed that using a single location would result in a geographical bias.

The use of Trucknet as a free-to-use global forum aimed to counteract some of the potential limitations of the face-to-face interviews. Due to ethical constraints, the location of the drivers using the forum was not recorded, however, through participants' responses it became apparent that drivers were based all over the UK. Of these drivers, many mentioned past experiences of driving within Europe, America and Australia. Additionally, one of the limitations of recruiting drivers through a specialist truck driving forum, was that many of the drivers saw HGVs as a passion, hobby and even a way of life. It was unlikely that discussions would be held on the forum with individuals who were driving HGVs as a stop-gap or perhaps because they had no other job opportunities. The face-to-face interviews allowed for a greater opportunity to engage with a user group who were less passionate about the industry.

3.13 Ethics

This research was approved by the Lancaster University Faculty of Arts and Social Sciences and the Management School Research Ethics Committee (FASS-LUMS REC).

3.13.1 Phase one - forums

Two primary ethical aspects were considered when collecting data as part of phase one. The first was how participants could give consent to take part in a research study that was online. Although we anticipated that the questioning would be non-sensitive, it was nevertheless important to gain the informed consent of participants in order to use their comments as research data. It was decided that by informing the participants with a footnote to every question, it could be assumed that consent had been given for research to be conducted (Appendix 2 Phase one consent statement). Also, before any research was conducted permission was sought from the forum (Appendix 3 Phase one forum consent letter).

The second ethical issue considered was that the research team would have limited control of the discussion and what participants and forum members said. This was considered as a problem, which could lead to inappropriate behaviour and bullying. It was a concern which was also compounded by the fact that such behaviours could be seen as associated to the University and the research team. As a result, the decision was made that phase one should be conducted on credible forum platforms. TruckNet was used a is has a credible record as a platform for discussion and has enforced forum rules with moderators overseeing all threads.

3.13.2 Phase two

The primary ethical consideration of phase two was how consent was obtained. At the beginning of the interview, the participant was provided with the participant information sheet (Appendix 4 Phase two Participant information sheet) and was verbally informed about the aims of the research and how their information would be used (Appendix 5 Phase two verbal consent). The consent statement asked for two consents, the permission to record the interview and the consent to take part. In order for the interview to proceed, consent for both recording and taking part in the study was required before participation could be proceed. Once the participant had initially agreed to taking part, the interviewer asked if it was ok to start the audio recording. If permission was granted by the participant, the audio-recording device was started, and the participant was asked to verbally confirm that they had: a) understood the participant information b) agreed to taking part in the study and c) agreed to being recorded. If they agreed, the interviewer stated the participants' ID number which was written on the participant information sheet. This allowed the interview data to be stored against an ID number and deleted at a later date if the participant requested. The participant information sheet also provided contact details (email and postal address for the research team), along with the individual randomly generated ID. This ID could be used by the participants to withdraw from the study within six weeks if they wished for their data to be excluded.

3.13.3 Ethics All Phases

It was not anticipated that the topics discussed as part of this study would cause discomfort, distress or danger above those encountered in normal life. However, there was a low risk that participants could experience some embarrassment when describing aspects of their daily routine and reasons for particular behaviours, e.g. living out of a car due to financial difficulty, or due to a marriage breakdown. Discomfort such as this was particularly unlikely for phase one but could be an issue in the face to face meetings of phase two, where individuals may have felt more pressured to provide a response. If participants did volunteer this kind of information, it was of the participants' own choice as the interviewer did not question with the intent of discovering such personal information. At the request of the ethics committee, contact details for both the Samaritans and Relate were kept by the interviewer in case of distress.

It was also possible that taking part in this study would cause minor inconvenience to participants through taking up their time. The study made all efforts to minimise inconvenience. For phase one, it was not anticipated that participants would likely be inconvenienced. Phase two interviews were conducted at the participants' place of work to minimise inconvenience.

It is worth noting that in all phases of this research, participants could reveal driving misdemeanours such as speeding offences and parking on double yellow lines. It was considered not the responsibility of the research team to police roads and doing so would have undermined the validity of the participants' responses. Consequently, the research team chose not to report such admissions.

3.14 Safety and work practices

Phase one presented no real risk to the researcher in that any contact with participants was made through reputable forums, which had strict policies of use. This still meant that the researcher could have been the subject of abuse or antisocial behaviour, but the risks were minimal. There was also a slight risk in all phases, of the researchers receiving abuse via the email addresses displayed on participant information statements/sheets used as part of this study. This risk was very slight, and it was considered that using email addresses which were already in the public domain presented little additional risk. It was planned that if any of the research team did receive abuse, then the email addresses responsible would be blocked. If blocking was inadequate and abuse continued, it was agreed that this would be referred to Lancaster University IT Services so that appropriate action could be taken. Phase two of the study required the researcher to enter the field alone to interview participants. All interviews were conducted in public locations. Meeting locations, dates/times were logged with the research team. Interviews were conducted away from hazardous environments and exposed the researchers to the same level of risk as would be routinely experienced in day to day life. Locations were selected for their suitability to be accessed safely by public transport or car. Any vehicles used by the researcher were appropriately insured for the task. All phase two work was carried out within the guidelines of safety in the field policy and the lone working policies.

(http://www.lancaster.ac.uk/depts/safety/files/Fieldwork.pdf),(http://www.lancaster.ac.uk/depts/safety/files/loneworking.pdf). A risk assessment was conducted and signed by the appropriate member of Lancaster University staff.

3.14.1 Data storage

All data was stored on Lancaster University's Box, a secure cloud service. Transcripts from phase one and three were anonymised using a randomly generated ID instead of user names and stored in Microsoft Word and individually password protected. The audio recordings made in phase two of the study were initially made using a password protected and encrypted iPhone with iCloud sync switched off. Once the interview was completed the file was transferred to the Lancaster University Box using the mobile app. At this point the audio recording on the iPhone was deleted. This was a quick process and so took place after each interview to ensure security and prevent loss of the data. At a later date these audio recordings were typed up into anonymised transcripts using Microsoft Word and stored within the Lancaster Box. The audio files were destroyed at the end of the study. The forum selected (TruckNet) had their own data protection policies which complied with the Data Protection Act 1998. Once the study was completed, the anonymised data from phase one and two was transferred to the Pure database under a CC BY-NC licence for dissemination and storage. During the study, Richard Morton (PhD student) was responsible for the storage and stewardship of the data. The supervisory team, Nick Dunn, Daniel Richards and Paul Coulton also had access to the data.

4 'Smart' Autonomous vehicles in cities of the future

Parts of this chapter were published at Mobile Utopia 2017.

Morton, R., Dunn, N. S., Coulton, P., & Richards, D. C. (2017). *'Smart' Autonomous vehicles in cities of the future*. Paper presented at Mobile Utopia, Lancaster, United Kingdom.

This chapter builds on the literature review by using speculative design to test and question some of the findings of the review, to elicit new understandings about the emergence of autonomous vehicles.

4.1 Introduction

Over the last century, cities have been reconfigured to move cars around in the most efficient way. Road networks were first developed as military infrastructure, but soon became consumed by trade and commuters; driving the economy and reconfiguring the city. The result is a landscape that can be difficult to navigate, without the density to be walkable, or supported by mass transit. Driving is not productive and prevents us from performing tasks that we value. The future concepts of autonomous vehicles are no longer based around driving, they are being re-imagined as our new Smartphone; always present, highly configurable and embedded into every aspect of our lives.

Current developers of driverless vehicles place AI technologies, cloud mapping and embedded smart devices at the centre of their concepts in an attempt to create an intelligently filtered city. Developers of these technologies such as Google will play a central role in determining how this newly filtered city will be presented to us. The likes of Google will have the ability to subversively control vehicle movements and engagements within the city through their embedded autonomous technologies. How people and vehicles currently engage with the city, is set to change but who will be in control of the protocols that will determine these changes.

4.1.1 Methods

This chapter uses speculative design techniques to explore the ethical and infrastructural opportunities and challenges that autonomous vehicle technologies may present to the city and its users.

Speculative design is a method through which designers can critically re-think products, systems and in fact, the way in which societies and user groups operate within the context of our cities. Based on methods described by James Auger (2013), this work draws on speculative design methods as a way of considering future technologies, without the constraints imposed by commercialisation. Through the combination of emergent technologies, datasets and policy, designers can explore futures which can test society and technology. It is within this rich discourse between society and technology (Urry, 2016) that speculative design is most valuable; enabling dialogue between experts and potential users (Auger,2013).

Speculative design differs from more traditional design practices in that it turns away from more commercial practices by exploring the “what if’s”. Traditional design practices typically explore market demands by either recognising gaps in the market or solving issues that consumers face. Speculative design focuses towards questioning the effect that emergent technology may have on individuals and society (Auger, 2013). The aim of speculative design is not to attempt to predict the future, or to identify need, but to facilitate a platform for discussion where desirable, undesirable and potential issues can be identified and discussed (Dunne & Raby, 2013).

Speculative design however is not without its critics. The use of visualisations to explore technology in future cities is a method which has been used by architects, artists and designers for over a century (Dunn et al., 2014) but the discipline of speculative design is a relatively new practice with no clearly defined methods or methodologies (Pollastri et al., 2018). Voros' cone (Voros, 2003), provides a framework for exploring future scenarios, but Voros makes the assumption that different stakeholders' visions of the future are contiguous and that the past has no bearing on the future (Coulton et al., 2016). Coulton "et al" go on to argue that plausible and probable speculations are the most valuable when engaging end users in debate surrounding the visualisations created, as they are closer to users' current experiences and knowledge.

In response to these critiques, the visualisations will be explored through narrative, using the context of day in the life of a stakeholder using emergent technologies. In this case, an autonomous vehicle similar to the concepts being portrayed by the automotive manufacturers. This use of narrative, intrinsically links the societal and historical constructs of the world around us with the technologies being explored. The use of visualisations makes the relationship between users, cities and the proposed technology tangible and quantifiable to the reader (Dunne & Raby, 2013). Speculative design is a diverse subject area. At one end is speculative fiction, influenced by the work of futurists and authors such as Bruce Sterling, which typically explore alternative futures, influenced by science fiction and imaginative alternative worlds. By contrast, speculative design can be used to explore near futures to test and explore the societal and individual impact of disruptive technologies; an area in which this work sits.

Through the combination of narrative, society and technology, designers are able to test and explore how future interactions between autonomous vehicles, cities and stakeholders may take place. This process should not be considered as a linear process, but as a process of iteration and indeed the results found in figure 4.1 are the result of using design iteration to produce a coherent speculative narrative, exploring a series of scenarios. The comic strips which form the basis of this chapter were created by combining the technology concepts visualised by manufacturers of autonomous vehicles and placing them into the commuting patterns that we are today familiar with. This allowed for an exploratory study, which began to identify where opportunities and challenges may begin to arise as a result of fully autonomous vehicles being introduced to our cities' streets.

4.1.2 Visual design speculation

The following section shows the speculative design narratives used to explore how driverless vehicles may engage with citizens and the city in the future. These narratives where based on the findings of the literature review to explore and test the futures being suggested. The drawn speculations, formed the basis of the speculation outline in chapter 4.

Figure 4.1. An overview of the design exploration through narrative study which helped to inform the findings of chapter 4.

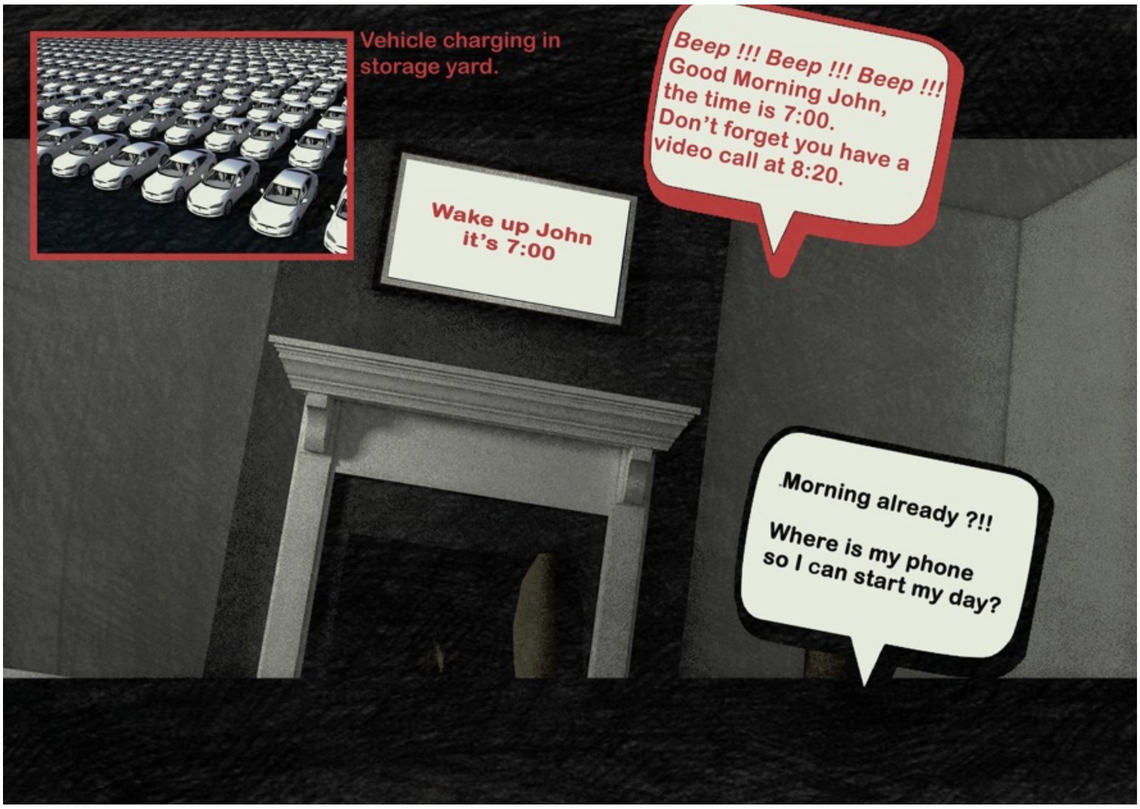


Figure 4.2. The first slide shows how the smartphone becomes a facilitator, waking up the user according to their schedule or even in response to traffic congestion.

Figure 4.3. The smartphone gives the user preference options and also begins to deploy assets to enable seamless mobility.

Figure 4.4. The option to select additional services, such as pick up shopping on route, are also provided.

Figure 4.5. The system provides seamless mobility. As the user steps out of their house, the car is ready and waiting.

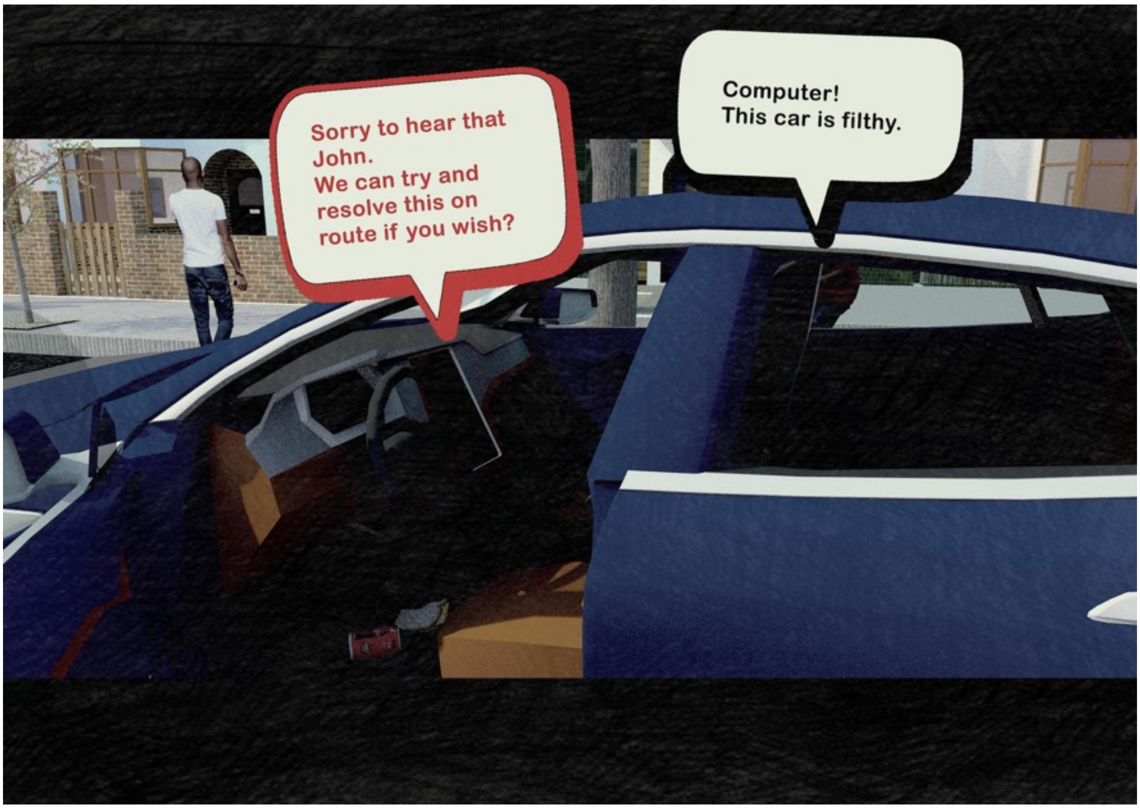


Figure 4.6. There are challenges to this kind of autonomous system. If the previous user leaves the vehicle in a mess, there is no one to clean it up.

Figure 4.7. If a vehicle was to arrive dirty, time pressures may mean that the user has to take the vehicle regardless.

Figure 4.8. The system would have to find means to compensate for a dirty vehicle or any other kind of poor service.

Figure 4.9. Current infrastructure intended to support vehicles could feasibly support autonomous vehicles.

Figure 4.10. The issue with current infrastructure is that it is not a very rewarding place to spend time. Future infrastructure strategies require more consideration.

Figure 4.11. Even if driverless vehicles do take to our roads, there are time when users may still want to drive while being monitored by the vehicle's systems.

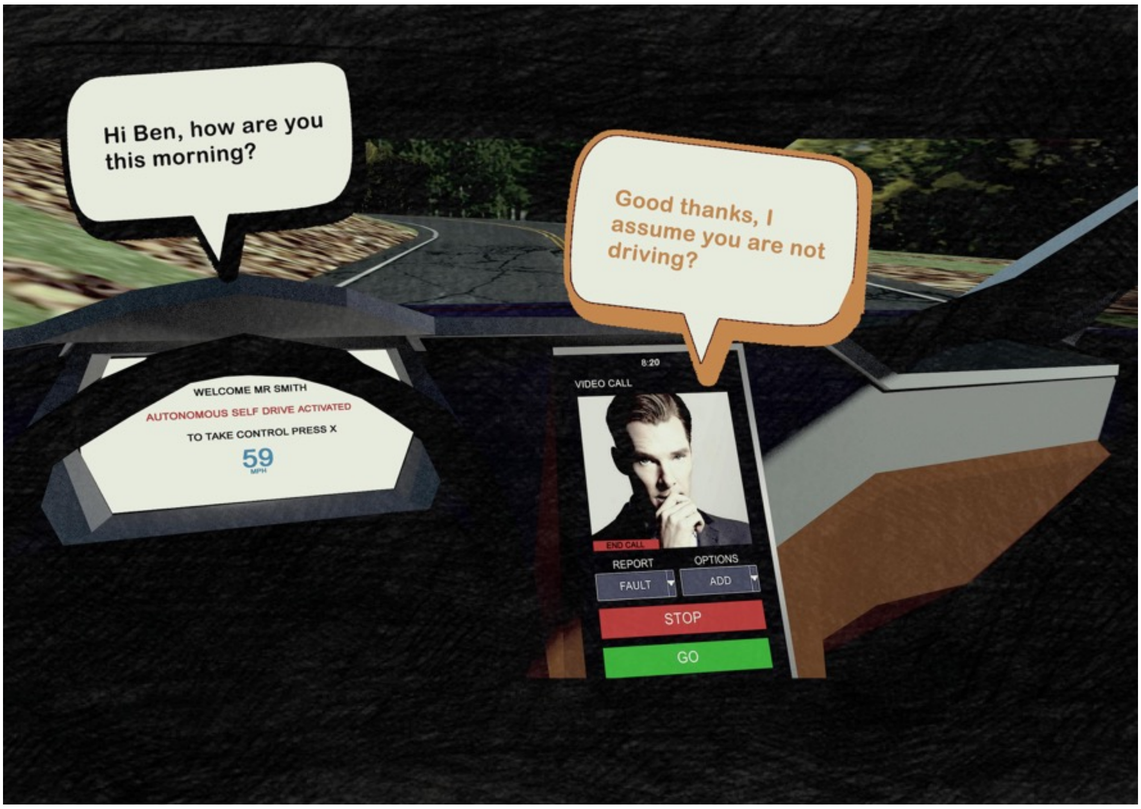


Figure 4.12. Drivers could choose to engage in other activities such as meetings rather than driving, making the journey more productive.

Figure 4.13. Vehicles could also seamlessly connect with other modes of transport. In this case, a cycle which is located outside the city centre.

Figure 4.14. With the possibility of personalised transport the system could set goals to encourage fitness targets.

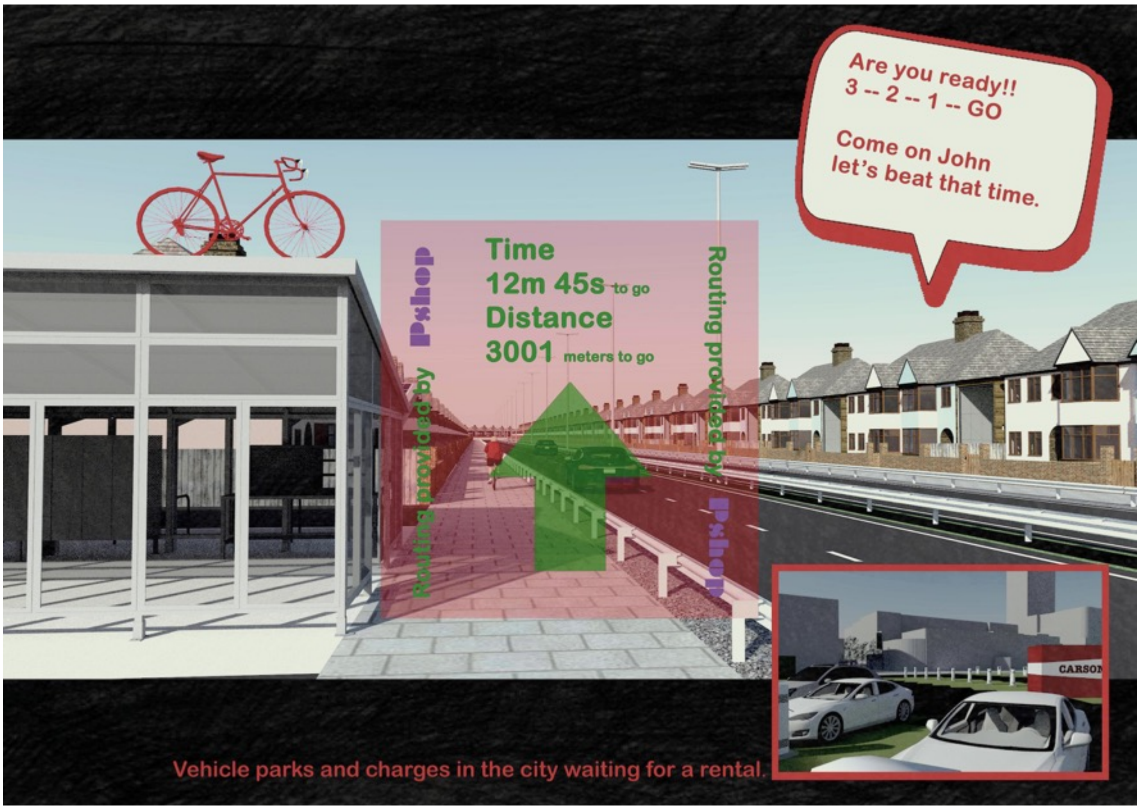


Figure 4.15. Once the user has moved to another mode of transport, the vehicle can be moved to a storage area while it awaits another user.

Figure 4.16. Cycles can be left at a convenient location for the user. The cycle will then be available to be picked up by the next user.

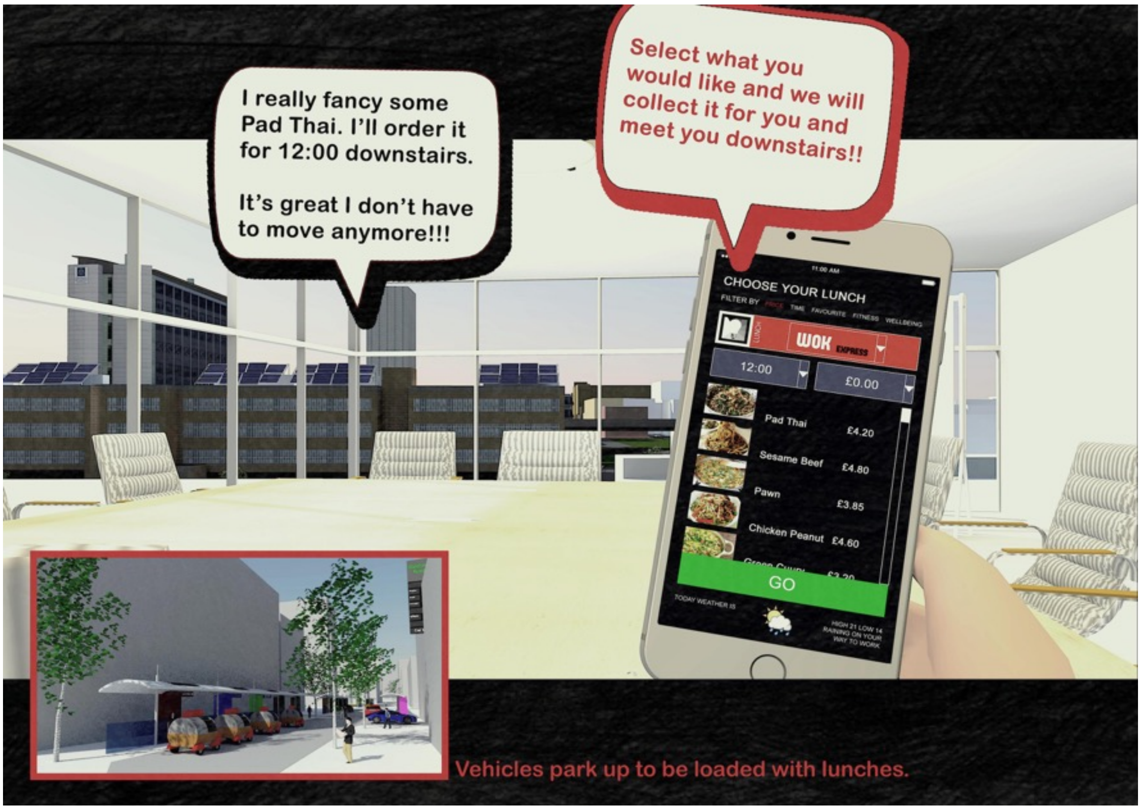


Figure 4.17. Lunch could be ordered through a smartphone and delivered to the user's place of work. A pod is dispatched to the takeaway to collect the order.

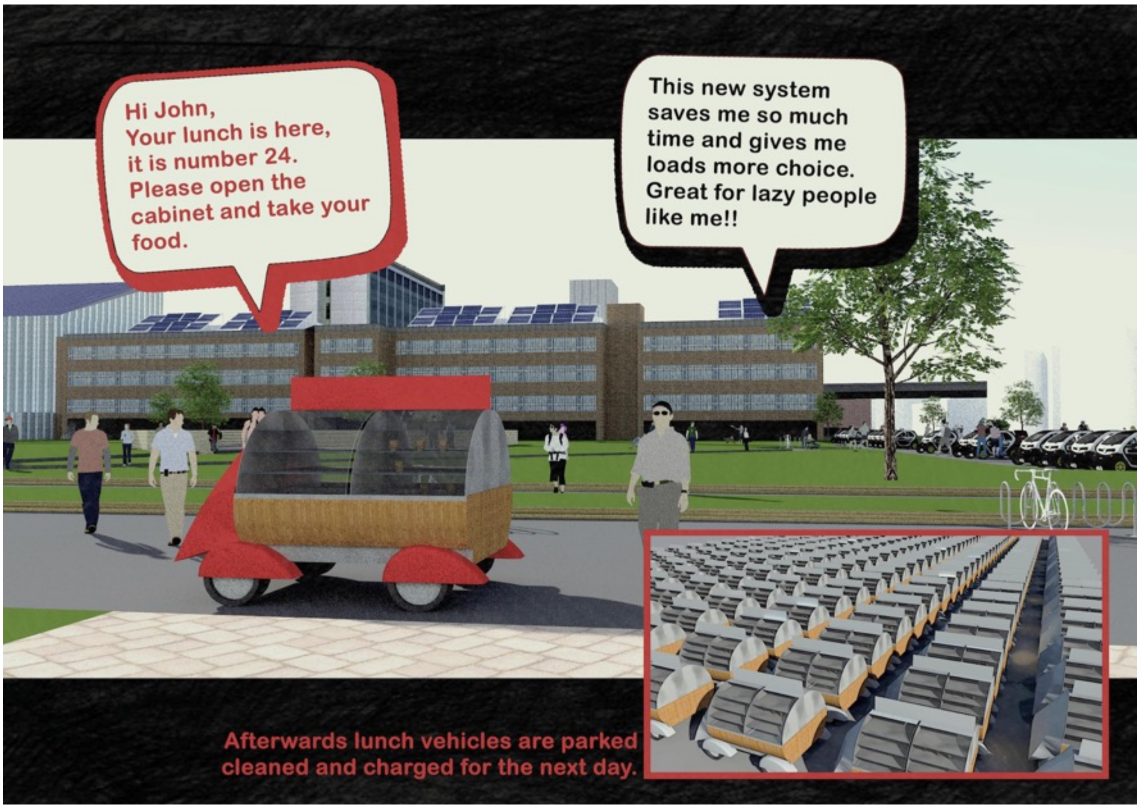


Figure 4.18. The pod then drives to the user's place of work to deliver the takeaway. The pod can then return to a storage location.

Figure 4.19. Using a smartphone or other interface, a user can request a journey. As this happens, the system begins to prepare assets for the journey.

Figure 4.20. When planning a trip, users can select their preferred stopping location which will allow the vehicle to recharge.

Figure 4.21. Within urban environments, users could be met by pod like vehicles. These pods could transfer users to interchanges; potentially freeing up streets.

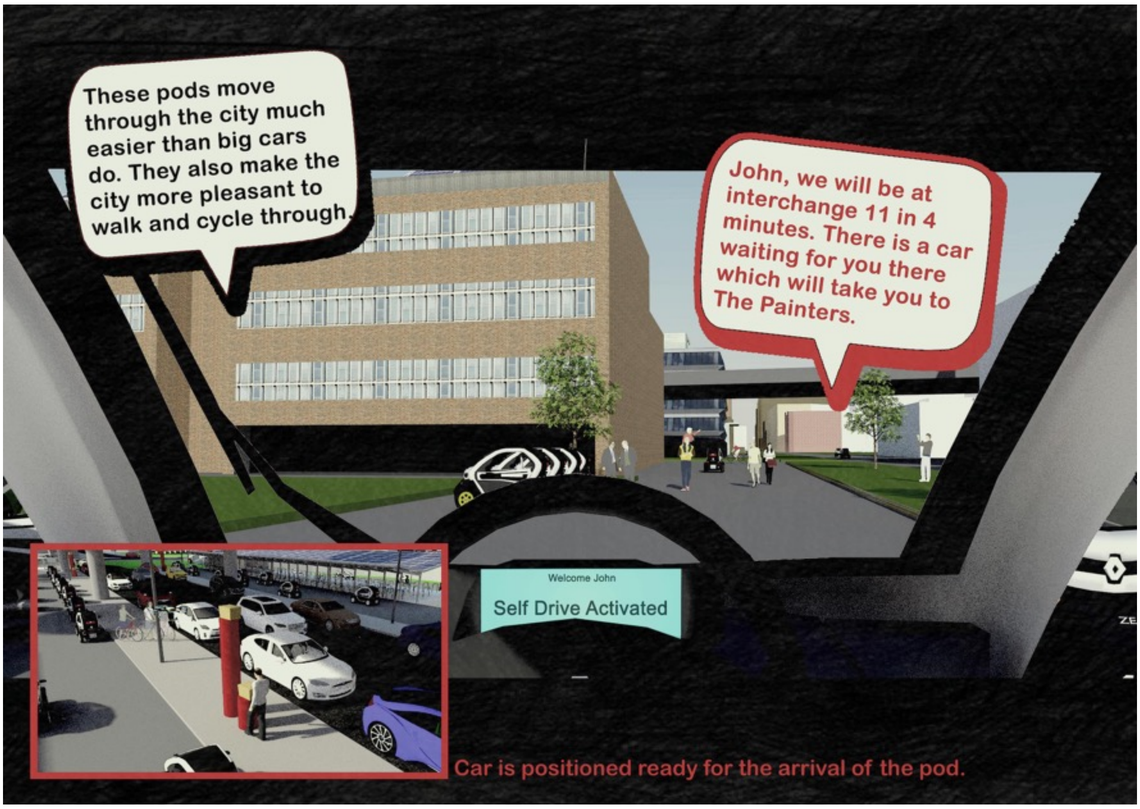


Figure 4.22. In this case, the pod is transferring the user to an interchange where a car is waiting. Pods could also transfer passengers to other modes of transport.

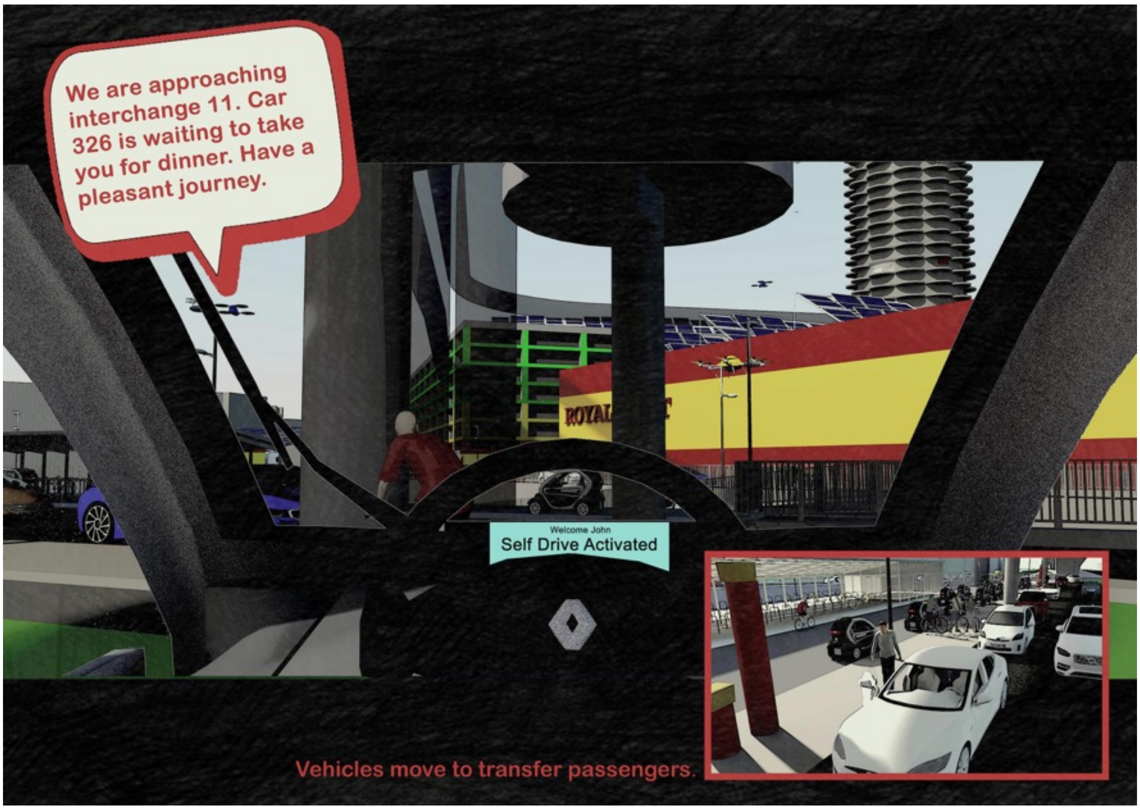


Figure 4.23. The pod reaches a transport interchange on the outskirts of the city centre next to the major road networks such as motorways.

Figure 4.24. The user can transfer directly to a larger car-like vehicle which will offer greater comfort and travel at far higher speeds.

Figure 4.25. The user had already decided to stop at a restaurant while the vehicle recharges. Advance decision making could benefit both the system and user.

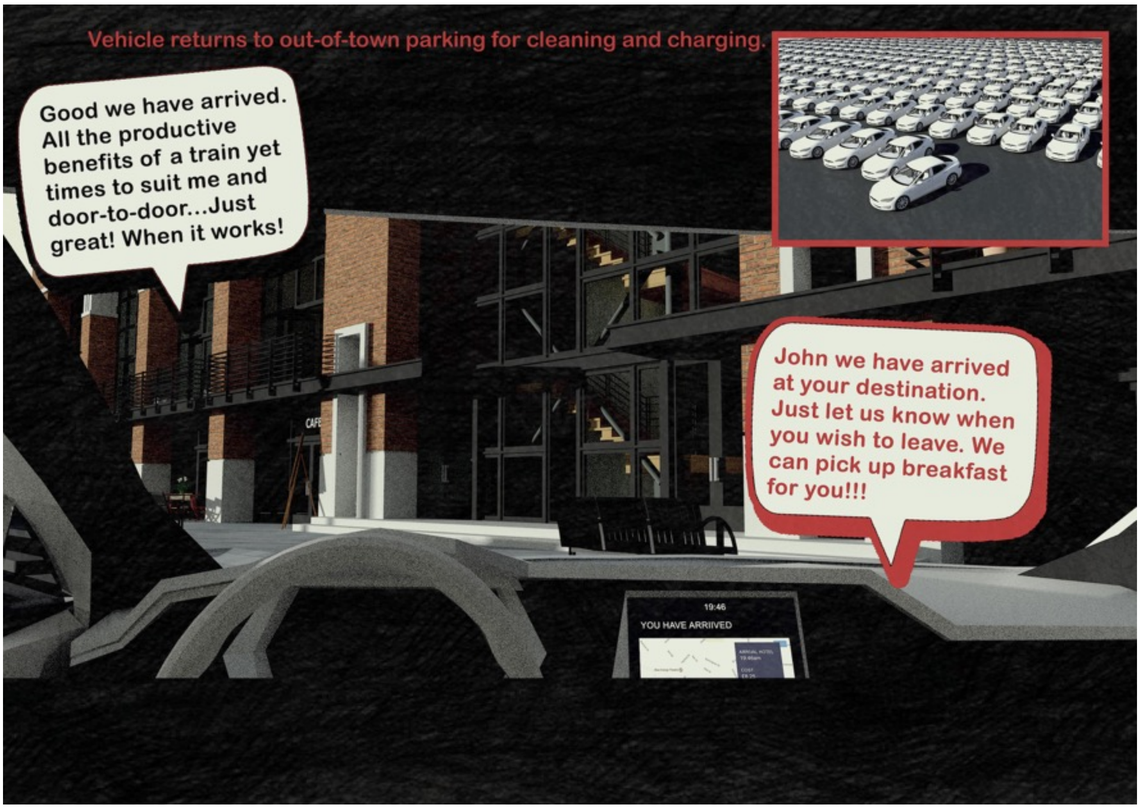


Figure 4.26. The vehicle drops off the user outside the door of the hotel before returning to a storage area to recharge and receive any maintenance required.

4.1.3 Background

Throughout the last decade, we have seen huge advances in automotive technology. The designers of the next generation of concept cars are looking to change our relationship with the car. Despite advances in technology, such as satellite navigation and augmented driver technologies, the driver remains at the centre of control. The role of the driver is about to change, owing to the introduction of autonomous technologies. This will create a new landscape of the city, driven through new business models, an energy centred infrastructure and changing consumer demands. Cities must acknowledge that they are currently presented with the same scale of challenges that the motor vehicle presented to the city in the early 20th Century. Vehicle technologies advance quickly and due to their built-in obsolescence, they are always evolving. Cities by contrast are slow to evolve and have a comparably limited capacity for change or obsolescence. Cities as a result have had to be responsive to the motor industry; they have not been proactive in dictating vehicle technologies.

Autonomous vehicles are still in testing and as such "policy makers are only just beginning to think about the challenges and opportunities this technology presents" (Anderson et al., 2016, p.13). As of 2013, only one of the twenty-five largest metropolitan areas in the US had any mention of autonomous cars in their long-term regional plans (Guerra, 2015). By starting the conversation early to understand the potential opportunities and areas of conflict, cities must begin to establish a discourse with stakeholders, leading technology companies and vehicle manufacturers to influence the next generation of vehicles. This will allow cities to influence vehicle design, forcing manufacturers to innovate in line with city issues and agendas.

Autonomous vehicles are understood by many to be a passenger car which is controlled by an individual computer. The autonomous car should be considered as a small part of a wider autonomous system. This autonomous system can be viewed as comprising three components. Firstly, the city, which represents the physical parameters, for example, buildings and roads. Secondly, the human, which currently represents the decision maker, but this role will change. Finally, the autonomous system; this represents the new decision maker which will be predictive and responsive to us, controlling a world of devices such as cars, buses and drones. The car will be one of many devices in the future. The autonomous vehicle should be viewed as part of a wider system and not just as an isolated object.

4.2 Current challenges

It has been widely argued that the car is now seen, particularly by millennials, as a burden to own and use and considered no longer productive or rewarding, operating within an over-capacity infrastructure (Schwartz & Rossen, 2015). Autonomous vehicles have the potential to change this relationship, by transforming the function of the car, from a tool which gets you from one place to another, to a device which is highly embedded into every part of our lives. It will become a productive space where we can perform tasks we value (Wadhwa, 2017). Cars today, are proving that our relationship is dependent upon the quality of our experiences. For example, driving on the M6 through Birmingham (Figure 4.27) at rush hour is not enjoyable, nor rewarding, or productive. By contrast driving across the empty roads of the Highlands of Scotland (Figure 4.27) is still enjoyable and rewarding and generates a £9 million per annum addition to the local economy (HIE, 2017).

Figure 4.27. Comparison of different driving experiences. Left image: Rush hour on the M6; an experience few enjoy. (Source. photo © Bill Boaden (cc-by-sa/2.0)). Right image: Road in the Scottish Highlands which draws holiday makers from around the world, contributing significantly to the local economy.

Vehicle energy is moving towards an electric future, with future policy based on supporting the charging of batteries. The UK Government's Faraday Challenge is investing £246 million in battery technologies (Innovate UK, 2017). The UK government's latest policy is to place charging infrastructure in petrol stations. With the current charge time of a vehicle being approximately 30 minutes, in terms of journey experience this appears to be a very poor decision. Does this mean that we are to spend our time drinking coffee out of vending machines while staring at offers for Jaffa cakes as show in Figure 4.28. We need to question not just the practicalities of the infrastructure, but the experience that the infrastructure affords us.

Figure 4.28. With investment in public charging infrastructure being centered around facilities such as petrol stations, are these the kinds of spaces we will have to wait in while vehicles recharge?

Traditional mapping techniques are invaluable for helping us to understand how we move from one street to another. They are however limited and perhaps incapable of demonstrating the complexity of the autonomous world. We need to consider the city in different dimensions to understand the significance of a new digital layer which will control our autonomous future (Graham, 2016b). This new layer will essentially be a digital control infrastructure which will operate with a tightly controlled set of parameters. Who will control the new layer? History has shown us that the automotive industry has influenced the infrastructure to support current vehicles. This has happened through manufacturers selling us a desirable vision of the future, which consumers have demanded and as a result cities and governments, pushed by lobbying have had to respond. This can be seen in the 1960 Chevrolet Nomad advert (Figure 4.29): “start the 60’s right, all you need for the USA’s way of going and living, now bigger and more comfortable than ever” (Chevrolet, 2014).

Figure 4.29. 1960 Chevrolet Nomad advert which shows how cars were marketed as a lifestyle choice which provided freedom and modernity (Source. Chevrolet).

We are again at the point where the automotive industry and tech giants, are making decisions which will determine how this new layer will operate. These corporations are selling us a future vision which looks utopian and thus convinces us that they are providing for the city and its users. Through these desirable visualisations, consumers will once again be demanding these futures. Nissan and their IDS concept (Nissan Online Newsroom, 2017), projects images of a shiny, barren city, with no congestion, entirely focused and seamlessly configured around one individual. There is no notion of the infrastructure; the controls and business models which will push and pull these autonomous systems.

Autonomous vehicles will capture many aspects of the Internet-of-things and may, as Bruce Sterling (2014) suggests, not be for the users but for the profit margins of these major corporations. As we begin to lay over these corporation's business models, will we recognise these utopian futures, or will they be subverted beyond recognition? History has proven that this can happen. A notable example includes Colin Buchannan's (1963) (Figure 4.30) work whose concepts of spacious cityscapes were never played out, largely due to the squeezing of space due to the consumption of the car.

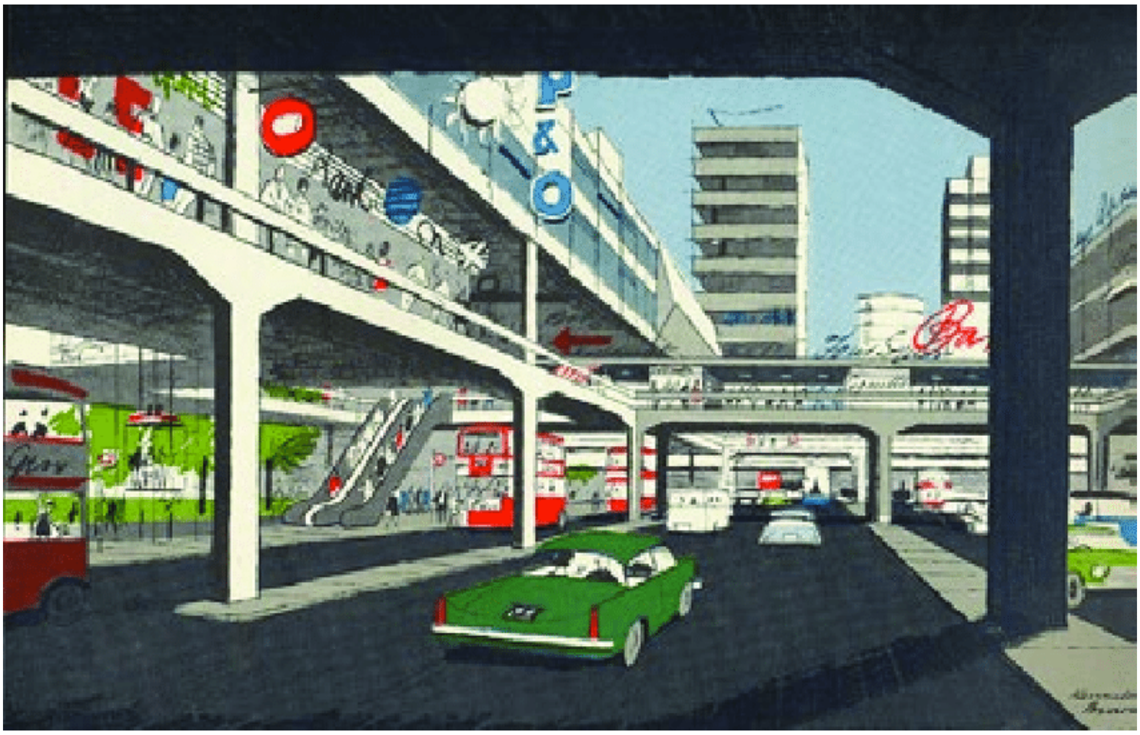


Figure 4.30. Colin Buchannan's 1963 future visions for cars show an urban infrastructure where vehicles and pedestrians are vertically separated (Source. Traffic in Towns, Colin Buchanan, 1963).

The motor industry and cities subverted and disrupted these conceptual ideas through their business models, to sell cheap cars to every adult and building plots to every developer. As a result, the experience and reward of engaging with the city had been lost in the pursuit of efficiency and profit. We must not lose sight of the experience of the user in the implementation of new technologies and it is for this reason that we must speculate on how these technologies will engage with the city and its stakeholders in the future.

4.3 Digital subversion

Recently Google have been fined €2.4bn for promoting its own marketplace over others. It is not uncommon for the ‘Big 5’ to shape, and tailor the digital content we see. It is very much their business, to place themselves at the forefront of our everyday lives to encourage us to share our data and use their services. Ironically, the ‘Big 5’ could be viewed as the modern-day Detroit. Some of the motor industry’s action during the 1950’s could be viewed as illegal today, such as the buying up of trolley buses (trams) in the US to monopolise the transport industry (Schwartz & Rossen, 2015). Autonomous vehicles fit precisely into the ‘Big 5’s’ business model; it gives them the biggest opportunity ever to capture our data. For this reason, it is not the vehicle itself, which is the goal, but to become the operator of the autonomous system. It becomes for them, the ultimate development of the smartphone. As a result, the ‘Big 5’ are the most likely investor of this new autonomous digital layer and therefore their controller and creator. Our engagement with the autonomous vehicle does not begin when we get in the car. In fact, this journey starts long before we even consider moving anywhere. Through the tracking of our actions and activities, predictive AIs will calculate our needs and configure the network, making it ready when we are. For these AIs to become accurate, there must be an unprecedented level of data gathering and analysis taking place (Bratton, 2016).

There are differences in opinion about who will own and operate autonomous vehicles. There is currently, a rise in the number of people renting or hiring cars on a journey-by-journey basis. Futurists such as Kevin Kelly, believe that shared ownership represents the future of car use. There is a great deal of sense in an autonomous world of shared ownership, currently most cars are used only 5% of the time (Kelly, 2016). A more intriguing reason for this type of ownership model, is that it might lend itself to more dynamic, multimodal routing, giving user the choice between shared, standard or luxury vehicles. They will also be able to choose different modes along the way, such as trains, buses, cycles and cars. This means, for the daily commute to work the user could select the most cost-effective option, maybe a shared budget car to a station, then a train to his or her place of work. At the weekend, the consumer could choose a luxury vehicle from start to finish. This brings advantage for both consumer and investor; the former in obtaining a lifestyle he/she would not ordinarily afford and the latter in gaining an opportunity to upsell products.

Autonomous vehicles will know when and how we want to travel, but how will it make decisions about the route to our destinations? This was once considered a skill, black cabbies in London were revered for their local “knowledge” and thus, their ability to find a destination and avoid traffic. The satellite navigation system, with its real-time traffic and dynamic routing, made some of this knowledge accessible to everyone, even enabling the development of new business models such as Uber. These skills and technologies ultimately retained the individual as the decision maker, to choose whether to ignore the information being provided. The autonomous vehicle is unlikely to keep the user as the decision maker, instead navigating the city is more likely to be like navigating the Internet. Like the Internet, we will be clear about where we are going, but the route we will take may not be of our choice as shown by Figure 4.31 (Galloway, 2006).

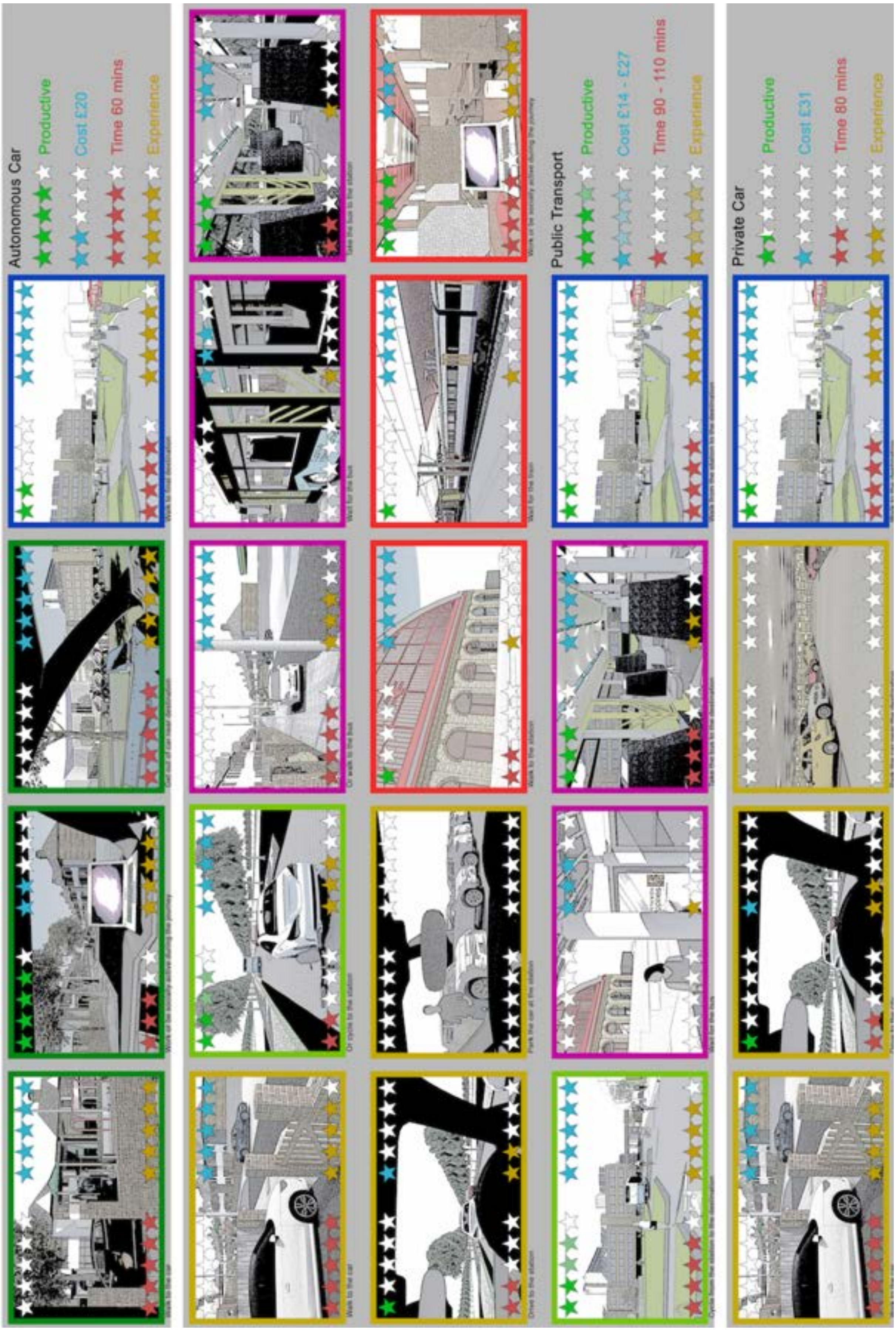


Figure 4.31. A speculative design exercise showing the different route options available for a commuter and how they may be perceived.

The current concepts market this autonomous navigation as a selling point, whereby decisions are always being made on the best route, calculated to avoid conditions which may delay us. This cloud controlled navigation may be influenced by other factors. Marketing revenue on the Internet is big business and currently contributes to £61.5 billion for Google alone in 2016 (Kollewe, 2017). If similar digital marketing opportunities could be applied to autonomous routing, then corporate algorithms could navigate our vehicle passed marketing opportunities. While routing may be removed from our decision making, there is a potential that so could our destination. Filtering of information already takes place. When we ask Siri or Google for an Italian restaurant nearby, both Google and Apple will present the results according to their own algorithms. At this stage, many of us will either recognise a restaurant or carry out more research with a platform such as TripAdvisor. This is not the seamless conceptual idea that we are being sold, if we must check the accuracy of the data being presented. The autonomous exchange is often portrayed something like the following:

John: (vehicle passenger): “Car take me to lunch on the way to my meeting.”
Car: “What would you like John?”
John: “I fancy some good pasta”.
Car: “Ok John, I’ve found Roma Pizza and Pasta. I’m heading there now.”

This decision could have been the results of an exchange of money between the autonomous operator and the restaurant. Some users will not like this lack of control, while others may think that this is a compromise worth making for the services gained. Figure 4.32 shown how different routes could be chosen by operators for different reasons.

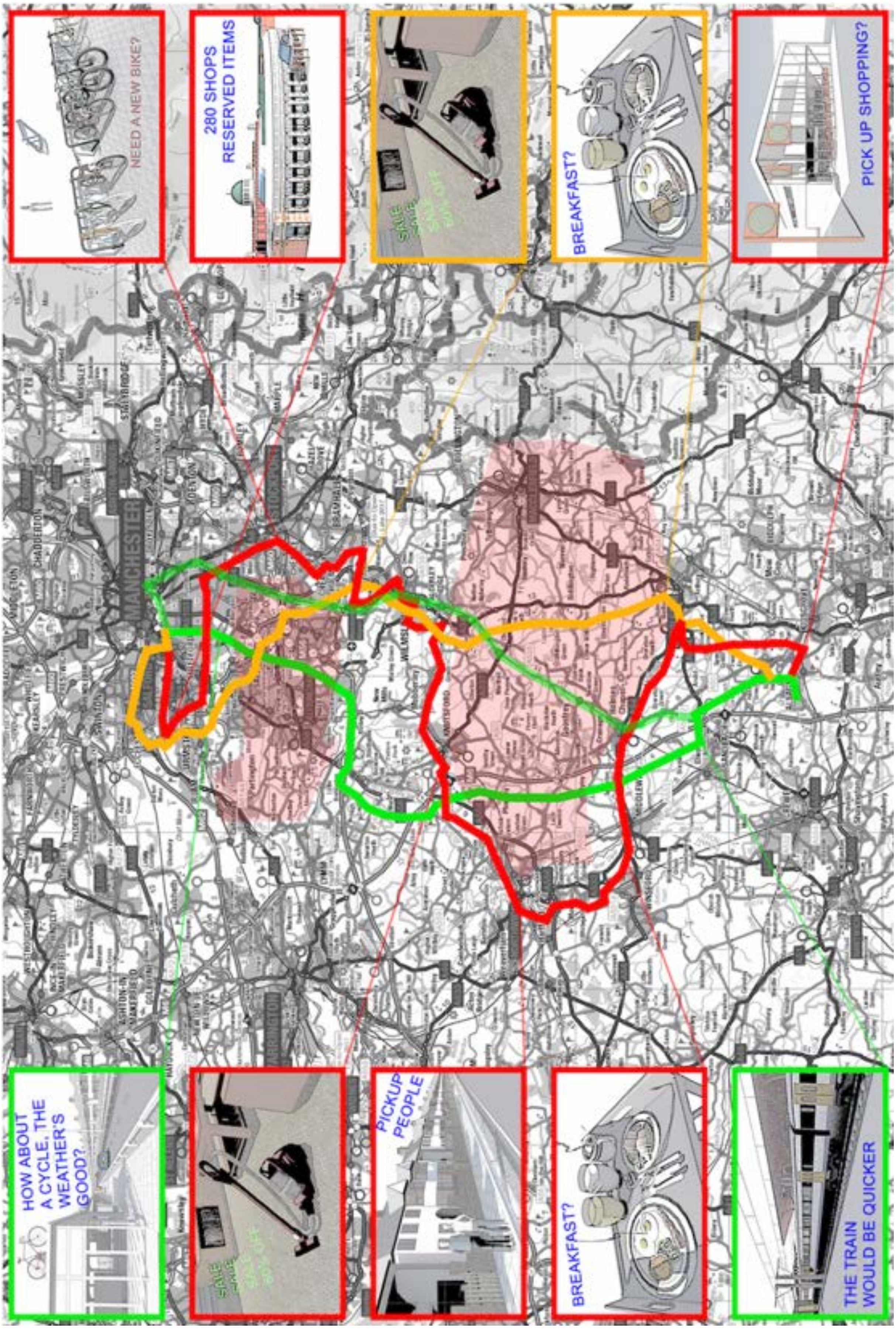


Figure 4.32. A speculative design exercise showing how operators could manipulate routes for their benefit.

4.4 Powering Autonomous vehicles

History has taught us that automotive manufacturing companies are likely to lead the way when it comes to the emergent technologies of the future. The motor industry has placed itself at the forefront of the decision making to fix the problems of their creation. As discussed in chapter four, industry and governments have decided that the future of personal transportation lies in electric vehicles, yet how this decision has been made is unclear. While the objectives of producing cleaner vehicles for cities undoubtedly is a good one, there are a few concerns about how the specific technology has been chosen when there are alternatives. Interestingly, early cars used batteries and electric motors as a form of propulsion. However, the petrol car was chosen not because of reliability, but because of the range and problems with access to charging stations (Høyer, 2008). The same challenges for battery-powered cars still exist today, as they did some 100 years ago.

The term 'zero emissions' is seen all over the electric car industry, but the term should perhaps be used with a little more caution. The objective of achieving zero emissions transport is the right trajectory but the realities need to be considered. For example, an electric zero emissions vehicle may not produce emissions while driving down the road, but the batteries are charged using electricity from a combination of fuels including coal, gas, biomass, nuclear, and renewables. In 2017, only 27.9% of electricity was produced by renewable energy (Department for Business, Energy & Industrial Strategy, 2018). Long-term government targets are to increase renewable energy to achieve zero emissions by 2050 (Environment Agency, 2019). The need for more renewables is brought to light by the fact that an electric car produces a total 124g/km of CO_2 when taking into account the inefficiencies of the UK grid and the energy required to produce the batteries (Saarinen, 2019). By comparison a diesel Volkswagen Golf produces 104g/km (Volkswagen UK, 2019). These government targets are the right way forward, but there are often consequences to these decisions that need to be better considered and managed. The technologies to deliver the renewables themselves are not without their own emissions; they are produced using silicone and metals, including steel and aluminium. These materials have high levels of embodied energy and are typically mined and produced in parts of the world without strict environmental policies (Etchart et al., 2012).

Electric cars themselves share some of the same issues, with lithium being mined in developing parts of the world, there are severe consequences to the ecosystems and the lives of people living near to these mines (Katwala, 2019). There are for some people equally severe consequences to the growing demand for 'clean energy' as there is from the burning of fossil fuels. The salt flats of South America are becoming some of the most intensively extracted areas of the world, not for oil but for lithium. There are concerns being raised about the process being used to evaporate the lithium from the salt water brine. This is causing a demand for water depriving communities, in an area of the world where water is already in short supply (Agusdinata et al., 2018). The health impacts of mining lithium through evaporation are also currently unknown. Lithium is a highly mobile element and so it is likely that the metal is blown from the evaporating ponds, contaminating both the environment and local communities and ultimately posing a risk of death at even very low levels of exposure (Figueroa et al., 2012).

Throughout the discourse surrounding the issue of emissions, there appears to be an agenda of displacement. Electric cars displace the emissions to power stations in the UK countryside and mines in Chile. Renewables displace the manufacturing emissions to places like China. All too often, the future is not considered as part of a complex holistic system but focuses around improving small parts of the wealthiest places in the world such as London and Paris. John Urry discusses such issues of displacement of wealth and energy in his book Offshoring (2014). Displacement exists around emissions, waste, energy, wealth and tax, there is an argument to stop this offshoring or at least recognise it and understand its implications on global society (Urry, 2014). All too often these issues are hidden or not understood, and this appears to be true of future vehicles.

There seems to be a one size fits all and oversimplification of the realities communicated by manufacturers and governments which is at times misleading citizens (Watson et al., 2015). There is also little consideration to those individuals who are not the priority for government targets. To give an example, today there is only one electric vehicle which can be fitted with a tow bar. This means that a farmer wishing to move hay bales or take their sheep to market would have to in invest an eye-watering £73,900 in a Tesla Model X (Tesla.com, 2019) compared £19,965 for a Mitsubishi L200 (Mitsubishi-motors.co.uk, 2019). Also, the Model X can only tow 2270Kg compared to the L200 3500kg, making it a far less useful tool for moving sheep, cattle and being less efficient. The act of towing also has a profound effect on the range of an electric vehicle with customers reporting a real-world range of fewer than 100 miles when towing (Hanley, 2019). This means that for a Highland sheep farmer, there would be insufficient infrastructure required to make using an electric vehicle feasible. Today there are currently no long-distance electric trucks available. Tesla is saying that they will have a truck capable of travelling 600 miles fully loaded on a single charge (Autocar, 2019). However, Daimler says that Tesla's figures defy the laws of physics (Autocar, 2019). What is undoubtedly clear is that our demand for electricity and lithium is only set to grow.

Both industry and government seem entirely set on an electric future run off batteries. Dyson, TerraE Holdings and Tesla are investing over $1 billion each in new battery technologies and factories (Wang, 2017). The UK government is investing a further £246 million into new battery technologies. There is going to have to be either a breakthrough in alternative technologies, or a major policy shift to change this course (Innovate UK, 2017). Currently the electricity grid is strained and managing peak demand has been a long-standing challenge, electric vehicles will only worsen this situation. Achieving an entirely electric transport model by 2035, the date predicted by ING, seems to be a near impossible challenge (Vaughan, 2017) without a major shift in behaviours, to create a synergic relationship between production and use. Currently the highest demand is around 9:00am and 18:00pm, with a much lower peak load during at night and in the summer (Gridwatch.co.uk, 2017). When we look at our current movement habits, we predominantly move during rush hour 7:00 to 9:00 and 17:00 to 19:00. There is a correlation between current energy peak use and potential future energy demand from electric vehicles (Figure 4.33). It is not necessarily the total energy consumed by electric vehicle which is of concern, but the short time scale in which the energy is drawn.

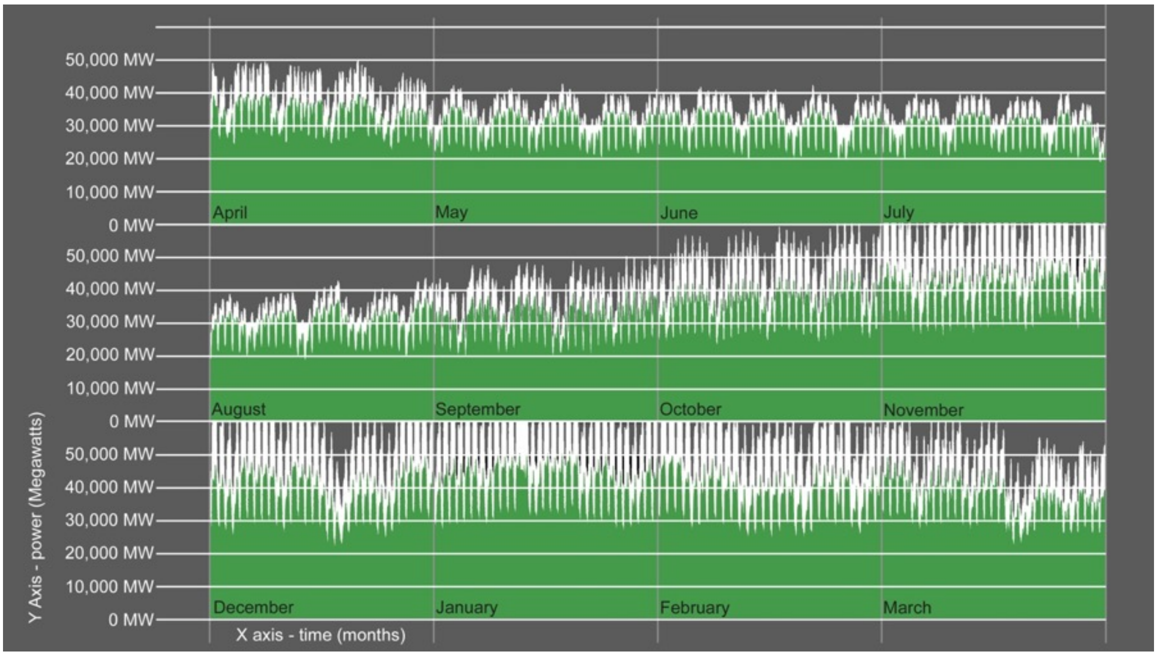


Figure 4.33. Green areas show current energy demand, while white areas show predicted increase in demand from electric vehicles. Based on National Grid 2050 projections. Data: April 2016 - March 2017 (Source. Gridwatch.co.uk, 2017).

A journey from Birmingham to Manchester at motorway speeds can equal the electricity usage of the average home, over 48 hours, approximately 24 kWh, yet the vehicle could be recharged in approximately 20 minutes (Henretty, 2013). Cars like houses also use more energy to operate in colder weather, both batteries, motors and heaters are less efficient, reducing the range in some cars by up to 33% (Renault, 2017). The current expectation of the consumer, is to recharge vehicles, as quickly as possible once they arrive at their destination, making the vehicle immediately ready for another journey. We need to consider a method of modifying expectations and behaviour and autonomous technologies, may certainly have a role to play in this. Models such as variable pricing could reduce demand when the electricity grid is strained. Other methods such as linking up passengers and sharing journeys to reduce energy demand also need to be considered.

4.5 Questioning the status quo through projected futures

There are already a few models being used in cities to change behaviours. These models are predominantly financial model such as congestion charging. London for example, has implemented a road pricing model, which charges private vehicles to enter a designated area of the city. So far, the London congestion charging system has move 10% of vehicles away from the city, although this has had no significantly measurable impact on emissions or public transport (Transport for London, 2008). While there is no doubt that this type of system has had an impact on people's behaviour, such interventions are not without their criticisms. There is an argument that such systems discriminate against the poorest members of society who will be disproportionately affected by added costs. A second issue is that having a set perimeter in which the charge applies, creates a surrounding area of congestion. This is caused by people attempting to skirt around the congestion charging zone, simply displacing congestion and pollution. This again brings unfair disadvantage to poorer members of society who often live outside the chargeable perimeter (Transport for London, 2008).

Recently a more advanced model has started to emerge. Uber is a model which incorporates many aspects of autonomous vehicle technology, but falls some way short of responding to the city and its users. Uber is of course a corporation where its shareholder are the stakeholders and not the city. Uber has come under some scrutiny for its employment practices, an issue which is beyond the scope of this chaper. Uber's so-called 'surge' pricing model relates to several factors: the demand on the system, the time of day, traffic congestion and the mode of transport. This means that once the demand or congestion rises, so does the price, helping to move non-essential journeys away from peak times, although still disproportionately affecting people according to wealth. There have been times, when Uber's system has come under criticism. During the terror attacks in 2017 at London Bridge, surge pricing caused Uber to charge 2.1 times their usual rate. Uber did later refund customers in this case, but it shows that these types of systems are still lacking the predictive 'human' intelligence required to respond as 'cabbies' did, offering free rides away from the scene (Cox, 2017). Uber's system also offers shared vehicles, which pick up other travellers on route. This shared transportation will become an important model for electric autonomous vehicles in terms of optimising traffic flows and energy. Uber still uses surge pricing across shared transportation, yet to respond to the city's stakeholders, Uber needs to adopt a public transportation model, with fixed pricing. Shared transportation becomes more efficient during peak times; vehicles do not have to move far off route to pick up and set down passengers, ultimately leading to reduced traffic and pollution.

The UK's current vehicle charging infrastructure shows a lack of joined-up thinking. Currently most publicly available electric vehicle infrastructure has been provisioned around service stations and out-of-town retail. A large percentage of these charging stations are positioned in on route locations. The issue with these on route locations is that there is a demand for instant energy as the locations are not places we wish to spend time. This promotes a high capacity demand for energy, as people are not willing to wait long while their vehicles recharge.

We need to be considering these locations to promote charging to take place in destinations. This means charging can take place smartly over longer periods, taking advantage of grid surplus. The shared ownership model has an even greater potential to optimise electricity grid surplus. By sharing vehicles, it may not be necessary for vehicles to be charged immediately. Instead vehicles could be swapped; a vehicle with low charge could be used for more local journeys where the energy requirement is low, while fully charged vehicles are used for longer journeys. This means not just better utilisation of the grid, but better utilisation of the energy already stored within vehicles. We need to review how information relating to grid, demand and electricity stored within vehicles is shared and ultimately used.

It is unrealistic to believe that the car will have no role within cities of the future. Owners of autonomous vehicles will not need to pay large sums of up to £32 per day to park in Manchester city centre when they can simply send their car home, or to peripheral areas of the city. This is demonstrated in Figure 4.34.

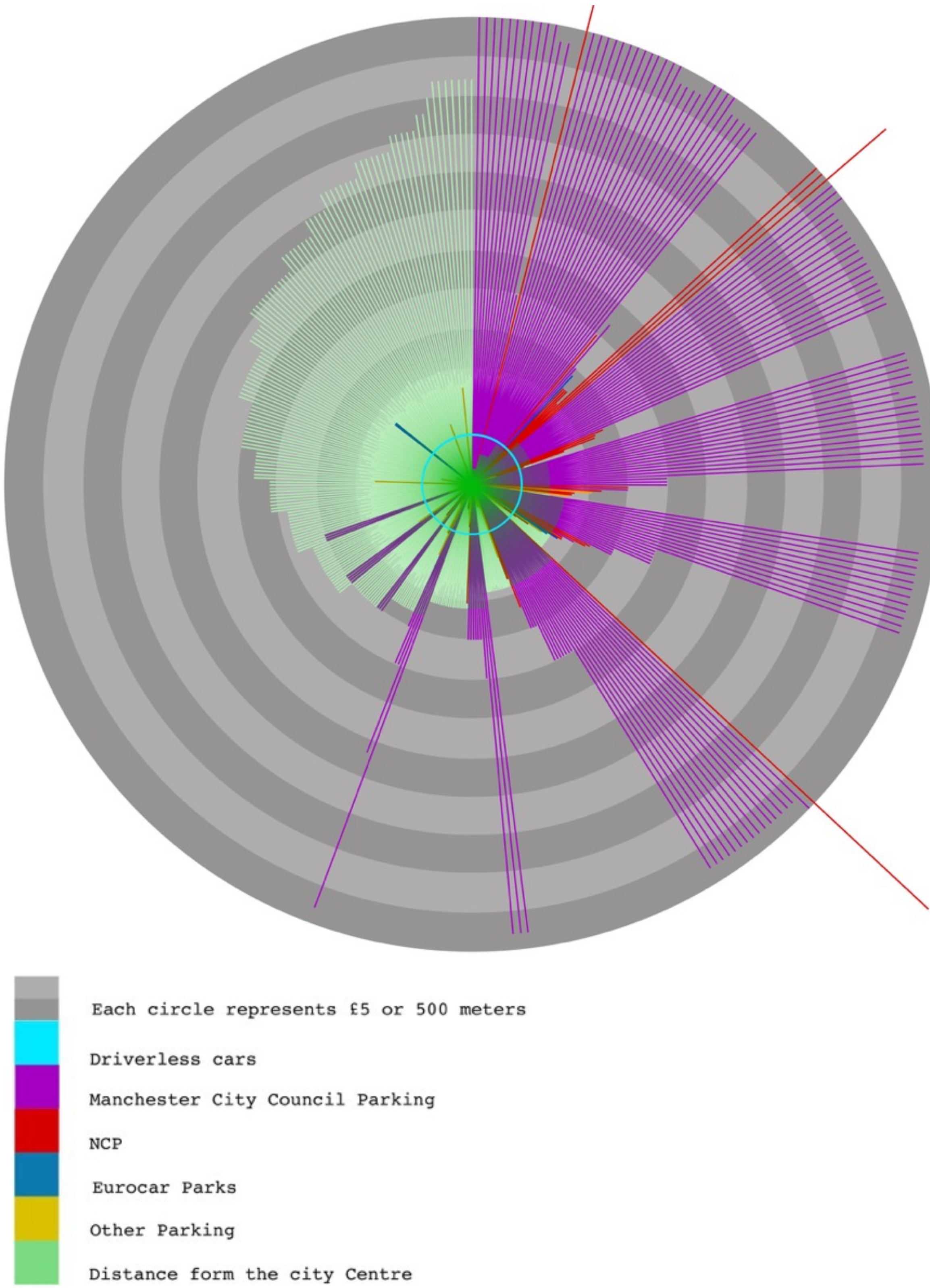


Figure 4.34. The diagram shows the cost of parking in Manchester compared to the distance from the city centre. You can see that the further from the centre a carpark is located, the cheaper it becomes.

However, there will still be a demand to charge and so park vehicles, without making them travel large distances to reduce traffic and energy. This view, unlike what some people are suggesting, does not mean that parking will disappear, but the business model will have to evolve. Parking in the future will likely no longer charge for the renting of space but for energy. As a business model, the more energy the car park can supply through renewables and batteries, the better the business model will stack up.

For some people who live in for example villages, there is no viable alternative to cars for the first or final stages of the journey. There are also other factors which are unlikely to change and support high vehicle dependency, such as parents who take their children to school. Parents' reliance on the car has often been linked to a fear of crime, with just 9% of children walking to school in 1990 compared to 80% in 1971 (Hillman et al., 1990). Autonomous cars and pods are most likely the chosen mode of transport for these users. Autonomous vehicles will drop and pick up their occupants at their destination, or at a transport interchange before parking. 'Pick up and drop off' vehicle usage, currently represents a small number of vehicles in the city, such as taxis. This situation will change rapidly with the introduction of autonomous vehicles and it may not be just people that are picked up and dropped off in the future. With autonomous vehicles, it is entirely possible that vehicles could start to perform tasks and errands for us such as picking up lunch. With no drivers in these vehicles, to pull up and gather goods, we will have to see the role reversed. Shops will have to have outposts in the street, where goods can be placed in vehicles, pods and drones. Without the city truly considering the way in which retail, restaurants and services will engage with the autonomous vehicles, there is a chance that our relationship between out-of-town retail and the car, will once again damage the economic opportunity of the city, as out-of-town facilities adapt more rapidly.

Interchange zones (Figure 4.35), are a space where travellers can move between modes, such as different types of cars, buses and cycles. With all vehicles being autonomously, controlled by the same system, there is an opportunity for truly fluid movement between different modes. This opens opportunities to re-engage vehicles with the city in a new way.

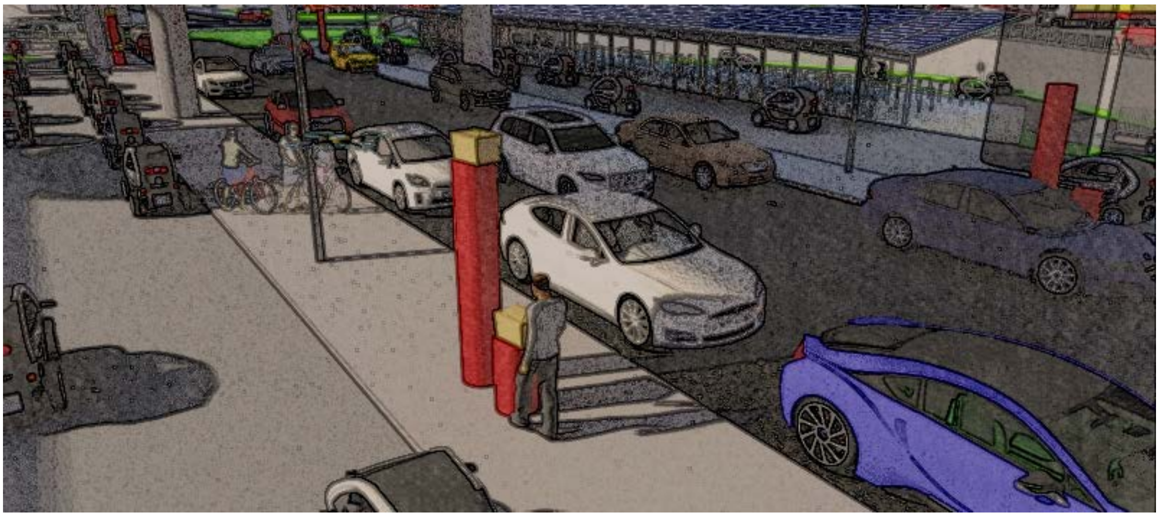


Figure 4.35. A visualisation of a transport interchange on the outskirts of the city centre where passengers could shift seamlessly between transpor*t* modes.

Vehicle scale and design has been dictated by manufacturers. Cars and buses have become ever bigger and as a result, they have become more difficult to incorporate into the historic context of our cities. This has led to public space being compressed, making way for more traffic and larger vehicles. Because of this compression, cities have become less walkable and, in some cases, roads have become impassable (Speck, 2013). This has presented a challenge to other types of transport such as cycling, which has been pushed to a 'no man's land', between vehicles and pedestrians (Walker, 2017). There is no need for city vehicles, to carry the abundance of paraphernalia, such as crumple zones and five seats, when 76% of vehicles entering Manchester in 2011 during peak hours, carried only a single occupant (Rowland, 2011). Yet at the same time, city vehicles would be inappropriate to travel on motorways and rural roads, where speeds are high. The solution is to use the right mode in the right place. This might mean pod-like vehicles in the city and the current style of vehicles across the remaining networks. In cities, this will enable the freeing up of space for other activities. These new spaces could be used to provide more green space, more space for pick up and drop off, or encouraging walking and cycling. For this to happen, there would have to be a series of autonomous controlled interchanges located around the city. For such infrastructure to function, these interchanges would need to operate seamlessly; as we arrive in one mode of transport, our next mode of transport would be ready and waiting. This would not just be an interchange between car types, but could be a place where we transfer between mass transit vehicle, drone or cycles. These autonomous technologies not only open opportunities to organise our movements but to change the way we move.

The truly multimodal city has been a dream of transport engineers, architects and futurists for decades. The dream of airborne transportation has only really been explored in films such as The Fifth Element (The Fifth Element, 1997). The realities of airborne cars were rather more challenging. The legislation and number of licences required to operate flying cars were effectively prohibitive. They were very expensive and had to meet both aviation and road regulations, while becoming a pilot is an onerous task (Gyger & Valery, 2011). Flying without the cost of ownership, with no need for licences and no requirement for the vehicle to be both car and plane, autonomous transportation begins to make flying vehicles viable for the future. Companies such as Ehang have started to develop flying passenger vehicles (Ehang, 2017) (Figure 4.36).

Figure 4.36. An Ehang flying passenger drone; a technology currently undergoing development and testing (Source. Ehnag.com).

Amazon is another company which is looking at flying vehicles for parcel deliveries. In Amazon's case, this technology seems very much centred around Amazon creating a commercial advantage over its competitor, the high street, by making deliveries faster while stocking a wider range of products. Tel Aviv, is investing in personal pods which move along magnetic tracks, known as SkyTran. This type of transportation represents the future of autonomous transportation, in that they provide seamless movement between locations with an on-demand service (SkyTran, 2017). The limitation of mass transit is its ability to offer an on-demand service. This makes some mass transit modes only suitable, where distances are long and so the time to the next service become less significant, such as with air travel or long rail routes. It is for this reason, that we have started to see since 2008 a decline and in some cases a complete withdrawal of bus services in rural areas of the UK (Department for Transport, 2017a).

4.6 The time is now

Autonomous technologies present great opportunities for the future of cities, but there are also potential problems. If autonomous vehicles do begin to open the three dimensionalities of the city, then we will have to consider that the city, its people and their property will become viewed from a very different aspect to that of today. There are already serious debates taking place over drones; this is only to become more of an issue, as we begin to allow everyone into our skies and even outer space. Air space is currently reserved for governments and their approved users, heavily monitored and secured through orbiting surveillance platforms; this will not be an environment easily given up (Graham, 2016b). From a health perspective, obesity is now becoming a global epidemic and represents one of the biggest concerns to health professionals. There is a link between obesity, city design and vehicle use which can be seen in the United States and Middle Eastern nations such as Qatar where 70% of the population are obese or overweight. Qatar is an entirely car dominated nation and walking is near impossible due to the cities road infrastructure and weather (Alnohair, 2014).

There is a very real possibility that a fully functioning seamless autonomous world would not require its users to walk anywhere. While such a system could promote cycling, there will always be an element of the population who will never get exercise unless this is forced. As designers, it is important to create opportunities to exercise. We need to consider the experience of the space created so that walking or cycling becomes an enjoyable activity of our choice. It is also important to remember that encouraging people to walk is better for a city's economy; it allows people to engage with the street and each other.

Cities must accept that the car will have a future in the city, while this may be reduced, failure to get the balance, between the city and the car right, will only move people to the suburbs and out-of-town retail. For the city to thrive through this second revolution, it must be a rewarding experience to visit, live and engage with our cities. If this reward is not present, people will stop visiting our cities, creating further suburban sprawl in which providing transport infrastructure through anything other than the car is near impossible. We need to recognise that this 50-year mistake of suburban sprawl and road building was the result of the motorised vehicle completing its first revolution (Schwartz & Rossen, 2015). Electric autonomous vehicles mark the start of the second transport revolution. History has taught us that cars and personal transportation can evolve far faster than our cities. This revolution has already begun and we must involve all stakeholders to decide the autonomous future we want before we are once again forced down the path of our cities having to play 'catch-up' to autonomous vehicles. It is crucial that stakeholders become involved in not only influencing the city's built form, but help to shape the digital algorithms that will navigate us through this landscape. Currently there is no regulation or policy to determine who will control this decision-making process and how it will take place.

This research is part of an ongoing investigation about how autonomous technologies will impact our routines and behaviours in urban environments. Through analysis of user experiences, this research investigates how we may change our movement habits and the impact that this may have on our health and lifestyle. Future work in this area intends to support future planning of cities by considering the role of autonomous vehicles as part of a holistic transport system.

5 Questioning the social and ethical implications of autonomous vehicles on professional drivers

5.1 Introduction

This chapter is based on findings presented at EAD 2019 and published in the Design Journal.

Morton, R., Richards, D. C., Dunn, N. S., & Coulton, P. (2019). Questioning the social and ethical implications of autonomous vehicle technologies on professional drivers. *The Design Journal*, *22*(Suppl. 1), 2061-2071. https://doi.org/10.1080/14606925.2019.1594930

This section builds on the previous chapters by identifying a specific group, HGV drivers who are already using driver assistance systems as part of their daily working lives. The research used qualitative methods as discussed in chapter three to better understand how these technologies are being received by drivers and what impact they may be having on drivers lives. Ultimately it allows us as designers to speculate on these increasing pertinent ethical concerns.

The author's observations identified that lorries and vans were being used by drivers for routines other than driving, such as sleeping in service stations, truck parks and lay-bys. With the advent of driverless technologies, it is hard to imagine what the role of the driver would be in these situations. Observations of drivers who spend nights in their vehicles (lorry trampers) identified a number of key roles currently performed by these drivers, raising questions about their potential role in an autonomous future.

Long distance drivers will perhaps no longer be required in an autonomous world, but there are other duties that these drivers usually perform in addition to driving. Firstly, the driver is responsible for ensuring the vehicle is in a roadworthy condition, which could be performed by an operative at a depot, who does not necessarily need to travel with the vehicle. The driver is also traditionally responsible for securing the load within a vehicle but as with the previous role, this could be carried out by an operative based at the depot. While on-route, the driver is usually responsible for fuelling the vehicle and its ongoing maintenance. Without a driver, it is entirely possible for this duty to be carried out by the fuelling station. Without a driver, there would be no need for the vehicle to stop other than for fuel. There would be no need for the operative to go to the toilet or to stop for lunch and take a break. In this long-distance distribution network, it is hard to conceive what role the driver would have in an age of autonomous vehicles.

There is a second way in which these larger vehicles are used, where the operator's driving role forms only part of his or her duties. An example of this is where vehicles are used to make multiple drops, or the vehicle is used as a tool to carry out other duties. In these cases what happens to the role of the driver in an autonomous future appears to be a more complex issue. In the future, the vehicle will be capable of driving, but will the vehicle be capable of performing the tasks required at the destination? It seems unlikely that the vehicle will be able to remove a package from a vehicle, open a gate, knock on a door and deliver a parcel. Likewise, it seems even less likely that the autonomous protocols driving a vehicle will ever be able to enter someone's home and fix a home owner's plumbing. These are tasks which as McAfee and Brynjolfsson (2014) describe in their book, The Second Machine Age, require in computing terms, complex pattern recognition and so will remain the stalwart of humans for the foreseeable future. It seems plausible that the role of the driver in such scenarios may shift from that of driving, to undertaking the complex pattern recognitions tasks such as the jobs mentioned.

Drivers undertaking complex pattern recognition tasks are unlikely to be removed altogether from the vehicle, but would co-exist with the algorithms, through an augmented human-machine protocol relationship. For the driver and vehicle to be able to carry out tasks such as unloading heavy items like building materials as seen in Figure 5.1, the driver often needs to park the vehicle in contrary to the rules of the road.

Figure 5.1. A truck unloading on the roadside. The photo shows the need for rule breaking to perform routine duties (Source. Philafrenzy, CC BY-SA 4.0).

In these cases, the human driver has to make a judgement based on safety and efficiency, for both other road users and themselves. These other road users include both drivers and pedestrians which the operator has to consider against his or her ability to carry out the task at hand and limit the disruption to these other users. How would a computer algorithm make these decisions, or would it simply say 'no', this task is not within its rules of operation. This is just one example, but this human judged rule breaking or bending, is an essential part of our road networks operation and can be seen throughout user groups and vehicle types.

It is hard to dispute, that human judged rule breaking on our roads can be disruptive and potentially dangerous, and we have all seen many bad examples. There is however an essential function of these contraventions, which follow a degree of logic and are neither a danger nor disruptive. How would driverless vehicles of the future make these kinds of decisions that humans find easy? Could the algorithms which will control the autonomous vehicles of the future make these kinds of decisions? How autonomous vehicles will engage with cities and their users, and make the decisions we currently take for granted in the future appears to be unclear. What is the alternative? Do we have to have a hybridised solution, where both the driver and the algorithms have a say in the decision making through augmented technologies, as opposed to technologies which entirely replace the human? This is a discussion that needs to be had as technology companies do not aspire towards augmented technologies, but complete autonomous control. We need to consider the human-machine relationships that will at least exist in the medium term. This will be considered through the qualitative study presented in this chapter.

5.1.1 Background

Future visions of autonomous vehicles produced by academics, technology and automotive giants tend to project a frictionless world where machines move seamlessly through our cities with no congestion or ambiguity as to their role and without any consideration as to their relationships to the inhabitants of those cities (Deloitte, 2018). Yet it seems unlikely that the algorithms that underpin driverless technologies will simply replace humans without meeting challenges when faced with the ‘messiness’ of existing infrastructure and working practices.

Since the 1st November 2015 HGV drivers have been using advanced driver assistance systems (ADAS) in their day to day lives. Governed by legislation, new Euro 6 HGVs are equipped with emergency brake assist (EBA) and lane departure warning systems (LDW). These technologies are often accompanied by adaptive cruise control (ACC) systems that maintain a specified distance to the vehicle in front. Truck drivers travel around 100,000 km per year, this is compared to car drivers, who cover approximately 12,500 km per year (RAC Foundation, 2018). To put this into perspective, it would take the average car driver around eight years to acquire the experiences that a HGV driver obtains in a single year. This means that some HGV drivers have the equivalent of 24 additional years of using ADAS when compared to the average car driver. It is for these reasons that this study has chosen to engage with HGV drivers as the pioneers of early driverless technologies, a group which is overlooked and undervalued for their knowledge.

The failure of designers to consider this critical group of drivers is evidenced in a recent BBC article discussing driverless mobility which asserts “you have (probably) already bought your last car” and “human drivers banned” (Rowlatt, 2018). It seems highly unlikely that hauliers would dispense of their trucks. If no drivers will be allowed, we would assume that the haulage industry would also be investing in the same technology. Yet without clear benefits to the haulage industry, why would companies invest in driverless technologies? Haulage makes up an essential part of the way in which we live our lives and so to ignore drivers in this industry, negates the fact that roads contribute economically and socially to our entire global system of operation. By engaging with this marginalised group, designers have the opportunity to highlight some of the design challenges and opportunities of driverless vehicles, based on the millions of miles of experiences that HGV drivers have. This chapter will discuss some of these challenges and opportunities through the experiences of drivers.

5.1.2 Why HGV drivers

HGV drivers and the industry in general have always been undervalued for their role within society. The haulage industry has always provided a supporting role and as a result it has always had to be responsive to other industries. It is worth putting the importance of the haulage industry in the UK into perspective, but it is also worth noting that the UK is representative of many other countries around the world. The haulage industry in the UK is huge and employs approximately 2.4 million people and is worth 124bn to the GVA of the UK economy. The industry moves 98% of all food and consumer products at some point in the supply chain, with 89% of all goods transported within the UK being moved on a lorry (RHA, 2019a). If the haulage network was to be unknowingly disrupted, it would cause chaos on a scale which is unprecedented in high income countries and yet this is a sector in which manufacturers are testing the very latest vehicles and technologies.

Historically the movement of goods has been critical to the economy of nations and is just as true today as it ever has been. To put the age of the industry into perspective, the second oldest company in the UK is Shore Potters Society, a removal and logistics company formed in Aberdeen in 1498 ('Profile Shore Porters Society', 1997). The third oldest company is the Royal Mail formed in 1516, again a company tasked with the movement of goods and operating around 48,000 vehicles (Commercial Fleet, 2018). Both of these companies are in fact only outdated by the Royal Mint. Throughout the past 520 years since the formation of Shore Potters Society, the haulage industry has seen lots of innovations come and go, in an attempt to become faster, more competitive and provide a better service. Yet in more recent times, it has also been an industry which has been protected by both legislation and law, let is an industry that often feels unwelcomed by society (RHA, 2019b).

The haulage industry has been one which has had to embrace change and technology in order to meet customer demands. The reality is that typically customers do not want to pay for their goods to be moved, but equally they want them delivered immediately at a time of their choosing. As a result of this, we have seen many technologies come and go through the course of history. Historically, the haulage industry tried to use faster horses with faster carriages, distributed among a network of posts or coach houses, between which the horses could gallop. While very good for moving letters, horses were limited by the weight that they could carry (Maw, 2013).

The start of the industrial revolution called for another solution. By the mid 1800s, both the canals and railways were being built in earnest, catering for different markets. The slow and steady canals were being tasked with the movement of large and heavy bulk goods, while the much faster railways were being tasked with the movement of people, parcels and end products (Maw, 2013). There were exceptions to this, such as trains running between coal mines and marketplaces, but on the whole, canals were the preferred option for bulk cargo. Both of these technologies changed the shape and face of the British landscape, but more than this, they changed the way generations of people lived their lives. The railways meant that goods could be moved long distances within a single day. The landscape of the UK had suddenly become smaller. In an attempt to compete, the canals had to change too. Before the 1850s, many boats had entire families living onboard, allowing families to remain together while travelling the country without the burden of additional rents. The efficiency of trains forced the canals to change this, opting for fly boats, which were made up of male only crews running the boat both day and night. The social cohesion that had existed was broken down to compete with consumer demands (Maw, 2013). Today this historic infrastructure, is now often re-appropriated to leisure activities, but the built fabric often remains as seen in Figure 5.2.

Figure 5.2. A photograph of canals at Bridge Street Birmingham showing latent transport infrastructure being used for leisure activities (Source. The Canal House).

By the 1900s, road transportation was slowly beginning to challenge the canals, with the introduction of steam haulage, which allowed goods to move from point to point. However, it was not long before legislation came into effect that started to make the internal combustion engine more cost effective (Coulls, 2017). During the 1920s and 1930s, laws were imposed which restricted the smoke and vapour production. The ‘wetted tax’ targeted steam engines by taxing them on the water held within their engines. This did not affect the ‘dry’ internal combustion engine. By 1933, the government introduced the axle tax, focused on protecting road surfaces, this meant that the much heavier steam traction engines became completely uneconomical compared to the lightweight internal combustion engine trucks (Coulls, 2017). By 1950, the canals were no longer viable, and the heavily taxed and slow steam traction engine was nearing its demise. Even the railways were losing customers to the now favoured truck. With trucks now offering increasing capacity, speed and point to point deliveries, the road haulage industry was seen as the way to meet the needs of the nation’s ever-increasing needs.

The 1960s represented the start of the haulage industry as we know it today. Before this, drivers were typically travelling short distances, any drivers who covered larger distances were staying in ‘digs’ or bed and breakfasts. This all changed in 1965, when Volvo introduced their F88 sleeper cab (Volvo Trucks, 2019) breaking down the social cohesion that had existed around the bunkhouses. Even by this early stage of the industry’s development, there was a growing concern that operators were working with a lack of ethics and a disregard for the law. The 1965 Geddes report documented this flouting of the rules and recommended that operators were licenced to ensure that any rule breaking could be swiftly dealt with, but it was not until 1970 that O (operator) licensing was introduced (Beesley, 1997).

1971 represented a trend in what would become perhaps one of the most difficult ethical issues facing lorry drivers today. The 1971 Highways Act paved the way for councils to build new transhipment areas out of towns, on the periphery of roads which were now being built around our towns and cities. Combined with the 1982 Armitage report, which recommended that HGVs should be kept away from towns, drivers now faced a life of truly living on the roads, laybys and services; no longer able to engage with our towns and cities (House of Commons, 1982). This meant that drivers were now forced away from the communities that they lived and worked in, expelled to industrial estates, with their lack of facilities and opportunities for social engagement. This report also had a knock-on effect on the many transport cafes, which were now considered to be located in unsuitable locations, forcing them to close. This left a dispersal of now over-priced, poor quality cafes and services, featuring food such as the 'trucker's breakfast'. Drivers now had to start eating at locations based purely on the location, as opposed to the quality and service they offered, as any competition remained out of bounds to the truck driver. This trend has only continued to worsen as more out of town retail, distribution and industry was constructed. The Sleeper cab had by the mid 1980s become essential to the existence of the long-distance driver.

1973 represented another challenge for the haulage industry as the UK joined the European Union. While this meant that trucks could now freely travel throughout the economic area, resulting in more work, it also meant that drivers were now expected to be away from home for longer periods. A second challenge that the EU presented for hauliers, was that they were now competing with other firms from other companies which may have had lower operating costs by being based in a different country. This was less of an issue until 2004, with the expansion of the European Union to the east. With tight margins, working conditions often suffered (Lowe, 2012). There was a divide in how operators decided to manage the situation. One group decided that they would continue to attempt to compete on price. A second group decided that the best way to compete, was on quality and service. This led to companies such as TNT logistics in 1980 establishing a guaranteed 24-hour parcel service using automated sorting warehouses (Johnson, 1999).

In an attempt to catch the large number of hauliers now flouting rules, compulsory tachographs (a device which records speed and time driving as shown in Figure 5.3) were introduced around the mid 1980s, but it was not long before incidences of drivers using devices to the produce false recordings were reported.

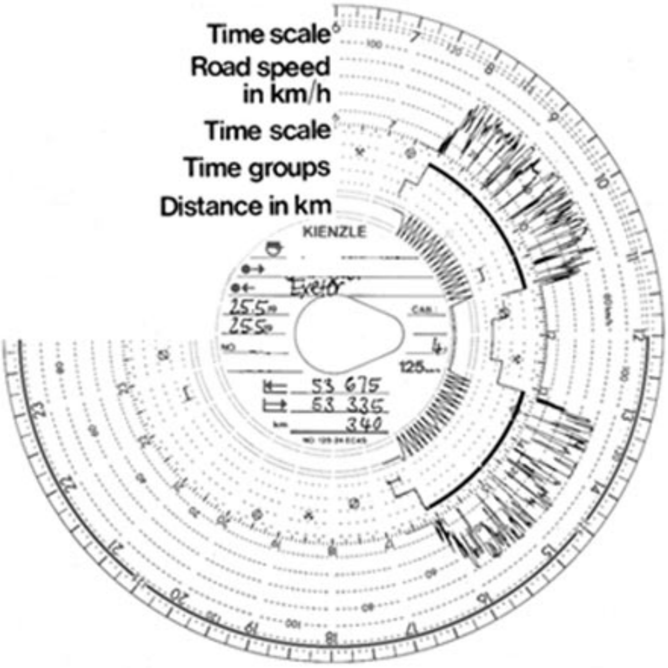


Figure 5.3. Analogue tachograph chart used to record drivers' speed and working hours (Source. TRL Limited).

By the 1990s and into the 2000s, technology slowly infiltrated into every aspect of the job, having both positive and negative consequences. The digital tachograph introduced in 2006 had a dramatic effect on the number of operators attempting to circumvent the rules. Despite being resisted initially, this technology slowly started to remove the pressure placed on drivers to break the rules (Butcher, 2009). By contrast the 1990s saw the introduction of tracking and mobile phones, and later in the last few years the introduction of live streaming cameras, which monitor the driver's actions. All of these technologies are starting to raise ethical and social challenges.

Outside of the cab, we have seen another piece of technology presenting implications for drivers. The regional distribution centre (RDC) has become increasingly automated with the removal of humans, resulting in a conflict between the human free RDC and the still human centred haulage industry. RDCs have been poor at managing this conflict, seeming surprisingly unable to appropriately look after a driver for an hour (Commercial Motors, 2018).

Since 2015 heavy goods vehicles are the closest vehicles we have on our roads to being autonomous. These regulations, as with many others, have been imposed with limited or no consultation with drivers, yet they are the ones most affected by the decisions of others. The focus of the government has been towards the protection of the built fabric, residents, car drivers and the environment. The haulage industry has focused towards its customers and its own margins. The driver has become just a component within an increasingly automated process, the social and ethical implications of which are currently going unchallenged.

5.2 Methods

This chapter presents findings from a qualitative study which used two methods to gather data from HGV drivers, owners and operators. Initially, a widely used Internet forum TruckNet was used to post scoping questions which were then followed up with more in-depth questions to encourage discussion. For ethical reasons no demographic data was asked, other than the type of work the participant did for a living. These findings were analysed to elicit an understanding about the current confidence in ADAS and how the future of HGV driving was perceived. Through identifying emerging topics and themes, questions were developed that could help the researcher explore the issues in greater depth using face to face interviews.

The face to face interviews were intended to develop a deeper understanding of how the industry has changed as a result of technology, while thinking about the social and ethical implications that driverless technologies may have in the near future. This research adopted ethnographic principles in that drivers were interviewed within their field of work at Haywood truck stop by a researcher who had previous experience of driving as part of their occupation. An interview schedule was used as a guide, but the interviewer tried to maintain a relaxed informal discussion through which data could be elicited. The pooled data from both the forums and the face to face interviews were analysed using thematic analysis (Braun & Clarke, 2014). This method was used to elicit a new understanding of early driverless technologies. This study obtained ethics approval from Lancaster University FASS-LUMS ethics committee #FL17161. Study information and the right to withdraw data was provided to all participants. Participants gave either verbal or written consent to taking part in this study.

5.3 Findings

A total of 25 participants responded to questions on the Trucknet forum, generating around 50,000 words of data. A further eight participants undertook face to face interviews at Haywood Truck stop over four sessions, averaging approximately 90 minutes per interview. Thematic analysis of the combined dataset led to the identification of five key themes: *Technology, Change, Relationships, Respect and Future.* Quotes from participants (p.#) are given to support the themes.

5.3.1 Technology

Current perceptions of ADAS technologies

Following discussions with drivers, systems such as EBA, LDW and ACC appear to be far from foolproof. As a result, the drivers who are using these systems find it hard to believe that Level IV (where the driver requires no input within predetermined conditions) or Level V autonomy (where a driver is never needed) (SAE International, 2019) could exist in their lifetime. One of the commonly reported issues was the interaction between automation and other human drivers. When approaching an off ramp, it is common for car drivers leaving the main carriageway to slip in-between HGVs. Drivers report that EBA systems have a tendency to emergency brake, potentially damaging their load and causing the driver to be reprimanded for heavy braking, which has been recorded by the tracking systems. This is something that drivers report as unnecessary and demonstrates that the systems are not able to read the road and other drivers appropriately. As a result, many drivers turn off the systems when driving in cities or on busy roads. Drivers also reported false positives, including *"EBS which applies the brakes for no good reason now and again"* (p.1).

Training or lack thereof

Drivers expressed concerns about how vehicle technologies were being introduced. No participant had received specific training in how to use EBA and LDW. The driver Certificate of Professional Competence (CPC) was described as a *"load of rubbish… After 40 years, what am I going to learn in a classroom"* (p.2). CPC was described as badly thought through and implemented, only covering subjects that drivers understand well. There was an opinion that "*CPC…should incorporate the technology… I wasn't shown when I was given my new Volvo*" (p.3). As of October 2018, the Driver CPC Syllabus states nothing about the use of new technologies and driver assist (Driver and Vehicle Standards Agency, 2018). This means that drivers have had no formal training about how to use EBA and LDW.

Robustness and maintenance

Concerns about the robustness of these systems were also raised. The industry sees HGVs as industrial bits of equipment which are used and abused and regularly covered in grime. Drivers indicated that technology and their sensors are proving susceptible to failure within a haulage environment. This opinion was echoed by a mechanic, who expressed concerns about the time it would take to repair such systems which had become damaged, saying that "*the most difficult fault to diagnose is an intermittent electrical issue.*" (p.4).

Trucks

On the other hand, drivers commended the way in which the comfort of trucks had improved over the years. They described trucks as *"easier to drive"* (p.4), *"very comfortable"* (p.5) enabling drivers to sleep well and make their own food as shown in

Figure 5.4. In fact, drivers often expressed the view that trucks needed no further improvement; it was the rest of the industry that needed to improve.

Figure 5.4. A view inside a Mercedes Actros cab show how trucks have become more comfortable than ever before (Source. Brisbane Truck Show).

5.3.2 Change

Responsibility - driver or machine?

One of the greatest concerns raised was how *"the driver is responsible for a vehicle that he has no control of"* (p.6). Anti-lock braking systems (ABS) were viewed positively, as the driver was viewed to remain as the decision maker. EBA was seen differently, as the decision is led by a computer and not the driver. This raised concerns about who is responsible for the vehicle as the truck is able to make decisions regardless of the driver, yet currently the law states that the driver is fully responsible for every aspect of the vehicle.

Challenges of road infrastructure

The UK's road infrastructure frequently challenges drivers. The design of the road network means "mounting pavements for all sorts of reasons, this is of course a routine issue. So is deviating from lanes and otherwise negotiating road space with other traffic" (p.7) as seen in Figure 5.5. Most drivers expressed concern about how a driverless vehicle would contend with this and if a driverless vehicle would ever be able to bend the rules of the road. Deviation from the rules were deemed essential in cases such as when vehicles needed to perform awkward manoeuvres.

Figure 5.5. A helmet-cam image of a lorry using the opposite side of the road to make a turn while staying clear of the lady and child on the pavement. Due to the A-pillar of the vehicle, the driver was unable to see motorcycle rider and subsequently collided with the bike (Source. BBC.co.uk).

In these cases, drivers reported the need to communicate with other road users, for example by using the vehicle's hazard lights, or by using hand signals, or even talking to other drivers. It appears unclear how driverless vehicles could communicate with other drivers or be communicated to by humans.

Disorganisation through technology

Mobile phones, trackers and despatch systems were seen as technologies that have had major impacts on the industry and had become the facilitators to what drivers described as the constant *"push"* to be quicker and do more. While not universally disliked, such systems had removed some of the self-reliance drivers once had, which was one of the aspects they used to enjoy most about the job. Prior to the introduction of such technologies, drivers spoke of the need to plan days in advance, checking in by pay phone once the jobs were complete. By contrast, today, drivers report that *"firms don't really seem to plan movements more than five minutes ahead"* (p.7). This shift is seen by drivers as a level of disorganisation which mean you have no ability to plan your life, "*you never know when you are going to be home"* (p.2). This has had repercussions for drivers' family and social lives, with drivers expressing that *"you miss your family and children growing up"* (p.8). Despite the changes that technology has had, drivers held the industry responsible as opposed to the technology.

The sweating of an industry

The haulage industry was often described as a *"sweated trade with poor conditions" (p.7)*. Gains in efficiency were often seen as a way of driving down prices and were rarely implemented for the benefit of drivers. Haulage firms are still predominantly family run businesses that have to be competitive and are at the mercy of large multi-national customers. The industry reports that smaller haulage firms are also competing with the few large national hauliers who operate on economies of scale. Drivers feel that no one person has overview of the transport industry and that decisions being made by large multi-national customers are adversely affecting them. This belief is perpetuated by the fact that drivers feel that they lack representation within the industry. There has always been a lack of union representation according to drivers, however in the past, haulage firms were often run by drivers and so they felt that they were represented and heard by their bosses. Today it is common for general haulage to be run by *"classroom transport managers"* (p.9) who have never experienced professional driving. As a result, drivers feel that genuine complaints and concerns are sometimes just met with, "*they're just complaining again*" (p.5). Drivers also feel that there is an attitude of comply or leave within the industry, as drivers feel that they are easily replaced.

5.3.3 Relationships

Social change through policy

Participants admitted, that HGV drivers are often "loners", but that is by choice and does not represent all drivers. Drivers interviewed in this study, were keen and appreciative of the opportunity to talk to someone. Drivers' social interactions have changed dramatically over the years. Drivers reported the first major change being the introduction of sleeper cabs in the 1970s. Initially intended for long distance work across the iron curtain, these trucks soon became the norm. Before this, drivers used bunk houses and slept in dorms. Although not overly liked at the time, these bunk houses were actually a hive of social activity with drivers sitting together to eat and chat. Because of the routines at the time, drivers used to get to know each other, reporting a *"real…camaraderie…we used to all sit together"* (p.9). Although these sleeper cabs were the start of a major social change, they were not singularly responsible. Most towns had recognised lorry parks for overnighting, usually the town car park would become a lorry park at night. Those who wanted to, could get out of their cabs and go to the pubs to have dinner and chat with other drivers and locals. However, "*gradually the councils have banned lorries from these parks"* (p.*1)*. Trucks were slowly pushed further and further away from towns, restricted to major roads, out of town truck parks and lay-bys as shown in Figure 5.6 where it is near impossible to conduct any sort of social exchange.

Figure 5.6. Lorries parked in a lay-by while drivers take a rest or sleep. Rest places like this have no facilities and do not make pleasant places to spend time (Source. Google.com).

Technology as a barrier/facilitator to social interaction

With increasing levels of automation, drivers reported a struggle to find opportunity to have conversations. Examples like automated fuel pumps and in-cab telemetrics mean that drivers often go long periods without talking to anyone. Technologies have also meant that when drivers are out of their cabs, they keep their heads down, looking at a mobile phone or tablet. Technology is also providing employers oversight of drivers' actions, generating tensions within the industry. Employers report that tracking in particular is being forced upon them by the customers, while drivers often report that it is a way of keeping continual observation over drivers. Some drivers felt that their employers used such systems in a responsible way, offering bonuses for good driving and only using the data in the event of an incident, to the benefit of both the driver and employer. Others perceived these technologies more negatively, believing the data to be used to continually evaluate performance and *"push, all the time"* (p.3).

Drivers viewed technologies as having some positive impacts on their working lives. Truck driving has always been a job which has taken drivers away from home and at one time there was little to overcome the distance. Today with phone, video calling, email and messaging services, drivers feel more able to remain connected to home than ever before.

5.3.4 Respect

Industry - please can I use the toilet?

Professional drivers have raised concerns about how changes in the industry have had a detrimental effect on the work satisfaction of drivers. One factor which was raised more than any other was respect. "*Money and respect is what is needed. But it's mainly respect*" (p.3). This is an underlying problem which at times boils down to something as simple as *"people don't say please and thank you"* (p.3). Drivers reported that it was common to be left in a room or confined to the truck's cab while the truck is being unloaded. If the driver was lucky, *"there may be a coffee machine, there may be a toilet and that's about it"* (p.2). All of the drivers could recall times when they had not been allowed to use the toilet when visiting customer premises. In fact, this has become such an issue across the industry that the HSE (Health and Safety Executive) has waded in, reminding companies including major UK high street retailers, such as John Lewis and Boots, of their legal responsibilities (Commercial Motors, 2018). Drivers understandably say that this kind of treatment makes them feel unwanted and viewed as second-class citizens.

HGV Infrastructure "a national scandal" (p.1)

The lack of infrastructure and the resultant impact of drivers having to stay in lay-bys with no facilities was regarded by drivers as a disgraceful situation. This view was not just predicated by the lack of facilities, but also by the fact that lots of hauliers simply will not pay for the drivers to stop in truck stops or services. When drivers did reach dedicated spaces, many felt they did not fare much better with motorway services bearing the brunt of the criticism. Services are expensive, and the quality of the facilities are poor. The food is often expensive, of poor quality and there are few healthy options. But what appeared most annoying for drivers was the lack of security and services. Drivers reported, *“there is so much vehicle theft and thieving… you're on pins all night”* (p.8). This was seen as a given when parking in a lay by, but drivers questioned what they were paying for when they parked in services. Truck stops fare much better, but there was still a concern about safety. One parked up young driver who had to keep the vehicle secure said *“I got a message to stay out, when I was on my way back... I could walk home from here”* (p.10). This again raises concerns for truck drivers in the way they are respected. There are few jobs that would expect employees to work all day and then do a second job overnight as a security guard.

Technology gone too far?

One of the latest debates is about cameras in trucks. Trucks can now live-stream footage from both road facing and in-cab facing cameras. Forward facing cameras appear to be widely accepted as a method of protecting drivers from scams. *“But inward facing cameras are a total invasion of privacy”* (p.5). Drivers see any inwards facing cameras as an invasion of their privacy, supporting an atmosphere in which drivers feel that they cannot be trusted and have to be continually monitored. Recent legal cases have shown the value of in-cab cameras including a case in 2018 which saw a driver using his phone up until the point he crashed into the back of another car, killing the driver (Figure 5.7) (The Independent, 2018b). With the increase in technology and driver assistance systems, cameras are likely to become more topical, but the balance between privacy and the protection of all road users need to be carefully considered.

Figure 5.7. In cab camera showing driver using a phone before an accident with the vehicle in front (Source. The Independent).

5.3.5 Future

The potential introduction of driverless technologies was perceived to only worsen a job that has become boring, deskilled, undervalued and unappreciated. The fear was, that the job role would move from a position of some responsibility to one in which drivers are only there to occasionally negotiate poor infrastructure. Vehicles are not far from being able to self-drive down motorways, but drivers felt that full autonomy would not be possible within the foreseeable future without a human available to take over instantly when required.

Autonomy vs infrastructure

Drivers felt that road infrastructure such as markings and road surfaces are simply not defined tightly enough for driverless vehicles to successful operate. This view is supported by Nitsche, Mocanu & Reinthaler, (2014) who conducted a survey of 54 international experts, many raising similar issues as the participants of this study.

Drivers believed that it would be possible to have autonomous trucks *"If depots are on a motorway with a slip road, automation could have its role"* (p.11). They did not believe that an autonomous vehicle would be able to contend with the current state of roads, with how much ambiguity there is surrounding markings and signs. Drivers doubted that autonomous trucks would ever exist outside of the major road networks. This was mainly attributed to the inadequate nature of non-major roads. Drivers reported that *"deviating from lanes and otherwise negotiating road space with other traffic, is commonplace"* (p.7). They appeared unconvinced that a driverless truck would ever be able to make such decisions.

Communication – syncing drivers and vehicles

Participants raised concerns about the way in which driven and driverless vehicles could be communicated with. Drivers talked about the frequent need to visually communicate with other drivers, in order to allow a HGV the space to perform a manoeuvre. It is unclear how such subtle communication could be performed in a world where one or both parties were driverless. It is quite conceivable that human drivers could manipulate an autonomous vehicle knowing that it would always give way. There was a feeling that until machines had consistently proven their ability to drive as well as, or better than humans, then we should not be considering autonomous vehicles for road use.

Currently we are seeing a situation where the duty of driving is being shared between the machine and human. Looking at the next generation of ADAS, the driver still remains ultimately responsible for the actions of the vehicle. This renders the driver as an observer who drives when the machine cannot. As previously mentioned, this raises major concerns about the attention of the driver and the ability of an observer to intervene effectively in an emergency. This form of relationship already exists between a pilot and a plane, but when this analogy is proposed to drivers, they immediately identified a difference in the response times required. A plane at altitude gives a pilot seconds to respond, where as a driver at 55mph may only have milliseconds to avert an accident.

Skill and knowledge – old and young drivers

Drivers raised concerns about how skills and knowledge will be retained in the industry. Currently in the UK, the average age of a HGV driver is around fifty (Health and Safety Executive, 2017). Despite government scheme to increase the number of young drivers there is currently still a shortage, *"Young drivers just say this isn't for me."* (p.2). The participants of this study also expressed concern about how young drivers were being introduced to the industry. With learners using the latest technologies as part of their test, including satellite navigation, and the latest trucks with automatic gear boxes and driver aids, there was a worry that new drivers would unduly trust and embrace these systems. Older drivers reported that satellite navigation had been a prime example of this, where young drivers believed and trusted in a technology. Drivers argued that technology rarely contains local knowledge. Drivers recalled conversations that they have had with younger drivers telling them not to use the navigation on a particular drop. Regardless of this, they had used their navigation and ended up getting stuck as shown in Figure 5.8. There was a feeling amongst drivers that a reliance on technology was starting to creep in, leading to a deskilling of the workforce. With many drivers near to retirement, there was a concern that the knowledge they possessed would be lost to technology.

Figure 5.8. HGV stuck in a town after following a satellite navigation system (Source. ITV.com).

5.4 Discussion

These findings paint a bleak picture of the current state of driving within the haulage industry. The advancements being made in autonomous technologies appear not to be based on consultation with drivers, especially HGV drivers, who are at the forefront as users of technology. This underlines a serious oversight as to the design and development of driver technologies. As the pioneers of driver assisted technologies, HGV drivers are raising real-world concerns about how these technologies may operate in the future. There is a consensus among drivers that major social change is needed to implement driverless technologies, but this does not mean that there are not real opportunities for users. It is the role of designers to test, understand and examine where these opportunities may lie and how we can inform the future of autonomous vehicles through the early real-world experiences of HGV drivers.

Designers of driverless vehicles have a real challenge to overcome if the technology is to be accepted by drivers. To date, early technologies have not performed as advertised or expected, particularly in their ability to understand and behave like humans. This has resulted in a lack of confidence that driverless technologies could ever be trusted to operate without human oversight. This opinion is not just held by the early adopters but is also shared by drivers in general. A recent study performed by DirectLine Group (2018) indicated that 67% of drivers would prefer to remain in control and that only 18% of people believed that computers were able to make better decisions than humans. Designers of driverless vehicles need to address the issue of acceptability as a result of current experience but also the issue of preference. These issues can only be addressed by designers being collectively involved in understanding real-world limitations of early driverless technologies. Through a shared process of development, drivers' expectations can be managed and collective goals set for the future. Driver CPC is an opportunity which already has a structure in which designers and developers could develop a forum for collective learning and information sharing about how these early technologies need to be developed.

In the immediate future, it is highly unlikely that drivers will be removed from the cab of trucks, due to the requirement for them to negotiate inadequate infrastructure and perform other duties. It is unlikely that the responsibility for the loading and unloading of trucks will be passed to an unknown third party. Also, if drivers are removed, what is to stop criminals placing cones in the road to stop a truck and unload it before removing the cones and sending it on its way? Despite this, there is an ambition to develop vehicles in which humans are expected to take a back seat to machines (Sparrow & Howard, 2017). Existing concerns about concentration are only going to become more topical as ADAS becomes prevalent. Currently we are rapidly moving towards a situation where drivers are quickly becoming the observer or overseer for vehicles. The consensus from current experiences is that this observer role will lead to boredom and the task becoming less rewarding. Designers must consider that if humans are to be retained, which seems to be the only option in the immediate future without major infrastructural change, then the human machine relationship must be active, as opposed to the passive relationship which we are seeing emerge. For the job to remain rewarding and practicable, the driver must remain involved in the act of driving and most importantly the decision making. Without this, it becomes questionable whether a human would be able to effectively respond to an emergency if required.

While it may be theoretically possible for the current vision of driverless vehicles to operate without human assistance in the near future, if humans are to be retained in cabs, we need to question if driverless vehicles are actually desirable. Within limited applications, such as moving vehicles in areas in which humans are not permitted for safety reasons, there are real benefits to fully autonomous trucks. In these type of scenarios, driverless trucks could free drivers from being locked in a room with no facilities to do what they enjoy; to drive on roads with other humans, moving goods. However, this represents only a small part of the way in which trucks are used and so as designers we must understand that there is not a one size fits all, which we are currently seeing in the development of driverless vehicles. Designers must begin to understand the complexities and differing requirements within the transport industry, rather than the pursuit of advancement in technology for the sake of advancement.

Without driverless vehicles being designed to deliver meaningful benefits to both drivers and hauliers, autonomous vehicles are likely to be challenged by issues of acceptability. This is evidenced in the findings of this study that drivers and some of the owner operators are questioning who the beneficiary of driverless technologies are. Designers have failed to represent the value of technologies such as tracking which is commonly imposed by the customer and EBA, LDW, ACC which have been imposed by legislation. The findings from this study suggest that technology imposed without shared objectives is often disliked and seen as for the benefit of others. This scepticism is already emerging in the discourse of drivers when discussing driverless technologies. For example, ABS was developed to help solve an issue of drivers controlling vehicles under heavy braking. Conversely, drivers today are not reporting that they struggle to keep a vehicle in its lane, as a result, they challenge who lane departure systems are truly for? These opinions are entirely understandable when you consider that no consultation, or shared objectives have been discussed and it is extremely hard for drivers to recognise how current visions of the future address the problems they face on a day-to-day basis.

Despite the distrust among drivers evidenced here, increased automation could have benefits within the haulage industry for end users. Rather than the development of driverless vehicles in which the objective is the removal of the driver, there are opportunities to develop mutually beneficial relationships in which collectively the vehicle and human add to each other's capabilities. Both humans and machines have their weakness, by working together in a collective capacity it is possible to create an environment in which each party can learn from each other, creating a higher standard of driving. If in the future drivers are to be retained, then we need to question who in the relationship becomes the observer. The current trajectory lacks sense when you consider that humans get bored and as a result, will find entertainment in doing things other than observing. Machines have no such problems and will diligently observe with zero interruption. It is the vehicle that should be viewed as the observer, which could actively inform the driver of hazards and local information. Vehicles could also share data with other vehicles, forming a local network of information, which is relayed to other drivers, helping to ensure that knowledge is not lost.

5.4.1 Reflection

This work has identified that drivers are rarely being involved in the future trajectory of their own industry and occupation. The main contributing factor to this, is the rate at which new technologies are being introduced without consultation and review with drivers. The automotive industry, and legislators need to be more proactive in engaging with their end users, the driver. Drivers often felt that the manufacturers saw the fleet manager or the haulage companies as the customer as opposed to the drivers themselves.

There is a growing need for research which seeks to understand how we can draw on the real-world experiences of this neglected group of drivers to test and explore the realities of increased machine decision making on users' lives. Many of the social and ethical challenges discussed in this chapter are going unnoticed among this group of pioneer drivers. We have the opportunity to learn from the experiences of these early adaptors before autonomous technologies become more widely adopted by car and van drivers. The following chapter will discuss methods of consulting with a range of stakeholders including drivers, manufacturers, policy makers, cities and their citizens, in the design of emerging autonomous vehicle technologies.

6 Participatory data comics – Exploring methods to test future technology

This chapter is pending submission as a paper to the Design Journal.

6.1 Introduction

The studies documented in chapters four and five have shown that there is a concern that driverless technologies are currently being implemented in a way that primarily serves the needs of manufacturers and technology giants, rather than the user. Although the methods employed in these chapters successfully identified drivers' fears and areas of concern for the future, as methods, they do not provide clear solutions to improve the relationship between drivers and machines. Designers have a role in providing a wider oversight to the conflicting agendas of the stakeholders involved in the development and implementation of autonomous technologies. To date, there are no methods which set out how designers can begin to address the role and implementation of autonomous vehicles.

This chapter will discuss methods that use participatory data comics to provide visual narratives representing the contradictory futures produced by differing stakeholders. The objective in doing this is to provide a shared platform through which the differing objectives can be captured and discussed in a way which facilitates common ground to be reached.

The aim of these methods is not to provide a utopian or cohesive view of the future but to document the conflicting agendas through visioning the future in three ways. These three methods are intended to represent key stakeholders. Firstly, projected futures are used to represent users, requiring us to draw on data about current lifestyles, social habits and working practices, such as the findings of chapter 5. Secondly concept futures are used to represent emergent technologies, in this case autonomous vehicles, which often already exist as visualisations, but are devoid of the context through which users can engage with the realities of the technology's operation. The third method can be drawn upon to represent alternative stakeholders or alternative realities and contexts.

The reason that this chapter advocates documenting futures with their warts and all, is because it is believed that it is not the drawn futures that will produce an equitable solution among all stakeholders, but the discourse that they create. It has been recognised that communicating futures through written and verbal media is challenging, leaving too much scope for ambiguity and confusion over the topics being discussed among stakeholders. This limitation is a reflection of the work conducted in chapter five. In order to test, explore and question these futures, we need to use a method which can more accurately demonstrate the subject, creating a richer and more inclusive conversation. It is for this reason that visualising the future scenarios through the media of comics has been proposed, but these methods are not without their own challenges. It is inevitable that any drawn future will be represented with a degree of bias towards an agenda and as such, we need to place value on the opinions of the stakeholders who engage with the futures we create.

Current projections of driverless technologies put forward by manufacturers and tech giants depict an exciting future with endless enhancements to mobility that will ultimately make our lives easier and more efficient (Nissan Online Newsroom, 2017). The realities of exactly how these technologies will integrate with existing infrastructure, our working practices and daily lives, which for decades have been built around the driver-led car, are yet to be determined. Early driverless technologies are already in use in the form of driver assistance systems such as lane keeping and adaptive cruise control. HGV drivers were among the first user groups to extensively use these systems. These technologies were introduced with no consultation with drivers, generating significant social and ethical implications for the way drivers live their lives (Morton et al., 2019).

It is therefore proposed, that the following methods of visualising futures, are used alongside qualitative, quantitative or mixed method approaches, eliciting new understanding from participatory engagement with the comics. Through this process this chapter will build on existing research through engaging participants not solely on the futures of their own creation but on the multiple perspectives of the future which make up our complex interwoven cites (Pollastri et al., 2018). This chapter offers designers a series of methods to relevantly engage all stakeholders in the design of future technologies, taking into account their disparate objectives, to perhaps find common ground. It is inevitable that we will never find a future that will appease everyone and as John Urry says, 'A planned future may not be possible, but a coordinated one may be the best show in town' (2016; p.191). It is only through involvement of all stakeholders in future discourse, that we can begin to coordinate these disparate views.

6.2 Why Participatory data comics

Manufacturers and tech giants typically project driverless vehicles in two ways, the highly functional visions such as Local Motors' Olli bus (Local Motors, 2019), which depict a bus just like the ones seen around cities today, but with the absence of a driver. These futures do not challenge the perceptions of our current lives and working practices. The other category is made up of the extremely futuristic examples, such as Honda's Advance Design Studios with their CarPET concept, as seen in Figure 6.1, which was produced for the 2014 LA Design Challenge. Though these visions typically look exciting, the technologies shown are projected as objects, devoid from urban interactions. The realities of implementing the technology in the real-world are ignored.

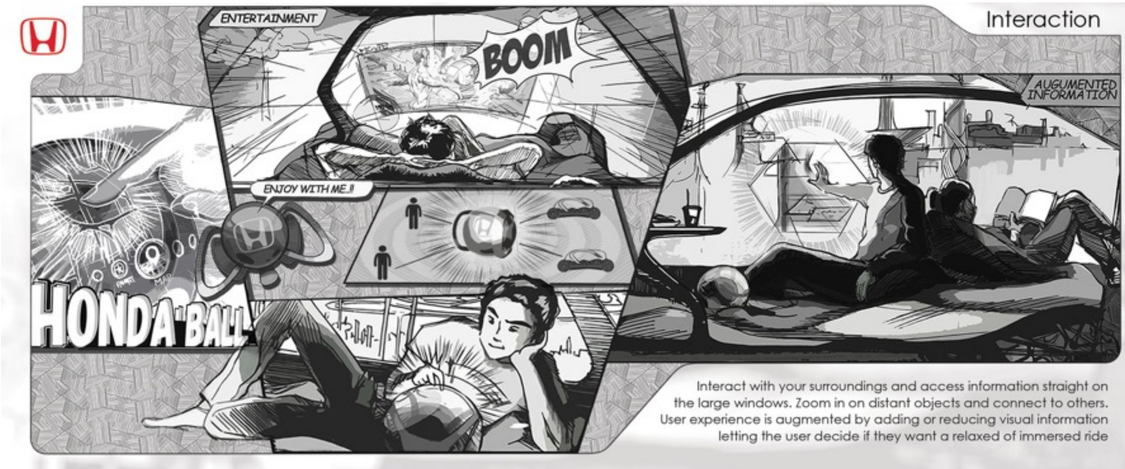


Figure 6.1. Honda CarPET concept is visually stimulating and exciting but lacks the urban context required to provide critical discourse (Source. Car Body Design).

This research will focus on the more futuristic explorations that challenge the way we will travel, engage with others and the city. Commercial visions of the future are often devoid of both context and recognisable social exchanges, making them hard to accept or believe by consumers. As a result, these kinds of visions of the future do not provide enough information for users to critique the way in which such technologies will evolve our daily routines and working practices. This chapter will build on these exploratory visions of the future, through discussing design methods which can enable designers to not just speculate on how the future will look, but to respond to the question of how these technologies should engage and interact with users and the city.

This chapter will set out a series of methods to explore how designers can critique and share futures with all stakeholders, especially the often overlooked users involved in the implementation of driverless technologies. Although this chapter will focus on the future exploration of a specific technology, it is believed that other researchers could use the methods discussed in this chapter to explore different emergent technologies. In order to communicate with stakeholders, comics have been chosen as a visual tool to stimulate participation in exploring their futures. Previous research has explored how we can communicate complex relationships which are typically difficult to understand through the use of data comics (Bach et al., 2017). Other research has looked at the value of visualising futures as a method to question the role of technology in society (Dunn et al., 2014). These explorations can be seen as a proxy to understand the futures people want and perhaps more importantly the futures people don't want.

The methods discussed in this chapter will build on existing work by combining data comic techniques with the long-practised techniques of visualising futures, to develop participatory data comics. This chapter will draw on the findings of a qualitative study that looked at the social and ethical implications of increased machine decision making among HGV drivers, to provide an example of how findings can be built on using the methods outlined in this chapter. The research looked at how drivers of HGVs viewed emergent driverless technologies by looking at early adopters of tracking, dispatch systems and driver assistance systems, such as adaptive cruise control and lane keeping. This study found that these technologies had been forced onto drivers with little consultation or monitoring as to their impact on drivers. The increasing amount of automation was perceived as problematic by drivers, who reported a range of social and ethical implications as a result of machine-led decision making (Morton et al., 2019).

While the results of the qualitative work provided insight into the problems that drivers were facing, decisions about how the future of these technologies should evolve proved a more challenging subject to discuss. There are potential explanations for this. Firstly, it is hard for a researcher to describe something which does not yet exist to a study participant. The result is often a drawn-out conversation between both parties to begin understanding one another, due to the hypothetical nature of the subject. Communicating these scenarios in written form is likely to be equally challenging and subject to misunderstanding.

Recently, there has been an emerging discipline of data comics. This approach has been developed as a method of communicating complex data, which has been traditionally difficult for people to understand (Bach et al., 2017). Comics are one tool which have the potential to provide researchers with the ability to communicate and record complex ideas around the introduction of new and future technologies. Without placing technologies into the context in which they will operate, it is hard to understand and perhaps pinpoint where new exciting opportunities may lie and where unforeseen challenges may arise. Comics can prove invaluable as a method of communicating complex layers of data, as they do not attempt to inform the reader through a single image, but are engaged with through narrative (Bach et al., 2017). Some researchers such as Jüngst (2010) argue that narrative is not a successful tool for knowledge exchange, however others argue that it is a powerful tool for exploratory data analysis (Brehmer et al., 2017). In the context of this subject area, it is believed that narrative is important to place the technology within the context of people's lives, enabling designers to use to use recognisable storylines such as the day in the life of an office worker. Without such narratives, it had for stakeholders to recognise the parallels between their lives today and the futures being communicated.

Automotive visions of the future are not without their critics. These futures are often created for commercial gain, a kind of physical vapourware, never intended to be produced but produced to manipulate markets and challenge competitors (Coulton & Lindley, 2017). While the intentions of these futures are for commercial gain, drawn futures represent a powerful tool to help designers engage with stakeholders and explore how future technologies could be developed to produce more equitable futures between the often-conflicting agendas of tech giants, manufacturers, policy makers and ultimately end users.

6.3 Speculative Design

Speculative design will be used as a method to both critique the technology we have today and explore future scenarios that may exist tomorrow. This exploration is based on three methods, projecting current technology and trends, injecting future concepts, and creating alternative futures. Before discussing the broader objectives, it is worth understanding the problems and opportunities presented by future speculations. When we produce speculative futures, whoever we may be, it is inevitable that our representations will be shaped by an individual group, a social agenda, or an economic model (Auger, 2013). All futures are inevitably represented in a certain way and with a particular focus. It is essential that designers are honest about the agendas that underlie our future visions. To provide a simple example, the case study represents the opinions and experiences of drivers in the haulage industry. It therefore follows that the futures produced will reflect their views about working practices, social exchanges and job satisfaction. If the research was based on the opinion of the haulage industry and the companies who employ the drivers, the visions of the future would look quite different. While there should be no doubt that the industry should still consider the views of drivers, it is inevitable that the focus would be somewhat different, alternatively focusing on the economics, productivity, environmental and customer services. Not only does the choice of stakeholder group influence the speculative futures, but the method deployed to create them also influences outcomes (Auger, 2013). This will be discussed further in the following sections about how or when we should use different kinds of methods to explore the future.

6.3.1 Projected futures or near futures

Projected or near futures are often used by governmental organisations and businesses to imagine what may happen in the next few years (Clear, 2009). These types of futures are an ideal tool to explore how changes or the uptake of technologies may evolve something we already recognise. Alternatively, near futures are often used for marketing; making us feel that by buying into a technology or a brand, we can have a little of the future, they sell us a story (Dunne & Raby, 2013). Depictions of near futures are commonplace in our daily lives, for example, we are shown images of how a new housing estate or retail space on the high street may look. As a marketing tool we are sent mail showing the latest car manufacturers' model, revealing a safer more connected, and economical car, tempting us to go to the dealer and commit to buying a newer vehicle. We all become drawn in by an image of products we cannot afford, or sometimes even yet buy. Projected futures create an excellent way for manufacturers to sell the future. However, for designers, near futures have become a powerful tool to test technologies, by placing the object within a context we know and understand, enabling us to think about the impact the emerging technology may have.

6.3.2 Concept futures

Concept-driven futures are something we again see regularly throughout our daily lives and are ideal to represent the views of manufacturers and technology giants. Unlike near futures, concept futures are often not as easy to relate to our current way of life. The concepts often project a world which is similar to the one we know but with noticeable differences. These differences show a change in the context, either in the way we live our lives or the built environment in which the concept exists. These concepts are typically the result of visualising either new economic models or technologies which fundamentally change a task we know well. This difference makes these visions far more difficult for the reader to relate to than projected futures. However, there are genuine reasons why this disconnect exists between the reader and the creator. The reality of these visions is not always intended to inform the reader about the future on offer (Sterling, 2014). Instead, they are often used as a tool to create a commercial position that suits the creator (Bylund, 2006). The likes of Telsa and Elon Musk have become the masters of the sensationalised concept for commercial gain, with claims that by 2021 Tesla's will be sold without a steering wheel as shown in Figure 6.2 (Allen, 2019).

Figure 6.2. Tesla's 2021 driverless car claims are being conveyed by images of vehicles without steering wheels. While these visuals grab headlines, the reality remains unclear (Source. Sunday Times Driving).

These types of concept futures could be commonly seen during the 1950s in America among automotive manufacturers. Their conceptual visions of the future helped influence over half a decade of urban development and lifestyles. This trend continues as much today as it did in the 1950s, accumulating among the technology and automotive industries. Today we continue to be bombarded with concepts of the future positioned around the creator's business model, to influence change or reposition businesses for the future. Future concepts represent an opportunity to unpick tech giants' and manufacturers' future trajectories, but they should be used with a level of caution. We must remember that such visions are not necessarily intended for the benefit of society but as a method to achieve the economic objectives of significant corporations. We have a role as designers not to accept these visions, but to critique and evaluate the proposals being presented (Auger, 2013).

6.3.3 Alternative futures

Alternative futures are typically used to explore futures where the way we live our lives, is fundamentally changed beyond what would be considered a projection of the world we know today. These futures are typically seen less in our day to day lives compared with speculative and conceptual futures and are not always seen as futures by the observer. Media such as cartoons, novels, TV, and film, regularly project alternative views of our future. Many examples could be chosen to demonstrate this idea, including Wall-E and its depiction of hyper-commercialisation, where humans have everything done for them, resulting in an obese, lazy society where no one can do anything for themselves as shown in Figure 6.3 (Stanton, 2008).

Figure 6.3. WALL-E depicts images of futures, where machines do everything and as a result, humans have become lazy and obese (Source. Pixar).

Another good example would be Altered Carbon, the series based on the book by the same name, which explores a world of AI and advanced cybernetics where humans can be downloaded into virtual worlds or new bodies referred to as 'sleeves' (Kalogridis, 2018).

On occasions, architects and designers use these techniques to explore scenarios, particularly when documenting the consequences of climate change and natural disasters. Clouds Architecture Office produced AQUALTA, alternative views of both New York and Tokyo as a result of rising sea levels as seen in Figure 6.4 (Cloud AO, 2019). These visions have been used as both a warning as to what rising sea levels may look like and an exploration of how we may have to live in the future whether we like it or not. The spaces are intended to function as bridges, re-distributing transport nodes to recreate the networks which existed before the flooded scenario.

Figure 6.4. Aqualta, New York city by Cloud Architecture Office explores how cities could look as a result of rising sea levels (Source. Clouds Architecture Office).

These types of futures are a valuable tool to understand both the challenges and opportunities that the future will present while exploring how we may wish to address these future challenges. There is a value in projecting futures whether they are perceived positively or negatively, it is essential to understand not just what is desirable, but also what is undesirable and why. Through the use of these future visualising techniques, we can begin to consider how we may want to the future to look. These kinds of techniques can be a valuable tool for policymakers and city stakeholders to challenge the conceptual futures of technology giants and automotive manufacturers. It is imperative that cities decide on their view of the future before it is imposed on the city and its citizens, by third parties such as car manufacturers and tech giants.

6.4 Exploration of methods

This chapter will present four methods to explore how we can use visualised futures to share findings and engage stakeholders. These methods could be used in sequence or individually; it is up to the investigators to decide which methods are most appropriate to employ. The four components are as follows:

> **Visually representing findings** – Using data comics to create visual representations of findings that are placed in both narrative and context.
> **Future design narratives** – How data comics can be used to explore emergent technologies.
> **Participant engagement** - Engaging participants (e.g. designers, end-users and policymakers)
> **Re-exploring participant engagement** - An iterative process to further examine the results of the previous methods.

The following sections will discuss how designers can use both data and participatory comics to explore future technologies. This chapter will not, however, discuss how to create comics, as there are many good references for this, such as Comics and Narration (Groensteen & Miller, 2018) and Creating Comics (Salavetz & Drate, 2010).

6.4.1 Visually representing findings

Comics were chosen as a media to represent the findings due to a few unique attributes that comics present to both their creators and readers. Comics represent one of the most universally readable forms of literature, through the combination of visual narrative, accompanied by text. These two contributing elements are at the basis of how comics promote knowledge transfer. As a result, the image and text are mutually influential, making comics highly accessible to readers (Guérin et al,. 2017).

Through the use of the visual artistry of comics, the need for text is significantly reduced when documenting complex issues, even when using non-linear storylines. This visual component of comics significantly reduces the time required to absorb the content by the reader over non-visual forms of literature (Kim et al., 2018). As a result, comics make an ideal media through which to engage with participants as they are essentially quick to engage with, do not discriminate against reading ability and reduce participant burden. Despite this, comics can be used to engage people in complex and challenging issues. Figure 6.5 gives an example of how these findings can be represented in comic form.

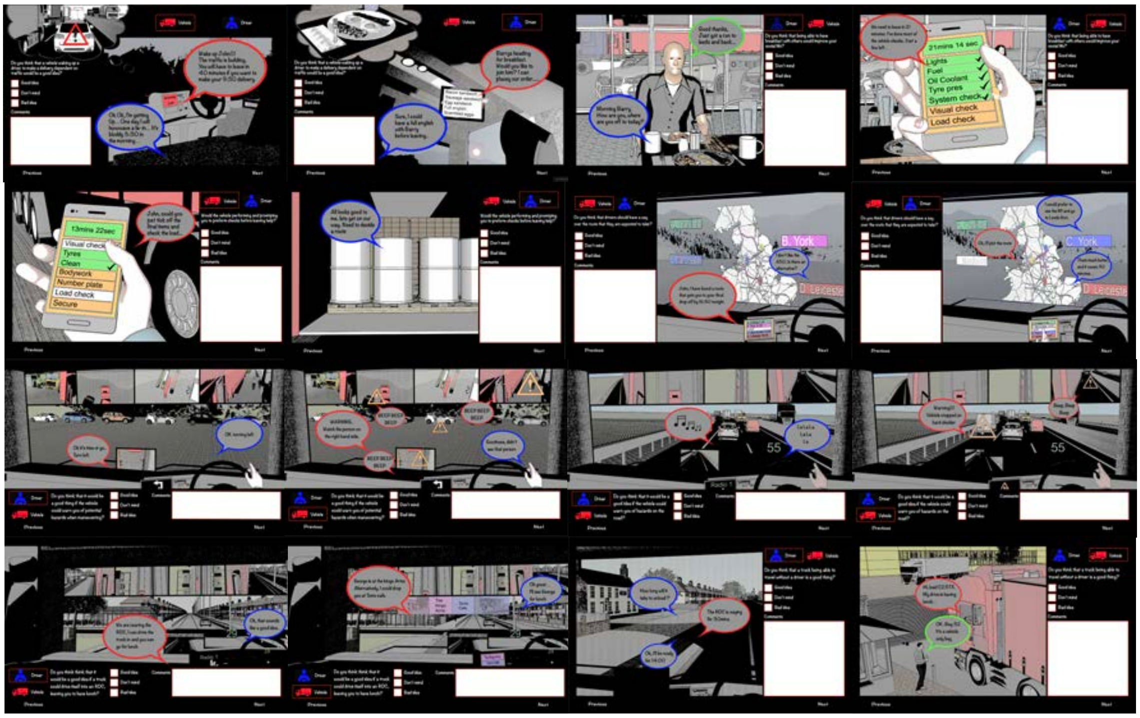


Figure 6.5. Data comic storyboard exploring the impact that autonomous control systems could have on drivers, based on chapter 5 findings. The red speech bubbles are that of the autonomous vehicle while the blue speech bubbles are those of the driver. The above shows the full storyboard overview, with individual frames below.

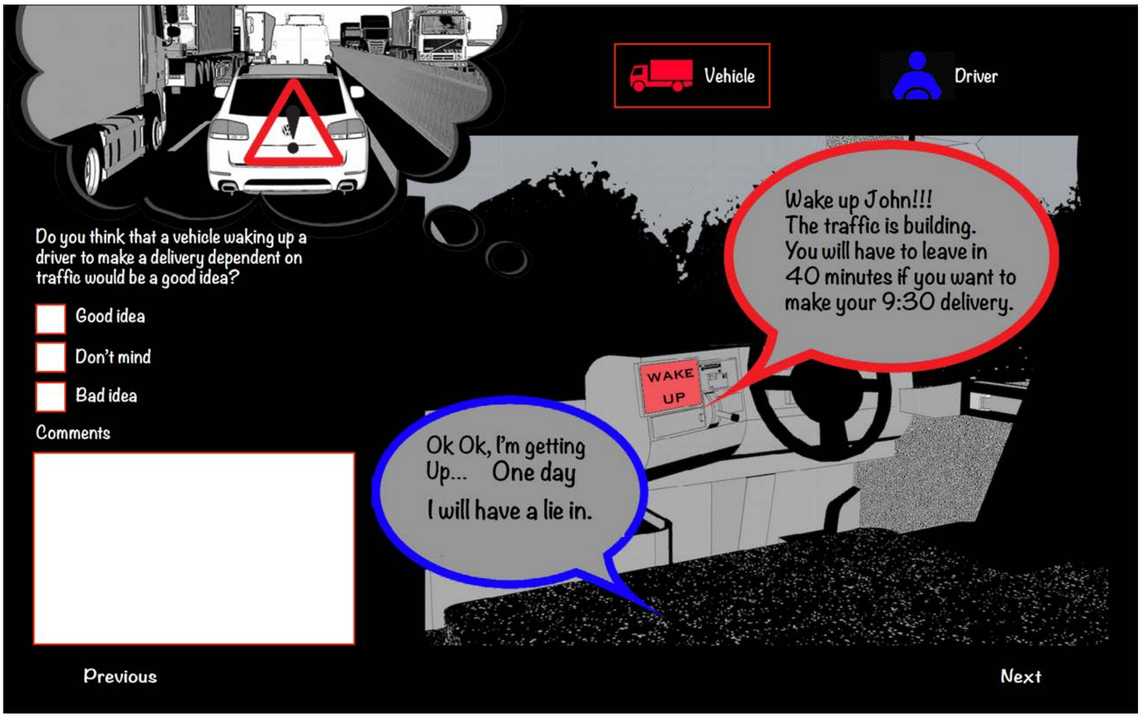


Figure 6.6. The truck wakes up the driver according to the scheduled deliveries and traffic on route.

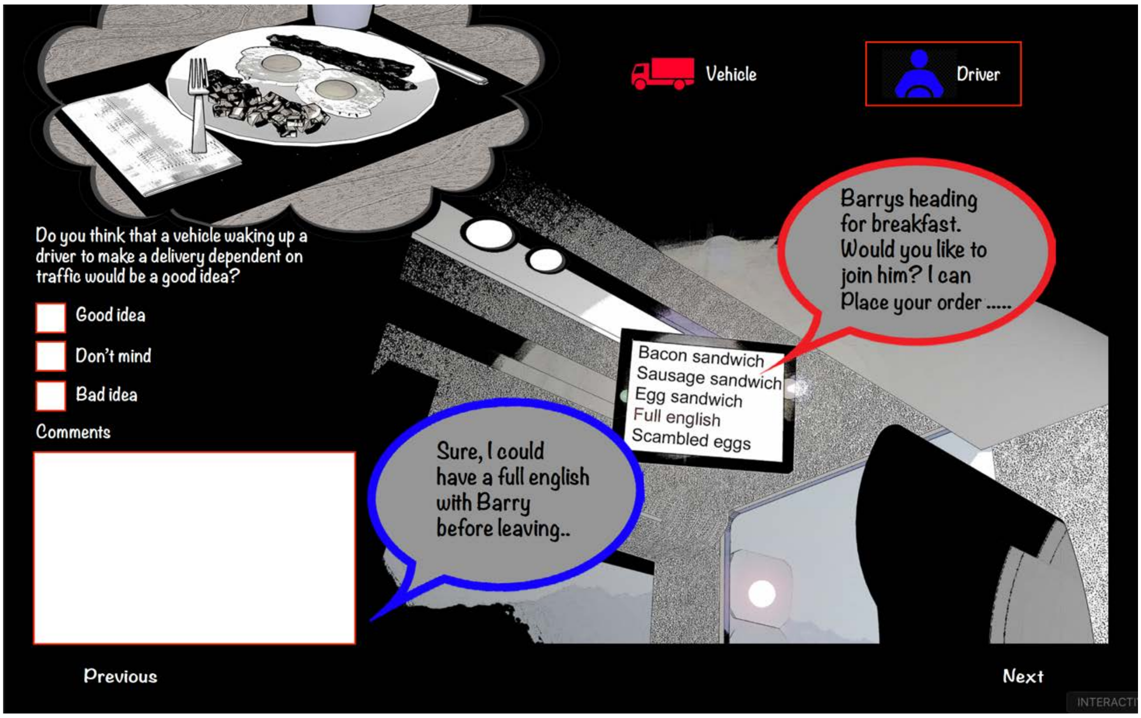


Figure 6.7. The truck informs the driver that one of his friends is having breakfast and asks whether he would like to order anything. The driver can place an order so that breakfast is waiting.

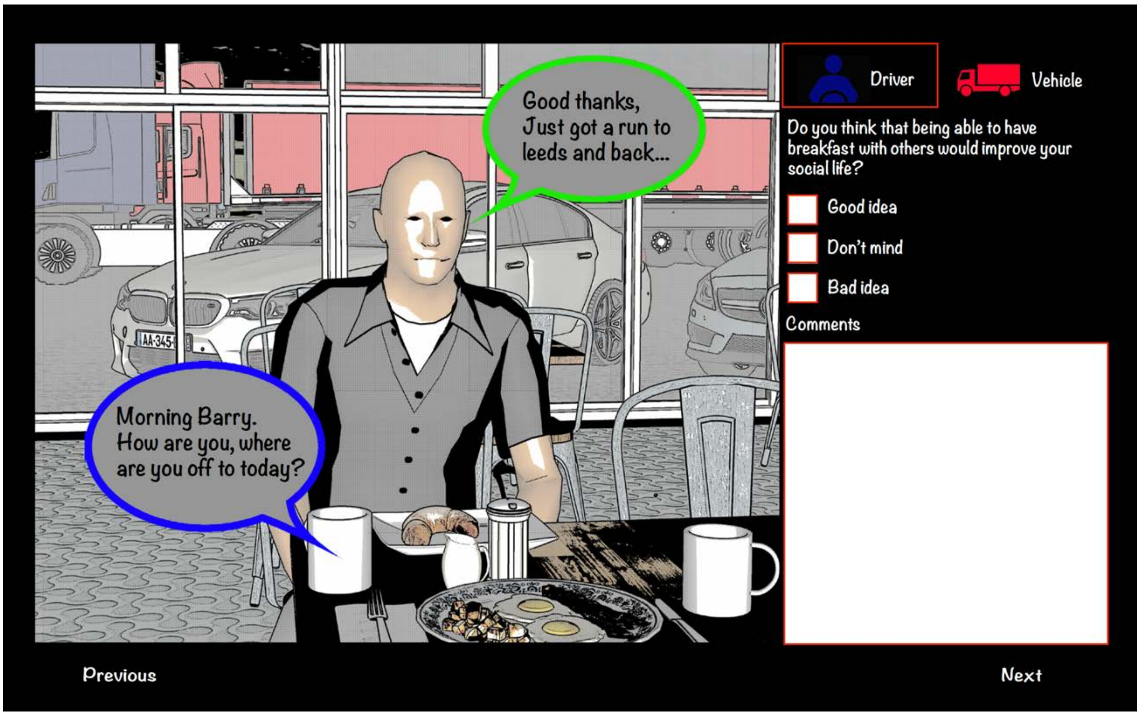


Figure 6.8. The driver gets the opportunity to have breakfast with a friend or colleague before setting off.

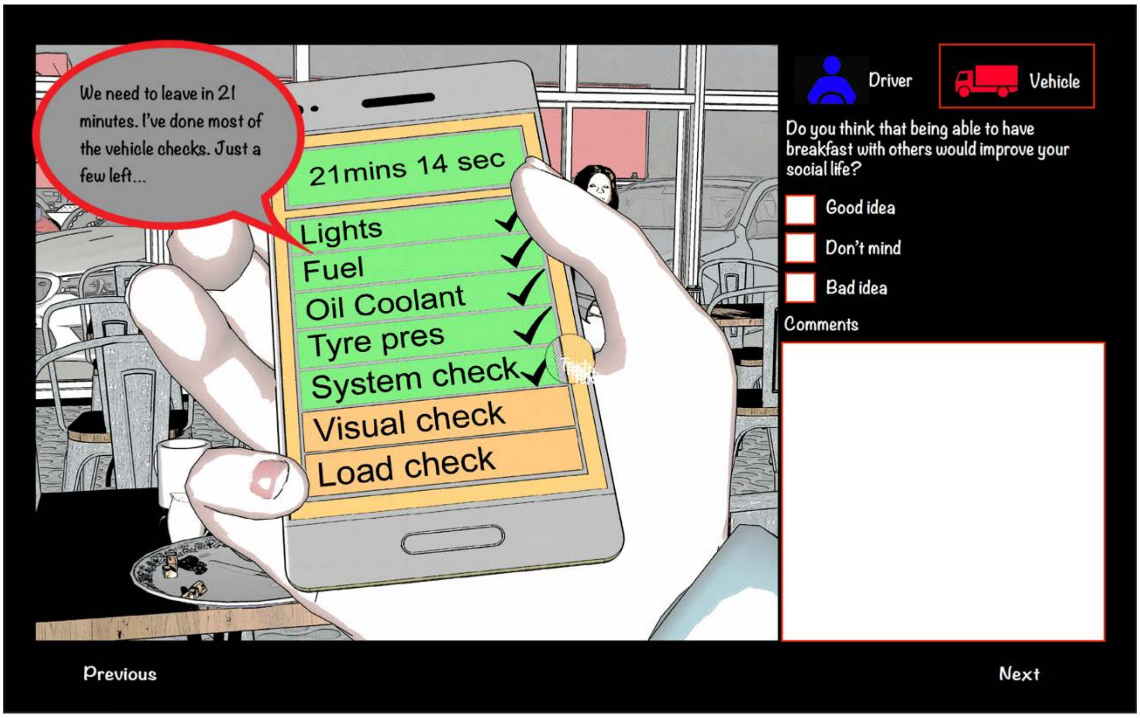


Figure 6.9. While the driver is having breakfast, the vehicle performs checks and informs the driver of any remaining checks that need to be carried out before leaving.

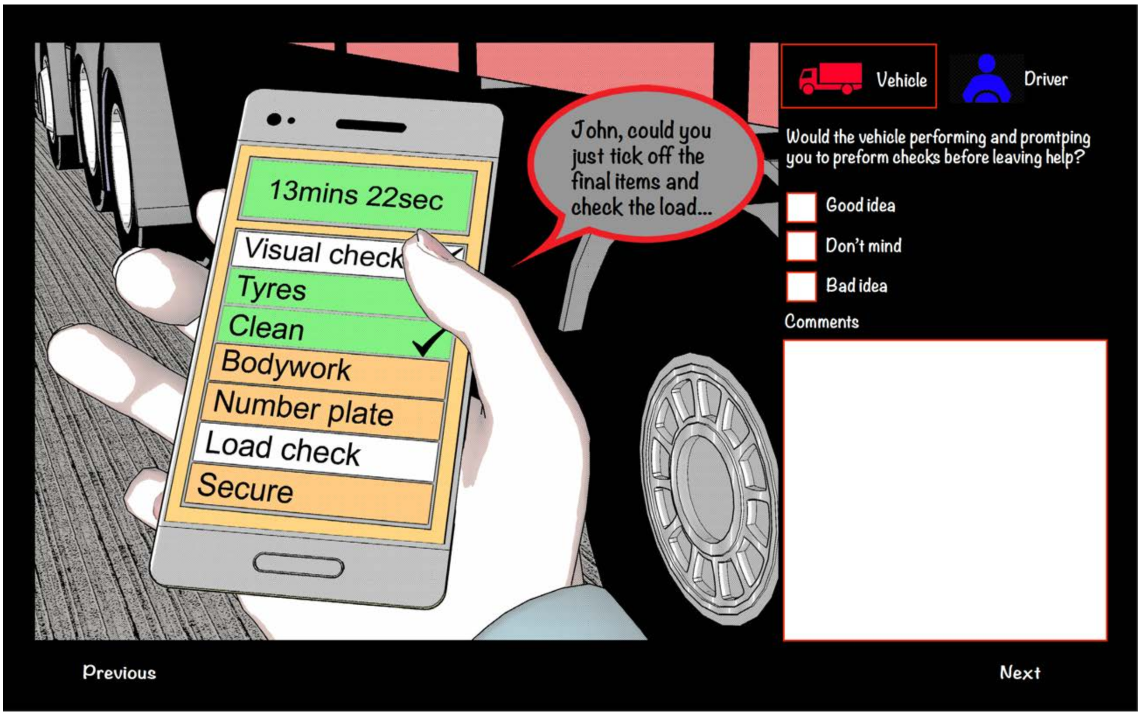


Figure 6.10. Before leaving, the vehicle prompts the drive to perform the required checks. Photos can be taken so that the driver has a record.

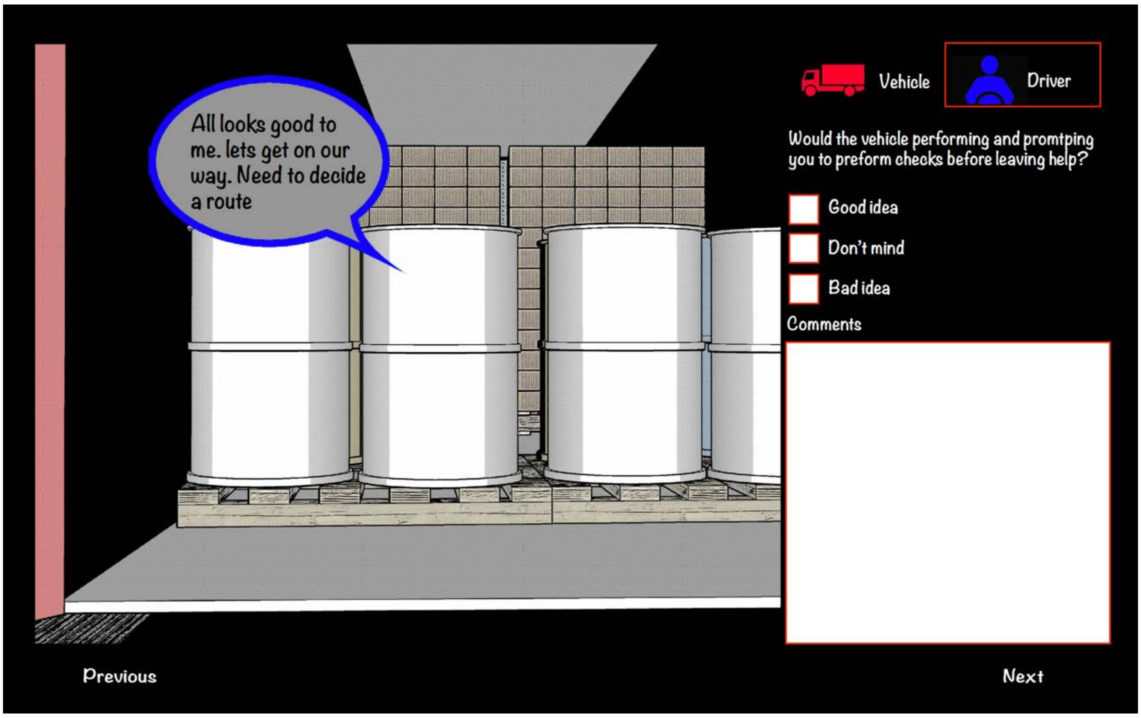


Figure 6.11. Finally, the load is checked, photos are taken and driver is ready to get on their way.

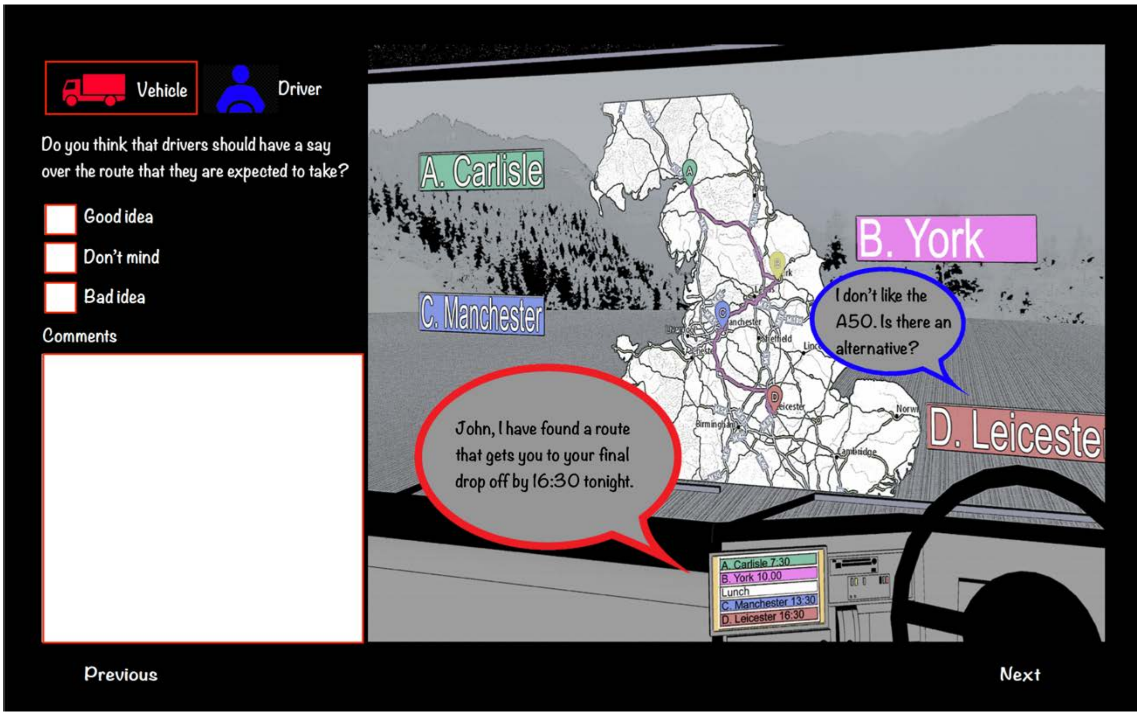


Figure 6.12. The vehicle suggests a route which gets the driver to their final drop off by 16:30.

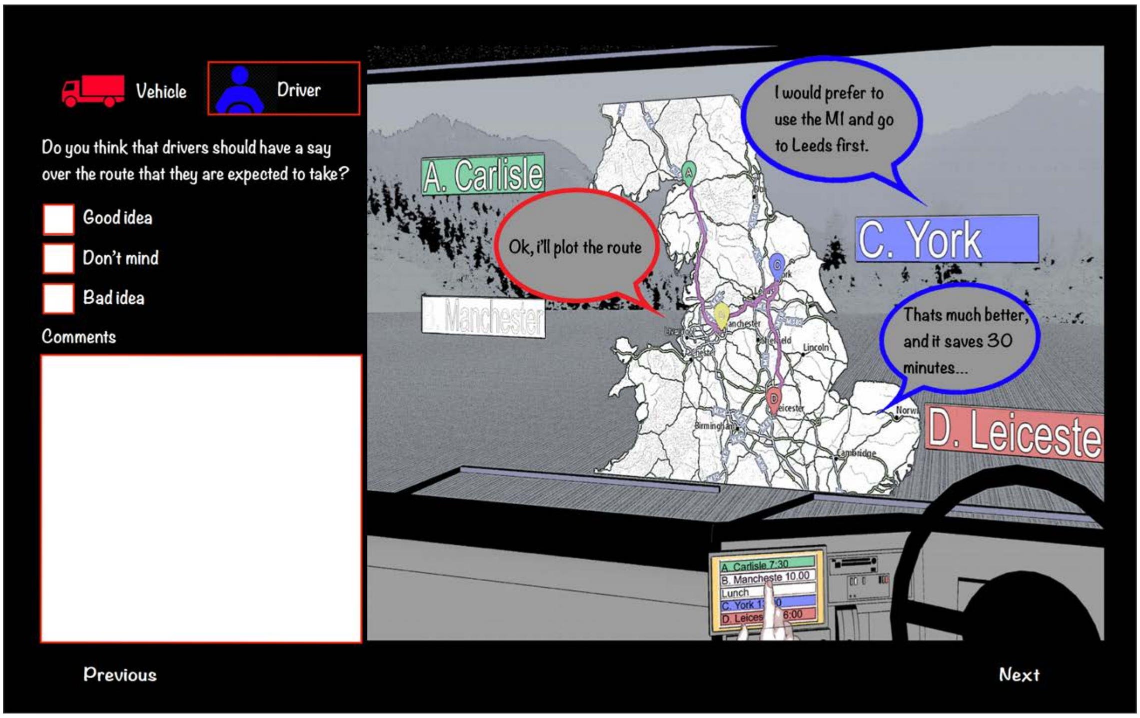


Figure 6.13. The driver however has a personal preference, which is actually scheduled to be 30 minutes quicker, despite the slightly longer distance. The vehicle updates the drop off schedule and informs the customers.

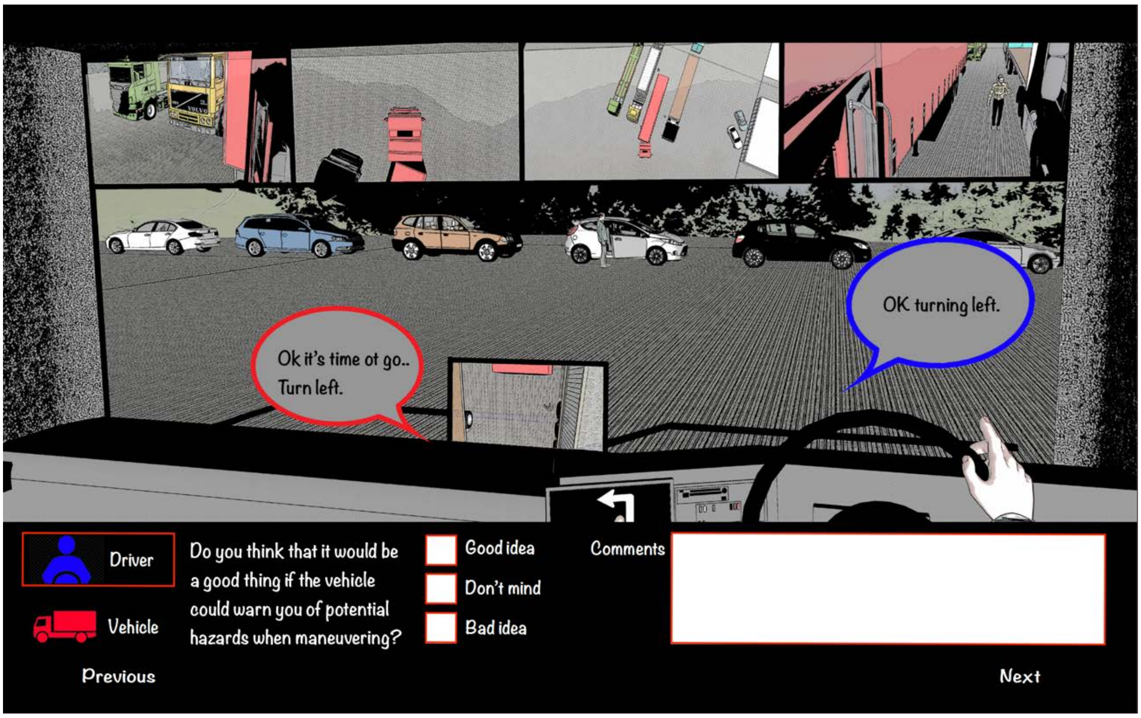


Figure 6.14. With checks done and the route set up, it's time to leave.

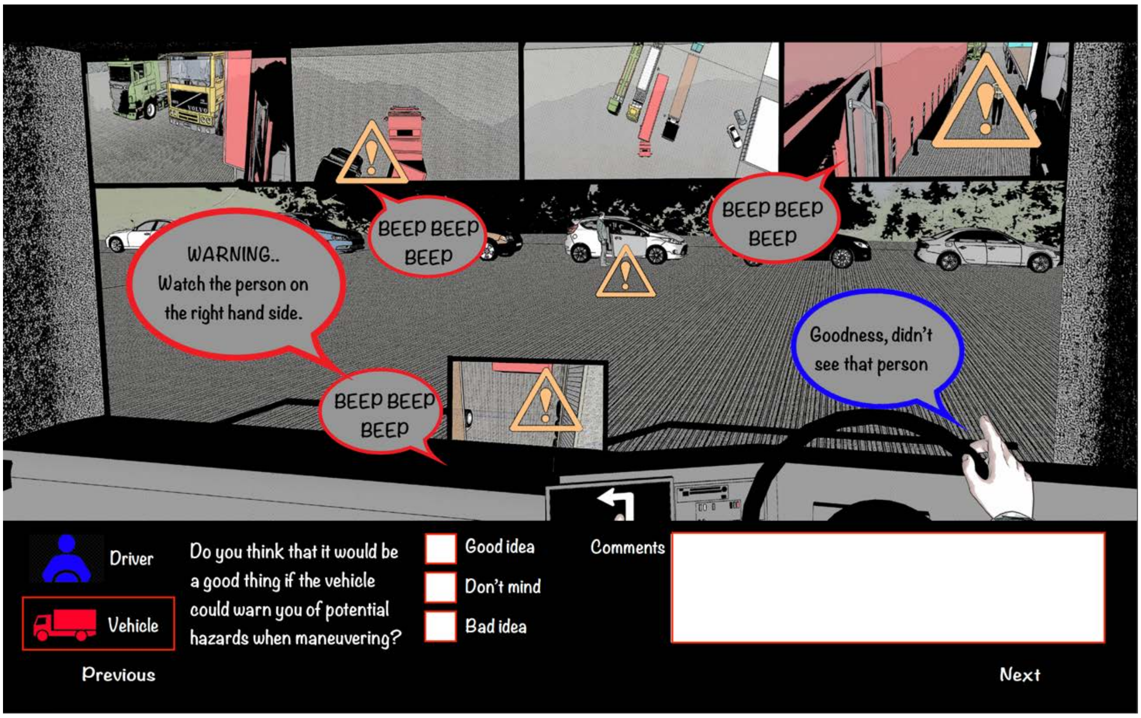
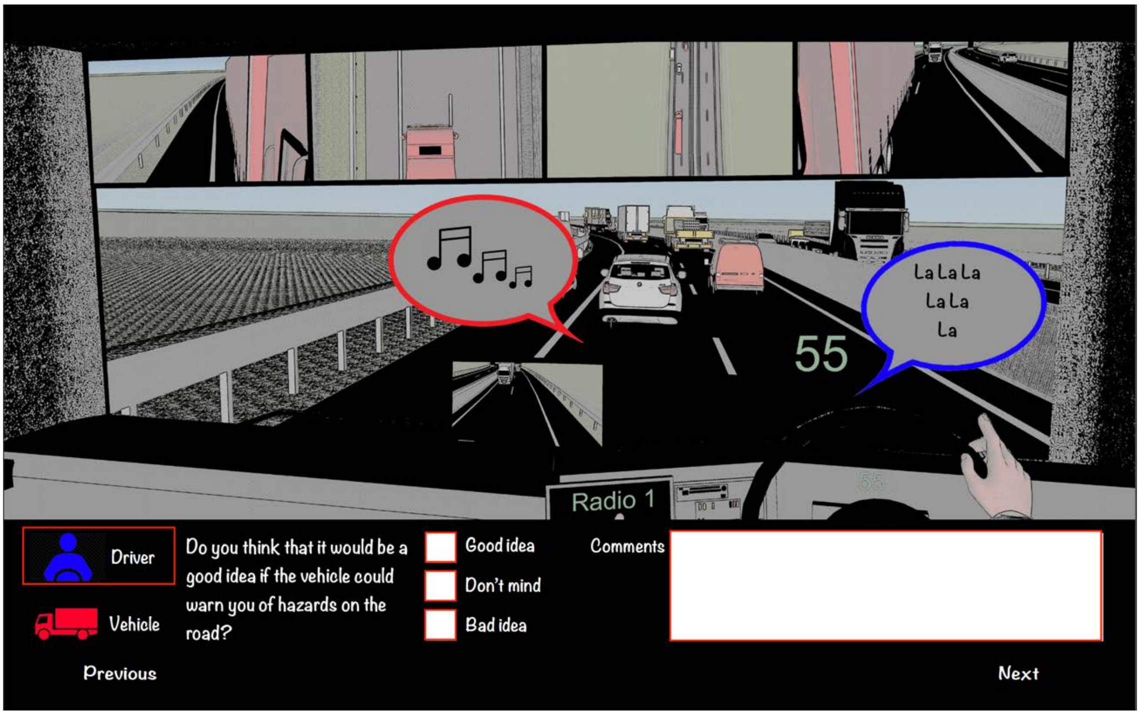


Figure 6.15. The vehicle warns the driver of the pedestrian he has missed on the right-hand side. The vehicle can also raise awareness of other potential hazards around the vehicle.



The driver is happily driving down the road while singing, sharing their workload with the vehicle.

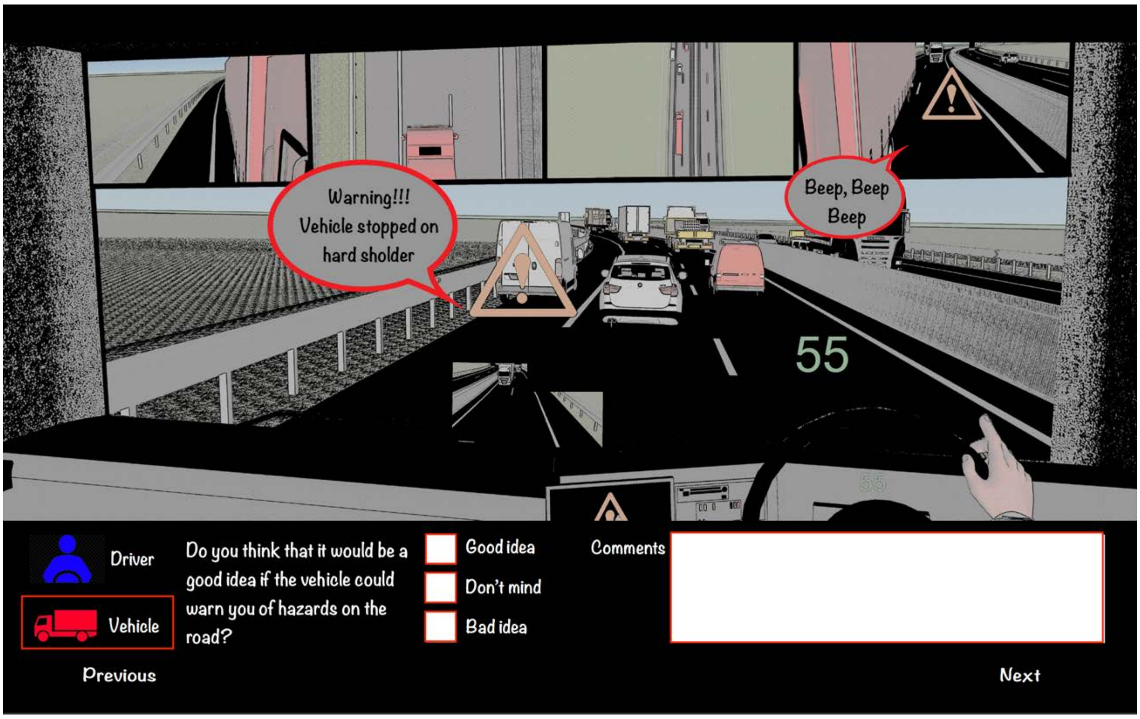


Figure 6.16. The vehicle alerts the driver to a potential hazard; a vehicle stopped on the hard shoulder as another lorry is overtaking, leaving the driver nowhere to go if needed.

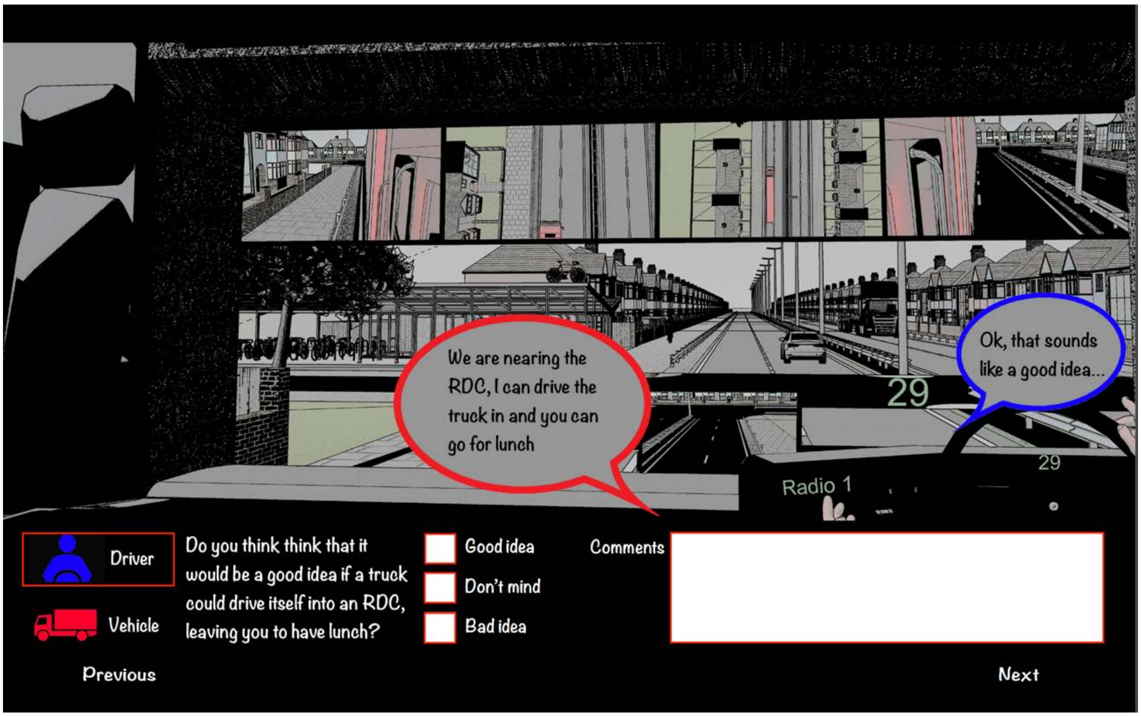


Figure 6.17. As the driver approaches an RDC, the lorry can take over, leaving the driver to have lunch.

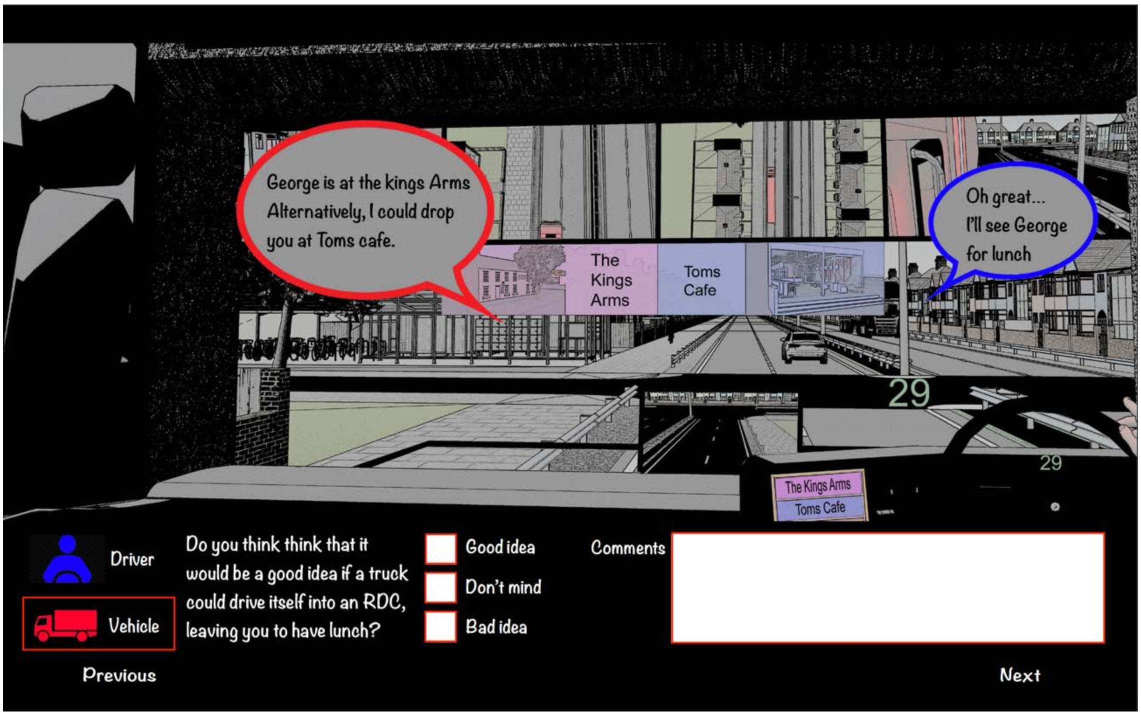


Figure 6.18. The driver chooses a place to have lunch while the lorry is being unloaded at the RDC. The driver decides to go to the Kings Head, where his colleague is.

Figure 6.19. The driver is dropped off at the Kings Head and the vehicle proceeds alone to the RDC.

Figure 6.20. The vehicle arrives at the RDC and is told where to go to be unloaded. This means that the vehicle could be unloaded in a bay which is designed without the need to look after drivers.

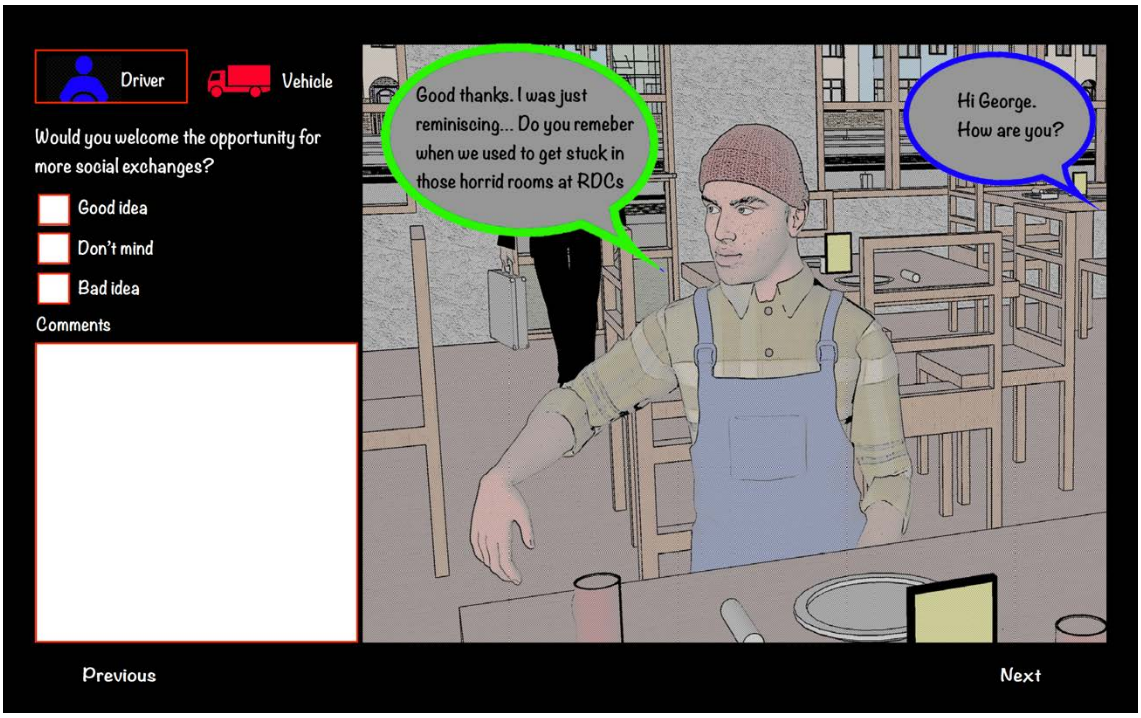


Figure 6.21. The driver sits happily having lunch with his colleague George.

Figure 6.22. When the unload is nearly complete, the vehicle informs the driver to get ready.

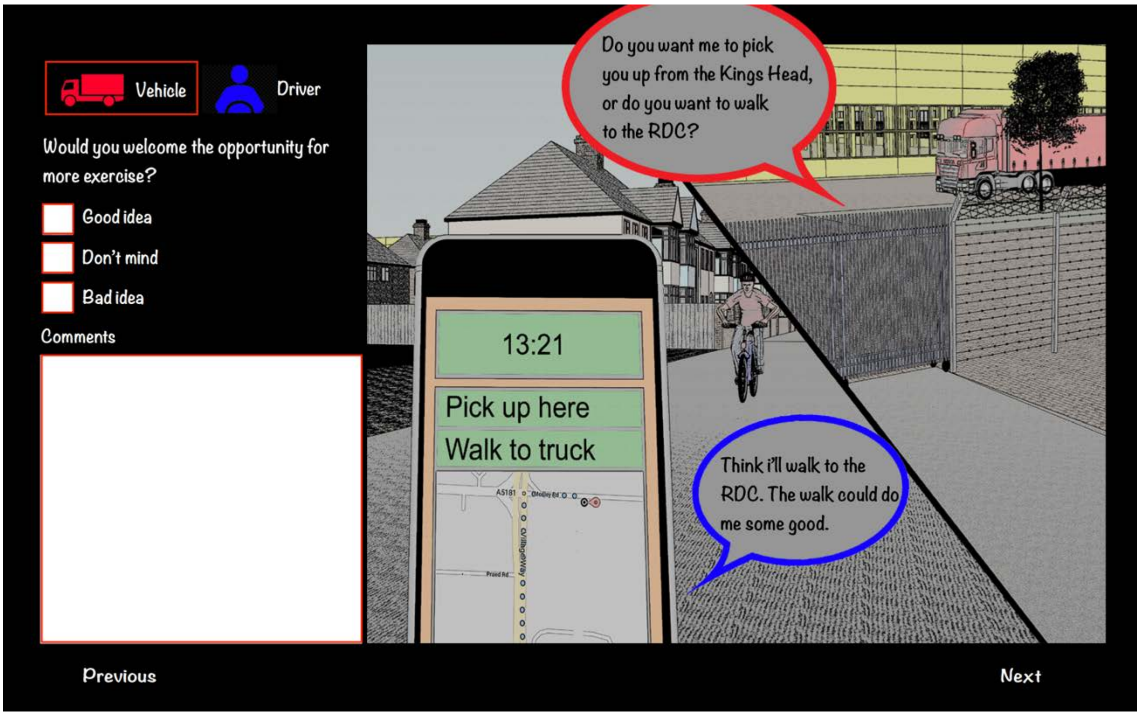


Figure 6.23. The driver has a choice whether to walk to the RDC or be picked up again from the Kings Head.

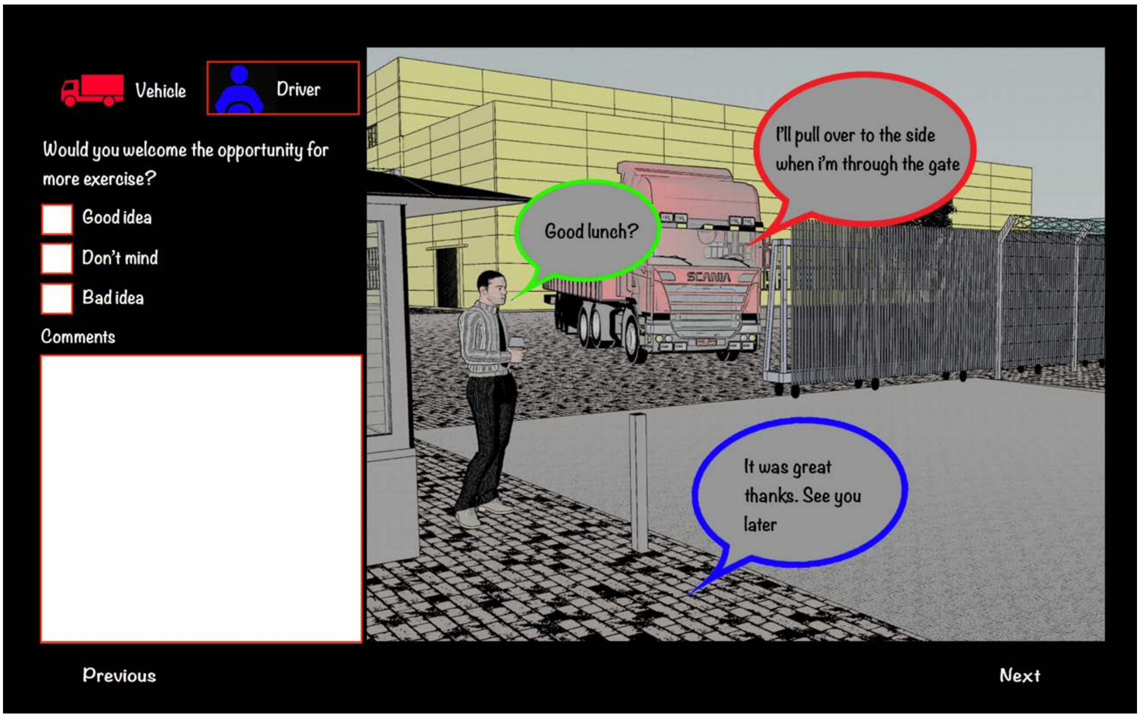


Figure 6.24. In this case, the driver decides to get some exercise and walks to the RDC; meeting the vehicle at the gate.

Figure 6.25. The next drop-off is a tricky one. The driver and vehicle pull to the side of the road to plan the next delivery.

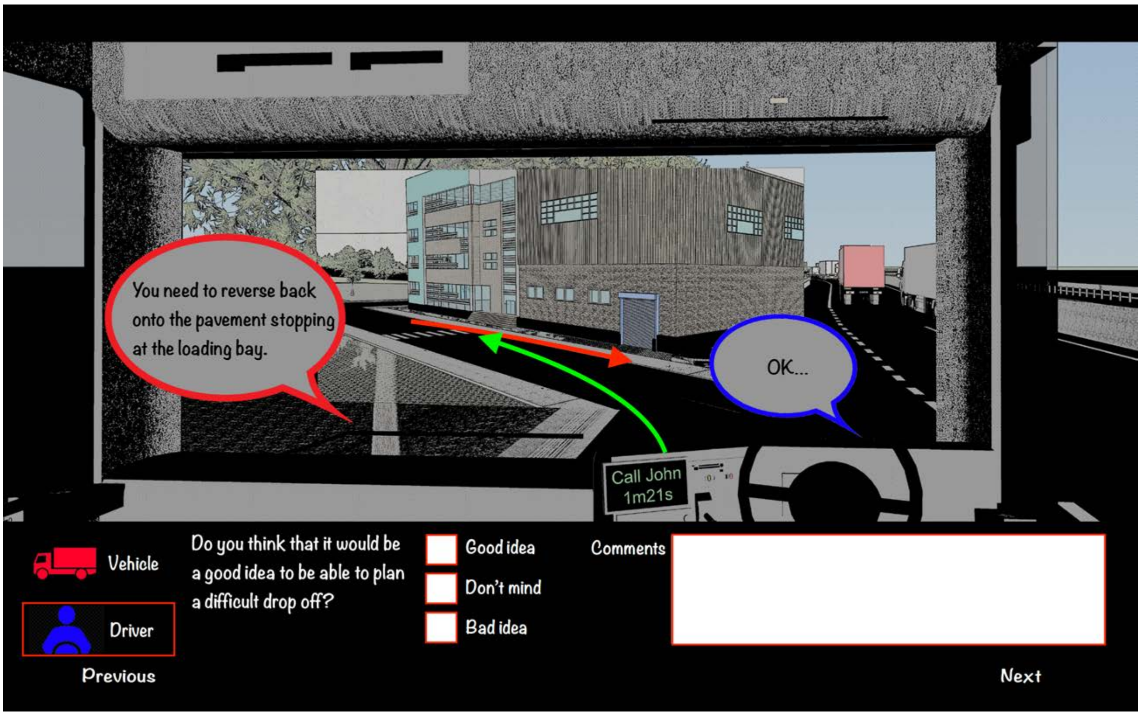


Figure 6.26. The vehicle has an uploaded plan of the next drop-off. The vehicle is unable to perform the manoeuvre as it requires driving on the pavement. The driver can look at the plans to understand how the manoeuvre needs to be performed.

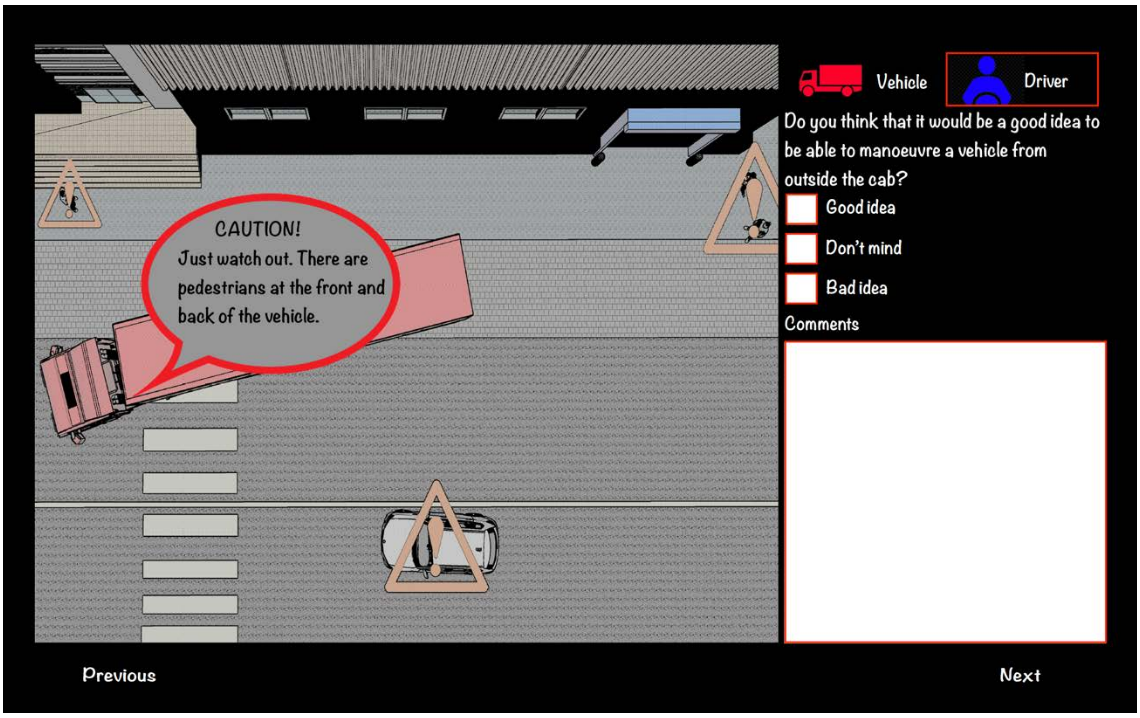


Figure 6.27. The vehicle can use sensors to keep a watchful eye over any hazards while the driver performs the manoeuvre.

Figure 6.28. The driver steps out of the cab to perform the manoeuvre using a tablet. This gives the driver greater visibility and the ability to communicate with other road users.

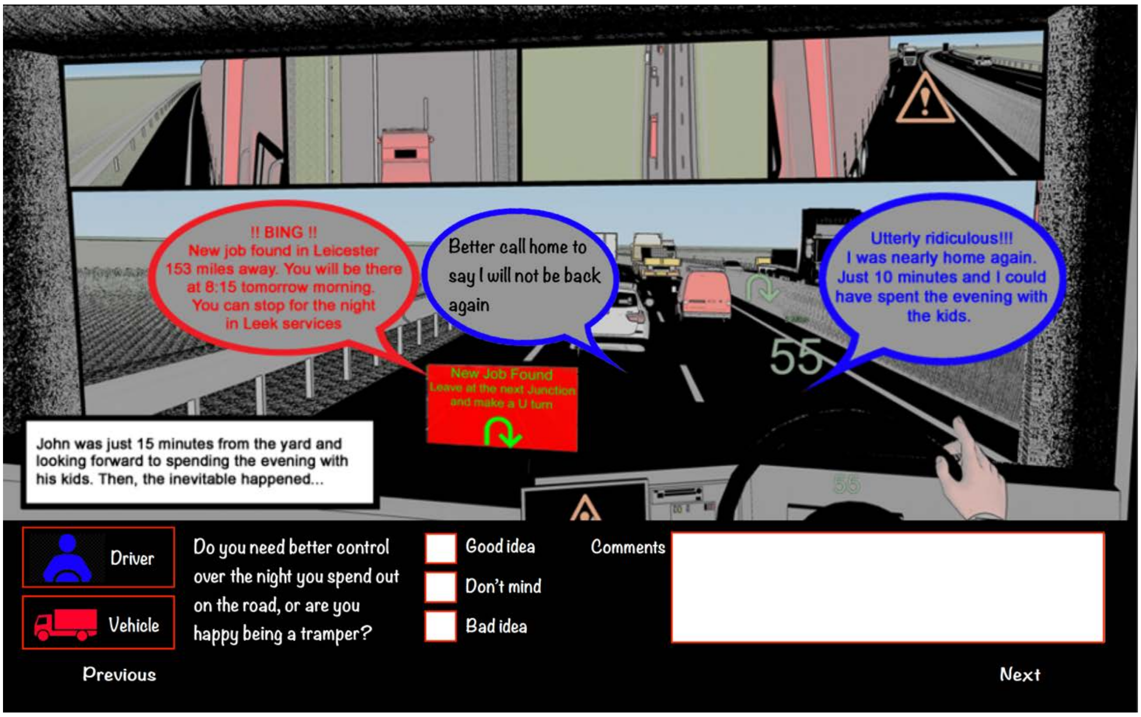


Figure 6.29. Finally, the driver is on their way home. However, it is not long before another job comes in, requiring the driver to turn around and spend another night out on the road.

The research into driver experiences found that the picture painted by drivers living by the side of the road was bleak (Morton et al., 2019). Drivers reported that an overnight stop with no facilities, or fresh produce and with other traffic passing by all night, resulted in sleep being hard to come by, this could again be depicted with a comic strip.

A common theme spoken about among participants was how drivers felt that technology had reduced the number of social exchanges which took. Drivers reported that when looking around a café or truck stop, nearly every driver has their head down in a phone or tablet. However, technologies such as phones and tablets had also proved to be positive. When drivers are away from home, stuck in a lay-by, Facetime and Skype provide a way of staying in touch with friends and family members as depicted in Figure 6.30. However, technology such as this did not make up for missing their children grow (Morton et al., 2019).

Figure 6.30. An example of a data comic showing the positives of digital devices that have been reported by HGV drivers.

Throughout the qualitative interviews, participants often gave examples of particular instances or anecdotes, as demonstrated in Figures 1 and 2. As the designer of the data comics, it is our role to place stories within the context of the research question, creating a narrative that stakeholders can understand and relate to. As the author of the participant's stories, we must consider how we place them in a real-world context. We must consider how the stories link the research question and the participant's meaning.

There are two main ways in which designers can articulate these stories; linear and non-linear. In a linear timeline, participants' stories can be played out by multiple characters within the comics, or, by combining stories to be played out by a single character. The advantage of a linear timeline is that stakeholders can often relate to the character within the narratives, recognising common trends between their own experiences and those portrayed in the comics (Kim et al., 2018). These recognisable narratives place the reader within the reality played out in the comics through which future speculations can be explored and tested. In a non-linear timeline, participants' stories converge and intersect, enabling the timeline to focus on a single event (Kim et al., 2018). This enables the mechanisms that lead up to an event and the consequences of the event to be played out in detail, through multiple characters. What is important, is that the stories are placed within the environment and social context in which they originated. Without this context or the mechanisms that led to the experience, the story could be seen as hypothetical or unrealistic. Visually, comics are a valuable tool to communicate this social context, as they can convey notions of movement, noise, expression, emotions and interaction (Flowers, 2017).

6.4.2 Future design narratives

One of the most critical aspects of these kinds of visual speculations is context. In this process of creating new futures, as designers we are looking to speculate on plausible future scenarios. For the plausible to remain true to the reader, we must be able to place the reader within the narrative (Auger, 2013). Therefore, the reader must be able to understand the context which takes us from the world we know today, to the futures that as designers we are exploring and testing (Auger, 2013).

As we project into the future, what remains important to this process is not the product or technology but the world that we create, the social, the ethical or the experience that is created. This method does not concern the object orientated ontology, how sexy or tactile this new technology may be, but how it changes transforms and disrupts our current lives and working practices (Dunne & Raby, 2013).

These comic strips could form a collection of short stories playing out different scenarios. Alternatively, the comics could portray a single story from differing perspectives and contexts. The final option could be a single story from the perspective of a single user, which may be a valid way of exploring scenarios, problems, or opportunities which present themselves in a single place or time. What is important is that we don’t just present the future from a single viewpoint but incorporate the views from as many stakeholders as we can. The futures that are then created should be shared again with as many stakeholders as possible in the participatory phase, to help mitigate bias.

Using projected futures

So how do we go about creating our projected or near futures? In the case study, a few future trajectories were identified through the discussions held with participants. One of the most pertinent discussions was about the role of the driver, as automation increases. Many participants gave good examples of how increased automation in trucks was beginning to have an effect on them. Using these discussions, we can both document and speculate on how technology is already changing the experience of drivers.

Speculating on the future, trucks today are getting ever closer to driving themselves. However, the reality is, that these systems are far from foolproof and as such, require constant monitoring (Körber et al., 2018). Therein lies the problem, if the driver is not carrying out the task of driving and the workload is nearly non-existent, the job becomes like sitting waiting in a doctor's surgery all day, waiting for your name to be called. It is not hard to think about how this could be explored within the narrative of a comic. We can explore both the experience and the consequences of the experience, such as when the driver is needed, they are not ready. So, at one level, we can explore the world as we know it today, showing how a driver could drift off to sleep while driving.

We can also speculate further into the future while still retaining a context that would be recognised by readers if automation does reach a level of capability, wherein specific environments, the driver is not required, for example, SAE level IV (SAE International, 2019), then what will be the role of the driver. It is unlikely that drivers could be removed entirely from vehicles in towns and cities in the near future. If this was to be the case, the role of the driver might look very different, with the driver asleep in the back of the cab while the vehicle drives down the motorway. When the vehicle nears a town or city, the driver gets woken up to take over. The cartoons could demonstrate ethically challenging issues that would exist around such working practices. For example, would the driver meet the regulatory requirements for ‘rest’ when he/she is asleep in the back of a truck? Would this mean that drivers would spend days trapped in a moving truck, as a prisoner to autonomous algorithms?

Using concept futures

Conceptual futures are often hinged around creating the narrative in which to place a commercial concept, which at times can be hard to achieve. To give an example of this, Renault has created a concept vehicle which they market as seamlessly fitting into the domestic lounge, becoming an extension of the living space (Renault, 2018).

It is hard to imagine how this concept is relevant to the world in which we live today. It is however still important to test such scenarios to gain responses, by placing such visions into comics. This kind of future could be drawn by creating scenarios. For example, when we drive home, rather than leaving the vehicle out on the driveway, the vehicle could drive itself inside for us to utilise all the digital capacity and interfaces such a vehicle would undoubtedly have. While many would not see a value in such concepts, some may see it from a different angle, reflecting on their own experiences and lives. There are, however, many similar concepts which place themselves within a different context. A similar example would be how designers from Rolls Royce with their next 100 concepts and Audi with their long-distance lounge concept as seen in Figure 6.31, have explored the notion that a vehicle can become an extension of the residential living space while away from home, the opposite way around to Renault. This vision of the future could be contextualised within the growing demographic group of super commuters, who travel long distances to work for one or two days a week while working from home the rest of the time.

Figure 6.31. Audi's long-distance lounge concept explores how the interior of vehicles could be reimagined (source. Alexander Herold and Audi).

While this method of documenting other concepts can provide a critique of the agenda of manufacturers and tech giants, we should also consider how these concepts are observed when placed within alternative contexts. Many truck concepts view the driver as essential to the operation of future trucks, like with Iveco's Z truck, which supplements the human role with autonomous technologies. By contrast, some future truck concepts remove the driver altogether. Through the exploration of both car and truck concepts, we can start to challenge and better understand the role of the driver in both the context of fully autonomous vehicles and vehicles which seek to augment the human driver's capability. As designers, we could explore these concepts through a range of contexts, for example, the commuter, the occasional user and the truck driver. While much of the work today focuses on the city, it is important that we do not forget the role of vehicle in both suburban and rural locations where vehicles play a more critical role in social mobility. By placing these concepts within a range of contexts, we can begin to explore where we are likely to see adoption, and where we are likely to see resistance from user groups.

Making alternative futures, the what ifs

Alternative futures are perhaps the most challenging stage for us as designers to explore. It is often hard to think of how alternative futures may play out or emerge, but through the rigorous investigation and exploration of the data on which the cartoons are based, it is highly likely that particular themes or topics may emerge. In the case study example, there were a few themes which emerged. The first theme to emerge was the widely reported belief among participants that if SAE level V (SAE International, 2019) vehicle automation did become viable, then there may be no human drivers on the same network of roads. As a result of the experiences and challenges faced by drivers using early driver assistance systems, there was a lack of confidence that machines could ever drive with humans (Morton et al., 2019). The main problem was the system’s ability to interact with other humans, namely the driver and other drivers. The participants believed that for driverless vehicles to be a reality, drivers would have to be removed from the equation altogether. It was thought among participants, that the total removal of human drivers would have profound effects on city design and how citizens would engage with vehicle infrastructure and each other.

Speculating on how alternative futures may play out, there were three main proposals of how the total removal of human drivers from autonomous infrastructure could be viewed. The first of these proposals was the most obvious; all vehicles would no longer have drivers in them, operated through ride-share. How trucks fitted into this view of the future was questioned by the participants. What also emerged, is that participants felt that if truly driverless vehicles were to exist, then the landscape in which they operate, would also have to change. For example, they believed that there would have to be a clear definition between people and vehicles (Morton et al., 2019). Vehicle space would have to be clearly defined between ancillary spaces and the highway, while they also expressed concern that the general state of road infrastructure would have to be improved. This improvement would most critically have to take place in towns and cities, to allow lorries to move without encroaching on other users' spaces.

An alternative proposal was a secondary layer of infrastructure exclusively for driverless vehicles. Participants saw these as potentially high-speed superhighways on which the rider would exit near to the destination. When reaching an exit point, the driver would be required to take over the task of driving. These superhighways in the participant's opinion would have to be highly engineered and defined motorway style spaces, utilised exclusively by driverless vehicles (Morton et al., 2019). While on these superhighways, drivers could do anything other than driving, before being told well in advance of needing to take over again. This proposal, in their opinion, would require a new layer of infrastructure on which these driverless cars would travel, old or driven vehicles would be required to use the older motorway and road networks. This new infrastructure would potentially end up producing a sci-fi like, layering of the city with old technologies confined to the ground. The latest and fastest driverless vehicles using the elevated superhighways as depicted in Figure 6.32. This future scenario could be pushed even further by the super wealthy, using driverless flying cars which dock directly into commercial and residential buildings, allowing the super wealthy never to make contact with the old redundant ground layer.

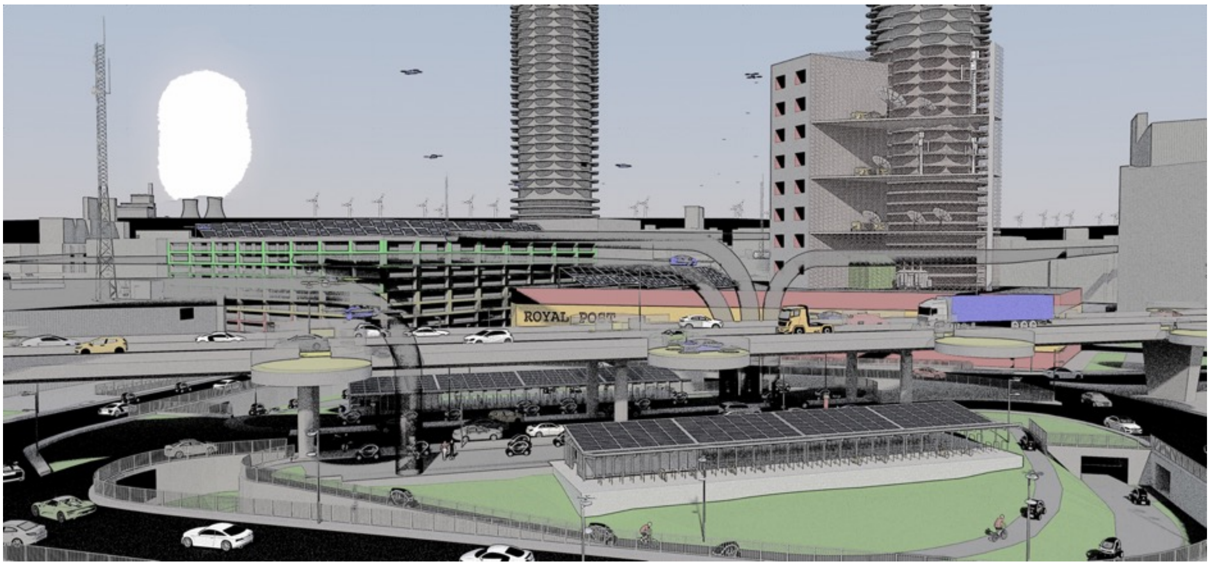


Figure 6.32. An image depicting a vertical superhighway with flying vehicles docking directly into buildings.

The final future scenario was not speculated on directly by participants but did emerge as a result of the discussions. Participants felt that driverless vehicles would not happen in cities due to the number of changes and cooperation required between different parties. As a result, we could speculate on a growing trend to remove vehicles such as cars, vans, and trucks altogether from cities. At first sight, this appears to create a utopian vision of the city, with no pollution or noise, with children free to play in the street and cyclists free to roam everywhere. However, on closer inspection, this utopian model could rather quickly turn quite dystopian. With city centre retail struggling for two reasons; the convenience of online shopping and the rising cost of owning and operating commercial space, it is hard to imagine the city surviving in its current form. Retailers are losing interest in city centres, partly due to supply chains as many inner-city stores cannot be accessed by HGVs, making the final mile of logistics more expensive (Gogas & Nathanail, 2017). What would be the case if these vans now had to make overnight deliveries or were banned altogether? Many businesses that once invigorated our city centres are beginning to turn their back on this urban model, increasingly closing city and town centre locations in favour of cheaper out of town space. If this trend continued, what would be the result? We would see visions of the future that portrayed a derelict wasteland on urban infrastructure, not dissimilar to what was seen in Detroit during the 1980s. Conversely, we could portray a shiny new vision of the city, with people engaging in the street, using space once consumed by cars for leisure activities, with cafés, shops and businesses booming as a result of people flocking to this now new urban leisure-scape as depicted by Fosters + Partners Figure 6.33.

Figure 6.33. Skyride, a carless vision of the future produced by Foster + Partners show how high-level roads could be re-imagined as cycle ways (Source. Fosters + Partners).

6.4.3 Participant engagement

This section will discuss how data comics can be used to test and explore futures through participation with key stakeholders. The main aim of this method is to get different stakeholders to engage with each other's futures and not just the futures of their own creation. It is through the common ground that the comics create that will generate new data, although the form that this data will take will depend on the research question and the methodological approach of the wider study.

A key decision at this point is whether to use research methods that fit within a quantitative or qualitative methodology. Cartoons can be designed in such a way to facilitate either approach. For example, a Likert rating scale could be embedded into a comic to gather data on participants attitudes to the desirability of a future scenario on a scale from 1 (strongly dislike) to 5 (strongly like). This would gather numerical data consistent with a quantitative approach (Creswell & Creswell, 2017).

Conversely, participants could simply be asked to respond to an open-ended question about a comic. This data be collected in written or verbal form and is consistent with a qualitative approach (Braun & Clarke, 2014) as seen in Figure 6.11. Whether a quantitative or qualitative approach is used may depend on the particular aims of the research. A quantitative approach may be most appropriate where the researcher aims to look for trends (Creswell & Creswell, 2017), for example, when the aim is to identify the most acceptable future technology of a choice of several. Conversely, qualitative methods may be most appropriate when the researcher wants to continue to explore the area in a more open-ended way while placing value on individual opinions (Braun & Clarke, 2014).

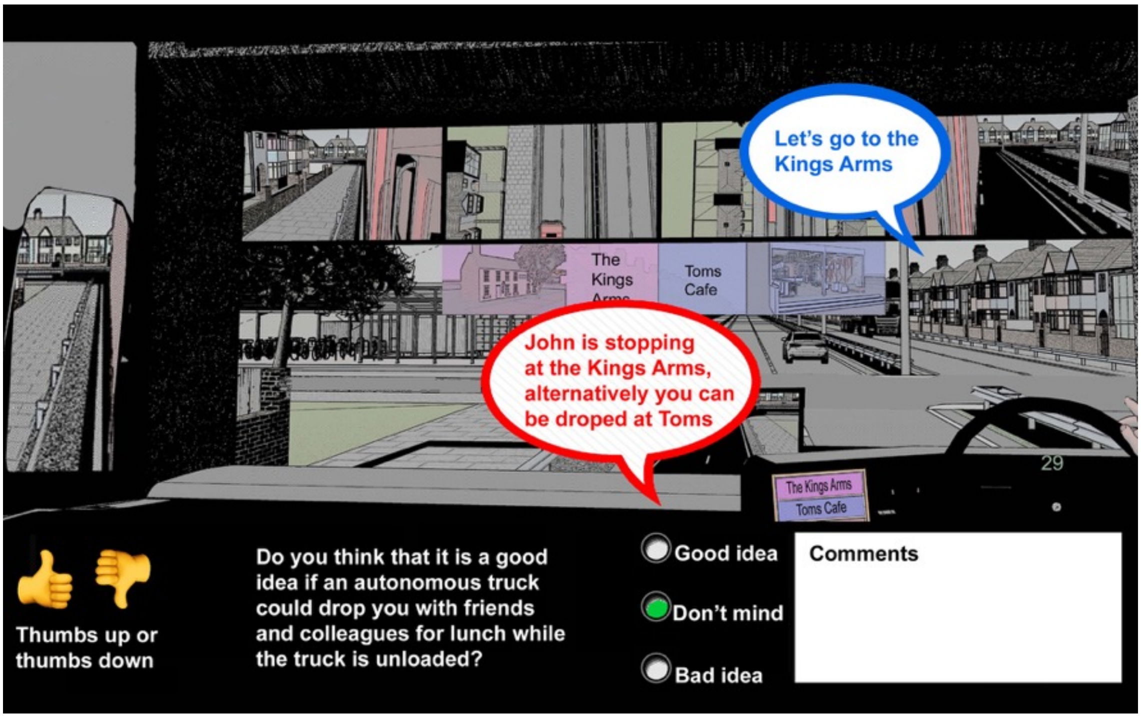


Figure 6.34. An example of a participatory data comic where stakeholders can rate and comment on the visions of the future being portrayed.

Designers should use their skills to think carefully about the best way to integrate data collection within their comics. Data collection methods do not have to be confined to simple question and answer formats, particularly given that comics may also be presented with the aid of technology. For example, the number of 'likes' would be counted if the comic strips were to be displayed digitally. Alternatively, a "choose your own adventure" style comic could be used where participants are asked to make decisions at critical points in a storyline, determining where the story leads depending on individual preference (Wilson-Stewart, 2017). The decisions made by individuals could be recorded, generating data which can be used to answer questions such as which demographic groups prefer a particular future. This method would have the advantage of being able to both set the context of the future scenario while making participants' engagement with the media, an integral part of data collection. This approach represents a new area of research engagement and as such, is a key area for further development by designers and investigators.

6.4.4 Re-exploring participant engagement

The following method considers how researchers would allow for reflection, reporting and if necessary, re-engagement in the design of the comics. Unlike the other methods outlined which can be used as a standalone approach, this method requires research findings to engage with. These findings can be dealt with in two ways. The first way is by using the results to present a report on the findings from participant engagement. The second option is to redesign or represent the narratives to create a second iterative round of research. The decision of what method to use depends upon what the findings have produced. In all cases, the final step will be to share the findings with other researchers and stakeholders. Essentially as designers, we want to think about these comics as data collection tools, however, from the perspective of the participants, we want them to think of them as compelling narratives on which they are providing their thoughts and experiences.

The researchers may take the decision to explore aspects of the narrative further, through the more in-depth exploration of a key area. Alternatively, the decision could be made to approach a different user group. Approaching a different or new user group may elicit a new understanding as participants place different experiences and priorities on the narratives explored. This iterative process could theoretically be cycled until the process stops identifying new knowledge. The final stage is to report on the findings, which may form part of a written report or could be shared using the process of data comics. Whatever form of reporting is decided upon, it should be remembered that values of visual representation apply, whether asking questions or reporting on them. Therefore, the cartoons which are used to engage participants should also be used in the reporting of the results.

6.5 Discussion

The methods outlined in this chapter provide a means to explore, test and challenge new technologies, to help understand their implications for stakeholders and the way in which we live our lives. Visualising problems, solutions, and opportunities is a powerful way of informing our future. Tech companies and automotive manufacturers have such a high rate of development that change often happens with little to no consultation with users, stakeholders, and policymakers. To this end, speculative tools such as the methods discussed in this chapter, provide researchers and designers with resources to help steer and direct the kind of futures people may want.

The use of data comics has the potential to give us the tools to help inform the future, this is a process which relies on the skill and craft of the researcher. While this chapter has outlined methods which can be used to test and explore futures, it is up to the investigators to decide the appropriate stages to use. What remains essential throughout this process is that the visual content has to provide a more in-depth insight into how we want our future to operate. The reality remains that perhaps the most powerful tool to communicate is the visuals themselves. Visualisations are a valid form of communication to share complex ideas, such as how a driver perceives their relationship with a vehicle.

Although this chapter draws on a qualitative study and the speculations are based upon driverless vehicles, it is believed that the methods discussed in this chapter could be used in a wide range of applications and industries. There are many industries which face challenges from emerging technologies. There is a real value in identifying where in those technologies, the opportunities and challenges lie. Through the mutual identification of opportunities and the mitigation of challenges, both technology companies and stakeholders have the potential to benefit. It is believed that these methods have the potential to inform how technologies are developed to better meet our needs, rather than the needs of major corporations.

6.6 Limitations

As already discussed in this chapter, designers need to be aware and honest about their influences and agendas when creating future scenarios. As researchers, we have to be careful to select both stories and visions which create a balanced view of the future. There are a lot of opportunities and challenges presented by increased vehicle automation, and it is the job of the researchers to represent them without bias or prejudice. This balance is sometimes hard to achieve as at times, researchers will be keen to show challenges, such as how an autonomous truck will undertake a manoeuvre which requires it to mount the pavement, something which is illegal but is currently an everyday necessity. Alternatively, a parent running late to pick up a child from school could theoretically send an autonomous vehicle to collect them and bring them home in complete safety, secured within the cabin of a vehicle. At individual points of the comics, it is inevitable that we are going to convey technology in a particular light. It is in the overall picture that we must be sure to present a balanced position.

How we represent visions of the future should have a degree of uniformity. For example, we should not represent one story as a depiction of horror on a dark, gloomy night, setting the scene for a horrific attack, while the other future is based around going to the beach for ice cream. In this extreme example, it is plausible that any technology represented in the first scenario would be viewed differently, purely due to the context in which it is set. The narrative and context in which the designer sets the technology should not convey particular emotional scenarios, which are beyond that of the technology's ordinary operational reach. The designer should also consider creating a similar style, colour pallet, and language to create consistency between narratives. It is, of course, acceptable to convey the emotion of characters in the story when something goes well or poorly.

As mentioned in the early phases of this chapter, futures will inevitably contain social and economic agendas which bias their approaches towards future discourse. This set of methods attempts to mitigate this bias in two ways. Firstly, it places value on a wide range of stakeholder agendas, by attempting to incorporate stakeholder visions and views. Secondly, the participatory phase of the research is intended to be used to speculate on the futures created. This is done not through the output of the comics themselves, but the opinions that are attributed to them by stakeholders. Any futures that are labelled as coordinated, should have been through an iterative process of: 1) Creating futures based on differing agendas, 2) participatory engagement with a range of user groups to capture opinions and views, 3) qualitative or quantitative analysis, to support an iterative design process.

The proposed methods require artistry, design skills, and a multimethods approach, while understanding both the historical and contextual background to the subject area. This makes this set of methods difficult to access by users other than researchers. Due to the complexity and difficulties of dealing with cities and emergent technologies, it is inevitable that a wide range of methods are required. With testing, these methods could be developed into a clear and more concise tool kit, making them more accessible to a wider audience.

6.7 Conclusion

This chapter does not claim to be the answer to the problem that has existed for the last 150 years about how we design and accommodate the changes that technology inevitably brings. The methods presented in this chapter are intended to be picked up, explored and expanded on by others. Through the continual exploration over time of this emerging subject area, it is believed that the skill and craft which underpins these methods will evolve as will the techniques. These developments will help to enable us as researchers to provide clearer insights into emerging technologies. It has never been the intent or belief that we will be able to predict the future. However, by understanding what people want, through where acceptance and resistance to new technologies may lie, we can perhaps start to begin informing an equitable future by engaging all stakeholders in collaborative practice.

6.7.1 Next stages

This chapter is intended to act as a springboard to encourage researchers to continue a trajectory of questioning future technology today to understand how it may project into the future tomorrow. It is intended to engage like-minded researchers and designers who are operating within a similar space of visually speculating futures, whether based on technology or other disruptive events.

Comics currently remain an emerging method for research and offer potential to question the role of individuals within emerging technologies. This research will continue to develop the emerging method of data comics, to provide insights about users who are often overlooked and undervalued in the pursuit of technology.

7 Discussion

There is a considerable body of academic literature devoted to the subject of autonomous vehicles, connected vehicles, and smart infrastructure (Alawadhi et al., 2020). The majority of this discourse explores the opportunities that such technologies will unlock for cities and their citizens, or the technical challenges of making autonomous vehicles operational. There is little research that takes a wider view of the introduction of autonomous vehicle technologies, including the social and behavioural challenges they may present (UCL Transport Institute, 2017). There is, however, much work which looks at the ethics of autonomy in terms of safety. Most of this work focuses on the trolley problem; the ethics which govern the decision making of an autonomous vehicle in an emergency. Through the literature review (chapter 2), it was recognised that there is very little work into the low-level aspects of how machine decision making affects people's lives and working practices. There are some examples of this kind of work from McBride (2016), focusing on the ethics of how data is used and Lu “et al” (2016), focusing on the role of humans and machines when driving. However, neither of these studies report the experience of machine decision making from the driver’s perspective. There is a surprising lack of critical review of autonomous vehicles within the academic literature, which is something that this thesis attempts to address.

This discussion will consider the four research questions set out in chapter one, highlighting where the research elicits new findings and the implications of these for the stakeholder community.

7.1 What is the current thinking about autonomous vehicles?

Early on in this thesis, autonomous vehicles emerged as a technology where human-machine interfaces were beginning to be played out. The autonomous vehicle appears to be viewed as the ultimate expression of the digital age, a smartphone 2.0. Much of the literature which exists around the subject supports the belief that driverless vehicles are going to be profoundly transformative to the way we live our lives and interact with the city (Nitsche et al., 2014; Fagnant & Kockelman, 2015). Chapter one of this thesis argues that this view is supported by the history of the automotive manufacturers of both the 1900s and 1940s onwards; these periods were a time of significant transition for both technologies and the urban landscape. The 1900s saw a race to discover a propulsion technology for the future. The 1940s onwards was a period where the car was pitched against other modes of mobility such as trains, trams and walking (Schwartz & Rossen, 2015). The visions of the future conveyed in 1939 by the likes of GM with their Futurama exhibit, helped to convince a generation of people that cars and roads were the future for modern society (Maffei, 2012). The history of the automobile has taught us that some stand to lose while others will stand to gain from these new technologies. During the 1950s – 1970s, those who were unable to afford a car and move to the new suburbs were sometimes left trapped in declining inner-city housing. By contrast, those with the ability to afford cars gained greater access to jobs, healthier lifestyles and leisure opportunities.

Today, the same trends exist, with manufacturers battling over clean energy and how users will engage with the vehicles of the future. It appears that the next 20 to 30 years will again be a period of significant transition, the so-called 4th industrial revolution (Schwab, 2017). Though figures such as Jane Jacobs have been vocal critics of the automotive industry, they have had limited success in controlling the way that the car has impacted and shaped our cities and lives (Jacobs,2016). The ability to deliver our wants and desires have kept these manufacturers relevant throughout the 20th century. However, these aspirations have left many isolated and trapped in polluted urban housing. There is a need for better policy and further research to create more balanced decision making about how autonomous vehicle technologies engage with the stakeholders of our future cities.

As discussed in chapter two, the question of whether autonomous vehicles will be deployed within our cities or not, appears to be no longer relevant; it is now only a matter of time before we see these vehicles on our roads. The more relevant question today is how the future is going to look and operate, particularly in the transitional period when machines and humans will have to work together, as discussed in chapter four and five. While the reality is that no one can answer this question, we can however, through testing and research, at least begin to understand that different versions of the future present their own set of opportunities and challenges, as proposed in chapter six. It is the role of all stakeholders involved in creating these technologies, including designers and researchers, to provide a critique of these futures and explore what they may mean to our lives and working practices.

Without research which seeks to understand the impact of autonomous vehicles on all stakeholders' lives, the future has the potential to be aligned not towards the citizens of tomorrow, but the technology and manufacturing companies of today, as concluded in the literature review (chapter 2). Chapter 5 has built on the literature review by demonstrating that whilst the ethics of data driven decision making is of concern, perhaps a greater and more fundamental issue is the current failure of future visions to align with the fundamental opinions and values of users about how they want to live their lives. For example, do users want to be driven around with no role to play in their own mobilities? The findings from this research suggest that such a future does not represent what drivers actually want. Indeed, the HGV drivers interviewed as part of this research reported that they enjoyed driving.

Critics of large technology companies, such as Bruce Sterling, have argued that the likes of Google have never been interested in searching or mapping the internet (Sterling, 2014). Instead, he argues that the real objective of Google was to gather our data. The intent of technology companies is something we are all very aware of, now knowing how companies provide services in exchange for our data. The ethical issues which dominate this subject surround how these corporations use our data. The level of interrogation being carried out in exchange for services is often unclear. With connected and driverless vehicles already becoming an opportunity for massive data capture as reported by Ford's CEO, Jim Hackett (Ramsey, 2019), this trajectory is only going to become more pertinent in the future. How our data will be exchanged for driverless services remains unclear, but it seems likely to happen given the potential value of data as demonstrated in digital markets such as the smartphone (Kelly, 2016). This raises ethical questions for the future, such as how data could be used to route users and give priority through our cities to higher profile clients. The haulage industry with its tracking and dispatch systems has shown us that when machines decide our routes and ultimately how we spend our day, they raise serious social and ethical concerns.

In many autonomous vehicle visions of the future, there is not enough context or complexity to really understand how the technology will operate. Instead, the visions convey a simple, singular perspective which is portrayed as the answer to all our problems as discussed in chapter two and demonstrated by the likes of Ben's Journey (Deloitte, 2016) and Nissan's IDS concept (Nissan Online Newsroom, 2017). This research has shown that we should not be viewing the future from a singular perspective, currently often the commuter or shopper. This has been demonstrated by looking at a different user group from those focused on in the current discourse. By studying the perspectives and experiences of HGV drivers, this thesis has shown that the requirements of this user group differ greatly from that of the published visions of the future.

Reflecting some of the same concerns about singular perspectives of the future, electric vehicles have been backed by the UK government as the future, but before this can happen, there are issues which need to be addressed. While there are some clear strengths to electric vehicles, they do not necessarily meet the demands of all stakeholders. Electric vehicles do not address the issues of congestion, nor do they change the fundamental operation of cars in the city. Electric vehicles will undoubtedly lower emissions levels within cities, but there will be a cost. Currently, there is no clear strategy for how electric vehicles will be charged, leading to home-made solutions, with cables being laid along roads. Electric vehicles have been implemented without having first resolved these issues. As discussed in chapters four and five, the introduction of autonomous vehicles will also require a level of infrastructure to be installed to support these vehicles. As raised in chapter 2, are cities going to be willing to invest in the new infrastructure required to support autonomous vehicles and who will control it? Will autonomous vehicles, like electric vehicles, be introduced without these issues having been resolved?

There are future mobility models that seek to reduce the number of vehicles on the road such as car sharing models and ride sharing models like Uber, as discussed in chapter two. These models already exist today but have been predominantly developed by technology companies and as such, have been designed to be commercial models which disrupt existing systems of operation such as trains and buses (Possen, 2015). If handled and regulated correctly, ride share platforms hold substantial potential for cities, by reducing the number of cars owned by private citizens, while increasing the utilisation of the cars on the road (Bajpai, 2016). Car share models similarly afford the city opportunities through fewer cars and higher utilisation. Autonomous vehicles combined with shared ownership models and rideshare models make the future look bright, which is perhaps why Uber and Volvo have created a partnership to collectively deploy their technologies in cities. With a city full of shared autonomous vehicles, there would be no need to park cars on streets to charge; they could drive themselves somewhere to do this. One vehicle could provide the role of tens of private vehicles, clearing the streets of cars and freeing space to be used more productively for cycling, walking or other leisure activities. However, this type of model does not make any sense to lots of users such as builders and delivery drivers whose vehicles are a tool to carry out tasks as discussed in chapter four.

While there are clear potential benefits to autonomous ride share and car share models, the introduction of such mobility models means that 285,400 black cab and private hire drivers could lose their jobs in England alone (Department of Transport, 2018). It does not end there, there may be a temptation for people to get cars to run errands for them without consideration to the time or traffic such decisions would create. This is because a car’s time spent stuck in traffic will no longer impinge on the users’ time. There are also issues around peak demand, meaning that outside of these hours, cars will have to be stored, but where this will happen remains unclear. People are unlikely to want someone else's car parking on their drive. Does this mean there would have to be an increase in surface and multi-storey parking by the operators of these vehicles? Also, as discussed in chapter four, there is an issue of where a car goes after it has been used by a citizen; does it wait in the drop off location or drive around waiting for the next job, creating congestion? There are still a lot of unanswered questions around the introduction of these technologies and it is up to the city and its citizens to be thinking about defining the limitations of these technologies, to ensure that they are introduced without causing major disruption and having an overall negative impact on the city. Cities and citizens however should not be alone in setting these limitations, it is the role of the entire stakeholder community to come together and decide these futures. This highlights an area which is currently in need of further research.

The autonomous vehicle agenda is being seen by local authorities and government as the great hope to fix the future of mobilities (Griffin, 2019). This thesis suggests that the reality however requires a little more caution, with drivers voicing concerns about the challenges of making driverless vehicles truly operational without human oversight. This scepticism is supported by a recent change in the rhetoric of manufacturers, which has only started to emerge in the last year (Marshall et al., 2019). Prior to this, many manufacturers and technology giants were making grandiose claims stating that SAE level IV vehicles (SAE International, 2016) would be commercially available by 2020. Only Tesla are standing by these claims (Allen, 2019). Autonomous vehicles are far from a simple proposition, and whether they are technically possible or not in the short-term remains to be seen. Despite this, cities and policymakers must define the limits of these technologies; otherwise, autonomous vehicles will be thrust upon them with potentially undesirable consequences, as we have seen over the last 100 years of the motor car. It appears that autonomous vehicles have the potential to create as many problems as they will fix.

7.2 How have driver assistance technologies impacted on users' lives?

The qualitative study presented in chapter five found that HGV drivers hold a wealth of knowledge and experiences as early adopters of autonomous technologies. These users have unique insight into the complexities, challenges, and opportunities that these technologies present when implemented in the real world. Drivers reported that technologies are responsible for a deterioration in their working and home lives. Drivers' main objection related to the way in which machines made decisions without common sense, compassion and with no opportunity for the user to object or modify the course of action. These concerns had been raised by the likes of Neil McBride (2016), but until the qualitative interviews had been conducted as part of this thesis, there had been no real world evidence to support the theory that the systems that HGV drivers are having to work with day to day, present real social and ethical implications for people's lives. This evidences that while driverless technologies present real opportunities, currently the pioneer users are seeing them as having an overall negative impact on their lives and working experiences.

As a result of the negative experiences that HGV drivers have had with driver assistance systems and the associated dispatch and tracking systems, drivers lacked any real confidence in the future of autonomous vehicles. Drivers believed that current technologies are yet to function appropriately within the unpredictable and ever-changing, human environment of roads. As a result, they believed that either humans would have to remain as the decision maker, or machines would have to work in isolation from humans. This contributes to a key finding of the thesis that the next 20 years or more of driverless vehicle development will be fraught with challenges, as humans and machines will have to work together as older vehicles are phased out to make way for vehicles with increased levels of machine decision making.

The drivers who participated in chapter five were worried that the law states that the driver is always responsible for the actions of a vehicle, yet we are seeing emergent technologies where responsibility over the vehicle is being called into question. These concerns are also being raised by insurance companies, some of whom have stated that they are unwilling to insure driverless vehicles until the government has set clear boundaries and responsibilities for manufacturers (Hook, 2019). Currently, the legal position of a vehicle with a semi-autonomous system such as Tesla's Auto-Pilot is unclear among consumers (Palmer, 2019). In the UK, the use of such systems is illegal, however vehicles are being sold with the system and being used. However, they are operating in a grey area whereby if drivers keep their hands on the wheel, they are technically driving and so are not in breach of the law. This is an unclear position which has seen drivers and other road users killed (Palmer, 2019). There needs to be a stronger legal position as to the distribution of responsibility between the human and the machine, which is clear and unequivocally defined across all vehicles types and makes. Without legislators providing a more explicit position, it is likely that we will see more deaths as use of these technologies increase.

This thesis has highlighted that the lack of dialogue between users and autonomous vehicle manufacturers appears outdated when you look at how their competitors, Google, Apple and Microsoft engage with their users. These technology companies have a very different relationship with their users when compared to the automotive manufacturers. Technology companies view the customer as a developer and not merely as a user (Kelly, 2016). They have recognised the value in users as product developers. Technology companies receive almost instant feedback from devices such as smartphones, computers and tablets, ensuring the ability to fault find, develop key areas and identify successes. When these technology companies finally release their autonomous vehicles, perhaps they will have very different relationship with their customers. Why this distanced relationship exists between auto manufacturers and drivers is unclear.

Vehicle manufacturers are not likely to test autonomous protocol updates on customers due to safety risks associated with errors. However, developments from users' data can still go through the same rigorous testing procedures as they do today. As for the HGV manufacturers, the lack of engagement with drivers could be a result of which stakeholder groups the truck manufacturers regard as their customers. There was a perception amongst those spoken to during this study that the real customer was the fleet buyer. Drivers felt that the only person who needed to be impressed was the individual who signed the order for the trucks. This means that the priority of the manufacturer is not necessarily the driveability and experience of the vehicle, but the cost and operational efficiency it delivers. Drivers gave the example of lane keeping as one such technology which appealed to their employer owing to its marketed safety credentials. In contrast, drivers felt that such systems were superfluous technologies which promoted laziness and encouraged drivers to become distracted from the road. In support of the need for lane keeping technologies, accident statistics show that incidents where lorries unintentionally leave their lane are relatively common, contributing to 40% of total accidents (Volvo Trucks, 2013). Drivers felt that such accidents were not a result of poor driving, but rather, were a result of distraction or fatigue. Solving the issue of vehicles leaving their lane by developing a technology which increases the level of fatigue and distraction of drivers was believed to be counter-productive.

Looking at the origins of lane departure warning and the legislation which governs its fitment, the technology has advanced beyond its initial premise. The early technology and legislative requirements were designed to alert the driver via a vibration or audible warning when approaching the edge of a lane, drawing the driver's attention back to the road. Developers of later versions of the technology, lane assistance, have further developed this system meaning that the vehicle can now amend its own course to keep to the centre of the road. It is this changing relationship with these kinds of technology that we need to be wary of in the future. When the machine begins to take the lead, the human becomes superfluous until the machine makes a mistake, at which point the human has already drifted off to do something else. These worrying trends raise the question of whether vehicle technology is advancing for technology's sake, rather than to meet the needs of the users for whom they have been designed to serve. In this race to be the first, manufacturers and technology giants need to stop and reflect to understand what they are developing rather than to simply have the newest, latest and greatest thing. This can only be done through the empowerment of all stakeholders to contribute towards common goals and objectives.

The role of the designer is to consider all stakeholders, while considering the objectives of the overall scheme. To date this is not happening in the development of driverless vehicles. This will undoubtedly have to be a negotiated position in which it is unlikely that everyone will get their own way, but we need to find a common ground. Throughout the last 100 years, too much power has been placed in the hands of automotive manufacturers and technology companies. Today we are more aware of this than we ever have been, with citizens now challenging companies such as Google and Apple about how they use our data (Kelly, 2016). The stakeholders as a collective group need to challenge these great innovators of the 20th and 21st Century as opposed to giving them a free rein to shape our cities, lives and futures.

7.3 Where may opportunity and resistance to future autonomous technologies lie?

There is a question about how the future looks which is not just about preferences, but desirability. While fully functioning, autonomous vehicles have the potential to increase efficiency, these technologies could potentially create unforeseen and undesirable implications. This could create cities where we no longer need to walk and suburban sprawl is expanded, as we perceive spending time in vehicles as no longer time wasted, but as productive; allowing us to perform tasks we enjoy or need to do. This could have negative implications for public health and would provide a greater need for a growing road transport infrastructure to support ever-growing cities supported by personal transportation. With chapter four highlighting a range of potential infrastructural challenges for cities and chapter five finding that there are user groups who enjoy driving, there is a question about why an autonomous vehicle future is being portrayed by the media as such a positive step forward. Although it should be acknowledged that other user groups (e.g. commuters, social drivers) may have differing views, we are only just on the cusp of being able to ask other user groups about their experiences owing to their later exposure to these technologies.

All the drivers interviewed as part of the qualitative study said that they enjoyed driving and that is why they became lorry drivers. This supports a commonly held belief that some drivers do not want to hand over control of their vehicle. By contrast, HGV drivers said that there have always been parts of the job which they do not enjoy, such as getting the truck ready and loading and unloading, especially at regional distribution centres. It is in these tasks that drivers believed that there is a genuine opportunity for automation to benefit the industry and drivers. This example highlights that through consultation with stakeholders, we can identify opportunities to increase automation in a way that benefits all stakeholders. Interestingly, due to their negative experiences of current driverless systems and their reservations about such technologies being able to behave like humans, drivers did not perceive autonomous vehicles as a risk to their livelihoods. As a result, drivers felt that SAE Level four and five driverless vehicles would not be on the road any time during their career, except in isolated locations.

The areas of opportunity and resistance that have been raised in this thesis throughout chapters two, four and five, challenge current trajectories of vehicle automation which seek to remove the role of driving altogether. This thesis has found that this trajectory appears unlikely to be realised within the foreseeable future, due to a lack of capability of current systems, the restrictions imposed by existing infrastructure and the lack of desire for these technologies within certain user groups, as shown in chapter five. The latter point is supported by a DirectLine group (2018) study which found that only 18% of drivers believe that computers would make better decisions than humans, while 67% of drivers state that they would prefer to remain in control of their vehicle.

There is considerable potential in driverless vehicles if all the positive attributes that we are told they will deliver come true, such as social mobility, low-cost mobility, reduction in congestion and a cleaner, safer environment. This rhetoric echoes that of the motor industry of the 1930s, seeing the car as the object through which modernity will be delivered to challenge the issues that future cities will face. However, the 1930s rhetoric of social mobility, faster and cheaper travel, a cleaner environment in which users can get back to nature, through the glass of an air-conditioned vehicle, did not take long to fall apart. As we now know, suburbia sprawled and densified, fuel rose in price and roads became congested and slow. Today both manufacturers and governments place the autonomous vehicle as the great hope to get us out of this quandary, yet the fundamentals have not changed. Autonomous visions of the future show pollution eradicated, through the use of alternative fuels, multi-modal transport increased through the linking up of journeys and courteous behaviour by autonomous cars towards cyclists and pedestrians. Ride-sharing and on-demand vehicle services will aim to reduce the number of cars in circulation, but this thesis has identified concerns about these speculations.

Chapter two has identified that in the immediate future, there are serious concerns about how clear vehicle manufacturers are being about the operational limitations of their driver assistance technologies. This issue is being compounded by the lack of training being given to drivers using these systems. Even the professional drivers spoken to in chapter five had not received any formal training in using new technologies. It seems likely that we will see increases in the number of accidents as a result of humans failing to understand driver assistance technologies' capability.

Cities are complex, made up of lots of individuals, conducting their routines for lots of reasons. The reality is that it is impossible to find a singular technology which is capable of meeting the needs of all users in the city. This thesis has identified that one user group, HGV drivers, are unlikely to embrace autonomous vehicles. With further research, it is highly likely that driverless vehicles would pose similar challenges to other user groups. History has shown us that technologies that benefit some will disadvantage others. Examples include mobile banking, which allows on-demand banking for the digitally savvy but disadvantages those groups who not able to use computers or smart devices (Chaouali & Souiden, 2019).

As discussed in chapters four and chapter five, if vehicles such as service vehicles and HGVs are driven on roads alongside autonomous vehicles, then infrastructure would have to accommodate both driven and driverless vehicles. It is highly unlikely that we will see two layers of infrastructure in cities of the future, one for autonomous vehicles and one for driven vehicles. Historically, the infrastructure of cities has not evolved or grown to accommodate the introduction of new technologies (Batty, 2006). The findings from chapter five suggest that drivers believe that the most likely scenario is that driverless vehicles will remain driven by humans in all but specific situations where the infrastructure allows driverless vehicles to operate. This mix of controls means that driverless vehicles will have to engage with humans. If drivers were to remain on the road, then this means that the visions of cars seamlessly moving through cities, without stopping at intersections would not be possible. Claims that driverless vehicles would reduce congestion and travel times would not transpire. Instead, it is possible that congestion would increase, with driverless vehicles running errands and driving back out of the city to find cheap parking. Academics have a role in exploring these futures to find the limits of acceptability, while ensuring that any technologies introduced can benefit as many stakeholders as possible.

As discussed in chapter two, policymakers and city governing bodies appear to be two stakeholder groups who are often absent in the discourse taking place surrounding autonomous vehicles. The general discourse seems to be focused towards creating cities which are free from vehicles such as cars and lorries, or the introduction of so-called zero-emission vehicles. Taking a pragmatic approach, it is hard to imagine that all vehicles would be removed from our city's roads. As shown in chapter five, the reality is that some of those vehicles are an essential part of the city's operations and growth, with lorries and vans delivering goods and services.

Cities are seeking to move away from a reliance on the motor vehicle (Schwartz & Rosen, 2015). For this to happen, however, there needs to be a fundamental change in the way that cities operate. This means cities need to offer both a better and more cost-effective alternative. In conjunction with this change, any solution needs to be a carefully considered approach to reposition the city's relationship with the role that cars, vans and lorries provide. It is unlikely that electric vehicles, driverless vehicles, or the complete removal of cars, vans, and lorries provide a solution to all the city's problems. Cities need to look towards a multi modal approach which combines personal transport with mass transit as discussed in chapter four.

The findings of this thesis suggest that the implementation of autonomous HGVs will be an even more complex challenge than autonomous cars, not least due to the lack of suitability of existing road infrastructure. While the role of some HGVs being used for long-distance travel can be fulfilled by rail, the role of others cannot due to the point-to-point nature of the industry's demands. For example, as participants of chapter five pointed out, in most cases, there is a lack of rail infrastructure connecting the point of origin such as a manufacturer to the destination, for example, a supermarket. In these cases, the only solution is a lorry. Therefore, the only answer is to make the industry more efficient. However, the drive for efficiency through increased automation and machine decision making is already having a profound impact on the lives of drivers, as discussed in chapter five. HGVs are very efficient due to their scale. HGVs in cities are a highly contentious issue due to the risks they present to other road users. Despite this, HGVs are essential to the city's operation, building our buildings, servicing our infrastructure and collecting our waste. In many cases, they cannot be substituted for vans due to the weight they carry. As reported by the drivers in chapter five, the safety risks posed by HGVs are not solely a result of the vehicles themselves, but the infrastructure in which they operate, which is typically too small, requiring the use of other users' space to perform their daily operations.

It is unlikely that cities will provide more space to roads to separate the operation of vehicles like HGVs. Without infrastructural change, it is highly unlikely that we will see autonomous trucks operating in our cities as no manufacturer is likely to allow a truck to use pavements or a cycle lane to perform a manoeuvre. This means that drivers of HGVs are here to stay for the foreseeable future, but technology has a role to play. Electric trucks are in development for short-range inner-city operations (Volvo Trucks, 2019), but for these to be successful, cities will have to provide space where long distance diesel trucks can drop their trailers, to be picked up by electric HGVs.

Technology also has a role to play in ensuring that all road users remain safe around these large vehicles. This means that cities, citizens and the manufacturers need to consider the relationship that exists between HGVs, their drivers, cyclists, and pedestrians.

7.4 How can designers work with stakeholders to develop collective goals?

The use of a multimethod approach has been a strength of this thesis. Through speculative design, chapter four identified that the implementation of autonomous HGVs would raise infrastructural, legal and ethical questions. These concerns were not evident in the literature, nor the manufacturers' visions of autonomous futures. This research identified HGV drivers as a pioneering group who had been using driver assistance technologies since late 2015, individually driving hundreds of thousands of kilometres per year. The use of qualitative methods (chapter five) made it possible to elicit new understanding about how these early technologies were being viewed and the social and ethical challenges that they are presenting to the lives of HGV drivers.

The future of transport is currently dominated by researchers, futurists, manufacturers and technology companies, yet the group with the greatest expertise on the subject, drivers, are nearly always excluded from the conversation. As discussed in chapter one, manufacturers and technology companies have really been at the forefront of informing our personal transport futures. The imagery produced during the 1930s by the car manufacturers of the time, convey a similar message to the imagery we see today. Thirties marketing was not just about the sale of a car, it was about a way of life, a method through which you could, as a member of the public, step out of the past and join the ranks of the new modern, healthy, and prosperous suburbanites. It could be argued that it was not the car as an object that caused the transformation of cities and suburbia, but the lifestyles the car afforded to its users (Freund & Martin, 1993). This placed automotive companies in the driving seat for the image of the future at the time. However, there is a reality as to why these technology companies and automotive manufacturers have remain influential today as discussed in chapter two. Automotive manufacturers and technology companies make up some the world's largest public companies, which is nearly entirely dominated by four sectors (Murphy, Ponciano, Hansen & Touryalai, 2019):

1. Technology companies, such as Apple, Samsung and Microsoft.
2. Automotive manufacturers including Volkswagen, Toyota and Daimler.
3. Oil and Gas companies which fuel cars, such as Shell, Exon and Chevron.
4. Banks and financial institutions, including ICBC, Bank of China and Bank of America.

With three of the four sectors developing some of the most disruptive technologies that have emerged over the past decade, it is no surprise that these corporations are attempting to remain at the forefront of future technologies. The ability to remain relevant is perhaps most clearly evident with the oil companies, who are among the biggest spenders in renewable energy. The oil majors have spent approximately $6.2 billion in purchasing renewable energy companies to date (Hirtenstein, 2017). These major enterprises are jostling to remain relevant for the future, which means that they are not just attempting to decide where the future lies, but they are also making every attempt to influence where the future is going. This thesis finds that the agenda of being relevant for the future does not necessarily equate to being relevant to the user of the product. This is exemplified by the findings of chapter five where drivers felt that manufacturers did not see the user as the driver but as the fleet manager or logistics organisation who employed them. This can also be seen in the concepts of vehicle manufacturers documented in chapter two which appear to respond to the challenges of governments and cities to reduce congestion and lower emissions, rather than the everyday driver.

To date, there has been a lack of dialogue between the companies deploying autonomous technologies and their end users. To the author's knowledge, no previous research conducted before this thesis had sought to directly understand the impact of increased automation on HGV drivers' lives, as the pioneer users of digital dispatch routing and driver assistance systems. Surprisingly this key user group have been ignored by the projections of the future discussed in chapter two and any future research discussing HGVs such as platooning is focused on the technology and not the role of the driver. The HGV drivers interviewed in chapter five appeared to appreciate being listened to and consulted.

While this thesis has focused on HGV drivers as the end user, the reality is that the end users of autonomous technologies in the future, will include the wider city and their citizens. Whether walking, cycling, or driving, everyone at some point has to engage with a vehicle, even if it is just to cross a road. The impact of increased machine decision making on HGV drivers that has been documented in chapter five, demonstrates that the future trajectory of driverless vehicle set out by manufacturers, technology giants and governments is likely to have unforeseen impacts on the lives of users. The fact that cities and their citizens are not currently being involved in the future development of driverless vehicles is evident in the visions of the future produced by the developers of driverless technologies (Deloitte, 2016; Nissan Online Newsroom, 2017). As discussed in chapter two, nearly every vision of future autonomous mobilities produced, shows a city which is devoid of life and activity, with no other actors other than the ones using the vehicles being portrayed. This trajectory is a significant concern and something that needs to be addressed by all stakeholders in order to begin to understand the complexity of different users and their agendas which make up our cities today. All too often, visions of the future produced for autonomous vehicles are based on a single user, undertaking a role of commuting, who rarely interacts in any meaningful way with other stakeholders.

These simplistic views of the future do not account for the movement of goods, trades and services, which contribute to over 20% of total vehicle miles (Department of Transport, 2017b). These futures negate the complexity and interoperability of different users and vehicles while underestimating the challenge of managing these futures within the scale and density of our cities. Without a more holistic view of the city and the role of technology and its users, these visions cannot be considered credible projections of reality, nor are they useful as tool to explore the impact and opportunities that driverless technologies. This highlights that government, manufacturers and end users are still some way off understanding the future role of autonomous vehicles. However, this thesis has highlighted that there is an opportunity to develop truly multimodal cities through the use of cloud based autonomous vehicles, which could talk to one another, seamlessly linking journeys and differing modes of transport together.

Academics have a significant role to play by providing a critical voice to the role of future technologies by conducting research which can help policymakers, designers, and governments to be better equipped to understand the consequences of emergent technologies. More work is needed to identify those people who remain outside of the scope of mainstream technologies and who commonly get left behind. There is real momentum behind the development of autonomous technologies. It seems likely that these technologies will be used in the future, in some format, however, it is impossible to know to what extent. While the benefit for the commuter or casual user is clear to see, it is far harder to see how these technologies stack up for other users such as the builder, delivery driver, or HGV drivers.

Having recognised the current failure of autonomous technology developers to engage with user groups and the negative consequences of this for the lives of drivers (chapter 5), the thesis turned to how to create this dialogue. Chapter six presents a proposed method to enable designers to meaningfully engage drivers, cities and their citizens in the development of driverless technologies. Without such methods, it is possible that these emergent technologies will be developed and implemented in a way which fails to serve our needs and preferences. Through developing methods to explore emergent technologies, the methods put forward in this thesis aim to engage all stakeholders so we can begin to understand the limitations and conflicting opinions of different user groups. We will never be able to predict the future, but it is essential that we begin to decide the kind of futures we may want.

7.5 Strengths and weaknesses

Strengths

This thesis has identified a gap in the literature. Aside from the potential safety implications of machine decision making in vehicles, there is a lack of discourse surrounding the social and ethical implications of these technologies for our everyday lives. This deficiency is not unique to the topic of driverless vehicles but is also true of current technologies, such as driver assistance systems. To date, other than this research, no work has sought to record the real-world experience and acceptability of driver assistance technologies among HGV drivers. Yet with the industry employing around 2.4 million people and moving around 98% of all food and consumer products at some point in the supply chain (RHA, 2019a), HGV drivers represent a critical user group.

Despite the importance of the industry, there is little representation for drivers and a complete lack of research as to the working conditions many drivers face. Despite improvements to legislation and the trucks themselves, the findings presented show that drivers attribute a perceived deterioration in their working and living conditions to emergent technologies. This research has reported some key new findings about the experiences of HGV drivers using driver assistance systems, bringing focus towards a disregarded user group and showing that they have value to add to future discourse. This also highlights the need for research to consult with the users of emerging technologies in general, particularly where it is likely that the technology will have such important effects on the way we live our lives.

As raised earlier in this discussion, new findings have been generated through combining differing methodological approaches, namely qualitative research and speculative design. This has enabled the research to not just record the situation as it is today but speculate on projected futures scenarios. This has enabled us to provide a critical voice to a technology that is generally seen as positive. While there is a great deal of potential in autonomous vehicles for all stakeholders, if we are not aware of where the pitfalls and challenges lie, then these technologies could fail through consumer resistance or worse, result in serious ethical and social implications to those who engage with them. The methods discussed in chapter six set out how we may explore and mitigate against conflicting stakeholder agendas in the future.

Weaknesses

The latter part of this thesis focuses on the opinions and experiences of a sole group, HGV drivers. HGV drivers were chosen due to their exposure to driver assistance systems; a precursor to autonomous technologies. However, this inevitably creates a bias towards the opinions of individuals who may be cynical about these technologies due to fear about the threat to jobs. However, many expressed such little confidence in driverless technologies that they did not see autonomous vehicles as a viable technology, at least in their careers. This represents both a weakness of the research and also identifies an area for further work. There would have been value in gaining the perspectives of legislators and the automotive industry on the findings of this research. This was not possible within the scope of this thesis.

This study identified HGV drivers as a user group and due to the scale of the research did not seek to engage with other types of drivers, instead using HGV drivers as an exemplar to identify opportunities and challenges which have relevance to other user groups. The research would have benefitted from engaging with drivers from different industries such as postal services, couriers and builders to identify how they are experiencing driver assistance systems. One problem with engaging with drivers other than HGV drivers, is that there is not enough saturation of driver assistance systems, as the technology still remains an expensive option on vans and other types of vehicles

In phase two, rather than discussing the day to day experiences of HGV drivers, it may have been beneficial to have experienced them first hand by going out with drivers while conducting their routines. This possibility was explored but did not prove viable due to insurance company restrictions which do not allow additional occupants in the cabs of trucks unless they are essential to the duties being carried out. An additional limitation is that all participants and the majority of the data used derived from the UK. This was primarily due to both access and the fact that the UK currently has legislative and socio-economic comparability with the rest of Western Europe, extending its relevance beyond UK borders.

7.6 Further work

The findings of this research demonstrate that early adopters of driver assistance systems represent a key source of information, providing insight into how autonomous technologies will be received and implemented in the future. Further work by designers should consider drawing on the real-world experiences of this neglected group to test and explore the realities of driverless vehicles. Likewise, further work could be conducted with other types of drivers such as taxi drivers who have a wealth of knowledge through the many hours, they spend driving each day. However, unlike HGVs where driver assistance systems are common place, vehicles typically used by taxi drivers and van drivers currently are rarely fitted with such systems. This situation is rapidly changing, as more vehicles are fitted with adaptive cruise control and lane assist. As a result, within a few years there will be many more users who have the experience that HGV drivers have today.

The findings of chapter five could be translated into a series of quick guides for employers, vehicle manufacturers, government bodies and the wider haulage industry. By designing quick guides, it is believed that the research could reach a wider audience and help to both inform and mitigate some of the concerns raised by drivers. Many of these concerns could be addressed through small changes which would not incur major cost or infrastructural changes. Examples being; councils could consider areas where trucks could park in reach of a pub or café where social exchanges could take place, reducing the feelings of isolation documented in chapter five. Employers could consider how to enable drivers to return to base to sleep at home rather than being sent back out by dispatch systems. There are a series of small changes that could begin to transform the experience of drivers and their families for the better.

Another area identified for further work is to test the methods developed in chapter six. It is intended that these methods will further explore the findings of chapter five but also through piloting the methods, enable their refinement and development. It is intended that over time the methods can be refined to create a toolkit which can be utilised by designers and researchers alike. It is intended that this toolkit could help to question the role of stakeholders and emergent technologies in cities of the future and crucially, enable end users to influence the design and implementation of emergent technologies going forward.

Additionally, there are opportunities in the near future to finally understand the impact that driver assistance systems are having on the safety of our roads as they become more widely used. Currently, as discussed in chapter two, there are not enough vehicles using these systems and those that are, have typically had the features added as an option. As a result, it is difficult for researchers to unpick the cause and effect of the increases in safety currently attributed to the technology. In the near future, researchers should be able to determine if these systems are truly contributing to safer roads, or if they are having any unintended effects as a result of increasing gaze behaviours among drivers and the systems not performing as intended.

7.7 Conclusion

History tells us that the vehicles have had a profound effect on the way we live our lives, although arguably not always for the better. Vehicles have made both negative and positive contributions to society, enabling some to become more mobile than ever before and creating greater economic opportunities. On the other hand, vehicles and their associated infrastructure have also isolated and secluded parts of society. There is no reason to believe that autonomous vehicles will not have the same varied effects on members of society in the future.

This thesis does not wish to commit the act of scaremongering or imply that we should not move forward and implement future technologies. Instead, it proposes to contribute a better understanding of the role for technology to help society meet the challenges of the future. This thesis has aimed to contribute to this better understanding in three primary ways. Firstly, by understanding the literature, chapter two has established an understanding as to the direction that these technologies are taking and the societal and ethical challenges that they pose. Secondly through the use of both speculative design in chapter four and qualitative research in chapter five, this thesis has sought to contribute towards a better understanding of how individual users have already and may continue to engage with emerging driverless technologies. Lastly in chapter six, this thesis has sought to consider methods of engaging with stakeholders including HGV drivers who have to date all too often been excluded from the development and introduction of driverless technologies, despite their wealth of relevant experience as evidenced in chapter five. By better understanding the opportunities and challenges that technology will present, we as a society can make conscious decisions about whether the benefits outweigh the negatives and how we want to engage their capability in our cities.

In order to integrate autonomous vehicles into our cities, this thesis has identified some key areas that need to be addressed. At present, manufacturers, policymakers, and governments are failing to provide enough due diligence and clear guidance around how these technologies are to be deployed. This thesis has shown that this lack of direction is allowing manufacturers to dictate the agenda without understanding the realities and implications of these technologies for the lives of people using them. This thesis has highlighted that the manufacturers technologies and visions of the future cannot be universally applied to all user groups.

Cities need to be considering these technologies as part of a holistic system, supported through a multi-modal approach which takes into account the most appropriate mode for the user whilst considering the limitations of our cities' historic infrastructure. Autonomous vehicles alone will not meet the demands of our future cities. It is only through considering them as part of a holistic system of mass transit, walking, cycling and shared mobilities that we can start to meet both the demands and sustainability challenges faced by cities today. This thesis has identified that there are clear roles for increased automation which can help to drive efficiency in our cities, without detracting from the human experience. Locations like parking garages and distribution depots are ideal locations for autonomous vehicles to be deployed in the short term, removing humans without any negative impacts.

This thesis has found that technology companies currently present a confusing picture with regards to the capability of their technology. Currently, there are no minimum standards that driver assistance systems need to meet. Manufacturers also present an unclear picture through the number of different types of systems and options available, providing vehicles with differing capabilities. Without knowing the exact specification of a car, it is highly unlikely that a user will be able to determine how a vehicle will behave in an emergency. Contributing to this confusion, the HGV drivers spoken to in the qualitative study said that driver assistance technologies are unreliable and incapable of behaving appropriately in the human environment of roads. This means that drivers were often turning the systems off in order to manage everyday events such as driving through a motorway junction. This means that at times when drivers need to pay attention, they are being burdened with the additional load of managing the vehicle's driver assistance systems, yet at night when they need to be engaged, the systems are essentially driving for them, creating boredom and increased gaze behaviours. Manufacturers need to consider the relationship that exists between humans and machines. The current trajectory of humans acting as the observer to the machine needs to be questioned.

If autonomous vehicles are to take to our city's streets then the discussion about how we want them to look and operate must involve everyone. This is because if we are to believe the future concepts portraying connected autonomous vehicles, where we have cities with no traffic lights or junctions, then all city users become stakeholders.

Under such scenarios, even simple routines like crossing the road become subject to machine controlled algorithms. To date cities have not been engaged and vocal enough in raising concerns about who is going to be in control of the algorithms and what impact driverless technologies are likely to have. Cities, policy makers, and governments need to consider creating their own visions of the future, which could begin to define the limits of vehicle automation. This could help to provide clear policy, to be implemented at least in the short term until we better understand the impact autonomous technologies are likely to have. Without such policies, it is possible that current trends of automotive manufacturers dictating how our cities are built and operate will continue well into the future.

Near future technologies such as increases in driver assistance systems, need to be implemented with far more consultation with end users than we have seen to date. The drivers spoken to believed that without such consultation and engagement, it is highly likely that any further development of driver assistance technologies is likely to be met with increased resistance due to safety concerns. With increasing levels of automation, manufacturers will soon no longer be able to reasonably displace responsibility of the vehicle's actions onto the driver. With laws still centred around the actions of drivers, laws around the world seem woefully unprepared for companies such as Tesla, who appear willing to test technology on customers with the stipulation that the driver remains ready to take over. The effects of such technologies on drivers' attention to the road is limited, with only a few studies reporting simulated findings (Ko & Ji, 2018). Governments need to give themselves time to understand how autonomous technologies can be implemented safely and without negatively affecting working and living practices. Additionally, cities need time to understand the role of both the autonomous vehicle and the driver in the future. Whether governments and manufacturers will be willing to delay implementation of technology which is promising to generate £62 billion to the UK economy by 2030 (SMMT, 2019) remains to be seen.

In order to answer these questions, speculative methods need to be developed and tested to engage all drivers and stakeholders in this discourse as discussed in chapter six. This will enable society to better understand their role and the role of technologies in the city of the future. To date, we have seen manufacturers deploy technology on cities and their citizens without understanding the real-world implications both socially and ethically. There is a high stakes game being played out by the developers of autonomous vehicles to be the first to demonstrate a viable technology, with citizens such as HGV drivers currently acting as the unempowered recipients.

8 References

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9 Appendices

Appendix 1 Interview question schedule

Lancaster University

Question Schedule V1 Date: 11/09/18

- Roughly how long have you been a HGV driver? Do you enjoy it.
- What would you say has been the biggest change in the industry since you started? Skill, infrastructure, traffic, trucks, technology.
- Do feel that technology in general has changed the industry? Sat nav, tracking, mobile phones.
- **How do you feel about driver aids?** (AEBS, AEB), Adaptive cruise control, older systems such as, ABS, automatic gear boxes. Current experiences, faults, systems not working, robustness, confidence.
- How has the experience of driving changed for the better or worse (both driving and when not driving)? De-skilling, valued, trusted, facilities, social, economics.

Moving forward, speculating on the future.

- **What are your beliefs about driverless technologies? Limitations and benefits.** Based on current technology, infrastructure, experience, tasks, communication driver to driver / driver to machine.
- Who do you think will be responsible for a truck in a driverless scenario? Scania, Volvo, human. What do you think the consequences will be?
- More broadly, do you think we will see more technology? More tracking of goods, drivers etc.
- **Again, more broadly. What do you think the future looks like for drivers like yourself?** How well you are being represented and heard, DCPC (driver certificate of professional competence), changing working practices.

Appendix 2 Phase one consent statement

"Please note that this question is posted as part of an academic research project at Lancaster University and as such comments made within this thread could be used for research purposes, in future reports, academic articles, publications or presentations by the researcher/s. We will not ask for any personal information. Any personal information you post will be anonymised. Anonymised data will be kept according to the University guidelines for a minimum of 10 years. Forum members of 17 years of age or older please. For further details please email: *r.morton1@lancaster.ac.uk* *(researcher) or alternatively d.richards@lancaster.ac.uk (supervisor)".*

Appendix 3 Phase one forum consent letter

Dear Sir/Madam,

My name is Richard Morton and I am a PhD student at Lancaster University (Lancaster University profile link). I am currently researching the potential impact that driverless vehicles may have on decision making, working practices and our daily lives. I would like to start a discussion with your members about how they currently use vehicles and to explore the impact that these new technologies may have. I am writing to seek permission for me to start a thread on your forum in order to engage your members on this topic. If you would more detailed information I would be happy to discuss in more depth.

Regards Richard Morton

Appendix 4 Phase two Participant information sheet

Lancaster University

Participant information sheet

Will vehicles of the future become entirely autonomous, or due to our requirements and behaviours, will humans have to remain part of the decision-making process?

I am a PhD student at Lancaster University and I would like to invite you to take part in a research study about the future impact of driverless vehicles.

Please take time to read the following information carefully before you decide whether or not you wish to take part.

What is the study about?

This study aims to understand how driverless cars may affect drivers of the future. We want to understand how and why drivers currently use their vehicles in their day-to-day lives. We hope that these findings will help to inform stakeholders and users about the potential impact of driverless technologies.

Why have I been invited?

We have approached you because you currently use vehicles as part of your livelihood. We think that people like you are likely to be affected by these technologies. To date, this discussion has been confined to manufacturers, governments and the media. Yet, you are in the best place to understand the implications of driverless technologies.

What will I be asked to do if I take part?

If you decide to take part, this will involve being interviewed for 10-15 minutes on your opinions about autonomous vehicles. An audio recording device will be used to record what you say. If you wish, you may also leave contact information (such as an email address) to be invited to participate in later stages of this study.

What are the possible benefits from taking part?

If you take part in this study, your insights will contribute to our understanding of how driverless technologies may in the future affect working practices, social interaction and cities.

Do I have to take part?

No. It's completely up to you to decide whether or not you take part. Your participation is voluntary.

What if I change my mind?

You can only withdraw up to 6 weeks after taking part in this interview by emailing any of the contacts on this information sheet with your ID number.

Your ID Number

…………………………………………………..

What are the possible disadvantages and risks of taking part?

It is unlikely that there will be any disadvantages to taking part other than spending 10-15 minutes of your time.

Will my data be identifiable?

Your audio-recorded interview will be transcribed and anonymised at the time of transcription. The original audio recording will be deleted at the end of the study and never shared with anyone outside of this study. Your information will be assigned a random ID number. This will enable us to delete your data if you later change your mind.

How will we use the information you have shared with us and what will happen to the results of the research study?

Your anonymised information will be used for research purposes only. This will include my PhD thesis and other publications, for example journal articles. I may also present the results of my study at academic conferences.

When writing up the findings from this study, I would like to reproduce some of the views and ideas you shared with me. I will only use anonymised quotes (e.g. from my interview with you), so that although I will use your exact words, you cannot be identified in our publications.

How my data will be stored

Your data will be stored in encrypted files (that is no-one other than me, the researcher will be able to access them) and on password-protected computers. I will store hard copies of any data securely in locked cabinets in my office. I will keep data that can identify you separately from non-personal information (e.g. your views on a specific topic). In accordance with University guidelines, I will keep the data securely for a minimum of ten years. For further information about how Lancaster University processes personal data for research purposes and your data rights please visit our webpage: www.lancaster.ac.uk/research/data-protection

What if I have a question or concern?

If you have any queries or if you are unhappy with anything that happens concerning your participation in the study, please contact myself: Richard Morton

r.morton1@lancaster.ac.uk or Daniel Richards d.richards@lancaster.ac.uk

Lancaster University

LICA Building

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United Kingdom

If you have any concerns or complaints that you wish to discuss with a person who is not directly involved in the research, you can also contact:

Judith Mottram Judith.mottram@lancaster.ac.uk

Tel: +44 (0) 1524 594395

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United Kingdom

This study has been reviewed and approved by the Faculty of Arts and Social Sciences and Lancaster Management School’s Research Ethics Committee.

Thank you for considering your participation in this project.

Appendix 5 Phase two verbal consent

The following statement will be read aloud by the researcher before undertaking the interview:

This research study aims to better understand the implications of driverless vehicles on drivers of the future. To help us understand the challenges and possible impact of driverless vehicles, we want to understand more about how and why drivers currently use their vehicles. We want to use the information you give to understand how these technologies may impact the working practices and daily lives of people like you. If you agree to take part, our conversation will last about 10-15 minutes.

During our conversation, an audio device will record what is said. This is to record your consent and also make it easier for me to focus on our conversation. An anonymised transcript of our conversation will be made. The audio recording will never be shared and will be destroyed at the end of the study. If you later decide that you are unhappy with anything you have said, please contact me within 6 weeks (providing your ID number) and your information will be removed from the study. If you agree to take part, the anonymised transcripts may be used for research purposes, in future reports, academic articles, publications or presentations by the researcher/s. We will not ask for any personal information. Any personal information will be anonymised.
Anonymised data will be kept according to the University guidelines for a minimum of 10 years. If you agree to taking part, I will start the audio recording and ask you to confirm that you agree to take part and being recorded. [START RECORDING] Do you agree to take part in this study and having our conversation recorded?
[INTERVIEW]