Autonomous road transport systems: a stakeholder perspective

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Abstract

Society has gripped the concept of road transport and has utilised it for social, personal and economic gain. Amidst the apparent benefits, a number of concerns exist around the dangers, congestion, and monetary loss associated with vehicular transport. To counteract this, the introduction of driverless vehicles is being discussed by manufacturers and the Government. Whilst there are a number of apparent benefits, there is an overwhelming need to consider public perception and acceptance of autonomous vehicles. This research study therefore investigates the aforementioned, analysing and presenting the major issues and concerns related to their uptake.

An interview and focus group based approach was adopted for this research, using the Charmaz (2006) constructivist grounded theory methodology. Interviews were conducted with a range of stakeholders and the results of the study detailed that the environment the vehicle and user operate in presents associated issues influencing perceptions, and that technology acceptance is strongly influenced by levels of Motivation in Intention, Acceptance/Usage and Control. Furthermore, acceptance is perceived differently by various stakeholder groups, each with their individual concerns and speculations. The discussion of the study considers the gathered perception to ascertain how best to introduce autonomous vehicles to the public market, highlighting and satisfying the current implications of doing so. This study highlights the need for further research in this discipline, based on the identification of many knowledge gaps. Further work is discussed and recommended in order to combat the limitations and opportunities identified within this thesis.

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Dedications and Acknowledgements

Devoting such a large amount of time to a piece of work does not come without its sacrifices. To all listed below, I owe more than I can ever repay.

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Chapter 1- Introduction

1.1 Introductory Statement

Technological advancements serve to disrupt legacy systems, markets and organisations, for the purpose of delivering noticeable change and savings (Desouza et al, 2015). If applied correctly, technology supersedes its predecessor by offering increased efficiency, consistency and stability, as well as bringing long term monetary savings (NASA, 1981).

In considering the environment of vehicular travel, major technological advancements have been implemented within the sector, increasing its appeal, safety and utility. However, these changes have been incremental, with the most noticeable revolution yet to come; the introduction of driverless vehicle technology (KPMG, 2012).

Transport has a rich history of utilising automation technology. During the 1960's, automation technology was introduced to the aviation sector, where its continued adoption has led to human error being the largest remaining obstacle to achieving 100% flight safety (Griffin, 2015). Given this success and increasing automation capability, vehicle manufacturers are now attempting to implement a similar approach within road travel. However, this is not without its challenges.

The total mileage covered by all vehicles on UK roads is estimated to have been 261 billion miles in 2010, with an expected rise to 376 billion by 2035 (CBI, 2015). The personal, social and economic growth benefits of this form of travel are evident, yet reports question the overall safety and arrangements associated with this mode of transport:

- On UK roads, in the year 2015, 186,209 casualties were reported as a result of road accidents (DfT, 2016);
- The RAC Foundation (2015) report, on behalf of the DfT (2013), that from all road accidents that led to a fatality, 69% note driver/rider error as one of the contributing factors for reported incidents; and
- For each mile a driver covered in 2010, 19.2 seconds were lost, this number can be expected to increase with the growth of vehicle usage (CBI, 2015).

The above introduces the notion that in a number of situations, human error is considered to be the leading cause of incidents, with some attributing the majority of the responsibility to human users. Current research suggests that this could continue in a driverless environment with human factors not keeping pace with technical advancements within the same environment (Rosenzweig and Bartl, 2015; Hausman, 2017).

To counteract this, and to ensure the full benefits of driverless cars are realised, this thesis investigates the stakeholder perception of driverless vehicles. The purpose of the study will involve establishing an understanding key issues facing stakeholders in their attempts to accept and use driverless technology. The work of this study is supported by current literature and the AV community with recommendations from Rosezweig and Bartl (2015), Bjorner, (2015) and Habibovic at el. (2014) to continue and develop knowledge in this fertile, yet unpopulated area.

In this thesis, a grounded theory methodology will serve as the qualitative analysis technique to facilitate an empirical study with potential users and stakeholders related to driverless cars and the road transport environment in general. The specifics of this proposal will be explored within the remainder of this chapter and thesis, starting with the aims and objectives of the study, presented below.

1.2 Aims and Objectives

This study explores stakeholder perceptions of autonomous vehicle acceptance and usage. The aim of the thesis is to develop categories of acceptance that support successful uptake of driverless vehicle technology across a range of stakeholder groups. This aim will be achieved through the following research objectives:

- To review current literature on autonomous vehicle acceptance, identifying existing knowledge gaps to motivate the need of this study;
- To undertake a grounded theory study to capture perception of, and attitudes towards, autonomous vehicle acceptance and usage;
- To present findings from the grounded theory study and review against existing literature, which supports autonomous vehicle acceptance and usage by a range of road users; and
- To recommend areas of further research, through identification of opportunities presented in this research.

1.3 Selected Methodology

The methodology selected for data collection is grounded theory. Grounded theory was first introduced in 1957 by Barney Glaser and Anselm Strauss to understand the awareness of dying. The social research method is now widely utilised to gather qualitative data to service knowledge gaps (Charmaz, 2006).

The key characteristics of the grounded theory are (Glaser and Strauss, 1967; Glaser, 1978, Strauss, 1987):

- Simultaneous involvement in data collection and analysis;
- Constructing an understanding from data, not from a preconceived notion;
- Comparatively analysing data at each stage of the analysis to develop findings;
- Memo writing to elicit categories, specifying properties and relationships between categories;
- Sampling aimed toward theory construction, not for population representativeness; and
- Conducting the literature review after developing an independent analysis.

Within grounded theory, variations exist in how it is conducted and analysed, this study selected the Charmaz (2006) constructivist variant. An introduction of this can be found at Section 3.1, with the alternative variations discussed at Section 3.4.

1.4 Stakeholders of Study

The stakeholders, or participants of the study are represented by the various road user types that have been identified as directly or indirectly interacting with AV systems. Specifically, this study will employ car and HGV drivers that will be expected to use AV systems. Also, those operating in the environment of AV systems, such as motorcyclists, pedestrians, cyclists and infrastructure organisations will be consulted to understand the wider context and implications of AV system introduction. An introduction into the sample, the sampling technique and size can be found at Section 3.8.

1.5 Contribution to Knowledge

The following discussion outlines key contributions achieved during this research.

This is primarily a contribution to current understanding around autonomous vehicle acceptance. The key contributions to knowledge relate to extending current understanding of AV acceptance, undertaking the first qualitative study of user AV acceptance involving a range of stakeholder groups, and, in terms of the analysis and conclusions, highlighting a range of targeted recommendations and areas to conduct further research.

1.5.1 Extending current understanding of AV acceptance

The overall contribution made by this thesis is through extending current understanding around the topic of AV acceptance. Current literature highlights a shortfall of acceptance literature, especially when compared to other areas of study concerning autonomous vehicles. Literature on users has contributed 1.3% to the overall knowledge-base, whereas literature concerning technological developments stands at 91.2% (Rosenzweig and Bartl, 2015). The user is widely considered to be the key factor in any successful system acceptance and implementation scenario (Sun, 2013). Alongside this, Nordhoff *et al.* (2016) and Bartl *et al*. (2012) also cited the importance of user research in this context and the need to further extend what is currently known.

1.5.2 Qualitative Approach to Data Collection

All but one of the existing research studies documented in Chapter 2 approaches the topic of autonomous vehicle acceptance (herein referred to as *AV acceptance*) by undertaking quantitative research. The general theme of existing collective studies is that they ask participants to score a number of factors related to AV acceptance to yield the most popular factors and present these as being factors to consider in the acceptance of the technology.

In this work, factors are not pre-defined but are instead co-constructed through the qualitative, grounded theory approach. By employing a methodology that facilitates the discussion of each factor, a thorough discussion and understanding is associated with each factor. For example, rather than presenting trust as a factor to consider in AV system acceptance, as determined by participants in a scoring system, this study explores ***why*** trust is concerning participants, ***what*** contributes to their current trust levels and ***how*** their trust deficiency may be overcome, as part of strategies which may help lead to successful AV acceptance.

1.5.3 Chosen Sample

Rather than process a randomly generated or assigned sample, a concentrated effort was made to ensure the sample was indicative of the stakeholders who would be interacting with the subject. It was understood that individual perspectives would differ across participants, given their role in an environment of AV systems (Larcher, Grabowski and Cook 2014). With this variation, it is counterproductive to develop an understanding of AV system acceptance from participants, whilst trying to suppress views and attempt to derive a singular viewpoint of the topic from a contrasting sample. The presentation of AV system acceptance from a range of stakeholder views is a new contribution to research into AV acceptance. The reader can access specific findings, related to specific stakeholders, or a general section of findings. The split in the findings is as follows:

- The first section of findings considers acceptance of AV systems from direct stakeholders, i.e. those who would be expected to use AV systems (car drivers, HGV drivers); and
- The second section of findings considers acceptance from indirect stakeholders, i.e. those who would be operating in the vicinity of AV systems and expected to interact with the subject (cyclists, pedestrians, motorcyclists etc.).

An example of qualitative stakeholder research previously is that of Bjorner (2015) who exclusively employed car drivers to assess the perceived driving pleasure of autonomous vehicles (See Section 2.1.2).

1.5.4 Recommendations

From the findings, the study was able to make informed and targeted recommendations (Section 6.2) for manufacturers and system providers. This increases the value of the contributions of this study as they considered the major problems associated with the subject and provided recommendations through participants and analysis on how to overcome each particular barrier. Each recommendation was considered within the specific context of the associated factor, the stakeholder it derived from and the implication of overlooking it.

1.6 Roadmap of Thesis

Discussed below is a roadmap of the thesis, outlining the aims and construct of each chapter within the thesis. As this is one of the concluding sections of the first chapter, a description of this chapter will not be given.

1.6.1 Chapter 2- Literature Review

Chapter 2 gives a comprehensive overview of the literature currently available to support the empirical study of this thesis. The chapter considers three key areas of literature; AV system adoption, a general overview of technology acceptance and the role of attitudes within the context of AV systems. The key aim of the chapter is to provide a detailed account of current literature, providing an identification of the feasibility and knowledge gap this thesis can service.

1.6.2 Chapter 3- Methodology

Chapter 3 introduces the selected methodology to facilitate data collection, analysis and presentation. The chosen methodology (Grounded Theory) is compared to other qualitative and quantitative techniques to assess its efficiency in being applied to this study as well as its relevance to the subject area. Additionally, this chapter discusses sampling issues and techniques, and introduces the sample group selected as participants for the study. The key aim of the chapter is to introduce the reader to the selected methodology, understands its selection over alternative approaches, and also to ensure they are aware of how the particular sample can service the needs of the study.

1.6.3 Chapter 4- Techniques

Chapter 4 gives a detailed account of how grounded theory is applied to the study. Each stage of the empirical study was highlighted, starting with the pre-study requisite fulfilment (ethics, consent, location etc.) and moving to a comprehensive overview of the data collection, analysis and categorisation phase. The key aim of the chapter was to provide the reader with an insight into how spoken words are translated into concepts and categories relevant to AV system acceptance.

1.6.4 Chapter 5- Results

Chapter 5 presents the findings of the empirical study. The findings are in two parts; those related to AV system acceptance and those related to specific stakeholders. The findings are presented as concepts within overall categories as per the facilitation advice of the grounded theory. The key aim of the chapter is to provide an overview of the results, focussing only on descriptions.

1.6.5 Chapter 6- Discussion of Findings

Chapter 6 extends the work of the previous chapter by providing a comprehensive and detailed discussion around each findings presented in Chapter 5. The findings are assessed against extant literature discussed in Chapter 2 to draw out confirmatory and new knowledge. Additionally, this chapter also provides a number of recommendations in light of findings that are designed to progress AV system implementation onto public roads. The key aim of this chapter is to ensure the reader understands the position of literature alongside current literature and how this study can contribute to progressing AV system acceptance.

1.6.6 Chapter 7- Critical Evaluation

Chapter 7 analyses the impact, weaknesses and limitations of the thesis. Using extant tools, the chapter evaluates the findings by way of employing grounded theory metrics for assessment. Qualitative analysis techniques were applied to the methodology and sample employed by the study to conclude on their utility, restrictions and overall input to the thesis, as well as any limitations and opportunities understood through experience of application.

1.6.7 Chapter 8- Conclusion

The final chapter of this thesis considers the implications of this work, including the context within which this thesis operates, as well as developing an understanding of the issues related to the practical introduction of AV systems to public roads. This chapter also specifically identifies future research opportunities and limitations, building on those presented in Chapter 7. The chapter concludes by summarising the thesis and lessons learned, ahead of a final conclusion section.

1.7 Chapter Conclusion

In conclusion, this chapter provides an introduction to the subject area of autonomous vehicles, with a specific focus on the associated human factors and acceptance elements. The chapter specifies the aims and objectives that guide this work, the methodology that has been selected to lead the data collection process and stakeholders nominated to contribute to the study. The key contributions and utility of this research and the structure of the thesis itself are also discussed. The next chapter introduces and discusses current research related to AV acceptance.

Chapter 2- Literature Review

This chapter provides an overview of the available literature concerning autonomous vehicle acceptance. The aim of this chapter is to gain an appreciation of the literature for two reasons. The first is to highlight niche areas that require further research. The second reason is to document literature that guides and refines the primary data being gathered through the adoption of the grounded theory. As the data collection is running in conjunction with the literature review, key themes being discussed by participants will be explored within this literature review, to further clarify participant discussion. The literature will then be revisited in Chapter 6, where it will be used to analyse the quality of study results and assist in developing recommendations for the AV community.

As a result of the subject matter and the inherent themes discovered through the grounded theory, the structure and content of the remainder of this chapter is as follows:

- **Autonomous Vehicle Acceptance:** Documenting current knowledge on AV acceptance will contribute to addressing the aims and research gap identified in the thesis;
- **Technology Acceptance:** As the thesis operates in the environment of acceptance, attempts will be made to document a selection of models pertaining to technology acceptance. This will allow best practice within technology acceptance to be transferred into the context of autonomous vehicles and applied to the findings of the study;
- **Attitudes to Autonomous Vehicle Acceptance:** This topic will discuss current knowledge on the influence of attitudes on individual acceptance. Data gathered by the study-included attitudes, which were discussed regularly by participants, warranting its inclusion.

2.1 Autonomous Vehicle Acceptance Literature

A key requirement of this chapter is to gain a thorough appreciation of autonomous vehicle acceptance literature, from a theoretical and empirical standing. This will be performed by undertaking a comprehensive review into current state of the art research publications, largely disseminated within relevant research communities. The primary aim of this survey is to discover pertinent gaps in knowledge, which are affecting upon autonomous vehicle acceptance.

2.1.1 Theoretical Literature on AV Acceptance

The role and consideration of user acceptance in the adoption of AV systems is important (Merat and Madigan, 2016). The problem faced by the AV community is the lack of understanding that surrounds AV acceptance given it is a relatively recent research topic. Furthermore, a lack of understanding exists on how acceptance should be modelled in an AV scenario and how associated key performance indicators should be measured (Regan *et al.* 2006; Vlassenroot, 2006).

This section has two key aims, firstly to assess the theoretical literature concerning AV acceptance and secondly to discuss the various public studies conducted with potential users. An investigation into these two domains aims to yield a comprehensive review of current knowledge, thinking and future direction.

Rosenzweig and Bartl (2015) studied literature on autonomous driving to highlight knowledge gaps to motivate further research. Little research has been identified on the issues of user perspective and potential acceptance towards AV systems. The majority of research in existence primarily served the technical element of the phenomenon. Given that a network of 200 IEEE AV experts concluded that the three main obstacles to the introduction of autonomous vehicles were legal liability, policymakers and user acceptance, the finding of Rosezweig and Bartl (2015) serves as a serious concern regarding the level of research conducted into user acceptance (IEEE, 2014).

An additional review by Rosenzweig and Bartl (2015) found that through a systematic investigation into available literature on autonomous vehicles, the market shares of knowledge and published work was as follows: Technological development (91.2%), Foresight and Trend (4.85), Law and Regulations (1.5%), Environmental Impact (1.3%), User Acceptance of Technology (1.3%).

The work of Nordhoff *et al.* (2016) represents a synthesis of existing acceptance studies on automated driving, focussing specifically on vehicle automation level 4. As a deliverable, in addressing the multidimensional nature of acceptance, the authors developed a conceptual model integrating a holistic and comprehensive set of variables to explain, improve and predict user acceptance of driverless vehicles. (See Figure 1)

Divided into five categories, the results display external variables, psychological variables, variables from the UTATU (Unified Theory of Acceptance and Technology Use) model; the PAD (Pleasure-Arousal-Dominance) framework and the acceptance construct to be the key frameworks for autonomous vehicle acceptance. Within these five categories, Nordhoff *et al.* (2016) identify factors pertinent to each, all of which combine to address user requirements in the event of autonomous vehicle acceptance. Figure 1 displays the key acceptance factors discussed by the authors.

Developing models to display technology acceptance is not a new concept, the original technology acceptance model (1989), TAM 2 (2002), TAM 3 (2008) exist to understand technology acceptance from a general standing. However, in this work a model has been created that specifically focussing on technology acceptance in the form of user acceptance of autonomous vehicles. This deliverable displays factors to consider in a heightened level of automation, providing clarity to the aims of this thesis.

Given the work is based on a theoretical approach, the conclusions of the paper discuss the need to conduct qualitative studies with users and decision makers to further develop relevant acceptance models and populate the knowledge gap that exists in this particular field. The importance of user involvement is further motivated by Bartl *et al.* (2012) who cite integrating user perspective and user involvement as key to developing meaningful insight, which can be translated through a development cycle to product delivery. Fagnant and Kockleman (2015) address the issue by considering the barriers to acceptance. Their argument consists of cost, licensing, and security and privacy issues surrounding acceptance and usage.

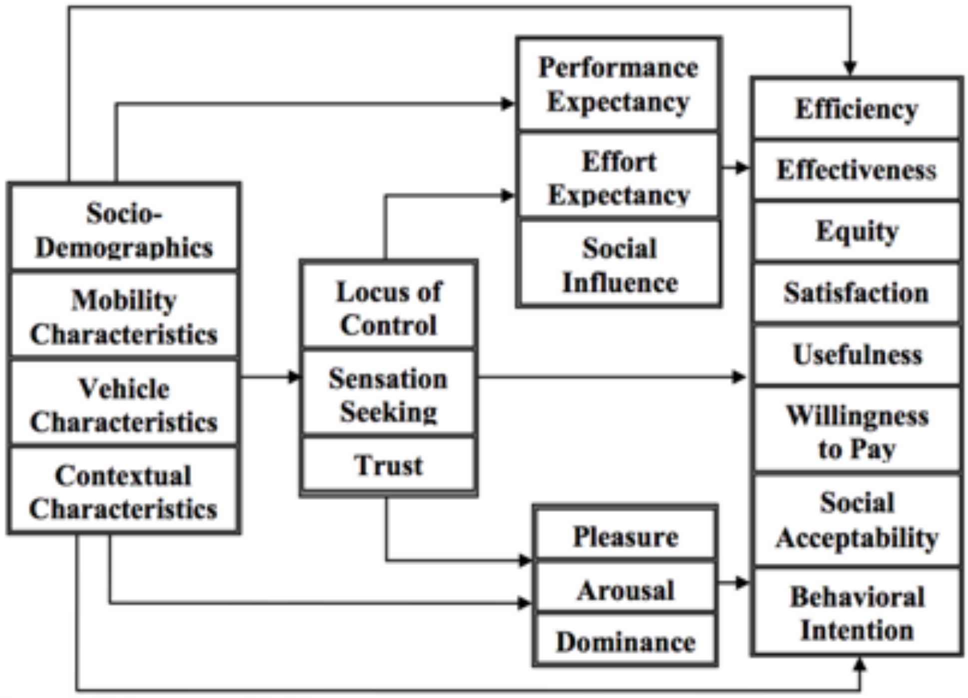

Figure 1- Autonomous vehicle acceptance factors (Nordhoff et al. 2016)

In contrast to Nordhoff *et al.* (2016) who approach the field from a social/behavioural standing, the work of Fagnant and Kockleman (2015) creates a set of factors that are more tangible, easier to understand and influence. This difference in presentation shows that user acceptance of autonomous vehicles can be seen as a multi-disciplinary approach, with factors to be considered from a range of areas.

Habibovic, Cristofer and Johan (2014) set out to understand key research gaps, challenges and opportunities that exist in light of driverless vehicle adoption. Their review of current literature found four key challenges that required further research, they are:

1. Understanding the transfer of control between the vehicle and the driver;
2. Defining behaviour of automated vehicles in relation to other road users;
3. Identifying how to communicate the system reliability information to the drivers; and
4. Clarifying the impact on societal values.

The above four challenges, although not directly focussed on the area of acceptance, have a direct effect on the acceptance of the technology from a stakeholder perspective. For example, point 2 discusses defining behaviour of the vehicle in relation to other road users and point 4 emphasises the influence of social issues, similar to the Nordhoff *et al*. (2016)

paper. Point 1 discusses control, one of the key issues currently being discussed in empirical studies, and is a contentious issue amongst potential users. Here lessons can be learned from aviation, where issues such as pilots falling out of the loop, misunderstanding when to retake control and assuming the aircraft has features that it does are all identified as control related issues. Habibovic *et al.* (2014) highlight the issue of control as the first key challenge to consider, given the negative effect it can have on usage, interaction and the associated confusion. They also discuss how successful interaction with different parties of users would help stimulate better long-term acceptance for society. Within this conclusion, and the emphasis on other road users, a study is required that works alongside different stakeholders with the aim of understanding their individual forecast on potential acceptance.

Ernst and Young (2016) conducted a recent study into the evolution of artificial intelligence and acceptance of autonomous vehicles, discussing current knowledge and how this affects future challenges. Within their report, acceptance is discussed in the scenario of the autonomous vehicle operating alongside vehicles under full human control. In light of this and acceptance of autonomous vehicles in general, they propose four key challenges to consider assisting society in its quest to accept autonomous vehicles. The four challenges are:

1. **Incremental improvement in automation**: As the industry has been incrementally introducing driving assistance features over the past few decades, this step by step procedure has worked and must continue through to driverless vehicle technology;
2. **Humanising driving:** In the driving situation, vehicles must adopt driving characteristics that are similar, if not identical to that of the model human driver;
3. **Taking cues from the aviation industry**: Taking learning from the aviation sector will greatly improve consumer trust, and therefore acceptance;
4. **Educating and incentivising customers:** By incentivising change, consumers would be more inclined to adopt and use autonomous technology.

The Ernst and Young (2016) discuss how trust will be built by defining the boundaries of human and vehicle control. Furthermore, the need for sophisticated and customisable interfaces is reiterated in a cabin overhaul to improve usability and human machine interaction. The report contributes a number of factors to be considered, in the same way that previous papers discuss a number of relevant factors and issues. This paper, however, rather than discuss specific factors or output, recommends further research and work in very specific fields.

Within the above subsection, attempts were made gain a deeper understanding into what knowledge currently exists to support and help create a niche for this thesis to research in. In the majority of the papers, including those that undertook a comprehensive review of literature on AV acceptance, the actual knowledge pertaining to AV acceptance was minimal The majority served as working papers or providing entry to researching within this opportunity by making recommendations. From that which does exist, the key underlying theme of current knowledge is that it built on the disciplines of acceptance and change management, with a specific application to the field of AV acceptance. Issues such as incremental change, educating and incentivising customers is reminiscent of the various Change Management principles that exist such as the work of Lewin (1951) and that of Kotter (Kotter, 2016; Bozak, 2003).

Each of the papers discussed above all spoke of that that research into user acceptance is currently very low and activity in that research field is minimal. Given that the IEEE (2014) professionals ranked user acceptance of autonomous vehicles to be one of three key challenges to the introduction of this phenomenon, opportunities exist to populate this research gap.

However, upon considering the reasoning behind this deficiency, it was concluded that due to the required research stemming from user and stakeholder perception, theoretical literature cannot currently suffice. This, due to the fact that this is a state-of-the-art field and current literature has no readily available answer as an AV system is yet to be introduced, the investigation or development of knowledge has to come from the subject of this investigation; potential users. By conducting research into the empirical studies that exist with users and stakeholders, much more usable knowledge can be gathered. This is because users have the opportunity to express their views, concerns and key challenges in the uptake of autonomous vehicles. In terms of AV acceptance, this is a stronger method of approaching, understanding and populating the knowledge gap. From this knowledge gathering exercise, the theoretical element can be reintroduced to make sense of and carry the knowledge forward to its intended outcome.

The work documented above is a representation of the minimal activity in the field from a theoretical standing. The extant knowledge provides direction for researchers willing to operate in this field. Much of the literature supports the conducting of further study to fill the void that currently exists. To react to this, the review will now document and discuss a representative number of empirical studies that have focussed on user acceptance of AV technology.

2.1.2 Empirical Studies of AV Acceptance

This section will document results and recommendations from a number of empirical studies conducted on the topic of AV acceptance. The majority of studies have presented findings they perceive to be relevant to AV acceptance and factors have formed the discussion of their results. To emulate this practice, any relevant finding or factor gleaned from the literature will be highlighted in bold and labelled as a theme, prior to further discussion in the following section. In addition, themes gathered from the literature will be compared against themes generated from the methodology application.

J D Power and Associates (2012) conducted a large-scale survey with 17,400 vehicle owners to measure interest and purchase intent for emergent automotive technology. Of their findings, the most relevant to this literature review was the finding that 37% of participants were willing to use autonomous vehicles. However, with the associated cost increase, perceived acceptance reduced to 20%. Additional findings were focussed on the specific autonomous features required by users, such as traffic assist, emergency stop assist and speed limit assistance. From this study, cost can be highlighted as a potential hindrance to AV acceptance and a theme to consider in the analysis section of this thesis.

Schoettle and Sivak (2014) conducted a survey on public opinion of autonomous and self-driving vehicles with respondents from the USA, UK and Australia. With 1,533 respondents aged 18 or over, the key findings of the study were as follows:

- Respondents were generally positive towards the technology with a high expectation of its function;
- Respondents displayed concerns around the vehicle in higher levels of automation, mainly around it not being able to drive as well as a human driver; and
- Although the majority of respondents were accepting of the technology, the majority were unhappy to pay for it.

From the summary of results, the themes of **expectation, cost and fear of surrendering control** have been collated. Users were generally receptive of this technology and the related themes were fewer than initially expected. The issue of cost was once again highlighted with the majority of participants feeling an associated cost should not be expected or involved for user uptake of AV technologies. The last theme was around control and the fear/concern participants have in allowing a system in this case, to carry out the driving task.

The above two studies display the motivations of this thesis in regards to this literature review. The identified themes discussed will be analysed at Section 2.1.3, alongside themes and key findings from fellow studies to gain a balanced appreciation of current knowledge and factors related to user acceptance of autonomous vehicle technology. This process and structure will be applied across this section.

A 2011 Accenture study involving 2006 UK and US participants found that nearly half the respondents felt comfortable adopting driverless cars. The remaining participants were more likely to use the AV system if they had the ability to resume control at their discretion. The study was aimed at intelligent software overall and not just driverless cars. The Accenture (2011) study contributes **control** as a relevant theme to AV system uptake. It is worth noting that in this case, participants highlighted the need, rather than the fear of taking back control from an AV system. This represents a certain level of mistrust or fear around system operation, and highlights control as one of the key barriers to acceptance.

Social Intelligence Reporting (SIR) conducted a review on public attitudes to automated vehicles on behalf of the Department of Business Innovation and Skills. Working alongside the Ipsos MORI Loyalty Automotive Survey (2014) who conducted a quantitative survey on over 2800 public comments posted online, SIR (2014) sought to gain a deeper understanding of the positive and negative attitudes that currently exist in relation to adoption of autonomous vehicles.

Positive perceptions:

- Accessibility – for elderly;
- Comfort and convenience;
- Increased safety;
- Decreasing travel cost;
- Environment (efficiency).

In terms of the benefits related to public perception, participants spoke about accessibility for all users, both with or without a disability. Further benefits included comfort and safety for users as the vehicle entered the higher levels of automation, relieving users of the associated stress of driving. The benefits concluded with participants describing costs reduction in relation to travel being a possibility with the increased efficiency of the system, both in the context of time and the environment.

Negative Perceptions:

Negative participant perceptions are focussed on three key themes. Issues around **system abuse** were regularly mentioned by participants, with examples of unmanned car bombs, hackers abusing software and pranksters jumping in front of moving self-driving vehicles. **Unwelcome lifestyle change** was discussed in light of people becoming inactive due to vehicles being more accessible. The last theme discussed **(Privacy)** highlights that, like the fellow studies discussed, social issues are very important in the context of user acceptance. In this instance, social issues are represented by privacy and concerns that participants have about their travel data and behaviour being recorded by companies and exploited for monetary or control gain.

The recommendations of the SIR (2014) advised on further studies with users/stakeholders and noted the potential impact these studies could have on informing policy makers and system owners, increasing the quality and reliability of the AV proposition.

This method of conducting studies by way of analysing online posts is supported by the study of Bartl and Rosezweig (2015) who conducted innovation mining on 106,305 user generated content posts on a selection of websites. Innovation mining is a method of ‘listening in’ on online conversation, with the resulting qualitative analysis providing an unobtrusive insight on user perception. Their study was motivated by what they felt was a clear gap between knowledge on the technological challenge of AV systems and research on the end user acceptance.

For this reason, their work emphasizes the importance of understanding the needs and wants of the end user by way of research, promoting user involvement and allowing the community to react to the requirements of the user.

Bartl and Rosezweig (2015) focussed their results on what users felt was the best term to describe driverless cars. The most popular websites for AV systems were discussed (on

Reddit.com) together with how people would occupy spare time in a fully autonomous environment (Internet/email, mobile/TV). In terms of results applicable to acceptance, the authors found that the expensive **cost** of uptake and the **danger** that users felt AV systems posed were the most common themes.

Although the study of Bartl and Rosezweig (2015) has a similar title to this thesis, their work approached the area using a different approach. Their study aimed to understand the social attitude that exists in relation to adoption, replaced workloads, user feeling and how conversation on the topic has evolved over time. Even so, the authors still reiterate the importance of acceptance research to close the gulf between it and its technical counterpart, with their report stating that the main driver of this technology introduction is user acceptance.

Further contributions to the literature come from the Boston Consulting Group (2015) who conducted a large-scale quantitative and qualitative survey with over 5500 respondents in 10 countries. The group claim it to be the largest survey of its type that is solely focussed on the concept of autonomous driving. The relevant results that are applicable to this study can be found in Figure 2.

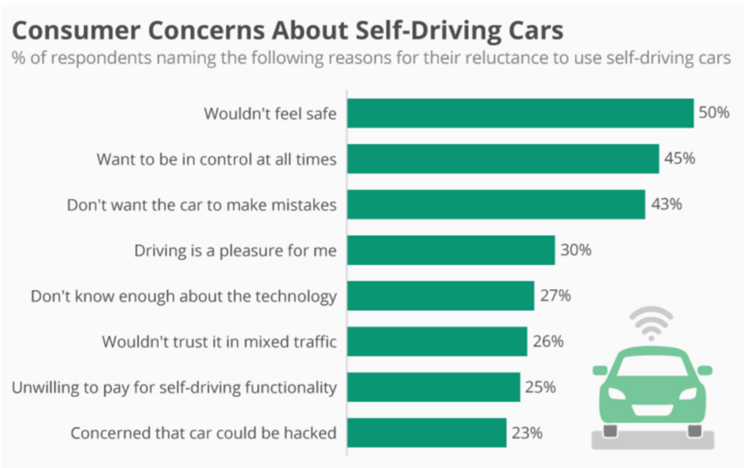

Figure 2-Potential consumer concerns ranked by percentage. (Boston Consulting Group, 2015)

Figure 2 displays user concern in regards to autonomous vehicles. This individual element of the survey was answered by the 1260 consumers who declared themselves unlikely/very unlikely to take a ride in a self-driving car. The results of Figure 2 are applicable to this literature review due to the concerns being potential barriers to acceptance, possibly preventing or delaying acceptance and usage.

By attempting to categorise and understand the main concerns displayed by consumers, the following serve as the key themes to add to the understanding of acceptance of AV systems. The themes are:

- Safety;
- Control over proceedings;
- Knowledge Deficiency;
- Competence Trust;
- Cost; and
- Privacy Concerns.

Safety was highlighted by consumers as the key concern they hold about their reluctance of AV system usage. In attempting to understand why consumers would feel unsafe, the second concern highlighted was the inability to have full control over proceedings. This could signify why consumers would not be willing to accept AV technology. However, consumers who were willing to use AV technology cited increased safety and the ability to conduct other tasks when the vehicle drove (Boston Consulting Group, 2015).

The minority of respondents cited in Figure 2 display contrasting views to the majority who are accepting of the technology. This difference of perception is synonymous with the adopter categories mentioned by Rogers (1962) in the diffusion of Innovation Theory.

This theory, discussed at Section 2.3.1, displays quite clearly that in the context of AV adoption, categories still exist to define consumers and their acceptance rates and likeliness, with certain individuals accepting without hesitation, and others requiring more time, clarification and evidence.

Additional themes displayed in Figure 2 speak of competence trust, the fear that the system could not carry out tasks such as operating in mixed traffic conditions, mentioning how mistakes would begin to appear. The themes of **unwillingness to pay** and concerns around **privacy** in relation to data collection have been noted as key themes to acceptance by Schoettle and Sivak (2014) and Social Intelligence Reporting (2014) amongst others, displaying their relevance and importance to the thesis and field.

The theme of **knowledge** however, represents the key to understanding and being able to manipulate four of the themes that discuss user reluctance to acceptance (**Safety, Control over proceedings, Competence Trust and Privacy concerns**) If consumers were provided with the correct knowledge and a clear understanding of the AV system capabilities and limitations, the likelihood of user reluctance as a result of the themes listed above are likely to decrease. This improved understanding would lead to a better feel of control, trust and awareness of the AV system, increasing the potential acceptance of it as a result.

Kyriakidis, Happee and Winter (2015) conducted an international questionnaire study with over 5000 respondents. The aim of the study was to capture public opinion on user acceptance, incorporating user viewpoint on concerns, willingness to buy and usage of partial or fully automated vehicles. Built up of a 63 question survey on a data collection website which was targeted worldwide in 109 countries, Kyriakidis *et al*. (2015) were able to develop a set of results applicable to user acceptance. The results displayed that public opinion is diverse on the topic of AV systems, similar to the findings of Boston Consulting Group (2015). A portion of the respondents perceived the system to be beneficial and embraced the idea, whereas another large portion spoke of the unwanted costs of adoption and the lack of enjoyment AV systems would deliver.

In terms of themes to contribute to the growing vocabulary of acceptance themes, respondents selected **privacy, misuse, safety and AV legalities** to be the key issues to consider in AV system uptake**.** The first three themes have been discussed thoroughly by each of the aforementioned mentioned surveys. Kyriakidis *et al.* (2015) distinguish the theme of privacy by stating that individuals from high-income countries are more concerned with the theme of privacy, in contrast to low-income countries where privacy is not a primary concern. This correlation was also applied to individuals from developed countries.

A new theme added to this literature review speaks of legalities and surrounding challenges. Although further explanation is not provided by the report, legal issues in this context can be defined as issues relating to liability, responsibility and insurance requirements. However, as this is the first mention of legal issues, without further evidence or justification, the theme will be overlooked and recalled once additional studies identify legal issues as a key attribute to user acceptance.

The next public study considered is the work of Fraedrich, Cyganski, Wolf and Lenz (2016) who surveyed 1000 members of the German population aged 18 or over. Their survey employed four use cases (Highway pilot, parking pilot, fully automated vehicle and vehicle on demand) and questioned respondents around these use cases to assess their attitudes and perspectives to AV systems.

In relation to applicable responses, the authors concluded that **attitudes towards** and **emotions** when using were the key themes to consider. In addition to these key themes, **control** was again mentioned with the addition of **system transparency**. The theme of control has been discussed; however, transparency is new to this literature review. Hoff and Bashir (2014), within their systematic review of trust literature ranked system transparency as being a key factor to develop trust. In this scenario, Fraedrich *et al.* (2016) have cited it as relevant to the field of acceptance too. By system transparency in this context, the author can state that respondents were discussing the need to understand the behaviour and function of the vehicle, especially in the higher automation levels. This directly leads to that control theme respondents were discussing the importance and ability to maintain full control at all times, regardless of automation level.

Upon the conclusion of the Fraedrich *et al.* (2016) study, the authors identified the need to conduct further research in the field of acceptance of AV systems. They recommended doing this by surveying specific user groups. For example, urban, car users, public transport users. The authors praised this user-centred approach, based on the ability to understand the environment from the viewpoint of different users. By surveying different user types, the community can understand how acceptance is perceived through different users, rather than adopting a ‘one size fits all’ approach to AV system acceptance.

Concluding the large sample surveys is the work of Casley, Jardim and Quartulli (2013) on public acceptance of autonomous cars. Casley *et al*. (2013) set up an anonymous survey online with the aim of collecting participants’ feeling, belief, expectation and prediction around acceptance and usage of the technology. The study attracted 467 responses in total over a one-month period.

Casley *et al.* (2013) questioned participants on how many years after AV system introduction to the public market would they be willing to purchase and use. Over 60% of participants said they would be willing to purchase ‘after 3 years’. Although the study did not clarify the reasoning behind participants delaying adoption, it can be assumed that waiting for evidence, reviews and allowing any teething problems to be fixed can be the reasoning behind the delay in adoption.

Already reported by a previous survey in this literature review is the theme of **efficiency**. In the Casley et al. (2013) study, only 6.8% of participants stated that an environmentally friendly vehicle would not persuade them to purchase and use an AV system, with the remaining 93.2% neutral or much more likely to consider usage.

Consistent with previous studies discussed within the literature review such as Schoettle and Sivak (2014), the importance of **knowledge** was reiterated by participants with 77% of respondents highlighting they had little knowledge about the spectrum of AV systems. With such a negative response, this lack of knowledge could serve as a hindrance to technology acceptance and to change, leading to the consideration of knowledge being a key theme for AV system progression.

When questioned around the theme of **licensing**, 56.6% of responses agreed that training and the obtaining of proper licensing was key to the correct usage and proper conduct of AV system usage. Similar to the theme of legal issues, participants felt strongly around the need to evaluate current laws around driving practice and usage with the introduction of AV systems, citing current legislation as being unfit for purpose.

As an overall conclusion to the study, Casley *et al*. (2013) highlighted three primary influences in the field of acceptance (safety, law and cost) and three secondary influences (productivity, efficiency and environmental impact. This thesis has also highlighted these themes through analysis of fellow studies, signifying their importance to the AV community. Moving forward, a discussion will take place of the key findings of the above documentation, the context they operate in and how they serve the motivation of this thesis. Prior to that, the literature review will now document and discuss public surveys that have been conducted with smaller samples, similar to the study of this thesis.

Bjorner (2015) conducted a user acceptance survey to understand the perceived driving pleasure of autonomous vehicles. To achieve this aim, Bjorner (2015) carried out 13 in depth interviews with participants using video and scenario based testing.

The first of three key themes uncovered by the study is **trust,** a theme previously discussed, but presented in a different context. Taking inspiration from the spoken word of each participant and the in-depth review on trust in automation by Hoff and Bashir (2014), trust is discussed here as being multi-dimensional and appearing in a number of forms. Trust is discussed as trusting one’s self, trusting the technology and trusting the technology provider. Trust was discussed as being presented in many forms by Hoff and Bashir (2014), the key extensions were dynamic trust (culture, age, gender, personal traits) and situational trust (setting, task, difficulty, risk). The Bjorner (2015) study and the work of Hoff and Bashir (2014) display that as previously thought, trust within an AV environment is not one-dimensional. To consider trust within this environment, one must assume that trust challenges users on a number of levels. This thesis will aim to assess the impact of trust and how it affects and appeals to different potential users and their proposed acceptance of AV systems.

The second theme created in the Bjorner (2015) study is **cabin distractions,** where participants consider the different technology that will become mainstay in cabins and how this will affect concentration levels of users. Participants discussed this theme and noted cabin distractions, regardless of the automation level or stress load of the driving task.

The theme of cabin distractions raises a discussion around the replaced workload of individuals who drive a vehicle for employment purposes. The future state of autonomous vehicles will affect the job role of individuals and the potential inactivity could lead to an effect on their earnings as certain responsibilities are removed. In contrast to this, employers could develop further work or alternative tasks for drivers to carry out, thus offering further distractions to the driver. Bjorner (2015) comments on cabin distractions by stating no study has been conducted to understand the full effects of distractions inside a cabin that is in semi or full autonomous mode. Furthermore, Bjorner (2015) state these distractions as being one of the key reasons why vehicle manufacturers such as Audi class the technology as piloted driving, rather than autonomous driving.

The concluding theme raised was concerned around **legislation** and the need for an updated framework, highlighting responsibility and accountability for incidents involving semi and fully autonomous vehicles. Bjorner (2015) mentions how this is not solely a participant concern, but is identified by major research studies and pilot testing as a key hindrance to technology advancement. The reasoning behind this being that currently, it is relatively straightforward to identify accountability and resulting factors within a road traffic collision involving vehicles under full manual control. However, in an environment involving autonomy, the number of contributing parties increases (vehicle, user, manufacturer, software developer) and this leads to confusion of responsibility, from both user and manufacturer perspective. In light of this, studies have been proposed by organisations such as MIT to test the discussed theme in ANN Arbour with 2000 driverless vehicles and Volvo who plan to test driverless cars with real users in Gothenburg public traffic. (Knight, 2014)

The premise of the paper reiterates the advice to not only focus on the technical element of development, but to assign importance to considering user perspectives and a thorough assessment of stakeholders to feedback into the design and development of autonomous systems.

Howard and Dai (2013) investigated public attitudes to self-driving cars with 107 participants in a case study scenario. The authors focussed on what users found attractive about the technology, how they envisioned its inclusion and whether they would adopt it. The study found that **user safety**, not having to find parking and being able to **multitask** as the key benefits, with key adoption concerns being the themes of **liability, the cost of adoption** and **losing control.**

To further justify studying public perception of AV acceptance and the need to pursue further research, the authors provided further clarification. Howard and Dai (2013) describe how the public shapes technology demand and create policy to govern usage. An earlier return on investment of these studies is an understanding of the factors or themes that play a role in the decision making process of a representative range of users. This would allow the industry to tailor their products and marketing to the public, ensuring maximum acceptance and usage.

The concluding study discussed is by Piao *et al.* (2016) who invited 425 participants into an online and phone interview survey. These participants, all living near the CityMobil2 Arts vehicle project in La Rochelle, were interviewed on issues related to automated buses, taxis and cars in comparison to manual vehicles. The study found that the majority of respondents were positive towards AV systems if they were offered it at a lower **cost** than traditional travelling. Associated issues of concern raised were around the **safety** and **security** of users of such public services, especially during night hours.

The survey of Piao *et al.* (2016) displays an alternative method of assessing acceptance, by changing the subject of the study to public vehicles as opposed to personal means of transport (i.e., cars). Although this is not part of the aims of the *Piao et al*. (2016) study, it represents another research opportunity being pursued in the large spectrum of transport by the research community. Given the differences between the systems, the acceptance factors are still very similar to the ones raised above, leading into a correlation between the two and the potential to transfer findings between that of those study and those considering fellow vehicles.

2.1.3 Discussion of AV Acceptance Literature

To understand the current literature surrounding AV acceptance, key research undertaken in this area has been documented, together with key themes extracted from the works that are relevant to AV acceptance. The work demonstrates potential methods of conducting, analysing and presenting knowledge pertaining to AV acceptance.

Through analysing the work of each author, two key areas have become apparent. The first being that each author presented their findings as themes or factors that users consider as key to the acceptance and usage of autonomous vehicles. The second being that the overwhelming majority of papers advise on the need and importance of future work in the field. Amongst the authors discussed, two key quotes display both the need for work in this field and the current disregard being given to research on acceptance. Given the fact that 200 IEEE experts rank customer acceptance as one of key issues to consider in the AV spectrum, it is surprising that Rosenzweig and Bartl (2015) discovered that as a percentage of 100% market share, user acceptance is ranked at 1.3%, whilst research on technological development is at 91.2%. Whilst the community is aware of the need to fill the void that currently exists in research on acceptance, current research is minimal and not conclusive. In trying to understand why this is the case, it was concluded that because no system is currently available for the public to test with, research based on perceptions and imagination is not as conclusive as waiting for a system to become available. A 'Wizard of Oz' approach can only provide findings that are dependent on the imagination and knowhow of participants, whereas waiting for a tangible system to become available would render more reliable, conclusive findings. In addition to this, those who currently operate a perception-based approach would have to reconsider their studies when a tangible asset became available in a bid to confirm or adjust their results.

However, current work on AV acceptance and user perception has much to offer the field. Bjorner (2015) mentions how a proper assessment of stakeholders and continued work in this field will allow feedback to assist the design and development of AV systems, a benefit also discussed by Fraedrich *et al*. (2016). This is a running theme that continues with SIR (2014) who praise this type of work, especially given the knowledge it can provide to policy and decision makers.

In attempting to justify operating in this context, this section stands as evidence to the need, importance and current shortfall that surrounds user perception and acceptance of AV systems. In attempting to find a particular niche or focus area from literature, any direction cannot be sought. Much of the literature mentions the need to extend knowledge in the area, without providing a particular focus area. This could be due to researchers guarding intellectual property in such a young and fertile field. A more probable explanation could be that given the current lack of understanding of this field, the next steps are not yet known by the community.

What is currently known is as follows:

- Each paper documented above discussed the need for further research in AV acceptance. The current trend is a realisation that more work is required, but a shortfall in the current supply of user acceptance related studies;
- From the above two subsections, it is clear that best practice in the community is to conduct empirical studies over theoretical ones. This is not only evident in the number of studies available, but the quality of results reported. Furthermore, with the majority of studies citing the need to conduct further study with users, it is clear that the aims and methods of this thesis are currently supported by the research community; and
- From ascertaining the benefit of observing an empirical study with users, the literature can be consulted again to consider what can be gained from operating in this way. A large number of tangible benefits can be sought from working in this environment; such is the advice of the authors. Influencing policy, providing users with a voice in the design and development of the system, tailoring products and marketing are a number of the direct and indirect benefits researchers can offer the community. This demonstrates the need for this research, its value and a number of the potential avenues it can affect.

Moving forward with this discussion, the second of the key dialogues will now be presented. The overall aim of this literature on AV acceptance was to collect relevant literature on the current understanding around AV acceptance. This was done with a view to having a clear appreciation of what the community currently knows, allowing progression and process for this thesis. To do this, various public studies performed within the last five years were consulted to identify key findings. An observation of each study was that they present their findings as key factors for consideration in AV uptake and this enabled the presentation of collective findings in the form of themes/factors relevant to the subject matter. The discussion will now present the collective themes in a discussion that will group similar themes to present the reader with the current understanding of AV acceptance according to existing literature.

The themes will be discussed in order of their importance, ascertained by their number of mentions within the collective studies. The themes and an expansion of their effect on acceptance of AV systems is as follows:

- **Cost**: The cost of AV system uptake served as the biggest hindrance to acceptance from the studies documented. Mentioned as a key theme in six studies, participants highlighted how they were unwilling to pay for autonomous features, but rather expected they would come at no extra cost. Interestingly, the theme of cost also served to reduce potential acceptance by 17% when the notion of it was introduced to technology welcoming participants by JD Power and Associates (2012). It is unknown whether participants were given the actual cost of adoption, given it is not mentioned in any of the studies, one can assume that the cost of adoption in general is unwanted, regardless of the amount;
- **Control**: Mentioned as a key theme in four studies, the theme of control was presented with three different variations. The first instance of control was a fear of relinquishing control to a computer-based system. The second was an apparent confusion around the process of transferring control between human and driver. The third instance of control was the current role of a driver as a constant monitor over proceedings and having complete control and how this would differ in an AV environment. Overall, this theme discusses the fear of allowing the system to carry out the task of the human driver;
- **Legal Issues/ System Abuse:** Discussed at length in three studies, legal issues have served as a concern for participants in the uptake of AV systems. The main concern being that current law and legislation cannot adopt AV systems. By this, participants spoke of existing regulations around insurance, liability, responsibility and how this requires an overhaul to incentivise prospective users into actual usage. The biggest concern in relation to legal issues is that participants require further clarification on liability and what would happen in the occurrence of an accident. The introduction of the system as the driver is the biggest threat to acceptance from a legal issues perspective. In extension to legal issues, participants spoke of system abuse, scenarios where vehicles could be used for a number of illegal or immoral purposes;
- **Privacy:** Mentioned as a key theme in three different studies, privacy was highlighted as an issue relating more to the environment surrounding the vehicle and user. In this case, participants spoke of two issues related to privacy. The first issue was the privacy of their travel data and what laws would be in place to protect it. The

second issue was around the potential exploitation for monetary or control purposes that existed if companies were allowed full access to concentrated travel and usage behaviour. This theme has similar traits to the above of legal issues but it lends more strongly to a new discussion around ethical issues, something not highlighted by participants;

- **Competence Trust/Expectation:** Including this theme, the following were highlighted twice or less by participants. Participants spoke of their fear that the system would be unable to comfortably operate in mixed traffic, with accidents set to increase as a result. This theme has been coupled with expectation, a theme operating on the opposite, highlighting a range of participants who currently have high expectation of the system and perceive it to carry out its function with comfort. This difference in understanding could lead to potential issues involving under/over trust. Solving issues such as this will be discussed in the themes below;
- **Knowledge:** With two definitions, knowledge is firstly discussed by participants who highlight their current lack of knowledge and how this affects their decision-making or thought process. The second definition of knowledge is that it is key for the acceptance and usage of AV systems as it provides motivation to use, builds trust, instils confidence and promotes renewed usage. The need for knowledge and understanding of the systems, its boundaries and capabilities is key to proper usage and although not identified by participants, the study of the thesis is to confirm knowledge as key to provide evidence of its importance;
- **Transparency:** Initially identified as a theme to develop trust by Hoff and Bashir (2014), participants also noted the strength of system transparency in promoting continued usage of AV systems. This theme relates loosely to the above as it discusses the importance of being able to see and understand the behaviour and process of AV systems, especially in higher level of automation. This theme is also pivotal to the discussion of control and a major factor in encouraging and allowing users to surrender control to the vehicle;
- **Attitudes/Emotion:** Slightly less data and information was gained from participants on the themes of attitudes and emotions. Grouped together due to their similar nature, attitudes were explained in this scenario as how the system was translated by users and the experiences they felt upon usage, yet to be recorded. Little knowledge was gleaned on these topics, however, their importance is unquestionable and their involvement within this thesis will be recognisable. Further discussion around attitudes can be found at Section 2.3.1;

- **Time:** The last theme identified from the studies is the theme of time. When questioned on the relevance of time in relation to acceptance, participants estimated a period of three years before they were to accept and use such technology. In attempting to understand this theme, this theme was defined as the role of time in relation to acceptance as a factor that would desensitise participants to AV systems and increase the prospects of usage, given progression over time. However, the model of Rogers (1964) contradicts this, with its adopter categories ranging from early adopters, regardless of time and late adopters, reliant on time. Further exploration is required on this theme to determine the true impact of time on the adoption of AV systems.

The overall aim of this section was to document current state of the art understanding of acceptance of AV systems. Current theoretical knowledge is behind its empirical counterpart. This was documented as being due to the revolutionary nature of AV systems and the current inability to test acceptance of these without a pilot system in place.

By conducting a thorough analysis of empirical study findings, the thesis was able to yield a list of themes to represent the current understanding of AV system acceptance. Although the list is by no means exhaustive, it is conclusive of the comprehensive range of studies that have been assessed in this review. Some of the findings were not presented in this review, as their presence was not relevant to acceptance and would not provide value to the needs of this thesis.

The current understanding is primarily formed from user perspective, captured from online surveys, analysis of user generated online posts and semi structured interviews. The bulk of the studies focus more on the study rather than the type of participant inducted. With little known about participants, or by not gauging how they are approaching their respective studies, it becomes challenging to extract a concentrated view of AV acceptance from participants. This is evident by viewing the themes above, all are relevant and knowledgeable, but can be considered vague and without domain specific context.

For this reason, the thesis changed the sample to include stakeholders who are defined specifically by their direct or indirect relationship to the road e.g. car driver, cyclist etc. This was devised upon the analysis of this literature and it is the aim of this thesis to provide themes that confirm the work of the above, or add new knowledge to this field of academia. In addition, this work will also be looking to document domain specific themes for each stakeholder type to apply context to acceptance and to enhance current understanding past the descriptive phase. The aim is to work towards a phase of categorisation and informed understanding of acceptance in light of different stakeholders and users. One clear benefit of doing this is the advice of Howard and Dai (2013) who speak of the need for this specific research and how it will allow the industry to tailor products and personalise services to users. In addition, Hoff and Bashir (2015) speak of the need to accommodate for a number of different cultures and demographics, with targeted user groups, with the aim of understanding specific needs and requirements. Grush *et al*. (2016) further the understanding determined from this literature around the stakeholder by stating AV designers must understand the different and varied customer preferences, due to a ‘one size fits all approach’ being unsuccessful in the transport sector. A study that highlights the needs and issues of different users would prove fruitful to the industry and its quest for AV system introduction. Further discussion of the sample in light of the sample groups documented in this literature review will occur at Section 3.7.

The literature discussed until this point aimed to introduce the reader to the available knowledge pertaining to AV acceptance. Within the work, key results or findings gleaned from the literature are presented as themes. These themes will be recalled in the proceeding chapters to be compared alongside study findings, as is the process of the grounded theory. Within this comprehensive overview, it was noticed that the literature currently does not travel past the descriptive phase of understanding and is not conclusive on the topic of AV acceptance. In addition, each empirical study discussed the need to conduct further research in the field, providing more knowledge to supplement what is currently known. The inability of current knowledge to explain this phenomenon and academics highlighting the need to carry out further researcher displays a niche and research gap within which this thesis can operate.

The next part of this literature review will consider technology acceptance in a general sense through consultation of leading acceptance models. This will reinforce the findings of the above sections and further populate the understanding being developed through this chapter on the topic of Acceptance.

Further discussions of this section of the literature review has been carried out at Section 1.5 (research gap), Section 3.8 (Sample) and Section 4.5 (Data Collection).

2.2 General Technology Acceptance Literature

In addition to the concentrated investigation on AV acceptance, the thesis will also document representative literature around technology acceptance. Having developed an appreciative understanding of AV acceptance from the preceding section, the following will discuss a number of existing technology acceptance models. As highlighted at the Section 2.1.1 of this chapter, the current theoretical literature supporting AV acceptance is minimal. Although the works listed below are concerned with technology acceptance from a general standpoint, they provide a strong foundation and introduction to technology acceptance. This will support the work discussed above and provide further knowledge the thesis can employ in its own study.

2.2.1 Technology Acceptance Model

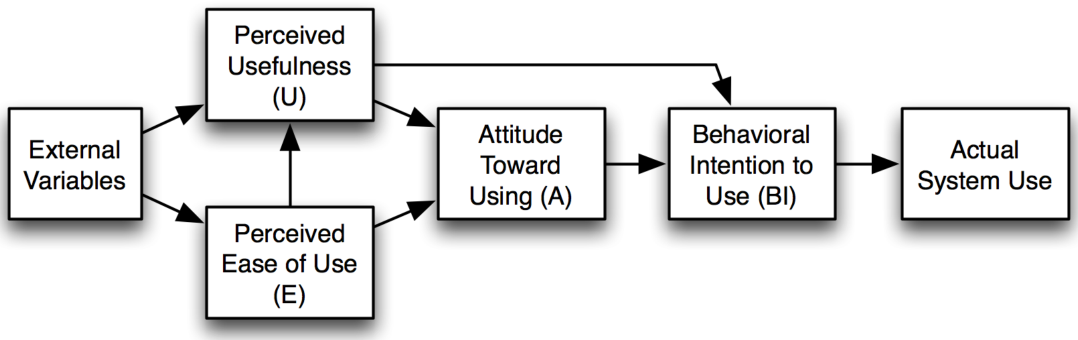

Figure 3- Technology Acceptance Model. (Davis, 1989)

Chuttur (2009) discusses that in the 1970's, growing technology requirements and investments were failed by adoption and acceptance in organisations. Predicting system use became an area of interest and from this; Fred Davis (1989) devised the technology acceptance model, adopting elements from Ajzen and Fishbein (1975). Figure 3 displays the the Technology Acceptance Model (TAM), developed to explore the relationship between various perceived emotion factors and the use of science and technology. It is one of the notable models that can explain and predict the behaviour of users in their uptake of information technology. (Legris, Ingham, & Collerette, 2003)

Subjecting the user as the beneficiary of the technology acceptance model, the argument presented by Davis (1989) is around the increasing complexity of computers and the negative effect this has on user perspective. Through this, unsure and fearful users begin to document their own attitudes and beliefs towards the system. This bias or perception has an effect on proceeding factors, which is argued to affect attitudes and intentions. (Bagozzi, 1992)

Regarding the mention of perception, the technology acceptance model assumes two beliefs that determine computer or system usage: perceived usefulness (the level to which a user believes that using a particular system will enhance their performance) and perceived ease of use (the level to which a user believes they will be able to use a system with none or minimal effort) (Davis et.al, 1989).

This focus on the two above factors as being important is echoed by Ajzen and Fishbein (1975) who speculate that perceived usefulness and perceived ease of use are two fundamental areas that are key determinants of ‘attitude toward using’ which help to predict ‘behavioural intention to use’ and ‘actual system use’. Focusing on the above two elements will ensure the model is utilised and all elements are considered to give a realistic response and solution before the ‘actual system use’ phase is addressed.

2.2.2 Technology Acceptance Model 3

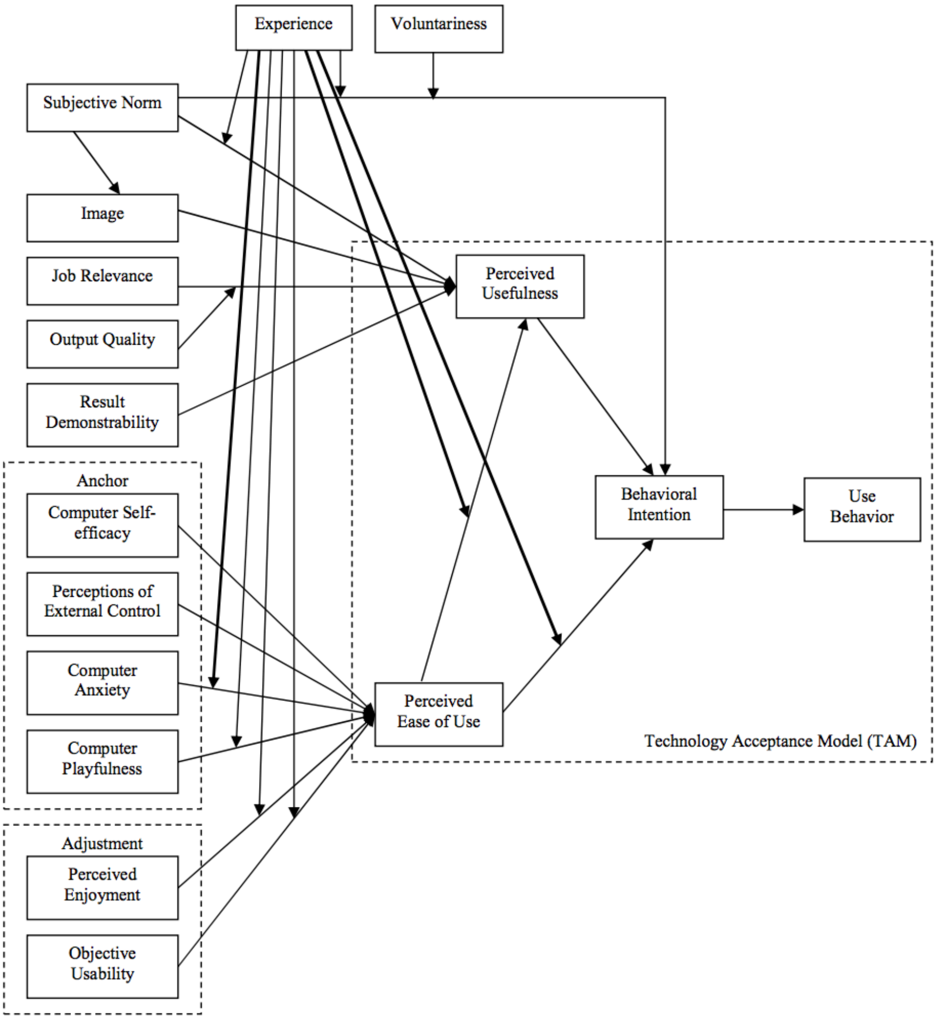

Figure 4- Technology Acceptance Model 3. (Venkatesh, 2008)

An extension of the original technology acceptance model was made by Venkatesh *et al*. (2008) who studied employee adoption of Information Technology. Their focus was on how management could make informed decisions regarding intervention, greater interaction and system utility. In their attempt to do this, the authors drew on existing research around the original TAM, paying particular focus on the detriments of usefulness and ease of use; these were then applied to the newly created TAM 3. (Figure 4)Some of the constructs included within TAM 3 that are deemed relevant to this thesis and have further advanced the original TAM are (Venkatesh *et al*. 2008):

- **Computer Anxiety**: The fear felt by an individual when faced with the potential usage of a computer;
- **Computer Playfulness**: The level of cognitive spontaneity in microcomputer interactions;
- **Computer Self Efficacy**: The degree to which an individual believes they have the ability to perform a particular task using a computer;
- **Effort Expectancy**: The level of ease associated with the use of the system.
- **Image**- The degree to which using an innovative 'product' enhances one's status in a social system;
- **Job Relevance**: An individual's perception regarding the degree to which the target system is relevant to their job;
- **Output Quality**: The degree to which an individual believes the system will perform a task well;
- **Perceived Enjoyment**: The extent to which a system is enjoyable to use, regardless of its performance;
- **Result Demonstrability**: Tangibility of result base using innovation.
- **Social Influence**: The level an individual perceives that others focus on their usage of the new system;
- **Subjective Norm**: The belief that the opinion of those around the individual are key in deciding system usage;
- **Voluntariness**: The extent to which potential adopters believe the decision to adopt usage of the new system is non-mandatory and optional.

2.2.3 Automation Acceptance Model

The most up to date model in this area is the Automation Acceptance Model (AAM) introduced by Ghazizadeh *et al.* (2012). The utility of this model derives from describing user adoption of automation combined with Information Systems and Cognitive Engineering research. The model builds upon the original TAM and capitalises on IS (Information Systems) and CE (Cognitive Engineering) literature to create a more detailed, up-to date model of acceptance. Key details included within the model are:

- Perceived usefulness and perceived ease of use from previous acceptance models; however, they are given weight in this discussion with their differing stances depending on the type or level of automation;
- Both academic communities and also the creator of the theory attribute trust as being a relevant key factor in the acceptance and usage of automation (Lee and Moray, 1992; Carter and Belanger, 2005; Pavlou, 2003);
- External factors remain as one of the core components with elements such as the design of the system, organisational influence and task characteristics (Davis *et al*. 1989);
- The last key point within the discussion of the automation acceptance model is around the notion of feedback and consideration of adoption over time. Where most studies are considered to be cross sectional, Ghazizadeh *et al.* 2012 argue about the benefit of a study over a time-period and how this develops perceptions or acceptance. This is an interesting point and is further discussed further in the analysis section.

2.2.4 Discussion on Technology Acceptance

Bagozzi (2007) believes the TAM to be too simplistic and overlooks key variables and processes. Its simplicity can be understood when considered alongside the AAM or TAM 3. This argument is also further pursued by Holden and Karsh (2010) who applied the model to the healthcare sector and found it to be lacking and in need of several modifications. The Holden and Karsh (2010) paper also raises the issue of the transferability of the TAM. It mentions that due to its general context, the model overlooks domain specific characteristics and processes that are evident in each sector that it has the potential to operate in. In the case of the Holden and Karsh paper, the authors applied the model to a computerised healthcare system and found it to be ignorant of the unique characteristics of the environment. As a result of this discovery, the reader can be left assured that already documented solutions to technology acceptance cannot be applied to the context of driverless vehicles. This is due to the finding of Holden and Karsh, but is also supported by the overwhelming number of related acceptance factors highlighted by the literature on AV acceptance in comparison to the smaller number of factors displayed by TAM.

The above serves to justify the aims and objectives of this thesis. It cannot be stated that the environment of AV acceptance can be sufficed by existing literature on technology acceptance. However, the work of Holden and Karsh (2010) and the difference between technology acceptance literature and current state of the art understanding on AV acceptance displays the need to study this field as extant literature does not suffice. The acceptance factors and requirements of the work in Section 2.1 details domain specific characteristics that specialise on the high-level acceptance factors detailed by the TAM. This describes to the reader that generic models are not the best fit when considering acceptance. Any creation must be done by a researcher who understands the context to ensure domain specific characteristics are not overlooked.

TAM 3 provides information on potential technology acceptance, utilising three of the key concepts (Perceived usefulness, perceived ease of use and behavioural intentions). The model is evolved to account for individual perception of technology adoption. This perception based approach accounts for elements of fear, the choice of usage, a number of social issues and the associated enjoyment of the systems. From the additions made to TAM 3, it is clear to see the model was created in the modern era. Unlike the original TAM that was created in an era where systems and technology were not freely available and their operation was usually carried out in isolated environments (i.e., back room offices). However, in the modern day, like the factors of TAM 3, technology, along with its adopter, operates with public involvement. For this reason, TAM 3 has considered various societal and individual issues that are relevant to AV acceptance. This evolution of acceptance displays that individuals are not solely concerned with usage of the technology. It is clear that acceptance is concerned with a wider range of issues, such as their enjoyment, their social status upon usage, and the image they portray upon adoption.

In the context of driverless technology, a phenomenon that is of key public interest is that it is now becomes clear the need to involve and act upon a range of social issues and ensure their inclusion into the study and deliverable. Further discussion of this will proceed at the premise of this section.

The final model considered in the section of Acceptance was a proposal by Ghazizadeh *et al*. (2012) to extend the technology acceptance model to account for automation acceptance. A weakness of the model, as stated by the authors is the transferability, with the model focusing on a general scenario, rather than a specific one. This reiterates problems that are associated with the original TAM, with limited context ensuring a situation cannot fully be understood or explored.

In addition to the incoherent transferability, the theoretical perspective within which this model has been developed is limited in terms of its penetrability. Ghazizadeh *et al*. (2012) recommend further study in the form of a theoretical literature review supported by a primary study conducted first hand with users/stakeholders to develop concentrated understanding on potential users. This echoes the work of this thesis and supports the adoption of the grounded theory.

Three contrasting models have been selected to build the body of discussion around technology acceptance. The contrast between the three is as follows: the technology acceptance model represents a time where technology was not readily available, hence its conservative narrative focussed on usage and ease of use. The TAM 3 presented by Venkatesh *et al*. (2008) represents the current period, where social issues and individual image are as important to individuals as actual usage. Added to this, the social issues are now more prevalent due to technology being easily accessible and freely available in all aspects of society. The last model to represent Acceptance is the AAM proposed by Ghazizadeh *et al*. (2012), an extension of the original TAM to assess automation acceptance. From the three, this work represents a shift change to the current focus of technology when considering the organic growth of technology or the technology readiness level of automation. As an evolvement over the two previous models, the AAM still draws comparison to the other two models with the survival of the usefulness and ease of use, as well as external factors such as organisation influence similar to social issues of TAM 3. A number of unique characteristics of this model exist to deal with the multi-level nature of automation such as system feedback and compatibility.

Displayed above are three contrasting models of technology acceptance, all considering different element of the same spectrum. The key observations and findings around the models can be found below.

Each model began with a foundation based on the original TAM emphasis on perceived ease of use and usefulness. In the TAM 3, this was portrayed by elements such as self-efficacy, enjoyment and job relevance. The AAM proposal also gave credence to the mentioned factors, highlighting their significance, even after 3 decades of their introduction. This represents a key learning to the study and an indication of two key themes that will shape and confirm findings. Surprisingly, the mention of these two key themes was almost non-existent across the literature on automation acceptance aside from loosely indirect themes such as competent trust. Given the focus to these themes across the three acceptance models considered, learning can be applied here and taken forward into the grounded theory study of this thesis.

When considering the timeline between the models, the concerns raised by the various social issues are relevant to the spectrum of technology acceptance in the case of driverless vehicle technology. The key theme surrounding the social issues is the image one portrays upon vehicle usage and the social influence that is associated with technology acceptance and adoption. In addition to this, the trade-offs between the fear of usage and the enjoyment of adoption are proposed by TAM 3. The closest piece of work to the discussion around social issues comes from the work of Nordhoff *et al*. (2016) who discuss the socio demographics and social acceptability of adopting driverless vehicle technology. The inherent social image that is now a companion of technology has been confirmed to play a role within the acceptance and usage of driverless vehicles. However, at this stage, the discussion is minimal with only one author attempting to make the connection between the two. In terms of the fear discussed by TAM 3, the existing literature on AV acceptance contextualises this fear by discussion it as the fear of losing or surrendering control to a system.

The model of acceptance focussed on automation adoption, the ease of use, usefulness, and has a key focus on social issues of its predecessors. However, as an evolution over the previous, and as providing insight on the shift towards automation of current and future technology, concerns were prevalent in the model. The factors of system design, task-technology compatibility, trust and feedback as being essential acceptance factors. Competence trust was highlighted by the literature at Section 2.1.3 to be a key acceptance theme, in similar fashion to the task-technology compatibility mentioned by the acceptance models of this section. This again displays the ability of this chapter and literature review to contextualise universal acceptance models for the purpose of this thesis and the transferability that exists in the extant literature. In addition, the spectrum of trust is persistent throughout the study, appearing in a number of scenarios, be it competence trust, trust in one's ability, in the manufacturer etc. This thesis will distinguish which types of trust are relevant to this phenomenon and in doing so, discuss and document each type. The concluding point of this section is around the design of the system, as mentioned by Ghazizadeh *et al*. (2012). Leaning slightly towards cognitive engineering, a major contributor to the AAM, system design in itself is a widely discussed topic within AV technology. Although it is out of the scope of this project, given the specialist knowledge required to discuss issues and solutions around design, its importance will be assessed in relation to acceptance and look to participants to document potential design criteria and user needs in relation to this theme.

This section introduced a representative number of models to display the process and thinking around technology acceptance. This led to a discussion on relevant factors and issues that consumers face in relation to general technology acceptance. The previous section took key learnings from the models of acceptance and compared this to the key learnings from the literature on AV acceptance to confirm findings, identify relationships and recognise any gaps within research. An example of the latter being the empirical studies' lack of knowledge around perceived ease of use or the usefulness associated with AV, whereas the work of technology acceptance ranked these two factors as important within each of the listed models. Comparisons of this nature result in knowledge gaps which can be addressed through further studies involving difference with participants to confirm relevance to AV acceptance or not.

2.3 Attitudes to Autonomous Vehicle Acceptance

At this stage, both theoretical and empirical literature that exists on the topic of autonomous vehicle acceptance has been discussed, and the section documented models of technology acceptance to gain an appreciation of Acceptance literature. Amongst this work, issue of attitudes and the influence that attitudes play on acceptance was prevalent, leading to further investigation.

The original TAM (Davis, 1989) displayed attitudes towards using as one of its key constructs, influenced by perceptions of usability and usefulness, in turn influencing behavioural intention to use. Park (2009) found that the intention to use is highly influenced by personal attitudes or perceptions, displaying the authority that attitudes have on individual actions. Yang and Yoo (2004) further signify the importance of attitudes by stating that it deserves more attention in Information Systems (IS) based research, given the considerable influence it has on individual and organisational usage of IS.

Kim, Chun and Song (2009) recognised how often attitudes are omitted from acceptance research and as a result of this discovery, attempted to create a research model focussing on the strength of attitudes and the promotion of attitude based acceptance in IT adoption. Their study revealed that attitudes towards using is the single biggest influencer of an individual's intentions towards the technology.

Agarwal and Prasad (1999) reported similar, noting prior experience, knowledge and tenure as the contributing factors of attitudes strength. The above arguments are also synonymous with the Theory of Reasoned Action (Ajzen and Fishbein, 1980), which is another model that looks favourably upon the role of attitudes in determining adoption.

The Theory of Planned Behaviour (TPB), a derivative from the Theory of Reasoned Action (1980), focusses on predicting individual intention to engage in a particular behaviour over a specific time and place. The key theme of this model is behavioural intent and how this is influenced by individual attitude about the likely resulting outcome a particular behaviour will have. The theory states behavioural achievements depend jointly on motivation or intention and ability also classed as behavioural control (BU Edu, 2013).
(See Figure 5)

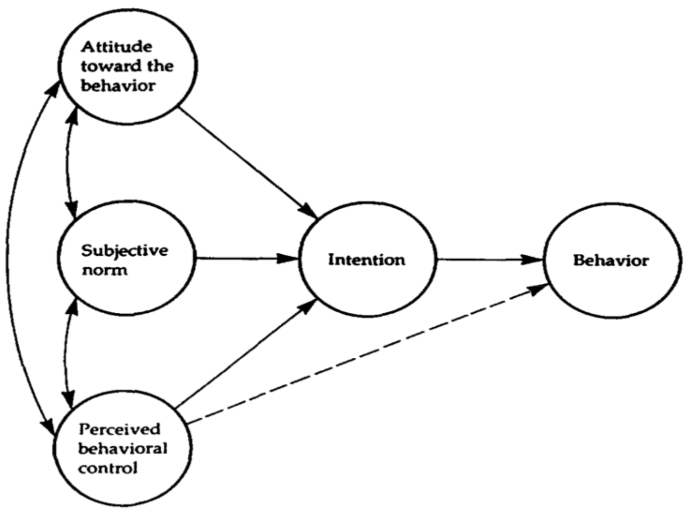

Figure 5- Theory of Planned Behaviour. (Ajzen, 1980)

Whilst much of the above was developed to account mainly for computing environments, the work of Dietterich & Horvitz (2015) confirms that the concepts are still relevant to robotics, drones, artificial intelligence and self-driving cars.

Within the TPB, attitudes play a similar role to that of the TAM. In this case, influencing intentions and ultimately behaviours in relation to adoption and usage. In terms of ascertaining the role of attitudes in acceptance for the perspective of this model, two related studies exist. Kelkel (2015) applied the TPB to the scenario of driverless vehicle purchasing and found that individual attitude was the biggest influencing factor on behavioural intention, purchase intention and subjective norm amongst other lesser characteristics of AV acceptance. In addition, KelKel (2015) also stated that OEM's must understand the acceptance characteristics of potential users in order to feed their solution, thus converting the attitudes of their prospective buyers. Truong (2009) also investigated consumer acceptance through the TPB, in this instance applying it to consumer acceptance of online video and television services. Truong (2009) found that the strongest influencing factor is perceived behavioural control. The factors of attitudes and subjective norm were positive on the acceptance issue, but more conservative. The paper concluded by stating that the reasons for attitudes being more conservative in this and related scenarios is due to the subject (online video) being a more favourable activity of participants. Given this fondness of the subject, the need of attitudes to serve as an influencing factor reduces, applicable to this subject and others. Due to this, the attitude of the participant is generally responsive and therefore has little predictive power over their intentions. Further academic use of the TPB, and more specifically employing attitudes to assess acceptance can be found in the work of Knabe (2012), who applied the TPB to online course adoption and found attitudes, alongside the other components of the model are strong predictors of adoption.

The introductory paragraphs of this section set out to understand whether attitudes played a role within technology acceptance. More specifically the section attempted to understand whether attitudes played a significant role in influencing participant adoption of technology. Through documenting models of technology acceptance and discussing a number of studies that infused attitudes and acceptance, it is clear that attitudes play a strong role in determining individual technology adoption. This discovery, commissioned the development of the next section, researching the role of attitudes in the spectrum of driverless vehicle technology. A correlation between this section and that of literature on autonomous vehicle acceptance is that both discuss the need for further research in their respective fields. In relation to attitudes on AV acceptance, given the influence of attitudes on technology acceptance, it is assumed that attitudes will also play a key role in influencing acceptance of AV systems. The following section will attempt to validate this assumption.

A 2014 intelligence report on behalf of the Department for Business Innovation and Skills set out to review information around public attitudes and perceptions to automated vehicles. Their work is supported by the Ipsos MORI Automotive survey (2014) and found that a number of positive and negative attitudes exist. In terms of attitudes towards autonomous vehicles, only 18% of surveyed individuals felt the technology was an important avenue for manufacturers to pursue, with 41% finding it unimportant. This individual finding displays that participants are disinterested and a real urgency is vacant. The survey concluded that participants felt it was a 'tech for tech sake' scenario, rather than a true innovation or overhaul of the driving environment. This example of a quantifiable attitude measurement based on a large number of participants displays the effect of attitudes on acceptance, signifying that participants who felt the system was unimportant, would not accept or adopt it. In addition to this, the ability to understand attitudes at an early stage means the study of this thesis will have a list of attitudes that can be discussed with participants. This will enable the understanding of the relevance, impact and influence of attitudes on the ability to accept and adopt autonomous vehicles. To further, highlight the importance of attitudes, Debord (2016) states that a proper understanding of attitudes will shape the next 20 years of driverless vehicles. Ng and Lin (2016) discuss AV system introduction by mentioning the system will become ready, the challenges for humans is to adapt the road and to change user attitudes.

The importance of attitudes in relation to public acceptance is signified by the UK AutoDrive (2016) project that has worked alongside the University of Cambridge Engineering Department. This project created a 48-point questionnaire related to tracking public attitudes towards autonomous driving. The UK AutoDrive project commissioned until October 2018 represents a consortium of members such as Jaguar Land Rover, Ford, various UK councils and a number of Universities. The project, intent on introducing autonomous driving to the UK market, employs a mix of public road testing and a questionnaire to allow the development of its business case and requirements design. The longitudinal approach of the UK AutoDrive (2016) project, mapping attitudes over a time period is reminiscent of the advice of Ghazizadeh *et al*. (2012) signifying the ever changing nature of acceptance and attitudes to a subject. Although this is out of the remit of this thesis, a discussion will be provided in the future work section.

Gateway (2016) explored current public attitudes towards automated vehicles and found that the collective thoughts were of a future unknown that could prove highly disruptive. Further attitudes towards the system were the further influx of traffic due to the driving task becoming less challenging and more accessible. However, participants also had a positive attitude towards the technology, praising its safety features for pets and animals, its ability to ensure consumers do not receive speeding tickets and its gradual evolution towards a system that allows the towns to become less road/driving orientated. These findings suggest that participants are not opposed to the system and its introduction; they are questioning some of its effects and features. In the case of the Gateway (2016), particular quantitative data was unavailable to assess whether the positive attitudes outweighed the bad or vice versa. Therefore, it was assumed that each had an equal weighting and effect on the potential acceptance of participants.

The ramifications of the Gateway (2016) study could be perceived as an identification of particular attitudes, both good and bad, but the authors of the study extended the role of these findings to a further degree. The study leader, Dan Phillips, discussed how the preconceptions and preoccupations of public attitudes could be factored into the design process of the system, allowing a user centred design and converting attitudes by consumer involvement.

Cyganski and Fraedrich (2015) further investigated user attitudes to AV acceptance with a quantitative survey with 1000 participants. Their survey set out to capture information regarding attitudes towards and anticipated usage of automated systems. Within their findings, the authors noted that previous use of driver assistance systems did not have a strong influence on attitudes, whereas knowledge of the perceived benefits did influence participant attitude. This directly contradicts the work of Agarwal and Prasad (1999) who list prior experience as contributing factors to converting attitudes. Furthermore, in Section 2.1.3, potential acceptance factors of AV systems have been documented as learned from literature and discovered knowledge to be a contributing theme. Past experience was discussed as a method of gaining knowledge and understanding; however, it was considered only a minor contributor, given its lack of discussion within the literature

Another influencing factor of attitudes towards autonomous driving was raised by Fraedrich *et al*. (2016) who propose that the worldview individuals have towards driving corresponds to their eventual attitude towards autonomous vehicles. Their work stated that if an individual viewed their car as a pragmatic method of transport, then a positive attitude would transcend toward the technology. In contrast to this, those who enjoy driving would hold negative attitudes towards the technology (Fraedrich and Lenz, 2014).

Further findings of the study were of participants displaying positive attitudes towards the technology. Negative attitudes were recorded when discussing their willingness to use or to replace their existing method of transport with autonomous driving. In addition, the study confirmed that alongside emotions, attitudes were one of the main influencers of acceptance.

Automotive Fleet (2016), reporting on behalf of the Volvo Future of Driving Survey present a number of findings related to determining attitudes to autonomous cars in the USA. The survey found that the majority had a positive attitude to autonomous driving. In addition, 86% of Californian and 90% of New York residents felt that AV systems could bring ease to their daily life. The overwhelming negative attitude held by participants was towards government and local authority due to their delayed reaction to and approach in planning for the arrival of AV systems.

Automotive Fleet (2016) found that positive attitudes were portrayed by participants towards the technology, with the only real negativity being towards those in authority. In the large online study with over 50,000 responses, many encouraging positive attitudes were recorded. However, this is in contrast to other studies being discussed, where attitudes are negative or not inclined towards AV usage. A challenge of these studies does not know anything about the participant base, and it becomes unclear as to which attitudes are negative, positive and which require some influence or intervention. In trying to influence negative attitudes to encourage acceptance, identities and stakeholder identification is required.

Whereas the above reports a set of positive attitudes towards AV technology, the following represents a range of negative attitudes. An AA (2013) survey of over 23,000 motorists found that 65% of respondents enjoyed driving too much to be enticed into the adoption of an AV vehicle. Similarly, a study by Adams (2015) found that 61% of respondents would definitely not consider purchasing a driverless car. In addition to this, an Accenture research study (2011) found that 51% of respondents would not feel comfortable using a driverless vehicle. In addition to this, 30% of Western Australians continued this negative attitude with strong negative feelings towards the technology (RAC, 2016). In contrast to this finding, Fraedrich and Lenz (2014) found that commenters of the AV environment were positive about the technology, rather their negative attitude was towards the expected consequences for individual use and societal effect.

Hollenburg (2014) report that only 24% of US adults would be willing to give up vehicle control to an autonomous system if it meant a collision would be avoided. Further findings of the study found that only 15% of those surveyed reported a desire to ride in a driverless car and 17% of participants stating the AV system feature of self-park was desirable. This set of results reporting an overall negative outlook to AV systems from a US adult perspective further highlights the divide that exists in attitudes. Hollenburg (2014) attributes this attitude being down to the inability to currently see, feel or use AV technology and the adverse effect on attitudes this difficulty of imagining currently poses. To further understand the results, Hollenburg recalls the Rogers (1964) Diffusion of Innovation Theory to explain why the current positivity towards AV systems is as it is. The Diffusion of Innovation Theory introduces various adopter categories to understand acceptance of innovation with its early stages (Innovators and early adopters) being those individuals that adopt technology early as innovators, with very little need of evidence or persuasion. Hollenburg (2014) attributes these two adopter categories as being those individuals who make up the small minority with positive attitudes as reported by the SBI (2014) study. The discussion will outline the role and state of the remaining three-adopter categories (Early majority, late majority, laggards) in relation to current understanding of attitudes towards autonomous vehicles.

Within the spectrum of attitudes towards AV system acceptance, a growing repository of studies have conducted studies in different geographical locations in a bid to compare how attitudes vary in different locations. The sample group of this thesis is built up of stakeholders from the UK who are differentiated by characteristics related to their relationship to the road. However, the various studies still display a wide body of knowledge surrounding attitudes, signifying the reason for their inclusion.

In the case of a German study, 1000 participants to understand German driver attitudes towards driverless cars, only a fifth (22%) of participants had a positive attitude towards AV systems. In contrast, 44% of participants were unconvinced, 10% were undecided and 24% of participants were reported as hostile towards AV systems (Motovision, 2012).

A UK based survey with aims similar to the above study found that although 60% of UK participants (1200) had an awareness of what driverless cars offered, 48% of them would not consider purchasing and 33% would not consider being a passenger. In addition, of 60% of the participants, 80% stated a preference to have some form of control over proceedings (Bedwell, 2015). In contrast to these negative attitudes, 85% Indian and 75% of Chinese participants displayed overwhelmingly positive attitudes towards driverless vehicle technology (Geiselr, 2016).

Although the studies listed are not conclusive of their respective locations, they do represent a difference in opinion and attitudes across the locations discussed. As mentioned, this thesis will only include participants from the UK, allowing for comparison with fellow UK based studies. A future development or field of work would see comparisons made with neighbouring countries to assess the difference in attitudes across different communities. Furthermore, a valuable piece of research would see this work re-enacted in the mentioned countries and them results used in comparison with the results of a UK based sample. This would represent a better working method, given the similarities that could exist between the studies, improving the reliability of the results.

2.3.1 Discussion on Attitudes to Autonomous Vehicle Acceptance

To investigate the influence of attitudes on technology acceptance, the technology acceptance model and theory of planned behaviour were discussed at Section 2.2. Through this investigation, attitudes were found to be an influencer of technology acceptance. In both cases, the concept of attitudes was introduced to be one of the key and early influencers of behavioural intentions and the resulting acceptance. Through this confirmation, studies concerning attitudes towards AV systems were documented to understand current attitudes towards driverless vehicles.

By documenting the various studies related to attitudes, it is clear that much of the community has approached the issue in different ways. A number of studies investigate attitudes in the context of particular age groups, gender based attitudes towards driverless vehicles or location based studies. Although this is relevant to the spectrum of driverless vehicles, this thesis was approaching attitudes in a general context, similar to a number of studies that have been documented above. For the benefit of the thesis, a representative set of results pertaining to location based acceptance have been listed to highlight the wealth of knowledge that exists on areas not considered by the thesis, representing potential future work. As the overarching theme of this thesis is to study acceptance of driverless vehicles, with attitudes being a key contributor, general studies related to attitudes were documented. These studies test attitudes of participants with no defining features such as age or gender; it is only their attitude that contributes to the set of results gathered.

This method of investigating and documenting attitudes yielded a varied set of results. The above section displays the split between studies reporting positive attitudes towards driverless cars with a number reporting negative attitudes. As the literature review is not conclusive of attitude-based studies, a quantitative analysis between the two is not yet possible, although the swing between the two is noticeable. By considering the results that are available, the positive attitudes towards driverless vehicles are currently less than 50% of the total studies displayed. LaFrance (2015) discusses the reasoning for this being due to the Rogers (1964) adopter categories of innovation adopters (See Figure 6).

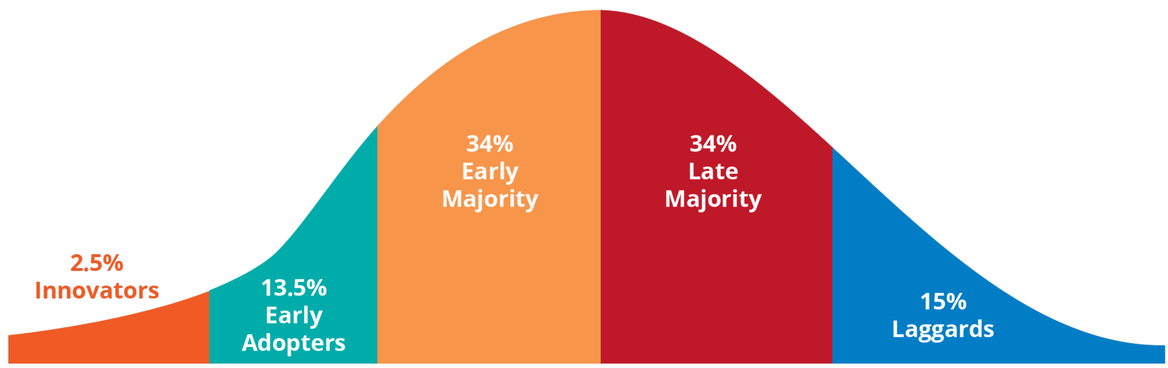

Figure 6- Diffusion of Innovation (Rogers, 1964)

Those who report positive attitudes towards AV technology fit into the first two categories (Innovators and early adopters) with the remaining majority (Early majority, late majority and laggards) still reporting negative attitudes. Characteristics of the negative majority and the potential reasoning behind their negativity towards driverless cars can be due to their scepticism and cautiousness towards the upcoming technology. As a more traditionalist group of adopters, they are not welcoming of change and require evidence to approve of change and adoption (Rogers, 1971).

The concept of driverless cars challenges adopters on a number of levels. It requires a change of effort from a settled traditional system to an innovative and potentially risky. Users are required to let go of reservations with little current knowledge or understanding of a system that is not yet available to see or use. In addition, users are unable to access evidence to support change or adoption and associated benefits. These are contributing factors to why the majority have an overwhelming negative attitude set towards driverless cars. The Rogers (1964) theory provides a timeline through its adopter categories that ultimately displays adopters of all categories coming together and using the technology, albeit at different intervals and through different avenues of persuasion. This building is also supported by the work of Hollenburg (2014) who predicts this lengthy process of driverless car adoption.

The ability to differentiate adopters by their category and assign characteristics and properties to each adopter category (age, gender, location etc.) would prove valuable. At this point, the Rogers (1964) study provides one of the more influential and relative methods of understanding the attitude split. This method of identification and user understanding represents an insightful and much needed piece of research that would provide context and consideration for the human factors community.

What becomes clear from this work on attitudes towards AV systems is that adoption and acceptance is not a 'one size fits all' scenario. Many factors are in play that will ensure adoption is a time-consuming process and that no readily available answer will be available to predict or guide acceptance of driverless cars. Furthermore, the introduction of higher levels of automation will serve to further the confusion and lengthen the process.

In extension of the above, the discussion touched upon the diversity of this field in terms of how various researchers have attempted to understand attitudes with some focussing on age, culture etc. The majority paid more attention to the results rather than beginning with the sample and tailoring results towards the participants. In taking learning from the work of Rogers (1964) and by observation of the generalised samples that the majority of studies have taken, this thesis has further reinforced the sample group that has been devised. The sample, discussed at Section 3.8, is built up of a number of stakeholders connected to the road network (car drivers, cyclists, large goods vehicles etc.), and approaching the study with this particular sample group will enrich the community with new knowledge. Whereas the studies above discuss the results in light of participants, this thesis will be able to discuss attitudes of particular stakeholder groups. This will develop an understanding of stakeholders groups, their attitudes and how they affect potential acceptance and usage of driverless vehicles. In turn, further research opportunities will become available as this understanding develops as advocated by the research around acceptance, tailored solutions and targeted approaches can be made to maximise positivity and acceptance. Further discussion and a recall of the learning of attitudes in reference to the sample group can be found at Section 5.2 and 6.2.

Within this section, attempts were made to understand the impact, influencers and factors concerning attitudes in relation to driverless vehicles. From the studies conducted, the following can be presented as the key factors and influences of attitudes in the adoption of driverless vehicles:

- **Prior Experience**: The first key factor within attitudes is prior experiences. This factor was highlighted by participants to influence attitudes, either positive or negative, depending on the experiences. Prior experience is a factor that is almost non-applicable, due to system being a revolution into the driving environment, rather than a system extension or progression. However, some learning that can be taken from this factor is the first instance of system exposure that users have. For example, public display, trials, and advertisements must all be in line with users' own values and clearly display the positivity that surrounds the system in its entirety. For most, this will be their first interaction and the biggest opportunity for manufacturers, system creators and product owners to convert attitudes that are currently mostly negative.
- **Tangibility**: Tied into the above point, attitude studies discussed the notion of tangibility and the fact that users cannot currently see, feel or use AV systems is a key factor for negativity towards. As this tangibility constitutes as evidence for users as they can begin to believe that they are seeing, attitudes will begin to shift and improve;
- **System Knowledge**: In extension of the above two factors, any available knowledge that potential users have of the system will serve to reinforce their particular attitude. Also highlighted as a key acceptance factor, the literature uncovered the fact that the current knowledge held by users is minimal, a contributor to the current negativity towards AV systems;
- **Adopter Type**: Utilising the Rogers (1964) categories, the type of adopter each user is, will determine their attitude towards the technology. As can be seen from the majority of studies, the positive attitudes towards the technology amounts to less than a quarter of total attitudes consulted. This corresponds with the earlier adopter categories that discuss participants who generally display positive attitudes towards new technology and adopt before the negative majority. Further discussion of this can be found in the preceding section;
- **Worldview of Driving**: The study found the worldview individuals have of driving will affect their attitudes. By this, those individuals who see the need for improvement to infrastructure, safety, efficiency, congestion etc. will understand and therefore support the introduction and usage of AV systems. On the contrary, those who have no knowledge of the current problems associated with road transport and feel the

current method of road travelling is working, without any issues, will not see the need for change and therefore will not be inclined towards the technology;

- **Driving Enjoyment**: One negative perception highlighted in the literature was around the driving enjoyment an individual felt and how this influences their proposed acceptance. In a future driverless car state, a number of users feared this would be taken away from them in an autonomous environment, and as a result of this would not accept the use of driverless technology. This discussion extends into the attitudes dialogue with driving enjoyment also mentioned by researchers as a potential attitude influencer;
- **Defining Factors**: The concluding key theme found in the literature review is the different number of defining factors that affect attitudes on AV systems. Available literature suggests that factors such as age culture, location and gender have an influence on attitudes. The inability to confirm this is due to a focus on acceptance as single entity, rather than attitudes in isolation and the specific documenting this would require. However, the literature discusses that geographic location impacts on attitudes. As this work is considering UK stakeholders in the first instance, considering stakeholders from other geographic regions is considered future work. Previous studies also do not consider different stakeholder groups that samples fall into, a knowledge gap to be filled by this thesis.

The remainder of this section documents key factors that are relevant to the spectrum of attitudes towards driverless vehicles. The initial understanding is that even though there are few factors in comparison considering acceptance factors, the influence and importance of attitudes within driverless vehicles is evident. To understand this, one must consider that acceptance is the broad field that will govern usage of driverless vehicles, whereas attitudes is one of the themes or contributors towards acceptance, hence the smalle number of factors or studies attributed to it, in comparison with the overall subject of acceptance.

One factor discussed within previous studies but not listed above is the issue of perceptions and the influence individual perceptions have on attitudes. Perceptions in itself is a broad spectrum of study with the range of acceptance models discussed all presenting perceptions through ease of use, usefulness and control. Upon reflection into perceptions and considering the above categorisation of acceptance and its constructs, it can be stated that perceptions fuel attitudes, which in turn influence acceptance. This is in line with existing research around acceptance models that document perceptions as being an attitude influencer.

One clear difference that exists in the listing of factors for attitudes is that the work is not as conclusive as that of acceptance. For that section, factors are included due to mentions by different studies, whereas in the case of these factors, their mention was once or twice. This displays that the field and importance of attitudes is still not fully recognised and thus motivates the gap in knowledge for this thesis.

In this thesis, attitude factors will be applied to the study and discussed alongside participants to understand whether the factors discussed are relevant to this specific sample. In addition, differences amongst the varying stakeholders will be documented to further understand attitudes and the resulting influence within AV systems.

To conclude on this section, the discussion of attitudes has highlighted a number of relevant issues to the thesis. A number of studies, although less in comparison to acceptance studies, exist to survey attitudes towards driverless cars, all with mixed results. However, the overwhelming majority reporting negative attitudes towards current AV systems. Rationale has been provided for this and why the positive minority is as it is, with the Rogers (1964) model validating this swing as being usual and expected in technology adoption at this scale. An opportunity exists to further populate the field to provide results that could be considered conclusive or representative. The main opportunity focussed on in this thesis is the focus on particular and definitive samples, rather than a general sample approach adopted by the majority of studies documented within this literature review. This will enable new knowledge and context to be provided to the community to gain understanding of individual stakeholder groups, a need identified by Howard and Dai (2013) earlier on in the literature review.

2.4 Chapter Conclusion

The purpose of this chapter was to develop an understanding of the literature currently available on autonomous vehicles, specifically focussing on its uptake and usage. This was done through documenting and analysing quantitative and qualitative studies that recorded participant perception to assess and prioritise key factors and concerns in relation to AV system uptake. This knowledge would then be subject to comparison with the results of this thesis to ascertain which results are confirmatory, and which represent new or underreported knowledge. Existing literature on empirical studies of AV acceptance were plentiful, given the youth and fertility of the subject. A list of the key findings can be found at Section 2.1.3.

Further contributions to this section of the literature review were made from theoretical knowledge and not through user participation. This set of literature was limited as it was concluded that a strong empirical understanding was required to establish an understanding of his new topic, prior to a theoretical contribution.
To complement the above, general technology acceptance literature was also assessed to gain a broad appreciation of the subject area. Here, popular acceptance models were discussed and similarities between them and current understanding of technology acceptance in the context of autonomous vehicles were discussed. This created an understanding of which factors of technology acceptance are still relevant and applicable and where legacy literature could still contribute to current research and technology acceptance scenarios.

The role of the literature within grounded theory is different to that of fellow qualitative studies. To avoid literature bias, adopters of the grounded theory conduct their literature review in conjunction with data collection, or slightly after it, as opposed to completing it beforehand. This concept is discussed at Section 3.2.4. Therefore, topics of the literature review are influenced by the outcome of the various stages of data collection. A late addition to the literature review was the consideration of attitudes towards autonomous vehicles, as literature and data both pointed to its importance and role in technology acceptance. This section of literature would then be recalled in the results, where the discussion attempted to assess the attitudes and resulting influence of attitudes of the various road user groups involved within the study.

Overall, the role of literature within this grounded theory study is of paramount importance as it guides theorists who are collecting data with little pre-conceived knowledge or a developing understanding of the topic. The literature, therefore, provides context and a deeper understanding to the data collected and plays a significant role from the stage of comparison through to results presentation. For the needs of this study and to sufficiently represent collected data, the topics of AV acceptance, technology acceptance and attitudes to autonomous vehicles were established as the three key areas of interest. The findings of this literature review are reintroduced at Chapter 6, where they are compared to findings of this study. The thesis will now introduce the methodology (grounded theory) employed and the associated sample.

Chapter 3- Selected Methodology Introduction and Discussion

A full overview of the methodology, including key processes, discussion of alternative approaches and a justification is documented in this chapter. Subsequent sections will introduce the sample, sampling strategy and recruitment techniques. Chapter 3 discusses the application of the methodology, and Chapter 4 will highlight its implementation and actual usage. In attempting to understand users' perspectives of autonomous road transport technology, the grounded theory methodology, introduced by Glaser and Strauss (1967), was selected as the methodology of choice. A supplementary discussion of the associated research ethics can be found at Appendix 1.

3.1 Grounded Theory Introduction

Originating in 1967, the grounded theory methodology was introduced by Barney Glaser and Anselm Strauss. The methodology was introduced to understand the awareness of dying from a patient perspective, a revolutionary study at the time (Charmaz, 2006). It was considered a successful alternative to the predominantly quantitative research paradigms that were in use at the time (Gorra, 2007). The key offering of the methodology was to discover and generate theory in fertile, yet vacant areas, rather than testing existing theory (Patton, 1990). As a qualitative research development tool, Glaser and Strauss (1967) highlighted the need to systematically gather data from social research to ensure the effectiveness of the model. In addition, the methodology is best placed to enable understanding and exploration of social relationships, perceptions and behaviour. Any successful grounded theory study examines the Six C's of social process (cause, context, contingency, consequence, covariance and conditions) to understand relationships amongst the nominated elements (Strauss & Corbin, 1998).

Scott (2009) summarised the theory as a research tool that allows an adopter to seek out and conceptualise social patterns and structures. To do this, researchers address a particular area of interest and undertake the process of constant comparison and matching from primary data collection. Crooks (2001) recommended establishing the grounded theory as the primary tool of exploration when attempting to service phenomena that lacked a readily available answer. Within these areas, the tool is established in an inductive manner, allowing the collection of codes (interpretations) from data. In doing this, the developing theory then becomes a deductive process, guiding the narrative to the next participant or literature item for further investigation. The term grounded theory refers to a theory that is grounded in the data it has been collected in (Glaser, 1978).

Grounded theory shares a number of characteristics with fellow qualitative studies, such as the following highlighted by Marshall and Rossman (1999):

- Maintaining a focus on everyday life experience;
- Valuing participant perspective;
- Developing an interactive process between researcher and participants; and
- Primarily a descriptive approach that relies on the spoken word of the participant.

3.2 Grounded Theory Process

As a research tool, grounded theory guides researchers toward a working theory/substantive hypothesis stage. This process allows the improvement of understanding of the area and answer questions posed. The theory is an iterative development with a number of phases that entwine to form a mid-level hypothesis or theory. Within this particular implementation, the grounded theory process was applied to a field that lacked a readily available answer, the required context for the grounded theory to operate. The process adopted by this thesis followed a strict structure, agreed upon by the majority of grounded theorists. Figure 7 displays a grounded theory process from inception to delivery, as graphically presented by Lehmann (2001). This diagram displays a clear primary path through the adoption of the grounded theory, the definition and relevance of which will be discussed below. Figure 7 also displays a simpler primary path of a typical grounded theory process, as displayed by Gorra (2007).

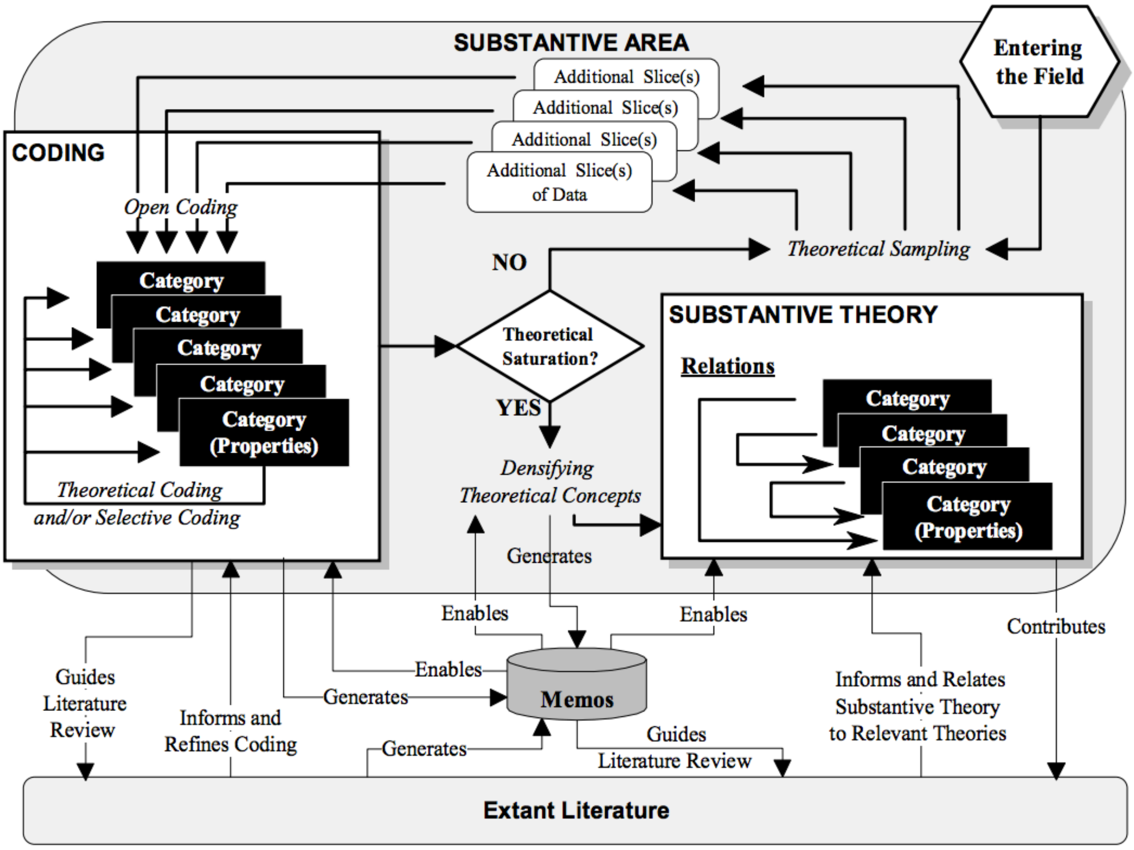

Figure 7- Grounded Theory Process. (Lehmann, 2001)

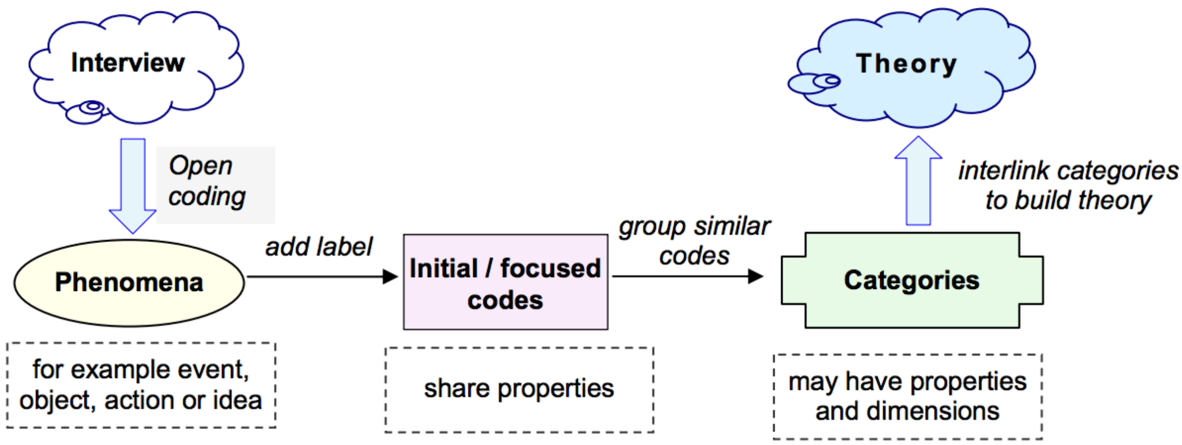

Figure 8- Grounded Theory Process. (Gorra, 2007)

3.2.1 Entering the Field

The first step is to enter the field of investigation. The majority of pre-requisites around gaining ethical consent, participant permission and various other practicalities have been completed before this stage. A researcher at this stage is ready to begin and is aware of who they intend to interview and what they wish to discuss with them in light of the subject area (Ahmed and Haag, 2016). A unique feature of grounded theory is that adopters should enter the field with little or no prior knowledge in the area, a popular Glaser and Strauss (1998) teaching. In doing this, researcher bias is minimised, and the study remains data dependant, in that it allows the data to lead to the theory, rather than researcher bias dictating the direction of data (Ahmed and Haag, 2016; Glaser, 1998).

The status of being data dependant delays the literature review until after data collection begins. This is discussed further below in the 'extant literature' phase. In reference to the practicalities discussed above, Fernandez (2004) offers practical advice for this, such as selecting the relevant software and hardware required, gaining ethical consent from participants, selecting locations and contacting participants.

3.2.2 Theoretical Sampling/ Additional Slices of Data

A central belief of the grounded theory is the process of theoretical sampling. This is an essential development and refinement tool employed to develop a theory grounded in data (Breckenridge and Jones, 2009). At this stage, data is collected and analysed in an iterative development in order to allow theory development to emerge (Glaser and Strauss, 1967).

Charmaz (2006) describes theoretical sampling as a means of focussing data collection and increasing the analytic abstraction of the subject by highlighting variation and identifying gaps that require elaboration. Charmaz (1990) also suggests that employing a preliminary study highlights a number of key concepts to consider, with the introduction of theoretical sampling allowing further investigation with participants to develop data. Adding additional slices of data, via interviews and focus groups, are the primary tools of exploration. Further discussion of these tools can be found in Section 4.1.1.

At this second stage of grounded theory, a number of participants will be involved in the study, providing the required slices of data, with an estimation of further participants and numbers required. At the close of this stage, gathered transcripts, recordings and notes will be available to move forward into the next phase; coding.

3.2.3 Coding

The initial process of analysing data begins at this coding phase, where data is transcribed, conceptualised and various procedures are applied in order to draw out 'codes' also known as new pieces of knowledge or phenomena. Bryant and Charmaz (2007) discuss this stage as being one where attempts are made to understand participant transcripts.

Holton (2010) describes coding as being the core process within grounded theory where data is segmented and the early foundations of theory are developed. By analysing and segmenting data within this phase, 'codes' are developed that form the basis of further analysis. Charmaz (2006) describes this process as qualitative coding where segments of data are categorised with a descriptive name that accounts for and summarises each piece of gathered data.

A simple example of a coding application adapted from the work of Charmaz (2006) is as follows:

- The data is '*you never tell me anything, I have to find information out from Linda*'. The resulting code would be the feeling of being left out and the process of confrontation.

Cohen and Crabtree (2006) present the most common processes of coding and the order by which to observe them to reach segmented, managed and defined codes. They are as follows:

- **Open Coding-** Where the grounded theorist begins to divide the data into similar groupings and form preliminary categories of information about the subject under examination;
- **Axial Coding-** The identified categories developed within the open coding phase are now brought together into groupings. These new groupings resemble themes collected from data and are new ways of seeing the subject under study; and
- **Theoretical Coding-** The final coding process organises categories and themes in an articulate method to create an understanding the phenomenon of study.

3.2.4 Existing Literature Comparison

The next two stages within the grounded theory (extant literature and memos) run simultaneously at the discretion of the research study. The existing literature phase is where coded data is compared to existing literature to confirm findings, inform and refine codes and acquire sensitivity on the data set (Giske and Artinian, 2007).

In addition to the above role of the literature, Lehmann (2001) discusses further responsibility of the literature review alongside the process of the grounded theory. Within the grounded theory community, the positioning of the literature review has been widely contested. Ross (2014) states the debate has been ongoing for at least twenty years. Although the role of the literature review is unquestionable, the issue is when it should be introduced and how it should be used.

The initial Glaserian approach (1987) and the more recent constructivist Charmaz approach (2006) both champion the process of avoiding a pre-study literature review. Charmaz (2006) discusses how a pre study literature review can stifle creativity when coding data. In doing this, rather than developing new knowledge, theorists align their data with pre-existing studies. Glaser (1998) continues this theme by stating the premise of the grounded theory is the unpredictability it develops and how this will lead the theorist down unexpected avenues towards new findings. The danger of a premature literature review is that it may be misleading, create bias within the research team. A premature review could also become wasteful as the data of the study may warrant investigation into alternative literature, rather than that which has already collated.

As this study adopted the constructivist approach of Charmaz (2006), an initial literature review was conducted. The purpose of this was to investigate if this thesis had found a niche to service, and also to ensure a developed understanding of the environment for the purpose of the interviews and the ethics documentation. On the issues of the interviews, Charmaz (2006) promotes co-creation between the grounded theorist and participant to develop data. For this reason, an initial understanding of the environment was imperative.

3.2.5 Memos/ Theoretical Coding

Running in conjunction with the literature review phade is the process of writing theoretical memos. Memo writing is an essential distillation process that assists in evolving data into theory. This is done by gathering the raw interview and transcribed data, and coding and comparing it in a bid to find patterns. These patterns then go on to form the mid-level theory that is grounded in the data it is collected in, and a culmination of the research study (Bryant & Charmaz, 2007).

The memo process allows researchers to determine which of their codes provides the best relation and patterns for theory development (Hernandez, 2009). Glaser (1998) defines this phase as one that captures the meaning and ideas that are being developed to grow the theory.

Charmaz (2006) provides a detailed definition and guideline for conducting memos, her definition is as follows:

- A memo is an informal, free hand analytical tool used to analyse data and codes gathered earlier in the coding phase;
- The memo process is primarily concerned with comparisons, abstraction of ideas, digging into implicit codes and data interrogation; and
- Memo writing should be an informal, free hand discussion tool that is free from the structure of formal academic writing. This is done to allow the grounded theorist to focus primarily on discussing the content.

The memo writing in this study will begin as soon as the transcription from the first interview is available to the point of theoretical saturation. By increasing the number of memos written, maximum extraction can take place on data, which is especially important given the small number of participants that will be taking part (Charmaz, 1990).

3.2.6 Theoretical Saturation

Theoretical saturation is defined by Morse (2004) as the point where the iteration of the study has conducted a multitude of data collection phases, coding and analysis. Any new data coming into the study at this point adds no value to the work in the form of categories or properties, as it repeats what is already known. At this stage, most of the concepts and categories are strongly linked and the need for additional data is not required. Holton (2010) discusses theoretical saturation as being achieved through constant comparison of the data through coding and memos. Holton notes that at this point, the theorist shifts focus from analysing codes toward attempting to understand the emergent fit of the knowledge towards producing a hypothesis or working theory. Riley (1996) identifies 8-24 interviews usually being the range of numbers in achieving saturation. An exhaustive discussion of the sample size can be found at Section 3.8.1.

3.2.7 Substantive Theory/Category Development

The final phase of a grounded theory cycle is the substantive theory phase. The pinnacle of the grounded theory is reached upon entering the stage of 'Substantive Theory', which can be classed as a mid-range theory, hovering between a working hypothesis and an advanced theory (Glaser & Strauss, 1967).

Fernandez (2004) notes this stage as being a culmination of the integrated literature and a range of concepts gleaned from data (including memo output). Hernandez and Andrews (2012) propose that usage of the grounded theory is based on the desire to find out what is going on in a particular substantive area. The reaching of this phase signifies a developed understanding of the area and a presentation of output.

Calman (2006) discusses that all concepts and codes are subject to categorisation by their major themes. These categories must be a direct result of analytic codes ad must not be subject to modification to fit within the constraints of existing literature. This categorisation must account for all relational data, hypotheses and properties associated with the data (Glaser and Strauss, 1967).

The final output of this substantive theory phase is defined by Glaser and Strauss (1967) as a mid range theory that ranges between minor working hypotheses and mid level theory. The authors continue to stress that the theory is relevant to the people concerned, not currently representative but readily modifiable.

3.2.8 Grounded Theory Evaluation Criteria

At the close of the Substantive Theory phase of the grounded theory cycle, an evaluation of findings takes place. To understand the utility of the research gathered, Charmaz (2006) provides a number of criteria by which to judge the study, findings and data. This is performed through four key evaluation areas. They are as follows:

1. **Credibility**
   - Is the data sufficient enough to merit claims?

- Has the research provided sufficient evidence?
- Do the categories cover a range of observations?

2. **Originality**
   - Are the categories fresh, do they offer new insight?
   - Does the analysis provide a new conceptual rendering of the data?
   - What is the social and theoretical significance of the work?

3. **Resonance**
   - Does the grounded theory make sense to participants and/or people who share their circumstances?
   - Does the analysis offer deeper insight about their life and world?
   - Do the categories portray the fullness of the studied experience?

4. **Usefulness**
   - Do the analytic categories suggest any generic processes?
   - Does the analysis have the potential to spark research in further categories?
   - How does your work contribute to a better world?
   - Does the research have the potential to offer interpretation that people can use in their everyday world?

In addition to the domain specific evaluation technique discussed above, the CASP (2014) 10-point qualitative study checklist will also be utilised. Introduced in 1993 to meet the various challenges of evidence based medicine, the current day format includes many peer reviewed checklists and metrics to provide critical appraisal for qualitative studies. Amongst the variety of metrics offered by CASP, the qualitative checklist is synonymous with many qualitative studies, given its ability to make sense of and assess qualitative research (CASP, 2014).

The 10-point checklist is as follows:

1) Was there a clear statement of the aims of the research?
2) Is a qualitative methodology appropriate?
3) Was the research design appropriate to address the aims of the research?
4) Was the recruitment strategy appropriate to the aims of the research?
5) Was the data collected in a way that addressed the research issue?

6) Has the relationship between researcher and participants been adequately considered?
7) Have ethical issues been taken into consideration?
8) Was the data analysis sufficiently rigorous?
9) Is there a clear statement of findings?
10) How valuable is the research?

Section 7.1 on the research utility of this thesis will revisit the criteria of the Charmaz (2006) evaluation and the CASP (2014) qualitative checklist to determine the quality and utility of the research study.

3.2.9 Theory Terminology

Within the grounded theory, a number of terms are used to define particular features of the theory. A list of the terms and their definition provided by Holton (2010) is as follows:

- **Codes**: Abstract views of the data containing scope and dimension. Codes provide an understanding of what is happening in the data i.e. they provide a concise explanation of the subject data;
- **Concepts**: The use of concepts is employed to group codes of similar content; and
- **Categories**: A broad range of concepts that have similarities and begin the development of theory are labelled as categories.

3.3 Justification of Grounded Theory Usage

To justify adoption, an investigation was made into studies that have adopted the grounded theory to study perceptions. Also studies that used the grounded theory in the environment of driverless cars were considered. In doing this, the concern that the grounded theory is primarily used and relevant only within healthcare and nursing can be nullified.

Within environments where researchers cannot access developed solutions, the grounded theory establishes itself as the primary tool for exploration (Crooks, 2001). Given the very introduction of the grounded theory was due to its ability to generate or develop theory, its inductive approach is ripe for developing understanding within the respective situations it is applied in (Glaser and Strauss, 1967). In this situation, Pauleen, Corbitt and Young (2007) applied grounded theory, alongside action learning, to articulate ‘what is not yet known’.

Their study based on managing organisational knowledge, especially that which surrounded human interaction with new technologies, used the theory as a research method. They found that by adopting the two mentioned methods, a researcher has the ability to formalise learning and to uncover patterns that have the potential to create practice.

Further examples exist, such as Gorra (2007) who applied grounded theory to formulate an understanding of the relationship between individuals' perception of privacy and mobile phone location data. Williams and Keady (2012) also utilised constructivist grounded theory to study late stage Parkinson's disease. Fundamentally, the majority of adopters of grounded theory do so to study, in an inductive manner, niche areas or fields that require further exploration.

Moving forward, this section now considers using grounded theory in settings that are focussed on analysis of user perceptions. Strauss and Corbin (1998) speak of the utility of the grounded theory as being "If an individual wanted to know whether one drug was more effective than the other, a double blind clinical trial would be appropriate. However, if they wanted to know what it was like to be a participant in a drug study, then they might engage in a grounded theory or some other qualitative study".

Marshall and Rossman (1999) note that one of the core assets of grounded theory is that it values participant perspectives. Value in this sense is defined as the respect assigned to perception and its status as potent data to service methodology processes. Charmaz (2000) mentions that participant values and cultural context help to discover the data required to create meaningful theory.

Examples of successful studies that have used grounded theory to study perceptions can be found in the work of Gover and Duxbury (2014) who explored perceptions of organisational change. Their study investigated the change effort as perceived by participants, highlighting influential characteristics to compare with extant change theory. Wentzel, Yadavalli and Diatha (2013) applied grounded theory alongside the technology acceptance model to understand financial service adoption in South Africa. This study of perceptions and acceptance yielded a proposed enhancement to current understanding of technology enabled financial services. Shiau and George (2014) also used grounded theory to develop a theory related to understanding information adoption in an organisational context.

Further examples such as Gorra (2007), Feeler (2012) or Hardy (2005) justify using grounded theory to derive understanding from studying perceptions. However, given the inductive nature and ability to generate theory from participant understanding, the majority of studies adopting grounded theory investigate perception and develop a theory or heightened understanding from this. The grounded theory itself was created to study perceptions, by way of understanding the awareness of dying from the patient perspective (Glaser and Strauss, 1967). By confirming the ability of the grounded theory in studying perceptions, the study can move forward with the justification.

The proceeding discussion will discuss grounded theory related studies in the field of autonomous vehicles and their acceptance. Possibly the closest work to this is the work of Lee *et al*. (2016), which investigated for the first time, user experience of autonomous systems. By applying grounded theory, Lee *et al*. (2016) were able to ascertain the factors concerning the user boarding experience, providing an early understanding of the interaction between users and vehicles, as well as a foundation for later studies through derived variables.

Although not primarily focussed on autonomy, Giacomin, Robertson and Malizia (2014) used grounded theory to assess and capture the changing nature of the driving task. This study, as a result of rapid change of technology, allowed designers to better understand and measure the naturalness of driver interaction. Their use of grounded theory, with an interview approach, yielded 10 constructs of driver and car interaction that are useful for understanding the naturalness of interaction amidst technology change.

To examine the viability of co-operative road vehicle systems, Walta, Driel, Krikke and Arem (2005) employed the grounded theory to take responsibility of the qualitative data analysis. The authors found usage of the grounded theory and semi structured interviews as being key to uncovering several issues that would not have been discovered otherwise. In light of the systems studied in this work, such as intelligent speed adaptation and advanced driver assistance systems, the authors concluded that further research on consumer behaviour and requirements were required.

A number of studies exist, as discussed above, that utilise grounded theory to achieve aims in the environment of autonomous vehicles. Although none are yet recorded that do this to study acceptance, the study of experiences, assistant systems and change are noted. As discussed in the introduction to this chapter, grounded theory is primarily associated with nursing and the healthcare sector. However, this section has provided evidence of its usage in a variety of fields related to perceptions, acceptance and transport. As mentioned by Giacomin *et al*. (2014), the nature of transport is ever changing, with the associated challenge being to understand user needs and requirements. In this situation, by capturing user requirements, analysing and taking learning from their perspective, the community can remain ahead of change and technological barriers. To do this, the grounded theory offers a clear approach to become proactive in this user focussed field. As displayed above, its usage has already been documented in a number of related fields, contributing to its utility and usefulness in addressing the aims of this thesis.

3.4 Grounded Theory Variations

Within grounded theory, a number of variations exist, including classical and constructivist grounded theory. Due to this, Cutcliffe (2004) mentions how many researchers misunderstand the theory and in turn, misinterpret the challenge of adoption. By doing this, many adopters develop a study that has taken various elements from different authors in a selective approach. The danger of doing this is the delivery of a distorted study (Breckenridge & Jones, 2009).

To ensure successful application and strict adherence to a particular version of grounded theory, a discussion will take place below documenting popular versions. Morse *et al*. (2009) suggest the following as being the most popular amongst theorists; Glaser (1978, multiple revisions), Strauss and Corbin (1998,) and Charmaz (2006).

During the 1980's, after the original Glaser and Strauss (1967) grounded theory introduction, a significant split occurred between Glaser and Strauss. The differences and cause of their professional parting was how each defined the theory and how they saw its portrayal. Walker and Myrick (2011) mention that listing all the differences between the approaches would require an individual book to be written. Ward (2014) summarises the difference as being due to whether theoretical and substantive coding processes should follow the same process. Glaser, in his constant comparative method with Strauss (1967) focussed on conceptual abstraction at the theoretical coding element, rather than an accurate description e.g. induction rather than validation, the preferred method of Strauss & Corbin (1990). The latter also focussed on axial coding as a three phase method whereas Glaser (1978, 1992) did not provide any support. Walker and Myrick (2011) suggested nothing in the coding dictionary of Glaser could offer a direct comparison.

An alternative method to the classic Glaserian and Straussian approaches is the recent, constructivist approach of Kathy Charmaz. This approach takes a standing point between post modernism and positivism in an effort to transform qualitative research into a 21st century context and understanding (Charmaz, 2003). The key difference between a classic (Glaser and Strauss) and constructivist (Charmaz) approach is that within a classic approach, meanings lie dormant within the data and wait to be discovered. In contrast to this, the constructivist approach aims to create meaning by way of individuals, and in this case, the theorist and participant interacting together to understand the particular subject. From this constructivist approach, a challenge is sought to measure or capture the objective truth through research enquiry (Crotty, 1998).

Charmaz mentions that both actors in the study (researcher and participant) should form their own data and analysis in a method of interaction. In doing this, the discovery of a singular finding is left behind. Rather a picture is painted, one that covers the entire spectrum and one that represents the subject sufficiently (Charmaz, 2003). This is further explained by Charmaz (1995) by the mention of both parties producing the data in conjunction, resulting in the shared results being of a higher quality and more representative.

The process of triangulation also helps to enrich studies, following the teachings of Charmaz. Triangulation offers users a means of constantly comparing findings. This effort helps to refine what the study has gathered and maximise what can be extracted. Comparison with existing literature helps to validate and match whether similar findings have been sourced and also to investigate any anomalies (Charmaz, 2006) (Hammersley and Atkinson, 2007).

The above discussion is centred on the alternative approach offered by Kathy Charmaz. This alternate offering is the most recent of all variations and has facilitated the transformation of grounded theory methods being able to handle the demand of modern day studies of complex phenomena.

Within this study, the constructivist approach of Charmaz (2006) was adopted. The following highlights the reasoning behind adoption, in light of the alternative classic approach. Charmaz (2003) introduced this alternative version of the grounded theory to transform qualitative research into a 21st century offering. As one of the key aims behind her contribution, this resonates with the subject of this study. In attempting to capture the essence of a phenomenon, the most recent version of the selected methodology is required.

Furthermore, upon inquiry of the relevant theorists, the work of Charmaz (2006) is more accessible, more relatable to 21st century researchers and is more relevant and in line with the study of driverless vehicles. An example of this is the co-constructive nature within Charmaz's (2006) process of mutual exploration (where both researcher and participant define and contribute to the data passing through the study in a shared reality setting). Rather than classical grounded theory, where meanings are perceived to lie dormant in the data (Crotty, 1998), when studying such a phenomenon with individuals who have not yet seen or interacted with, the role of the grounded theorist is intensified. With their contributed understanding of the wider context, the participants have the ability to go past the descriptive level of data towards the meaningful analytical data that is required to power grounded theory.

The concluding reason behind the selection of the Charmaz approach is relativism of social reality. A central tenet to constructivist grounded theory is to give each participant a voice. Whereas classic grounded theory focuses on one main concern and its continual resolution, constructivist grounded theory does not focus on a core category. Rather, it encompasses multiple truths and perspectives. This focus on relativism and multiple contributions resonates with the variety of stakeholders, the high degree of contracting opinion and the nature of stakeholders related to the subject of study. Furthermore, as this focus is more concerned with people rather than behaviour and experiences, the perceptive nature of this study and the views of participants are embedded in an environment suited for their capture (Martin, 2006; Breckeridge and Elliot, 2012).

In line with the values and ideals around constructivist grounded theory, the above were selected as the core reasoning behind the selection of the Charmaz (2006) approach. Although her approach has a number of different ideals, many academics describe it as a remodel of the original grounded theory. Also, as a student of both Glaser and Strauss, many consider that her approach has not deviated as much as to lose the essence of grounded theory (Mills, Bonner and Francis, 2006).

3.5 Justification of Grounded Theory over alternatives

This section discusses why grounded theory was selected over alternatives that could serve the aims of this thesis. The first part of this section will provide a definition of the chosen methodologies and the second part will discuss the justification behind their non-selection.

3.5.1 Thematic Analysis

Braun and Clarke (2006) define thematic analysis as a method to use when attempting to identify, analyse and report patterns within data. Boyatzis (1998) defines the analysis method as being able to interpret aspects of the research topic. Hammersley and Atkinson (1995) identify the utility of the approach by praising its ability to create identifiable themes and descriptions of strategies and behaviour.

The steps assumed to carry out thematic analysis are very similar to the grounded theory. They are as follows: Familiarising oneself with the data, generating initial codes, searching for and reviewing themes, defining and naming themes and report production (Braun and Clarke, 2006).

3.5.2 Phenomenology

Phenomenology is a method used to study the structure of various experiences such as perceptions, emotions, thoughts and memory in order to understand phenomena as it is experienced by participants (Stamford, 2013).

A study directed by phenomenology aims to answer the question of '**What is it like to experience such and such?'** and by assuming multiple perspectives of the same situation, a researcher is able to develop generalisations of the subject. The process of a phenomenology study follows the four key steps of Bracketing, Intuiting, Analysing and Describing (Van Manen, 1990).

Whitehead (2014) instructs that the process of phenomenology is not to breakdown the experience under study. Rather, the process will provide rich descriptions around being a specific individual in a particular world. Furthermore, Whitehead (2014) highlights that by wholly committing to the experience and process, a 'phatic' understanding of the phenomenon can be developed.

3.5.3 Quantitative Analysis

Quantitative analysis studies aim to gauge facts about a particular phenomenon by way of measurements, numerical comparisons and raw data (Minichiello, 1990). Analyses of a quantitative nature allow researchers to develop a summary of results in numerical terms and present these with a specified degree of confidence (Abeyasekera and Lawson-Mcdowell, 2000).

The Open University (2009) describes the utility of quantitative research to be concerned with exploring specific and clearly defined questions between two events. In this instance, the second event is a consequence of the first. The data of quantitative studies is usually gathered through surveys and questionnaires that are structured to provide numerical data. This can be explored statistically to yield a generalisable result for a wider population.

As the above method discuses quantitative analysis, and the two prior qualitative, the following Table 1 by the Open University (2009) highlights the key offerings and differences of each.

Table 1- Comparison of qualitative and quantitative techniques. (Open University, 2009)

	Qualitative Research	**Quantitative Research**
Type of Knowledge	Subjective	Objective
Aim	Exploratory and Observational	Generalisable and Testing
Characteristics	Flexible, Contextual Portrayal, Dynamic, Continuous view of change.	Fixed and Controlled, Independent and Dependant Variable, Pre- and Post measurement of change,
Sampling	Purposeful	Random
Data Collection	Semi- Structured and Structured	Structured
Nature of Data	Narratives, Quotations, Descriptions, Value, Uniqueness, Particularity	Numbers, Statistics, Replication
Analysis	Thematic	Statistical

Introduced above is a brief introduction into the alternative methodologies available to service the aims of this study. The following will discuss the non-selection of each methodology and where each falls short in comparison to the grounded theory.

3.5.4 Thematic Analysis Non Selection

It is essential to state that thematic analysis is a method, whereas the grounded theory is a methodology. However, the two share a number of similarities such as transcription, coding and searching for themes (Braun and Clarke, 2006).

To understand non-selection of thematic analysis, the following differences between thematic analysis and the grounded theory can be used for justification. The differences and how they affect the reasoning for selection are as follows:

Theory Development

The thematic analysis method does not focus on developing theory. Rather, the method is aimed at conceptually informed interpretations of data. As established in the literature review (Chapter 2) and contribution to knowledge (Section 1.5) sections, the aim of this study is to contribute to theory development for the particular subject. It can be argued that the works discussed in Section 2.1.2 are large scale thematic analysis projects as they contribute to a better understanding of acceptance in AV, but they do not attempt to develop a theory from their findings. This is noticeable, with the majority stating the need to commit to extra research in this area. In reference to grounded theory, Pidgeon and Henwood (1997) mention that a fully developed grounded theory is the working of a large-scale research project, but a working theory, one that develops categories and understands the relationships between the various categories, is the premise of a 'lite' grounded theory. In the case of this thesis, the clear difference between the end goal of a grounded theory and thematic analysis supports grounded theory adoption, especially when considering its usage in this context. If this study was implemented at the earliest introduction of AV systems, thematic analysis would be the correct method for probing the field and extracting knowledge about AV systems. However, at this stage, where a developed understanding is available, and the need to begin theory development is evident, grounded theory is the methodology of choice to further the current understanding around AV systems.

Inbuilt Framework

As mentioned by Braun and Clarke (2006), thematic analysis is a method and as such does not have the inbuilt theoretical framework or guidance that is available to adopters of grounded theory. This advocating of the usage of particular research approaches given by grounded theory is essential to the success of early career researchers. Although confusion can sometimes transcend over which version of grounded theory to follow, once a selection is made, clear direction and instruction can be sought.

Method of Data Collection

The University of Auckland (2017) describes the environment of adopting thematic analysis as being one where interviews are not established as the primary source of data collection. Within this study, interviews and focus groups were identified early on as the methods to adopt, given their benefits. In continuation of the above, this further prompted the selection of grounded theory over thematic analysis.

Although noticeable differences between grounded theory and the thematic analysis do exist, the two also share similarities as already discussed. A number of researchers have developed studies integrating the two, with grounded theory serving as the overarching methodology and thematic analysis serving as the analysis tool. Examples of this mixed methods approach can be found in the work of Chapman, Hadfield and Chapman (2015) and Heydarian (2016). Although this study will not be pursuing a mixed methods approach, similarities between the two allow for integration.

In addition to the above, many academics operating in the field of AV systems have adopted grounded theory as their employed methodology. Lee, Lim, Kim and Kim (2016) used grounded theory to study driver experience of AV systems. Owens, Walker and Musselwhite (2014) explored behavioural change in drivers, in light of carbon reduction and autonomy and used grounded theory to analyse findings. Further articles exist and these are discussed at Section 3.3 on the methodology justification. To support grounded theory usage over thematic analysis, the authors above can support the selection. No studies have yet been found that have used thematic analysis to study any aspect of AV systems.

On the issue of choosing between grounded theory and thematic analysis, both are very similar in their approach. The journey from data collection to analysis and delivery have almost identical steps, rendering either of the two as suitable to serve this thesis. However, it was noted that grounded theory is a methodology, whereas a thematic analysis approach is a method. As a result of this, the grounded theory is fuller in its approach, has a superior theoretical framework, offers more guidance and has the capacity to enable theory development.

3.5.5 Phenomenology Non Selection

A key reasoning behind the selection of the grounded theory also correlates with the discussion of why phenomenology was not selected. In the current environment of AV systems, public access to AV technology is very limited. In addition, gaining permission to alter simulation licensing to incorporate AV elements has been unsuccessful. At this stage, with the current shortfall and need for research on AV acceptance, the study is moving forward and utilising perceptions to fuel the data of the study. This 'Wizard of Oz' approach adopted works well with the grounded theory as it has enough depth to account for and process perceptions within its data sets. (Charmaz, 2006)

Moving onto Phenomenology, this is an approach that focusses on describing and exploring experiences, known also as 'lived experiences' (NT, 2011). With the system not yet at the stage of implementation, allowing participants to experience the system on the road. (UK AutoDrive, 2016).

In a future state, where AV systems have been introduced, and users are given an opportunity to experience them, phenomenology would then overtake grounded theory as the preferred approach. In that situation, phenomenology would best serve the community, as it would record experiences and interaction of participants with AV systems, to give a true reflection of acceptance in this environment. This would be an enhancement and an update on the perception based work carried out by studies such as this one.

The following table, adapted from the work of Starks and Trinidad (2007), highlights the differences between grounded theory and phenomenology. (See table 2)

	Phenomenology	**Grounded Theory**
History	European Philosophy	Sociology
Philosophy	There exists an essential, perceived reality with common features.	Theory is discovered by examining concepts within data.
Goal	Describe the meaning of the lived experience of a phenomenon.	Develop an explanatory theory of basic social processes.
Methodology	What is the lived experience of the phenomenon of interest?	How does the social process of [X] happen in the context of the [Y] environment.

Sampling	Those who have experienced the phenomenon.	Those who have experienced the phenomenon under different conditions
Data Collection	Observe participants in the context where the phenomenon is experienced.	Observe participants where the basic social processes takes place.
Interviewing strategy	Participant describes experience, interviewer probes for clarity	Participant describes experience, interviewer probes for clarity
Audience	Clinicians, practitioners and others who need to understand the lived experience of the phenomenon of interest.	Researchers and practitioners who seek explanatory models upon which to design interventions.
Product	A thematic description of the 'pre given essences' and structures of lived experiences	Generate theory from the range of participants' experience.

Table 2- Phenomenology and Grounded Theory Differences. (Starks and Trinidad, 2007)

Table 2 displays some of the common features of both phenomenology and grounded theory, highlighting similarities and differences between the two. As mentioned above, the key underlying difference is the time period in which the methodology becomes relevant and applicable, in this case the perceived perception vs. the embodied perception. As of this current time, it would be highly improbable that the required sample to conduct a study using phenomenology could be attracted. For this reason, phenomenology is discussed in Chapter 8 of this thesis and discounted as a suitable alternative to the current needs of this thesis. An example of a probable research title involving AV systems and phenomenology would be 'A study of driver interaction and experience of fully automated vehicles'.

3.5.6 Quantitative analysis Techniques

The last alternative approach available is selecting a technique from the quantitative analysis inventory. In the field of AV acceptance, the majority of studies discussed at Section 2.1 employ the use of quantitative analysis to investigate the phenomenon. In the first year of study, a quantitative approach (confirmatory factor analysis) was adopted to study AV acceptance, based on data collection from a questionnaire. During a pilot study, this approach yielded highly descriptive results from a number of participants who lacked understanding of autonomous vehicles, and as such, could not serve as a relative sample group. This was due to the infancy of autonomous vehicles at the time and the associated knowledge of this phenomenon being quite low. In addition to this, the nature of this quantitative approach was generally descriptive, with little qualitative data, producing results similar to those discussed at Section 2.1.2.

To ensure the thesis produced an output that made a contribution to current knowledge, a qualitative approach to data collection and analysis was selected, rather than a quantitative approach. A number of differences between the two exist and a discussion of how a qualitative approach met the needs of the research follows Table 3 (Minichiello, 1990).

Table 3- Qualitative and Quantitative Technique Properties. (Minichiello, 1990)

	Qualitative	**Quantitative**
Conceptual	Concerned with understanding human behaviour from the informant's perspective. Assumes a dynamic and negotiated reality	Concerned with discovering facts about social phenomena. Assumes a fixed and measurable reality.
Methodological	Data is collected through participant observation and interview. Data is analysed by themes from informant description. Data is reported in the language of the participant.	Data is collected through measuring things. Data is analysed through numerical comparisons and statistical inferences. Data is reported through statistical analysis.

In the case of this study, attempting to understand the perceptions of proposed AV system adopters and how they perceive acceptance, qualitative research offers more than quantitative research. As highlighted in table 3, to understand the perceptions of participants, in a setting that transcends the descriptive phase, a questionnaire or a method of fixed, measurable data collection does not suffice. More specifically, being able to enter a dialogue and tease out participant thoughts in a co-construction setting is a more effective method to develop participant understanding and enrich the resulting data. This process is synonymous with both qualitative research and grounded theory (Charmaz, 2006).

Further benefits of qualitative studies are their ability to allow researchers to understand human behaviour in light of participant perspective and language, rather than a fact finding or statistical analysis study. In a quantitative study, it is possible to make assumptions around results, whereas in qualitative studies, this is not possible due to the open-ended nature of these studies. This open-ended approach corresponds with the nature of this study and its current inability to ascertain a viable solution for AV acceptance.

Additionally, as this study is about participant feeling and perspective, Mcleod (2008) mentions that qualitative studies are ideal for understanding what people think or feel. Mcleod proceeds to discuss that the adoption of open-ended questions, allowing the participant to speak in their own language, and in an unstructured format will truly allow participants to express their situation, in turn allowing this to be recorded. In comparison, quantitative studies generally adopt closed ended questions and rating scales; this limits responses and yields descriptive responses (Mcleod, 2008).

Qualitative studies focus on multiple subjective realities being existent, rather than single objective realities. They also study phenomena in depth, a key requirement for this study (Johnsen & Christensen, 2008; Lichtman, 2006).

The concept of approaching the subject with a technique from within the quantitative approaches is familiar to the environment. The majority of works discussed within the literature review observe this same practise. This method has been successful in that instance with strong results and feedback presented. An additional understanding of the progression from quantitative studies to the now qualitative study can found in the work of Abeyasekera (2005).

Abeyasekera (2005) discussed that quantitative analysis approaches are meaningful when large amounts of data require summary. The value is developed when data summarisation techniques highlight common features across such repetitions. This development of understanding from a large data set highlights one usefulness of quantitative studies. The value of a qualitative study in reference to this can be found when the established themes or commonalities are then studied in depth. By discounting unnecessary data and themes, qualitative studies can focus on that data which is proven to be relevant. The related work discussed at chapter 2 is largely quantitative based and reports data that is useful and relevant for further study. In continuation of this, the study of this thesis is adopting a qualitative approach that investigates the relevance and usefulness of a number of these themes, as well as a number of new themes that are then subject to comparison with these extant themes. This process allows for triangulation between the two sets of data, a hallmark of the grounded theory and of qualitative research.

3.6 Research Paradigm

The adopted paradigm within this research is constructivism and interpretivist, whereby reliance is place on the participant view of the situation being studied (Creswell, 2003). By adopting this paradigm, constructivists do not have the benefit of a theory to begin with, rather they inductively create a theory from the data or a pattern of the meanings (Creswell, 2003). Constructivism also supports the qualitative research of this study and the primary data collection tool of interviews (Mackenzie and Knipe, 2006).

By selecting the constructivist approach, its residence as an inductive approach matches that of grounded theory, and more specifically, the Charmaz (2006) approach. These approaches allow both parties to combine in an interview setting, to co-create versions of reality or perceptions. Constructivism also lends itself to understand a situation through multiple, contrasting realities. By inductively collecting data from participants, relevant data can be drawn out that can be assigned and related with the aim of theory creation, a key factor in the process of grounded theory.

3.7 Sample

Within this section, the sampling technique adopted to recruit and induct stakeholders are discussed. In addition, specific grounded theory teachings around sample development and size are considered to ensure compliance. Finally, the chosen sample used within the study for data collection will be documented.

3.7.1 Sampling issues within Grounded Theory/ Sample Size

Prior to commencement, it is key to note that the discussion on the sample size is not attempting to predetermine the sample size. Theoretical saturation determines the sample size within grounded theory. The purpose of this subsection is to discuss how grounded theory advocates decision-making and the general process around collecting the chosen sample.

One of the key factors to undertaking a successful qualitative study is to generate enough data to develop categories, patterns, concepts and properties of the particular phenomenon (Glaser and Strauss; Strauss and Corbin, 1998). As this differs from study to study, it is essential that the appropriate sample size be involved with the study.

With this in mind, Charmaz (2006) discusses best practice within grounded theory to relate to smaller studies and samples with modest aims. This would help to achieve saturation quicker and be in line with the values of the grounded theory approach. Mason (2010) mentions that unlike quantitative studies with large samples, qualitative studies should adopt a smaller sample. The underlying reason is that quantitative studies look for generalisable hypotheses, qualitative studies looks for a particular meaning (Crouch and Mckenzie, 2006).

Gibbs (2010) recommends a sample size of around 20 participants. However, this is only true if interaction provides enough depth in responses to create the setting for a strong analysis and mid-level theory. This trade-off between the two will represent one of the key dangers to the harmony of the study.

Thompson (2011) conducted a study of over 100 grounded theory studies in a bid to find the average number of participants a typical grounded theory would employ. Upon completion of the study, it was identified that the average number was 25, with the majority of the studies employing between 20-30 participants for their research efforts.

Like the positioning of the literature review, the sample size within grounded theory is not agreed and is a contentious point. What is noticeable and can be concluded is that qualitative studies usually employ a smaller sample than quantitative studies, ranging from 10-30. Further determinants to the final sample size is the allotted time for the study, available resources and the aims of the study. (Patton, 1990)

Although the number cited above will not be the aim for the sample size as this is not preferred practice in grounded theory, it still has a number of associated uses. What is certain within the study is the sample size will be modest, give available resources, and through this concentration, saturation will determine the final sample size. If the study reaches over 20 participants and saturation is yet to be reached, a revisit of the data will be made in an effort to clarify whether data is being utilised correctly or whether more can be extracted.

The above discussion extends the narrative to discuss the issue of generalisability and representativeness of the study, in light of the sample size and type of participants induced into the study. This is addressed at various intervals throughout this section and remaining chapter.

This concludes the discussion of grounded theory specific issues in relation to the chosen sample. The remainder of the section will consider the sample in light of general qualitative studies, unless specified otherwise.

3.7.2 Sampling Technique/Sample Generation

In terms of the sampling technique, it is important to distinguish between probability and non-probability sampling. Probability sampling conducts random selection in a variety of methods from the sample frame of a particular population. This sampling type permits the use of statistical techniques which use random sampling and a study to calculate the difference between sample results and the population equivalent values to reach a finding (University of West England, 2007). In contrast, non-probability samples do not involve random selection and therefore are not dependant on the rationale of probability theory (Trochim, 2006). Non-probability samples work on the subjective judgement of the researcher as to what the required sample should be. Non-probability samples are synonymous with social research as they act in an exploratory method (Lund Research, 2012). For this research study, the family of non-probability sampling methods were selected. The remainder of this chapter will discuss the study in light of these approaches.

Wilmot (2005) describes the sampling technique applied during sample recruitment as a crucial element of the overall sampling strategy. Within this study, purposive and snowball sampling techniques were adopted. The purposive sampling method is synonymous with qualitative research and empowers researcher decision on whom, where and how one conducts a research study. The University of California (2008) define purposive sampling as a non-representative sample of a larger population that is constructed to serve a specific purpose. The advantages of adopting purposive sampling over alternatives is its cost effective and time saving nature, its ability to operate with limited primary data and its effectiveness in exploring anthropological situations (Dudovskiy, 2016).

Rubin and Rubin (1995) suggest three distinct guidelines when selecting participants for a study based around a purposive sampling strategy. They are:

- Individuals with knowledge about the topic or experience being discussed;
- Participants willing to talk freely;
- Representative of the range of views.

In relation to the grounded theory, Wilmot (2005) discusses that purposive sampling can assume the form of theoretical sampling, a grounded theory construct (Glaser and Strauss, 1967). In this case, the grounded theorist simultaneously collects data and analyses it to find patterns and concepts. Through this method, theoretical saturation is achieved where no new knowledge is emerging from the data. Due to this iterative nature, the importance of selecting a sampling technique with the ability to support this approach is heightened. Wilmot (2005) cites the purposive sampling approach as being well suited to this environment.

Within purposive sampling, a subset of the approach (snowball sampling) was observed. Snowball sampling is an approach of identifying respondents who are then used to refer researchers to additional respondents (Atkinson and Flint, 2001). An initial sample was generated from networking events. Upon the close of each interview or focus group, participants were always prompted to refer potential respondents to the study. This method yielded 60% of the total sample and was successful in assisting the participant recruitment process.

The calibre of participant required for this study are individuals or groups of individuals that were involved in organisations that represented the required participant type. For example, one participant represented over 1000 cyclists, their collective opinion and their interests, ensuring the study was given maximum exposure and a varied opinion from each interaction. As grounded theory studies generally employed smaller samples, this worked in the favour of this study as it allowed maximum extraction from each sample group.

Initially, a number of participants were recruited through networking, referrals from the supervisory team and online research. At the close of each interaction, participants recommended individuals they knew in the sector. This proved successful and was observed throughout the study until the last participant. In addition to this, organisations on occasion gave access to their intranet forum to expand on the interaction with their member base. This allowed a form of analysis to take place on the gathered data, yielding further useful and representative data. These processes were all relevant and correct in adhering to non-probability, purposive and snowball sampling.

By adopting snowball sampling, the issue of bias became a concern for the thesis. Griffifths *et al*. (1993) mentions that because samples are not randomly drawn, but are dependent on the subjective judgement of participants, a number of studies employing snowball sampling are biased. Furthermore, it is estimated that participants with many friends are more likely to be recruited in to the study, as opposed to those with less friends. (Baltar and Brunet, 2012)

To ensure bias did not influence the referral-based sample adopted by the study, a number of techniques were adopted. Although multiple referrals were made, the researcher decided on the inclusion of new participants. This ensured that not every referral or recommendation of new participant was invited and involved into the study. Furthermore, the study had pre-requisite requirements on the type of participant required for the study so the power of appointment was internal, ensuring neither participant or bias influenced the final appointment. This mirrored the Glaser and Strauss (1967) definition of theoretical sampling where the grounded theorist decides on what data to collect next and from whom. Within participant interaction, participants were not actively pursued to provide referrals, rather they were made aware of the recruitment process and were asked to recommend individuals or organisations if they were aware of any. This mirrored the advice of Lopez, Rodrigues and Sichieri (1996) who cite snowball sampling as being widely used in qualitative research as it allows researchers to gain access to hidden populations and networks that they could not have necessarily found themselves.

In summary, theoretical sampling determined the type of data that was required by the study. In the case of this study, the requirements were influenced by different stakeholder types, ensuring no one group was over or under represented. To complement theoretical sampling, snowball sampling served to provide access and introductions to participant group that could not have been accessed through solely adopting theoretical sampling.

3.7.3 Chosen Sample

The chosen sample selected to serve this study is a range of stakeholders who have a connection to the phenomenon. The sample is built up of car drivers, cyclists, motorcyclists, HGV drivers, road safety organisations, pedestrians and infrastructure organisations. These directly related stakeholders will at some point interact with AV systems, through usage or indirect relation. Due to this, it was imperative to collect a range of perceptions from all concerned parties and stakeholders. As the study has adopted a snowball sampling approach and the grounded theory, it is estimated that the sample will change and evolve as the study progresses. Section 4.3 discusses the final sample inducted into the study and will highlight any differences, inclusions and discounting carried out.

3.7.4 Sample Discussion

This section will attempt to justify selection of the sample discussed above. Here, a discussion around the sample appropriateness, alternative samples and a summary concluding on this specific sample is presented.

3.7.5 Alternative Samples/ Sample Appropriateness

The current sample has selected stakeholders linked to the road network in a number of capacities as the sample to serve the aims of this study. The aim being to understand stakeholder perception and acceptance of driverless vehicles. The following possible alternative samples could have served the aims of the thesis in alternative capacities:

Car Drivers-

The first alternative sample that could have been used in the study is solely car drivers, as the key beneficiaries of AV systems and the party with most exposure to the phenomenon. In recruiting this particular sample base, a concentrated view specific to car drivers can be gained. This would be unlike the sample of this study that is attempting to interact with all who would encounter the phenomenon. In addition, the ecological validity and reliability of the results would be heightened, given the employment of the most direct sample possible. Recruiting this particular sample could be done with relative ease through member sites, enthusiast forums and personal networking.

General Public-

A number of related works, discussed in Chapter 2, employ random samples from the general public to understand AV acceptance. This was a recurring theme throughout the literature review and the employment of this sample yielded an acceptable set of results with the required level of detail. In the instance of this sample, a number of studies used online mediums to attract participants, through organisation websites, educational establishments and transport forums. Examples of these studies can be found in the work of Boston Consulting Group (2015) and Kyriakidis *et al.* (2015).

Socio-economic determined Sample-

Possibly the least used sample from the alternatives discussed is an approach of defining samples by socio-economic factors such as age or gender. The community have not yet adopted this approach to developing solutions for AV acceptance. As an example, Schoettle and Sivak (2014) and Fraedrich *et al*. (2016) utilise the socio-economic factor of age, but only to use it as a guideline for participant entry. In the case of studying attitudes toward autonomous vehicles, an offshoot of Acceptance, such studies do exist (Adams 2015, RAC, 2016). Recruiting participants for the particular sample would prove more challenging as a random sample would have to be monitored to ensure a balance of characteristics were recruited. This sample also extends the previous sample of 'General Public' but presents a new method of analysis and findings in light of differing characteristics. Adopting this would give an enhanced insight into the mindset, perceptions and perceived acceptance of the public.

Location Based Sample-

The work of Motovision (2012) and Bedwell (2015) define the samples of their respective studies by their geographical location and compare the contrasting attitudes of each culture and location. Adopting a similar approach in this study would allow perceptions and acceptance to be studied in a similar fashion to the authors discussed.

3.7.6 Sample Role

One criticism of the chosen sample is that participants may adopt more than one stakeholder group. By this, participants could be car drivers, as well as motorcyclists or push bike cyclists. This is a likely possibility and one that could hinder the study as it could confuse stakeholder groups, ultimately affecting results. Additionally, the study could become biased with an influx of data on a specific participant group. To counteract this, as will be discussed in the proceeding section, participants will be recruited from organisations that represent each stakeholder type. In doing this, participants will have a heightened understanding and passion of their respective field, strengthening their positon and viewpoint. Ultimately, this will ensure a concentrated interaction with participants and a higher likeliness of reliable data.

3.7.7 Naming Convention

To maintain the anonymity of each participant in the study, a naming convention was utilised to replace actual participant identity. For example, participant John Smith would become GT01. The GT in reference to the grounded theory and the 01, the unique identifier assigned to each participant.

3.7.8 Sample Summary

Presented above are a number of alternative samples that could have been used within this study, to achieve the study aims. Each have been used in various studies before, some of which are discussed in Chapter 2. Although they would have been viable alternatives to the chosen sample, the following discussion will highlight why they were not selected.

The most logical or anticipated sample would have been employing solely car drivers for consideration. By employing this sample, the study would comfortably reach saturation with an exhaustion on the data provided by participants. However, as the sample would be built up of one stakeholder type, the possibility of developing interdisciplinary knowledge or patterns would reduce. This cross-referencing method of research is synonymous with grounded theory and employing this sample would not utilise grounded theory to its full potential.

Furthermore, the study aims are to understand stakeholders linked to AV systems, rather than just car drivers. Avoiding the majority of stakeholders in the pursuit of possibly the most direct one would render the study as potentially inadmissible, unless the aims were altered. This argument extends to all stakeholder types, applying to cyclists, pedestrians, HGV drivers etc. At this early stage of investigation, attempting to understand stakeholders of the proposed technology is important. By gaining a broad understanding of the spectrum in this manner, researchers can then divide the stakeholders and begin to investigate each group separately.

The above argument can also be applied to selecting samples based on a number of socio-economic factors. Upon developing a high-level understanding of potential users, the research community can investigate the influence of socio-economic factors on the acceptance of AV systems. Such factors could be age, gender, income etc.

This is the viewpoint of this thesis, and as displayed in the previous section, a small number of studies using these samples exist. However, until a well-developed understanding of AV acceptance is developed, it would prove wasteful to begin developing hypotheses around the effect of socio-economic factors on AV acceptance.

Most of the studies on AV acceptance and attitudes towards AV systems (Chapter 2) utilise random samples of the general public. Within the literature review, this was discovered to be a de facto standard with the majority of studies not assigning defining characteristics to their sample. Upon analysis of the studies and accessing the findings and conclusions, it is noted that the results are admissible. However, given that the findings relate to a random sample or to the general public, the findings are limited in their strength. This study has employed a sample with a number of defining characteristics that ensure the findings and analysis are associated with specific stakeholders. A deeper understanding of the different stakeholders and their perceptions will yield new knowledge and further research opportunities. An example of the association between participant and potential finding is as follows

'*Participant X mentioned they currently did not trust AV systems and would not use them*'.

In comparison, this study and its specific stakeholder type will be able to report

'*The stakeholder group of HGV drivers mentioned they did not currently trust AV systems and would not consider using them'*.

The above example displays the utility of defining the sample by a range of characteristics, which in this case is their relationship to AV systems. This association will develop a study of a higher calibre and the contribution to knowledge will be provided. In order to achieve this, co-construction will ensure that participants have a more informed viewpoint than the general public. This will further strengthen the results of the collective study.

To conclude on the above alternative samples, each appeals to the study for a number of reasons. However, what is clear from studying the alternative samples is that chronologically, they are not ready to serve in this study. The chosen sample employed for the study can be considered a benchmark and a broad intervention into the environment of AV acceptance. Form this intervention, an initial understanding of the challenges surrounding AV acceptance can be identified. Additionally, further research opportunities can be identified that focus on specific issues and narrow study aims, resulting from this survey. This echoes the teaching of grounded theory and what it offers to adopters.

The following quote by Taber (2000) displays the time-lapse of grounded theory studies and the avenues it offers to researchers by producing the bridge between mid-level theory studies and large-scale surveys. Taber (2000) mentions that grounded theory studies creates a bridge between case studies and large-scale surveys. By studying individual cases, a general understanding can be developed that enables the creation of testable outcomes. These outcomes are then subject to traditional experimenting and statistical testing. Within this quote, the overall utility of the grounded theory can be found. The fact that it operates in knowledge gaps contributes to its ability to carry understanding from a small scale and present it as useful output that is subject to further study to enforce generalisability and utility.

In the quest to develop knowledge of AV acceptance, the timeline, sample and methodology adopted by this study provide the best framework to do so. Currently, an initial understanding of the various stakeholders and their perceptions around AV acceptance will be gathered. Following this, the findings will identify future studies with each stakeholder type using both qualitative and quantitative methods to expand on the findings of this study and to create a definitive and exhaustive knowledge set on the perceptions and acceptance of each respective stakeholder group.

3.8 Chapter Conclusion

The aim of this chapter was to discuss the methodology selected to achieve the aims of the thesis. Grounded theory was introduced in the above Chapter, detailing its foundations, variations and suitability to qualitative research. The justification within the early stages of the Chapter focussed on two key areas; justifying usage of the grounded theory amongst fellow methodologies or high-level approaches and justifying usage of the particular variant of the grounded theory selected. For the latter, the constructivist Charmaz (2006) variant of the grounded theory was identified as the most appropriate to achieve the aims of this thesis, given its emphasis on 21st century research. As well as this, the Chapter provided information around the relevant ethics adhered to, the research paradigm and methods of evaluating grounded theory studies.

The Chapter also gave a justification around the choices associated with the sample of the study. This extended to outlining the sampling strategy adopted to recruit participants as well as an introduction to the chosen sample amongst possible alternatives. Applying the above information, the thesis will now present a detailed account of grounded theory application to this study.

Chapter 4- Grounded Theory Application

Chapter 4 will give an overview and provide evidence of how the techniques and processes of the theory and sampling technique were applied to develop the study and data collection phase of this thesis. The overall aim of the chapter is to ensure the reader is provided with enough clarity and understanding of the applied methodology. This will ensure that any recreations of the study will be able to do this with relative ease. Early sections of the chapter will focus on the study design, development and implementation before proceeding onto a comprehensive overview of the methodology application with complete examples from three participants for evidence and to inform understanding.

4.1 Study Design

This section will extend the understanding around the unique application of the methodology to this empirical study. A discussion will take place around how interviews and additional data collection tools were applied, the themes of data collection and how bias was avoided. Although strict methodology observance was committed to throughout the study life cycle, the grounded theory offers adopters flexibility in their approach to data collection and analysis techniques. A number of these will be discussed below.

4.1.1 Interview Types

Given Charmaz's (2006) preference of co creation between researcher and participant in an interview setting, structured interviews were deemed too constrained for this study. Upon attempting to employ structured interviews, it was witnessed that participants were unable to travel past the descriptive phase of their response. Furthermore, researcher contribution within the study would be restricted, further refuting the Charmaz (2006) preference. The ability to contribute in interviews was important as the phenomenon was relatively young and at times, participants did not have an informed understanding of the subject, allowing the opportunity to educate, resulting in further value being assigned to responses.

In light of these restrictions discussed above, semi-structured interviews were set as the method of investigation. Like structured interviews, semi-structured interviews still maintain a pre-determined set of questions, but are more exploratory and encourage participants to open up. Harrell & Bradley (2009) describe semi-structured interviews to be used when attempting to gather opinions, perceptions and attitudes of participants. Their ability to develop detailed responses matches the ethos of the grounded theory and aim of this study. Using semi structured interviews in grounded theory and by extension; qualitative research is endorsed by Strauss as advocated by Bluff (2005). Bluff also states that the majority of grounded theory interviews become semi-structured as key themes emerge and are established as focal to theory development.

In addition to one on one interviews, the study also established focus groups as a core method of data collection. Soklaridis (2009) notes that adopting focus groups within the grounded theory allows interaction between participants to occur in real time, and a comparison between their perceptions can begin, rather than comparing singular interviews. Soklaridis (2009) also mentions how focus groups complement the use of exploratory interviews as participants are given control over proceedings. Dick (2005) supports using focus groups, given their platform to accommodate co-construction. Morse and Field (1995) state that being able to observe participants interacting on a particular topic is fruitful as their similarities and differences providing the much-needed data.

In light of the constant comparison and data revisiting nature of the grounded theory, the use of focus groups also allowed the thesis to discuss current findings with participants. In this scenario, findings from past interviews and focus groups were discussed to allow further comparison and refinement to take place. Harrell and Bradley (2009) attribute this method of data comparison, providing opinion into participant insight and understating why individuals feel a certain way to be the key purpose of focus group adoption.

4.1.2 Interview Themes

With the adoption of semi-structured interviews, a set of pre-determined questions were required. Figure 9 demonstrates the general areas that were considered for questioning within the study. This set of areas changed regularly as the study evolved and learnt from the data provided by participants. An important point to raise here is that the list was not set, participants were allowed and encouraged to deviate from the topic, to points they considered relevant. (See appendix 2 for question list)

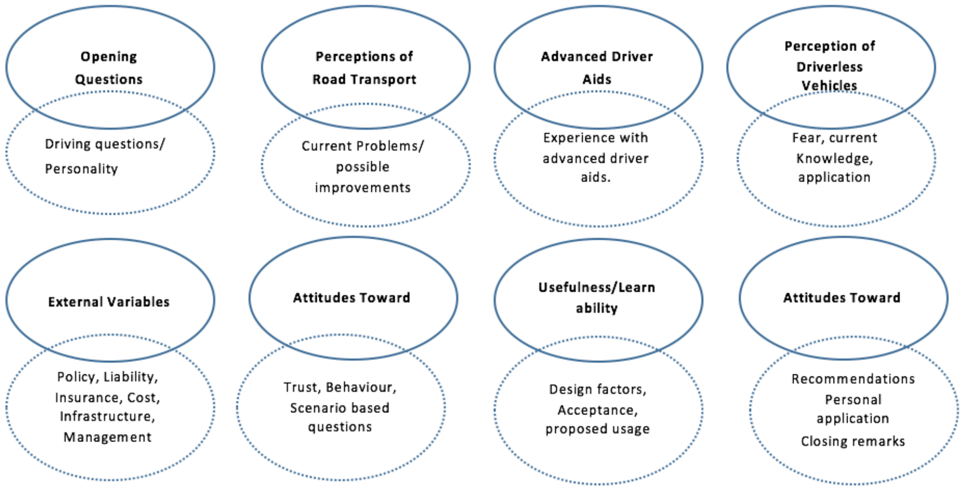

Figure 9- Interview Themes

4.1.3 Interview Bias

By establishing the use of interviews as the primary tool for data collection, the thesis must address the associated issues that accompany the use of interviews. Bias is a strong concern with using this method or any other where face-to-face contact is established. Leicester University (2015) mention age, gender, religion and political preference as factors that lead to researcher bias. The study was designed to ensure the above factors would never be established or discussed with the participant. This ensured these factors did not influence decision-making.

Interview or social bias is a common interview problem, where participants give answers that are socially acceptable, rather than their true account or beliefs. (Kaminska and Foulsham, 2013) To minimise the level of bias in responses, questions were introduced to participants so that they were aware of upcoming questions. Furthermore, the importance of their responses was highlighted as well as a reiteration of the ethical commitments of the study.

The penultimate point to mention here is that by employing the combination of semi-structured interviews and co-creation between researcher and participant, a level relationship was established between the two. This contributed to the corresponding ease being maintained between parties. This worked in the favour of both parties as in some instances; CEO's were the participants in interviews and in others, car drivers and motorcyclists. By democratising this relationship, participant could be more open with their responses and evade the above mentioned bias in their viewpoint as the need to match up to something was removed with the equal relationship.

Kvale (2006) established various power asymmetric relationships; however, the nature of this study did not fit in with any of the created categories as all seemed very one sided and did not discuss co-creation, except to question its validity. By avoiding any of the power asymmetric categories, a balance was struck that was informal but still had an acceptable level of professionalism.

4.1.4 Schematic Representation

Alongside the traditional written memos developed in the grounded theory to advanced analysis, this study established the use of diagrams to further understanding of the gathered data. Doing this is well received in the grounded theory community with Strauss and Corbin (1998) stating the tool allows researchers gain analytical distance from gathered material and a method of presenting results. Multi Grounded Theory (MGT) is an extension to traditional grounded theory is characterised by its reliance on diagrams to conceptualise learning in the coding procedure (Goldkuhl and Cronholm, 2003).

Williams and Keady (2012) used diagramming as a development/analytical tool within the confines of the constructivist Charmaz approach to the grounded theory. They used this combined method to study late onset Parkinson's disease and found that the diagrams were useful for thinking about a range of views, offering a different perception to its textual rival.

By confirming the use of schematic representation within the grounded theory, diagrams were used extensively. However, Strauss *et al.* (1998) do not provide a method by which to create such diagram. No boundaries or notation exists; rather they state the theorist should develop their own technique in conducting these diagrams. In attempting to create a structure for the diagrams, the conceptual models laid out by Checkland (1972) and his soft systems methodology were adopted.

Soft Systems Methodology (SSM) was introduced by Checkland in the 70's as a modelling tool that adopted a variety of techniques to understand a problem space (rich pictures, conceptual models etc.) Williams (2005) states its use in life has evolved towards being a learning and development tool, similar to the work of the grounded theory. This 'mixed methods' approach was also observed by Durant (2005) who concluded that both the grounded theory and the soft systems methodology had similarities in that they both surface and explore participants' beliefs. In doing this, both adopt a constructivist and interpretivist standpoint. (See Section 4.5.9 for analytical diagrams)

4.2 Grounded Theory Implementation

This section will discuss the practicalities of the research study implementation, providing an understanding around how, who when and where information of the research study.

4.2.1 Entering the Field

At the first stage of the study, the 'entering the field' stage of the Lehmann (2001) grounded theory structure will be applied. Within grounded theory, this is considered the 'housekeeping' phase where arrangements for the upcoming study are made (See Figure 7 for Lehmann diagram). Preparations for the study began in April 2014. At this stage, arrangements to begin interviews were made by carrying out the following:

- The nominated computers for data collection, processing and analysis were nominated. Additionally, each computer was serviced and treated to various security measures to ensure data was protected upon collection;
- Additional tools such as recording devices and notepads were sourced to assist with data capture at the interview stage;
- Data storage solutions were nominated to ensure multiple copies of the data were saved in case of data loss;
- Research was conducted into transcription services and coding software. Samples of the services were received and discussed with the supervisory team. As the budget constraints of the thesis were unable to digest such services, manual processes were put into place with training for taking place at this stage;
- As advised by Charmaz (2006), a pre study literature review began in May 2014. This shorter literature review was proposed to facilitate an understanding of the current status of autonomous vehicles in the UK. An investigation of the current literature was also carried out. The above two investigations contributed to a developed understanding that supported co-construction in interviews and assisted users in any understanding gap;
- The project plan was devised, accounting for major and incremental milestones as well as contingency timing;

- Upon developing an understanding of the subject area, interview themes and potential questions were established. These can be found at Section 4.1.2; and
- Concluding this stage of the implantation was the application of ethics to the study design. This was done through adherence to the Acts governing data and the University of Huddersfield policy on data collection. Further information on this can be found at 3.7.

4.2.2 Participant Recruitment

The above process took a period of three months. Upon reaching July 1st, the participant recruitment process began. As discussed at Section 3.8, snowball sampling, as part of theoretical sampling sampling was utilised to recruit participants. Participant contact began on July 1st and continued throughout the study, until the last participant (GT11) was recruited and surveyed. Any communication with participants was done through the use of emails. This was most convenient as telephone numbers were not always accessible. Through using emails, all correspondence was tracked and stored. Contacting individuals through social media was also an option but because the platform was also used for personal communications, professionalism would have been compromised. An example of an initial participant contact email can be found at Figure 10. A contact diary was maintained that tracked the last interaction time and current status of negotiations. This can be found at Figure 11.

To whom it may concern,

My name is Mohammed, I am a researcher based at the University of Huddersfield. I am currently working on a project that I feel your organisation could have valuable input into. My study is labelled 'Autonomic Road Transport Systems: A Road User Perspective.' This research, commissioned by the European Cooperation in Science and Technology (COST), is aimed at assessing the uptake of autonomic (driver less) transport systems. The research involves interviewing a variety of potential stakeholders of the road (cyclists, bus drivers, motorists, council, road safety organisations etc.)

As part of my research I am appealing to various road transport organisations to shed some light on the various road related issues that I am stumbling across. If you find my work interesting or feel that someone in your organisation may be able to come on board and assist me in my research, please do get in touch and I can forward further details to you.

Thank you for your time,
Mohammed
Post Graduate Researcher
University of Huddersfield

Figure 10- Participant Contact Email

Participant 1	01/07/2014	Sent form
Participant 2	01/07/2014	
Participant 3	08/07/2014	
Participant 4	9/7/14	
Participant 5	9/7/14	
Participant 6	16/7/14	
Participant 7	16/7/14	
Participant 8	21/07/2014	

Figure 11- Participant Contact Diary

After the initial contact was made, participants were given the opportunity to ask questions regarding any concerns or issues they had with the study. This option was made available through email or via telephone. Once the participant interest and involvement in the study was confirmed, each participant was sent a copy of the 'Research Study Explanation Form'. Upon receipt of this completed form, individuals were confirmed as participants in the study. A copy of the form can be found at appendix 3.

4.2.3 Location and Interview Standards

Through email interaction, the interview location was determined with participants. Concerted efforts were made to ensure the interview location was always where participants felt comfortable. By feeling comfortable, participants become more approachable and receptive to the interview, improving their responses (Huffcutt, Van Iddekinge & Roth 2011).

Building and maintaining good standards throughout the interview is also an important issue. Miller *et al.* (2002) state the interviewer should consciously dress in a way that would match the interviewee and surroundings. Furthermore, they recommend sitting in close proximity to the interviewee, always maintaining a smile and eye contact, speaking in a friendly tone and avoiding inappropriate expressions. To implement the above advice, a dress code of trousers/jeans and a shirt was appointed. A formal suit was not established as appropriate wear as it could have been translated as too formal or made the interviewee feel intimidated. The configured dress code was selected after observing how fellow academics/researchers dressed and that was translated into this process.

4.2.4 Data collection process

Within each interview or focus group, proceedings were recorded with participant permission. This was done to ensure that no data was left uncollected or misunderstood later. Furthermore, as field notes were being made, in addition to interview contribution, the ability to record interviews eased the transcription and data immersion process. Further information on this process can be found at Section 4.5.2.

4.3 Overview of Final Sample

With the sampling strategy reliant on referrals and referrals being provided at the close of each interaction, the final sample was unknown until saturation was reached by participant group GT11. This section will discuss each participant of the final sample and describe their stakeholder relationship to autonomous vehicles. Anonymity and participant confidentiality will still be maintained, the naming convention applied at Section 3.7.1 will be used to discuss each participant base.

GT01- Road safety charity

This participant represented a charity working with victims of road traffic collisions. The aim of the charity was to improve pedestrian and driver safety on the road network. This participant approached autonomous vehicles from a safety and usability perspective. Participant GT01 also discussed the trust element between human and machine and discussed the liability aspect of autonomous vehicles.

GT02- Cycling federation

Participant GT02 represented a large body of pushbike cyclists. This participant was asked to approach the interview in the mindset of a cyclist and present the views of the cyclists of their organisation. GT02 had a keen interest to discuss the interaction environment between car and cyclists as well as the design features of autonomous vehicles.

GT03- Road infrastructure organisation

Participant GT03 represented an infrastructure organisation that was concerned with designing parking and traffic solutions. GT03 was asked to consider autonomous vehicles from the aspect of altering the road network to digest autonomous vehicles. Furthermore, GT03 considered the environment from a driving perspective. GT03 discussed usage zones, scenario based usage and user change management.

GT04- Car driver forum

Participant GT04 represented a drivers' association of HGV drivers and vehicle drivers who used their vehicle for work purposes. Their approach to the interaction was based on their role developing with the introduction of vehicle aids. The collective participant group was interested in discussing evolving driver roles, replaced workloads and autonomous vehicle communication.

GT05- HGV driver union

Participant GT05 represented a federation of HGV drivers. Like GT04, this participant group was involved in the study to capture their views about autonomy affecting their job role. The main premise of their discussion was around system knowledge, the evolution of cabin technology and the role of the driver amidst changing autonomy conditions.

GT06- Transport authority

Participant GT06 presented a transport authority working on improving road safety and vehicle accessibility. From the sample, GT06 represented the most knowledgeable in reference to autonomous vehicles. The key discussion from GT06 was around user acceptance, system integration and technology trust.

GT07- Cyclists action group

Participant GT07 represented an action group of cyclists and motorcyclists. This participant group was asked to discuss system application in the real world and how it would affect them. The key themes discussed by participants were around safety of vulnerable users, system usefulness from different perspectives and how the system could be introduced to society.

GT08- Motorcyclists federation

Participant GT08 represented a federation supporting policy and legislation affecting motorcyclists. Their approach to the interaction discussed the various stakeholders who would come into contact with the system. Additionally, the vulnerability of motorcyclists and the need for specific related design was discussed.

GT09- Cyclist and Motor cyclist federation

Participant GT09 represented a federation of cyclists. Within this interaction, participants were interested in discussing the current issues that caused conflict between car driver and motorcyclist. In addition, participants considered the perceived needs of motorcyclists from the new system and the proposed communication method between stakeholders in the presence of autonomous vehicles.

GT10- Car enthusiast committee

Participants of GT10 represented a car enthusiast member network. Participants discussed the trade-off between vehicle and user in relation to control. Additionally, participants spoke about the various level of automation and how it affected the driving intention. This was the most extensive participant group, with over 50 unique contributors.

GT11- Pedestrians

GT 11 represented a wide range of participants that identified themselves as pedestrians. Although a number of participants also owned vehicles or bikes, each contributor was asked to consider their responses from the viewpoint of a pedestrian. Participants discussed issues related to system-pedestrian interaction, communication between stakeholders, comfort zones and discussing the current problems.

Across the sample, a wide range of data was collected. Although participants were providing responses to very similar questions, each approached their discussion from a different angle. In the participant introduction discussed above, the narrative mentions several high level areas of discussion that participants prioritised. This is not conclusive of the discussion of each participant or stakeholder group. A conclusive documentation of this can be found at Section 5.2.

In a number of instances, participants identified themselves as belonging to a number of stakeholder groups, potentially disturbing the balance between the varieties of stakeholders. In this instance, participants were advised to approach their answers from the viewpoint of the stakeholder type they were recruited under. At the close of each interaction, participant was encouraged to provide general feedback, here they were given license to discuss the environment form whichever angle they chose to.

As all the pre-requisites, initial activities and details of the sample have been documented above, the section outlining details of the pilot study and overall data collection can begin.

4.4 Data Collection

This section will discuss and document the grounded theory techniques applied to the data collection stage of this study. Detail is provided on how raw transcripts are processed to identify key themes.

To further complement understanding and to ensure the reader is fully aware of the process applied, two diagrams were developed. Figure 12 represents a flow chart highlighting the process adopted to move from research entry to study deliverable. Figure 14 displays the same process, but displays the influencing role of literature on the grounded theory cycle, the iterative nature of the coding process and the grouping of stages. Both Figure 12 and 13 are based on the Lehmann's (2001) grounded theory cycle and the Charmaz (2006) recommendation. An inclusive overview of the methodology can be found at Chapter 3.

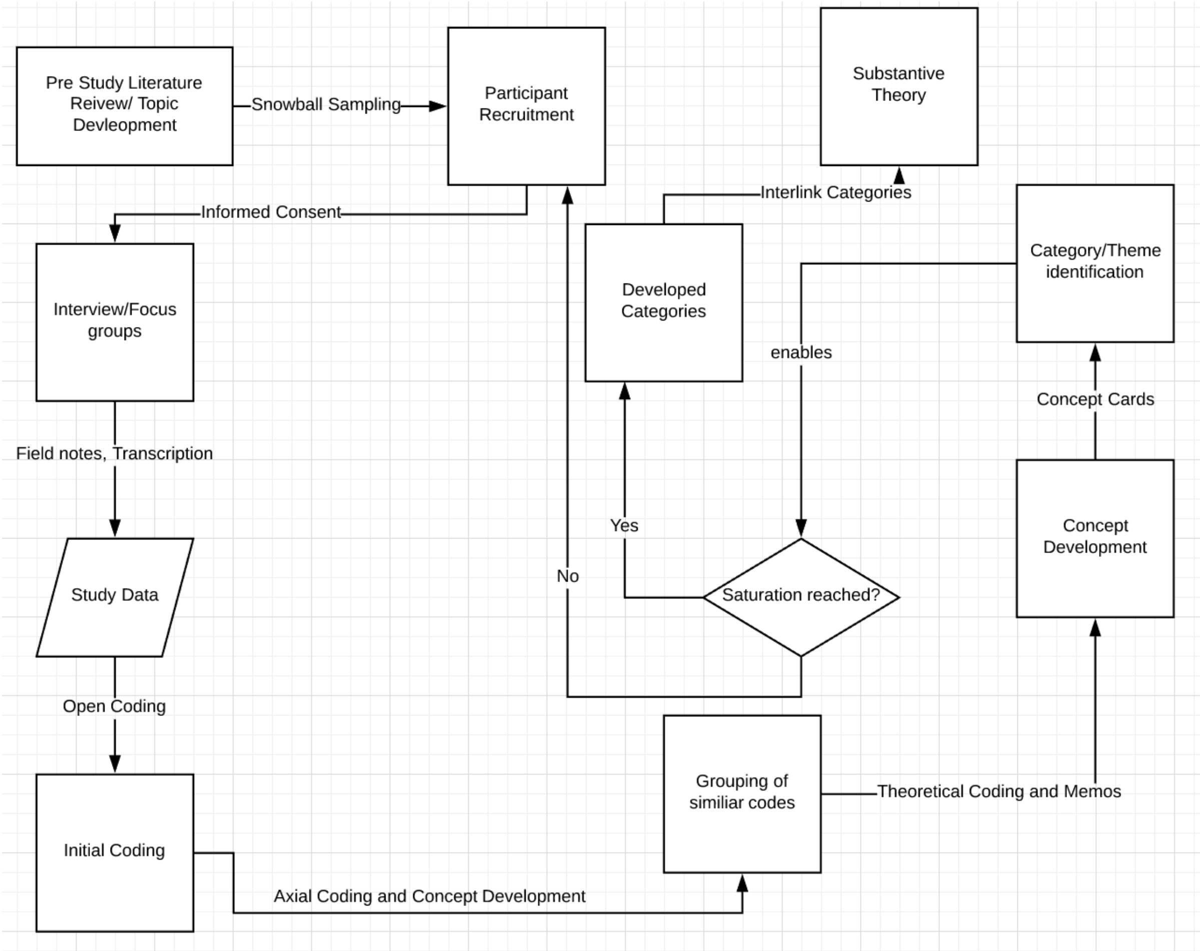

Figure 12- Methodology Flow Chart

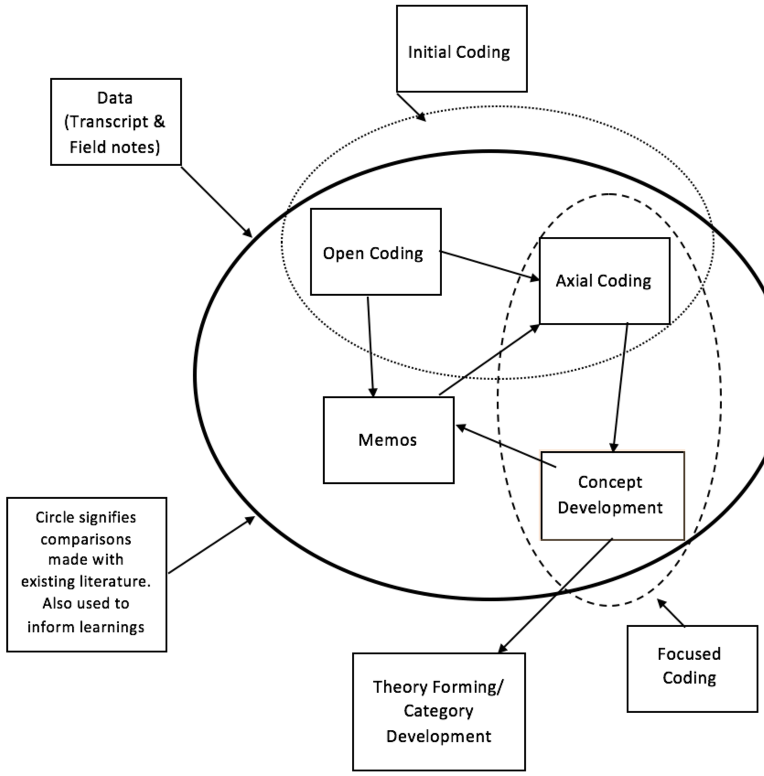

Figure 13- Grounded Theory Process

4.4.1 Pilot Study

Within qualitative research, pilot studies are under-represented and under-reported in qualitative literature (Baptista Nunes, Martins, Zhou, Alajamy & Al-Mamari, 2010; Whitheley & Whitheley, 2005). In the context of grounded theory, by performing pilot studies, researchers can develop well-grounded knowledge, acquire early contextual sensitivity and modify the research flow (Nunes *et al*. 2010)

In quantitative studies, pilot studies employ a larger sample. Within qualitative studies, this is the opposite. Campbell (2015) states that even though it is not necessary to conduct a pilot study, being able to carry out 'one or two' interviews will allow a researcher to refine their interview guide and remove any indifferent elements from within the study.

In the case of this study, three participants were involved into the pilot study. Although the data became part of the main study, the first three were identified as being part of the pilot and main study. As the grounded theory methodology generally assumes a more conservative sample, this smaller pilot study is in line with grounded theory values.

The piloting study began in early September 2015 and lasted for a month. Doing it yielded the following benefits to the study:

- The interview tools were assessed to ensure they worked and were suitable for the needs of the study. All recording devices, transcription tools and nominated computers were tested to ensure their efficiency in operation;
- Measuring question performance was a key factor in the pilot study. By exercising a variety of questions in the pilot study, adjustments were made to the question base. By basing performance of questions on the response and feedback of participants, the development of answers and participant trail of thought was tracked;
- Through the pilot study, the feasibility and interesting nature of the study was confirmed. This was done through observing the reaction and manner of participants under interview conditions. Participants on the whole engaged in stimulating discussion that carried discussion past the descriptive level;
- In extension to the above, by analysing responses, the usefulness of the study to the research community was established;
- A number of hypothetical categories were developed. Although not established, category development was forecasted, considering the outlook of the deliverable;
- This was purely hypothetical and only done to develop understanding of data and considering it in a wider context; and
- The last impact of the pilot study was the ability to appreciate whether sufficient knowledge of the phenomenon was available to successfully participate in a co-construction environment. The pilot study confirmed this, yet further further research is required in the current problems of road transport as participants questioned this to realise the need for driverless technology.

4.5 Main Study

The section will discuss each application stage of the grounded theory, with extensive examples and accompanying commentary of each stage. The application and layout of this section mirror the grounded theory cycles of Charmaz (2006) and Lehmann (2001) displayed at Figure 12 and 13 respectively.

The main study phase of the study began at November 2015 and concluded at August 2016. This time period involved carrying out the data collection process as well as the data analysis, such is the iterative and comparative nature of the grounded theory. In addition, participant GT11 was approached and interviewed in January 2017.

To maintain readability of this chapter, a representative number of examples will be provided for participant interactions. Appendix 4 displays further examples of coding.

4.5.1 Data Collection

Upon completing all pre-requisites of the study and gaining confidentiality and informed consent, the data collection process began. As discussed at Section 4.1.1, this was done through the use of interviews and forums where applicable. Within this first interaction, the participant used sound recording and field notes as the method of tools to record data.

4.5.2 Field Notes

As every spoken word was recorded during interaction with participants, this allowed for the writing of field notes. Glaser (1978) recommends the usage of field notes to write down key notes and concepts in the interview as they allow the triggering of each particular memory and thought at a later date. Field notes can also be expanded and updated a day or two after the interview with ideas previously unrecorded, but leaving it any longer contributes to overlooking key details and specifics from the interview (Martin and Turner, 1986).

As highlighted by the literature above, the need for note taking is imperative, especially during early interactions with the data. The importance of this is that the focus can be placed on the interview content, as opposed to attempting to remember or record interview details. The majority of the interviews were scheduled for morning sessions and the initial field notes that were developed in the interview, were consolidated by the afternoon of the next day. This ensured that key information was captured and early creativity was acknowledged and built upon.

It is important to state that the note taking procedure was free from academic writing or correct grammar/punctuation as this allowed the process to run freely and capture the thoughts at the time. In following this structured procedure, a basis was formed with high quality notes that came into activation not only at the open coding phase, but more importantly, the memo procedure (See Figure 14 for example field note).

Participant gt08 highlights how those who ride bikes and drive cars truly understand the vulnerability of two wheels. This implies issues around the lack of understanding that exists, or it could be put to a mistrust/hatred between the two… who thinks they own the road? We then go on to discuss application Areas and it now becomes evident that the participant does not think it would work in particular areas, in towns and highly populated areas, he seems to think it will not work. So his potential application

Figure 14- Participant GT08 Field Note

4.5.3 Transcription

As discussed at Section 4.2.1, each interview was manually transcribed. The decision to do this was twofold. As the cost to transcribe from a third party exceeded the budget of the study, individually transcribing was more cost effective. Furthermore, manual transcription allowed the development a deeper relationship with the data. This was the case as each recording was listened to repeatedly to ensure each spoken word was transferred onto the raw transcripts.

4.5.4 Coding

Upon transformation of the interview recordings into transcribed text, the first of the coding phases began. Here, a number of techniques were applied that allowed the raw transcriptions to be understood and evolved. The coding process of this grounded theory, as displayed at Section 4.4, begins with open coding which is followed by axial coding and identification of the concept development.

4.5.5 Open Coding

At this first official excursion into the gathered data, Charmaz (2012) advises researchers to remain open minded, keep the initial code and understanding short and to move through the data at pace. The primary purpose in the adoption of open coding is to break down, examine, compare and conceptualise data (Strauss and Corbin, 1990).

Within this study, a number of interactions had overlapping open code, given the multiple number of contributors. As the data was extensive, a tabular format was adopted to ease data management and improve understanding. As an example GT08 provided the thesis with 68 lines of potential open code. Upon applying the open coding procedure, this participant group yielded 30 lines of open code.

An example of open code is as follows:

Data - "In a town situation it is impossible for a machine to understand the unpredictability of the road network and be able to react to this" (GT08)

The resulting open code derived from this line of data is 'location driven usage'

The above example displays how a spoken sentence of the participant was converted into a usable line of code that is subject to further exploration.

Another example is as follows:

Data- "More demonstrations will allow people to become more comfortable with the system" (GT09)

The resulting code derived from this data is 'the need for public engagement to promote acceptance'

Further examples of open coding documentation lifted from the grounded theory cycle can be found below at table 4,5 and 6. The open coding process was administered through the use of a two column table. The left column listed the words of the participants and the right column applied the open coding.

Data Source	Words of Participants	Open Coding
GT01	**“current vehicles are being fitted with autonomous technologies on the road to fully autonomous vehicles”**	Participant has an understanding of autonomous vehicles. Timeline of introduction is gradual.
GT01	**“If you present a user with a Fully driverless car as a first solution they will be like whoa” “A fully automated solution is a big step” “Slow introductions are better” “Fully driverless is intimidating” “Step by Step works better”**	Overwhelming users Gradual Change Users support an approach that is easier to digest. Immediate change is unwelcome.
GT01	**“Most common feeling in times of accident is unfairness and not getting proper justice”**	Bad experiences Do users have faith in the justice system? How would this translate in an autonomous environment?

Table 4- GT01 Open Code

Words of Participants	Open Coding
The system will offer huge benefits on the highway and the rural road. there will be a more stable flow reduce in lane changes a possible future platooning of hgv in that environment a motorcycle would exist perfectly, because the car would be aware of their presence.	Zonal Usage of automation Perfect harmony between Cad and motorcycles on a highway System implanted with motorcycle actions/ behaviours System usage in situations with low risks Commercial usage Stabilising the highways…theme
In a town situation it is more complex to see it working.	Zonal usage of driverless technology High risk = decreased use of automation Low risk = increased use of automation
It would be impossible for the machine to input/predict situations in which it could become fully driverless.	System application in the real world System usefulness Unpredictability of driving task
imagine attempting to do this and a dog ran out onto the road, totally unpredictable, the car would just stand still, or school children running around some situations in urban zones are hard enough for a human to deal with	Zonal usage of driverless technology Unpredictability of driving task System understanding of its surroundings System lacks common sense System application in the real world
Common sense is key to this urban driving	Does the system need emotions/ logic?
Like motorcyclists, human rely on eye contact with other humans, this enables the accomplishment of tasks, in an urban zone we use this all the time, reading someone's face, would a driverless use it too? No	Communication breakdown between users There is not a need for this anymore if neither users are in control of their vehicles Control of system Social issues Unwritten rules of the road
humans detect behaviour in other stakeholders, machine cannot predict this	Unwritten rules of the road
the only way is to go out and learn this,	Attitudes towards system
System in real world- the machine would struggle in the real world	System usage in the real world Unpredictability of driving task Depends on design If designed as a standalone it wont work, it has to be designed as an interactive, dynamic and predictive of the situation system

Table 5- GT08 Open Code

Words of Participants	Open Coding
The key element of a system is the user	**Identifying their importance in this** **Understanding their responsibility** The key cog
"the current state of the roads with all the potholes causes many issues for motorcyclists such as veering" **""because motorcyclists have to move car users cannot predict what a cyclist will do and at the same time will nit expect sudden movement"** **"the state of the roads needs to be perfect like a motorway"**	**Infrastructure Issues** **Misunderstanding users of the road** Mistrust in fellow road users System application in the real world Differing rules for road users
"View and visibility is a serious issue for a car driver when a motorcycle is in the vicinity of a car driver especially at the blind spot"	**Not being able to see the motorcyclist at all times** **Design flaws in current system** **Shortcomings of current system** **Current failure factors**
" Car drivers have a negative perception of motorcyclists, they don't want a bike near them" **"don't want a bike in their proximity"** "Part of negative perception of car by bike is because they have that experience of being treated badly but driverless would give positive reinforcement with its predictable behaviour and right actions" "Computer programs are predictable, driverless is good because it always does the right things in situations we come across whereas driver cars are not as good at it . " "It might not have an incapable driver behind it but it still has technology and technology goes wrong." **"look how many times computers crash"** **""**	**Negative perceptions** **Mistrust in close proximity scenarios** **Perceived usefulness of system from bike perspective** **Predictable behaviour = positive reinforcement** **Characteristic of the system is that it should be predictable** **Current user perception of this system is that it is good and will do the right thing** **Mistrust in system**
"A motorcyclist from an early age is taught to be defensive, taught to not trust a car or its driver" **"I have had 2 accidents in 3 years, the main problem is not being seen by a car, especially when the motorbike is on the left or on hill"**	**Embedded distrust, forced distrust** **Embedding feelings of anger and hate** **Design flaws of current system** **Blocked vision** **The cosmopolitan road.**

Table 6- GT07 Open Code

By conducting the open coding phase of the grounded theory cycle, an initial understanding of the data was established. This allowed the ability to determine what participants were referring to in their spoken word. It also began to develop a researcher/data relationship at this initial coding stage. Additionally, the fact that this phase allowed the shortening of transcript into manageable sentences, and the removal of repeating data, strengthened the position of this phase and the associated efficiency. Charmaz (2012) advised keeping open codes to six words as a maximum. This advice was followed in most cases, unless specified. In addition to this understanding, open coding allows the categorisation of data into similar groupings. Although this officially takes place later in the grounded theory, doing a preliminary grouping aids to solidify gathered codes. Moving forward, a record of the open code was kept for each participant group (Table 7).

The tabular format employed at open coding was maintained and expanded for the next two coding phases. This was done as it provided a clear method of being able to trace each code back to the transcript it belonged to, as well as being able to view the development of codes from their raw transcript phase to their state at category development.

Stakeholders understanding each other	Bias between users leads to negative actions
Motorcyclist vulnerability	Knowledge and learning is key to progression
Trust between users is the key thing	What does user to machine trust look like
Driving task distractions	Misunderstanding road rules
Automation progression	Real world application
Driving zone dictates usage	Automation adaptability
Automation benefits	High risk – decreased use Low risk- increased use
System usefulness	Driving task unpredictability
System emotions/logic?	Unwritten rules of the road
Rules of the road	Attitudes towards system
System design- standalone/interactive	Manufacturer led liability

Table 7- Open Code Listing

4.5.6 Axial Coding and Concept Development

Upon the culmination of the open coding phase, the study had gained a number of open codes from each participants. Although each participant interaction was carried out at different time periods, the discussion and display of coding will display examples together.

At this stage, the open code is now presented to the constructs of axial coding and upon that, concept development. A brief definition of the two before proceedings is as follows:

Axial coding is defined by Charmaz (2006) as a procedure to reassemble data that has been divided into separate codes by the open coding procedure. The key aim of axial coding is to add depth and structure to data (Strauss and Corbin, 1998).

4.5.7 Concept Development

To prepare code for its transition into theoretical coding, the stage of ‘concept development’ has been performed. Here, attempts are made to summarise the transcript, open and axial code into a short concept that explains what has been discussed and learnt from the particular cycle. In doing this, the study will ensure that upon progression onto the phase of concept development and theoretical coding, the study has a list of potential concepts that have been derived from the data, ready for their comparisons.

4.5.8 Axial Coding Example

At this stage, the axial coding process began where the transcript are explored and previous open coding output. In addition to axial coding, concept development was utilised at this phase. In pursuing axial coding, attempts were made to develop data by adhering to the Georgia Institute of Technology (2014) principles of axial coding. They are:

- Attempting to expand knowledge of the phenomena;
- Locating the conditions that give rise to the data;
- The context within which the data is embedded;
- Consequences of the strategies; and
- Relating codes, categories and concepts.

The structure of axial coding expanded on the tabular format of open coding with the addition of two extra columns to represent the expansion of open coding through axial coding and concept development to represent summarised learning. (See table 8, 9 and 10)

Data Source	Words of Participants	Open Coding	Axial Coding	Concept Development
GT01	**"current vehicles are being fitted with autonomous technologies on the road to fully autonomous vehicles"**	Participant has an understanding of autonomous vehicles. Timeline of introduction is gradual.	Time helps with transition Information overload is not the solution Change management principles Stages of automation understanding is clear	Change Management Technology introduction/ Stages of Automation
GT01	**"If you present a user with a Fully driverless car as a first solution they will be like whoa" "A fully automated solution is a big step" "Slow introductions are better" "Fully driverless is intimidating" "Step by Step works better"**	Overwhelming users Gradual Change Users support an approach that is easier to digest. Immediate change is unwelcome.	Information overload Understanding behaviour of users Do system manufacturers know this? Do all users accept technology in this way?	Change management Timeline of Technology introduction User Requirements Acceptance factors
GT01	**"Most common feeling in times of accident is unfairness and not getting proper justice"**	Bad experiences Do users have faith in the justice system? How would this translate in an autonomous environment?	Require consistency Review liability and legislation Has the legal system for road transport become out of date too? Would modernising the road transport system also require a modification to the legislation surrounding it? Should we approach discussions of AV systems by discussing its safety features or the need to modify legislation for its introduction.	Legislation/liability Motivating factors for change Legalities of Autonomous Driving System Design Current Problems
GT01	**"harder to trust machinery" "more likely to trust human" Even though system is less fallible than a human "**	Trust issues in relation to the system. Comparisons of how we trust system/ humans	Participant is aware of benefits, yet trusts human. Which factors drive human machine interaction?	Technology Trust Competence trust Human /Machine Interaction User Engagement

Table 8- GT01 Axial Coding

Words of Participants	**Open Coding**	Axial Coding	Concept Development
The key element of a system is the user	Identifying their imoortance in this Understanding their responsibility The key cog	This whole study is around the user of the system, they themselves feel important, this highlights the key area of public engagement. maybe before we considerate system we consider the user. How can user engagement be enhanced.	Public Engagement
The current state of the roads with all the potholes causes many issues for motorcyclists such as veering. Because motorcyclists have to move car users cannot predict what a cyclist will do and at the same time will not expect sudden movement. The state of the roads needs to be perfect like a motorway.	Misunderstnading users of the road Mistrust in fellow road users System application in the real world Differing rules for road users	If a user cannot predict then in the same way a system cannot predict can it, this highlights how the infrastructure needs to change, change ot become better and laid out correctly. Applying this system, will it understand characteristics of motorcyclists and the sometimes random actions they need to take to save themselves?	Infastructure Issues Vulnerable Road User Unpredictability System Design
View and visibility is a serious issue for a car driver when a motorcycle is in the vicinity of a car driver especially at the blindspot.	Not being able to see the motorcyclist at all times Design flaws in currewnt system Shortcomings of current system Current failure factors	the motorcyclist lives in a car blindspot, a simple phase i coined ot explain the issue of visibility that causes may accidents, specially when turning and hone hasn't seen the motortcyclist. this should be a fundamental element introduced in the future SYSTEM DESIGN- however the method of its introduction should be a seamless one not an annoying one	System Design Current Failures

Table 9- GT07 Axial Coding

Participant	"Words of Participant"	Open Code	Axial Coding	Concept Development
GT08	The system will offer huge benefits on the highway and the rural road. there will be a more stable flow reduce in lane changes a possible future platooning of hgv in that environment a motorcycle would exist perfectly, because the car would be aware of their presence.	Zonal Usage of automation Perfect harmony between car and motorcycles on a highway System implanted with motorcycle actions/ behaviours System usage in situations with low risks Commercial usage Stabilising the highway network	Usage zones influencing acceptance, Motorcyclist has an inherent distrust in the system. Which factors can influence trust and usage? what are the key differences between usage on the rural/ highway zone to an urban one?	Zonal Usage of Automation System Usefulness System Behaviour Road user communication
GT08	It would be impossible for the machine to input/ predict situations in which it could become fully driverless.	System application in the real world System usefulness Unpredictability of driving task	Competence trust is a key influencer. What is the definitive role of the vehicle? Is this related to ease of use?	Competence Trust System Design
GT08	Like motorcyclists, human rely on eye contact with other humans, this enables the accomplishment of tasks, in an urban zone we use this all the time, reading someone's face, would a driverless use it too? No	Communication breakdown between users There is not a need for this anymore if neither users are in control of their vehicles Control of system Social issues Unwritten rules of the road	Could be considered irrelevant if the system is in charge of the machine	Unwritten Rule of the road Social Issues User Isolation Stakeholder Communication

Table 10- GT08 Axial Coding

Presented at table 8, 9 and 10 are examples of axial coding and concept development being carried out. It is evident that in the axial coding phase, the analysis process begins to question the data to gain a deeper understanding. More specifically, what it represents and any connections it may have. These connections and relationships are the key to unlocking the deeper understanding and this is explored in the next phase (Theoretical coding).

In addition to axial coding, the use of concept development allowed the narrative to develop a 'summary code' that encompassed the open/axial coding it represented. By shortening the code into a maximum of three words, this phase ended in a concise fashion and yielded a number of transferable codes that were then transported to the next coding phase. An example from table 9 discussed below is as follows:

- **Transcript**: The key element of the system is the user;
- **Open Code**: Identifying the responsibility of the user, understanding their importance for system success;
- **Axial Code**: The axial code discusses how user consideration is more important at this stage than system consideration. Furthermore, questions are raised around how user engagement can be enhance to promote acceptance and eventual usage. Lastly, the need to engage with users is revealed, in light of user needs and user consideration; and
- **Concept development**: Public Engagement.

Discussed above is an example from GT07 around the coding process. Focussing on the axial and concept development phase. As can be seen, the axial coding phase attempts to see the wider implication of the participant's views. Through their discussion of the user, the coding yields the areas of user engagement, factors to influence engagement and acceptance and considering user needs and requirements. Lastly, to summarise this code around users, public engagement is nominated as the concept of choice. The reasoning for this is that it represents the need to interact with users, but with the public on a wider scale, ensuring the needs of all those who interact with the system are satisfied and somewhat fulfilled prior to system interaction. Further examples of the coding process are in appendix 4.Table 11 displays a comprehensive list of the concepts gathered at this stage of the study.

Table 11- Gathered Core Concepts

Automation Level	System expectation	Trust in system ability	Driver role in AV environment
Incremental Introduction	System design/ ease of use/ predictability	Proximity based trust	Changes in infrastructure
Requirements of the User	System intimidation	Over/under trust	Real world application
Need to engage with users	System usefulness	Control of system	Willingness to adopt/change
Liability- Control and responsibility/ `System regulation	Vulnerable road user protection	Zonal usage of automation	Cosmopolitan road
Personal beliefs	Pedestrian protection	Driving reason influence on usage	Motorcyclist mindset

System influence on skill level	Pedestrian interaction with system	Cost of uptake	Social Issues
Road user communication	Relinquishing control to system	Automotive pervasive computing	Unwritten road rules
System abuse/misunderstanding	Correct knowledge and understanding	Occupying drivers/operators	System accessibility
Ownership symbolism	Pedestrian protection	Design learnability	Tangible trust

Moving forward, the developed concepts from the above examples as well as those from the remainder of the coding process will be presented at the theoretical coding phase.

4.5.9 Concept Development/Theoretical Coding

Theoretical coding is a heightened stage of coding that follows the focussed coding phase (Charmaz, 2006). It begins the stage of attempting to understand how the codes may relate to each other in the attempt to develop understanding to a hypotheses or theory stage (Charmaz, 2006). This is also known as concept development within the grounded theory. Within this study, theoretical coding in the form of written memos will assist in understanding the relationships that exist or can be forged between the developed concepts developed from the participant base. Furthermore, visual memos will also be employed to begin deriving concepts from the data.

To execute the above, all concepts documented in Table 11 will be subject to theoretical coding in the written form as well as theoretical memos to explore relationships and concepts. Section 4.1.4 highlighted the intention to employ a diagram tool to assist with the coding procedure. The conceptual models, adapted from the work of Checkland (1972) on SSM were utilised to achieve the theoretical coding element of the procedure. To begin the stitching of a developed understanding, current findings should in some way be relevant to each other or find relationships to begin developing concepts. Glaser (1978) describes this phase as a way to relate the substantive code and to use them in the creation of a set of hypotheses applicable to the gathering theory

In conducting the memos, the thesis firstly discussed the above themes but where applicable, included participant voices, ensuring their views were not lost in the analytical process, as instructed by Charmaz (1995).

From this point forward, the stage of writing memos and developing concepts is known as the bridge between coding and the first drafted study. (Calman, 2006)

Need for Information and Expectations of User

One of the codes found whilst investigating the transcript of GT01 was the need for information- the thought process that a possible user requires information as soon as possible regarding ARTS in order to make a rational judgement about involvement within the project. This is linked to the expectation of the user, in a primary path, it is currently hard to distinguish which one would precede the other as both are very similar but have many repercussions due to two key reasons. The selective code of KNOWLEDGE is linked to the need for information. One describes what is required whilst the latter code will discuss what specifically is required.

Before the user begins to create a picture of this system in their mind, information regarding it must be provided in a published and peer reviewed manner, this will stop any disappointments from the user, especially if they expect ‘driverless’ to be something normally seen in Artificial Intelligence themed films. If the system is not what a user expects then the initial reaction will be disappointment and a Percieved non usefulness of the system. As the saying goes ‘first impressions are key’ this community needs to ensure the first real impression stems a positive response. This is indirectly linked to COMPETENCE TRUST and the understanding of what the system can do, in relation to what it cannot do.

The need for information can also be linked to the massive area of trust, namely over trust and under trust, again the issue of which comes first, the need for information or expectations of user in the sense that if information isn’t provided in a clear and coherent manner then a user can become guilty of under or over trusting the system. The implications of such a scenario are well documented in section 4 of this thesis under Negative behavioural changes. This links into the selective codes of PUBLIC ENGAGEMENT, KNOWLEDGE and ACCEPTANCE FACTORS

Figure 15- GT01 Written Memo

THE COSMOPOLITAN ROAD

This topic is interesting, it highlights a fundamental issue that exists at this moment, no system or piece of technology can solve the problem that exists between different road users. this point has been mentioned by other participants but more so by motorcyclists because they can be considered the most vulnerable users of the road. the fundamental problems are around Understanding each other and understanding the prescribed actions of reach other. Because the road behaviour of say a motorcyclist is flamboyant where a car driver is usually conservative a negative perception and bias can sometimes exist from driver to bike and vice versa.

This can be a major cause of incidents and issues on the road from small aggression triggering mannerisms to full blown incidents simply because the car driver don't understand what he the cyclist or motorcycle user is doing and vice versa. STAGES OF AUTOMATION- mentioning fully autonomous- this can obviously solve any bias issues as the system is not bias it will act how we should be acting but there will be times when the system is not in control, when we are in control now if our mentality is still the same then it is pointless. it all boils down to the knowledge and the understanding required.

ATTITUDES TOWARDS SYSTEM

An interesting point raised by this user, car users wouldn't be interested in doing the extra training like many say because the REASON FOR DRIVING for users is primarily to do a chore, not a hobby.. this would be different for motorcyclists and cyclists, for them it is a mixture of a chore but more so a hobby of theres that would motivate them to do the training.

For a truck driver it would be a key thing, they wouldn't want to get left behind so they would carefully observe all related work . MOTIVATION, DRIVING REASON

ZONES VS. USAGE- mentioned many times, their is a potential to introduce here the notion of reason for usage linked to zone, so why are you in this vehicle and where will you use it , the answer to that will influence the whether automation use will make place.

Figure 16- GT08 Written Memo

System APPLICATION/ INFRASTRUCTURE CHANGES
The issue of system application in the real world has been mentioned and discussed over and over, here we mention it and introduce the factor of INFRASTRUCTURE CHANGES. we forged this when thinking that it could well be possible to introduce the system if we make massive infrastructure changes such asserting up every road in this example, that ohaldnt be the way it is though, with any change effort we want to cause the least amount of disruption possible while introducing the system etc. that a new point to bring not the study.

Vision 0 wanted to take bikes off the road, we have obviously also found out about them being the rogues of the road, but again even though for their flaws its to something that an be done, this system has to be fit for purpose and that means negotiating properly with bikes. Defining USER COMMUNICATION is interesting. The Highway code doesn't promote using hand gestures or vehicle features to communicate. However, participants discuss it as it is the accepted norm. How will the infrastructure accommodate for vehicles that negate this need, will a communication tool be established?

FEAR OF INTERACTION
Not just from the mindset of the user of the system, but this narrative is aimed at the people who interact with the system from an outside perspective, again the balance we have in the modern world of interaction between all of us is settled, its not like dodgems, wedding want our infrastructure balance to change due to the introduction of a new system.

Two things about this topic, ZONES/USAGE can now include ZONES/MOVING VARIABLES VS USAGE to include the fact that the number of moving variables, whatever they may be will influence usage of the system, we expanded moving include humans, animals, other cars and generally everything one has to interact with, the more moving variables that occurred, the less likely SYSTEM USAGE will be adopted. IN discussing ZONES/USAGE, the conversation on this has been exhausted already, however it will be briefly mentioned. participants all discuss where they would and would not use such technology. The study will now look at why they would/would not use in certain zones and how usage in these zones can be brought about or increased.

SYSTEM AVAILABILITY/ THE PRICE OF CHANGE
AV technology will come at a cost, maintenance alone will probably dwindle the already high purchase cost, we assume. LOSING CONTROL is also linked as maintenance will have to be done b specialists. Previously, most of us could fix our cars ourselves, because we learnt to and the cars were simple, in these times the cars are getting harder to understand and maintain as electronics era takes over our engines, so we have RAC and more garages which obviously comes at a high cost. now think ahead we will have a system that probably is regulated SYSTEM REGULATION so that maintenance has to be done by a professional on certain bits at an even higher cost, it seems the PRICE OF CHANGE is very high. One day, like all technology it will be freely available to everyone as the price decreases but the last of what we want is for the system to be considered a rich mans gimmick, like some already have. I am taking this angle here because considering LIABILITY, if we all argue that liability of a driverless vehicle in full driverless mode is down to the manufacturer, then in no way can we believe that they will let me and you fix them on our front gardens.

Figure 17- GT07 Written Memo

Table 11- Examples of Concepts and Assigned Codes

Concepts	**Automation Design**
Stakeholder Involvement	Liability
System Awareness	Incentivising Change
Stakeholder Belief	User Fears
Trust	Influencing Factors
Usability Perception	Usage
Accountability	System Adoption
Technology Adoption	System Implementation

Presented at Figure 15, 16 and 17 are a selection of written memos developed for the study based on concept development and participant voices. Taking inspiration and purpose from theoretical coding, the memos attempted to explore each concept developed by reconstructing its definition and assigned properties. In addition to this, each memo attempted to uncover related codes through association and these are displayed in capital letters in each memo.

At this stage, the study had a comprehensive range of written memos that represented and discussed all the gathered code from the study. This inclusive discussion documented, explored and found relationships between the code that prepared the study for the next stage; memo diagrams.

As discussed at the section beginning, memo diagrams will build on the written memos by conceptually presenting codes and concept developments with the aim of defining relationships between codes and concepts that transgresses each participant and considers the collective. This will be done through initially creating diagrams based on the concepts and codes for each individual participant. Upon gaining closure and being able to conclude on each individual participant, the study will attempt to combine learnings form each participant and create 'super' diagrams based on the collective concepts and relevant codes of each stakeholder type. For example, Figure 18 and 19 display 'super' diagrams with the relevant concepts of motorcyclists and car drivers respectively.

The purpose and utility of these diagrams is that they allow the uniting of data that transgresses participants and considers the collective. This process begins to lessen the data load, and at the same time, improve analysis and data extraction through further comparison and checking. This is also in line with the grounded theory values of starting with a large amount of data and discounting as each stage progresses until it reaches the substantive phase. All diagrams were originally hand drawn and digitally reproduced for the purpose of this thesis.

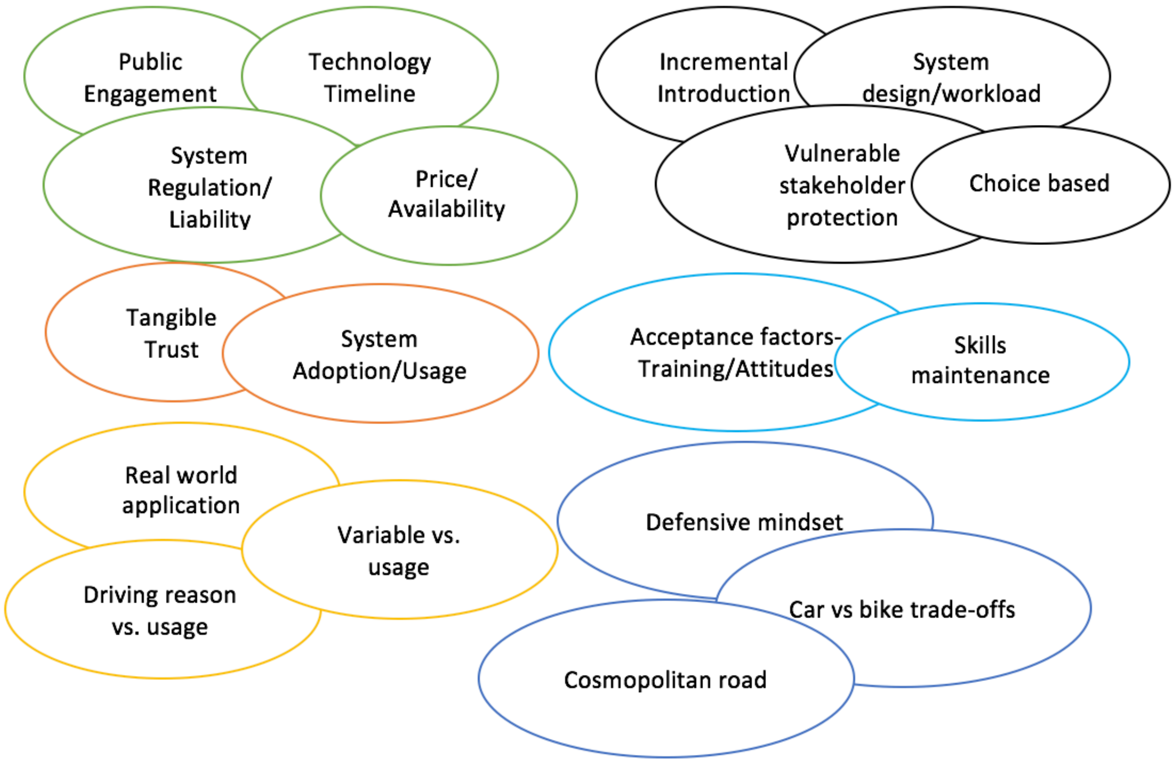

Figure 18- Combined Perception of Motorcyclists

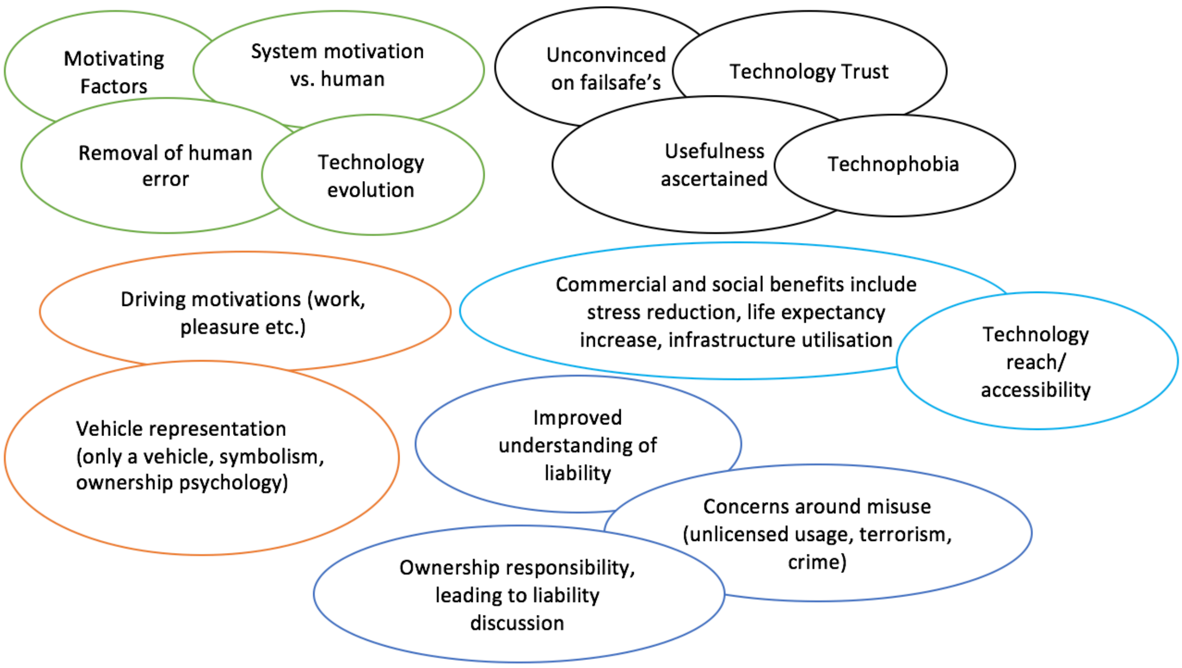

Figure 19- Combined Perception- Car Users

Presented above at Figures 18 and 19 are the theoretical memo diagrams. These diagrams were developed to display groupings of code to allow the introduction of concept development. The diagrams adopt a colour coded scheme with colours defining groupings of code. The groupings of code form together and the next cycle of the grounded theory will merge concepts, apply a naming convention to them and manage them into their relevant category/theme.

Furthermore, the theoretical memo process allowed the sorting of codes in the process of refinement. This facilitated the distilling of data down to a presentation level and one where each code and developing concept had been fully explored.

By joining participant data and using stakeholder type to distinguish between diagrams, a comprehensive overview of each stakeholder type has been provided. To further reinforce the learning that has been gathered about participants in relation to perception and acceptance of AV systems, the literature review will now be reintroduced to refine learning and contribute to category development.

4.5.10 Literature Contribution

Chapter 2 and more specifically Section 2.1.3 display the key learning gained from the literature review on AV acceptance and related works. Within the grounded theory, the 'comparison to existing literature' phase does not appear in the designated order or stages of the cycle. Rather, it has influence, developed and refined code throughout the study, upon the introduction of open coding.

On a higher level, the thesis will discuss the impact of current literature on the study data and on the findings. Discussion of this can be found in Chapter 6 where literature findings are compared to study results.

4.5.11 Category/Theme Development

At this penultimate stage of the grounded theory, attempts were made to develop categories or themes to represent the concepts and codes that had been extracted and developed from the study and literature. The significance of this stage is that it carried the study into the final phase, where a substantive theory or results presentation.

This emergence of theory is described by Allan (2003) as coming about as a direct result of grouping concepts to find higher order commonalities. Also known as categories, at this stage the subconscious grouping carried out at earlier stages can be acknowledge and brought to reality. To develop the required categories to enable substantive theory development, theoretical memos were commissioned. These were done with the sole intention of further refining concepts and to ensure a revisiting was made to all existing data, prior to progression onto the final phase.

The key tool employed by this stage was concept cards. Concept cards are highlighted s a flexible tool to allow the division and categorisation of data (Turner, 1981). Their compatibility with the grounded theory is noted, given its synonymous aim of developing data towards a higher level of abstraction.

Figure 30 displays a concept card application to generate categories for this study. The concept card is not conclusive; it represents a work in progress towards developing categories. In keeping with grounded theory value, this stage transgressed all participant and stakeholder boundaries to align learning and finding from each stakeholder memo. This allowed all learning to solidify within the required categories and the creation of a concentrated, specific view on stakeholder perception of AV system technology.

To develop the required categories, all available concepts were aligned and the theoretical memo process (written and diagram) was used to support the concept cards in categorising data by way of grouping similar data. Based on the number of groupings and the key themes discovered from each grouping, the required categories were formed, representing concepts and ultimately, the substantive theory of this study.

Figure 20 displays a work in progress concept card as the final categories and their relevant concepts are the results and deliverable of this study. The example displays emerging categories from the data set. The category of ‘trust’ was removed as it was irrelevant for all categories. Due to this, they will be introduced at Chapter 5 and accompanied by a conclusive discussion on the matter.

~~Trust~~	Change	Usage
	Burning bridges Change management/ guided Incremental change effort Belief in change/ required change	Uncontrollable variable based usage Choice based usage Optional adoption Perceived intimidation Driver role Responsible party Driving reason/zone vs. usage
Acceptance	**Motivation**	**Control**
Continuous training Converting stakeholder attitude Positive public demos Stakeholder involvement User centred design Competence trust Allaying fears System design	Dependent on system availability/price Fear influences motivation Freedom of choice Knowledge and understanding of system and its surrounding construct Flow of information Personal vehicle representation Overall clarity	Fear of higher automation levels Gradual relinquishment Clear responsibility indicators System experience Re engagement proposition Responsible party

Figure 20- Concept Card Development

4.5.12 Additional Study Notes

In addition to the comprehensive overview of the methodology application discussed above, a number of additional points must be documented and noted for the reader. They are as follows:

- Charmaz (1995) instructed theorists to include as much participant voice as possible in the final deliverable. To ensure this was adhered to, transcripts and open code were continually revisited to extract relevant transcript for utilisation within the final deliverable. Doing this also maintained a close relationship with the data and allowed for the constant comparison and revisiting nature of the grounded theory;
- In attempting to develop categories, the literature provided assistance at that phase as a number of literature sources had already identified associated characterises and properties of relevant themes from their respective work;
- Within the methodology application example of this chapter, memos were displayed as a singular stage of grounded theory cycle; and
- The concluding note of this section is around the significant amount of associated documentation that the study has generated. Through this Chapter, a minimum of two examples for each relevant grounded theory cycle have been displayed. It was deemed that any further examples would have hindered readability or flow of the chapter. Further examples of each stage of the cycle from each participant can be found in Appendix 4.

At this point, the study has run the required course through the grounded theory cycle. Each stage has been fulfilled with a clear output leading to the next stage. The Chapter will now move to discussing a summary before progressing onto chapter 5 to discuss to discuss the results and direct output of this chapter.

4.5.13 Chapter Conclusion

The purpose of Chapter 4 was to display application of the grounded theory to this study. This was achieved through demonstrating a typical coding procedure from data collection, through to a comprehensive application of the grounded theory analysis procedure with 3 participant examples. The overall aim of this Chapter was to build understanding on the introductions to the methodology made in Chapter 3. In considering a typical methodology lifecycle, this Chapter presented the input and process of data, prior to moving onto the output in the next Chapter.

As well as the grounded theory application, this Chapter discussed usage of the SSM methodology techniques to allow the development of theoretical memos and further data extraction. From this, a foreseeable opportunity of a future mixed methods approach can be noted and the discussion of this can be found at Section 8.3.

To view further coding examples, please refer to appendix 4. The thesis will now move to Chapter 5 where the results developed on behalf of the efforts of this Chapter will be presented.

Chapter 5- Results

This chapter will present a detailed interpretation of data collected through the empirical study outlined in this thesis. The work discussed here will build on the methodology outlined in Chapter 3 and applied extensively in Chapter 4. As depicted by Lehmann (2001) within Figure 7, this chapter signifies the substantive theory stage of the grounded theory cycle. As a result, the results chapter will present the findings by way of the categories assigned to represent codes and concepts. Further discussion of this can be found in Section 4.5.11.

In relation to this Chapter, the results are presented across two sections: those relevant to the adoption and usage of autonomous vehicles, and those relevant to stakeholder perception of AV systems in general. An overview of each follows:

- **Acceptance of AV systems**- Results pertinent to this section will focus on concepts developed as a result of participant discussion on direct contact with autonomous vehicles. Relevant concepts and resulting categories will describe results related to interaction with the vehicle in a usage environment. In this section of results, the study will take a high-level approach to presenting findings and will not introduce stakeholder specific data. Rather, a collective approach to presenting results will be adopted. This will allow the creation of shared results that focus specifically on the topic of AV system acceptance, free of additional results on related and unrelated topics. Within the presentation of these result, the category method of results presentation provided by Lehmann (2001) will be adopted. As usage in this context is defined as negotiating with the technology as a driver, this section is primarily built up of data relevant to car and HGV drivers (GT 4,5) with small contributions from the remaining participants; and
- **Stakeholder specific findings**- In contrast to the above, results pertaining to perceptions of AV systems will take a concentrated view and explore results relevant to each participant and stakeholder type. Here, the discussion will explore attitudes and factors unique to each participant and stakeholder group in their interpretation and perception of AV systems. As the study employed almost all stakeholders that

would be in direct and indirect contact with AV systems, this section of findings has been created to document findings related to participants who would be interacting with the system, but not directly using it.

By separating the results into two overall categories, a high level sorting of results can take place. As the bulk of results are related to the adoption of AV systems, creating a sole reference area on the topic will yield an unaltered knowledge set, not confused with secondary results gathered. Similarly, creating a secondary set of knowledge will also strengthen the alternative findings of the study. In addition, as the sample of the study was not defined by one core characteristic, attempting to generalise or present singular results would overlook the unique and key contributions from the variety of the sample. Presenting the stakeholder specific findings creates the possibility to discuss issues relevant to each participant and stakeholder group of the study. This will further improve the quality and robustness of the findings and resulting contribution to knowledge.

The findings will be in two parts, this chapter that will provide the interpretation of the data by way of categories and assigned concepts. Chapter 6 will then discuss the results in further detail, analysing the repercussions of the findings in light of transferability, application, implications and limitations.

5.1 Acceptance of AV systems

Concept cards are used alongside memos to allow category development. In developing these categories, it was expected that findings would be related to perceptions of the system; however during the data collection phase and throughout the analysis process, it became clear that participants were comfortable and willing to explore issues around actual usage. In presenting these categories and derived learning, it was noted that participants seemingly likened their responses to a complete journey of AV system adoption, ranging from intentions and motivations towards AV systems through to actual usage.

In relation to actual categories, a number of concepts are cross-referenced and appear in more than one instance across the categories. For example, trust and design are discussed within multiple concepts across two of the three categories. As AV system adoption is not a linear approach, this was expected to occur with participants discussing the same code as being relevant to them in a number of scenarios.

Figure 31 displays the IET (2015) levels of automation table that discusses the various stages of automation afforded to AV systems. The results heavily discuss and reference the various stages of automation, and any related discussion of these in interviews adopted the IET (2015) framework when discussing related elements.

Table 12- Levels of Automation. (IET, 2015)

Level	Description
1- Manual Driving	Human driver undertakes the manual driving task
2- Driver Assistance	The driver continuously monitors and controls all longitudinal or lateral support provided by particular systems that may automate aspects in the driving task e.g. ABS or Advanced cruise control
3- Partial Automation	The driver continuously monitors while the system takes over longitudinal and lateral control but the driver is expected to take control back at any time
4- High Automation	The system takes over longitudinal and lateral control of the vehicle; the driver is not required to continuously monitor the system but is expected to respond to a take-over request within a specific time window
5- Full Automation	The system takes over longitudinal and lateral control completely and permanently. When in full automation mode, drivers become “users”

Prior to the presentation of results pertinent to the categories of acceptance, it is key to note that the categories and inclusive concepts have been arranged in a chronological order. This has been done to improve readability of the findings and to facilitate the impression of a ‘journey’ of acceptance from a mental state to a physical usage environment. This is not to suggest that the order in which a person accepts and uses driverless cars is linear. Rather, as discovered in the thesis, the order of acceptance varies amongst users, with some activating concepts from the first category, and some being concerned by concepts presented in the third. This would suggest, as expected, that driverless vehicle adoption is a dynamic process, with ever-changing adoption methods. This can be put to the uniqueness of AV technology and the emotions/reactions it causes to its adopters, given the variety of tasks and situations it is used for and in. To conclude, the following work presents an account of what this thesis believes to be a collection of categories and concepts that require attention and satisfaction to bring about safe and continued acceptance and usage of driverless vehicles. This is in accordance with user data, derived from their perception and expectation.

When attempting to understand direct stakeholder perception of driverless vehicles, and the issues related to its acceptance, three overall categories were identified. These categories were identified from grouping similar concepts and creating a representative name to encompass these related concepts. The three categories are as follows:

5.1.1 Intention to Use

The first category developed and nominated to represent sorted concepts is Intentions to Use. This category was selected as it represents a range of concepts that discussed issues surrounding the development of motivation and firmness of intention to use AV systems. The category does not contain any concepts that are related to actual usage. Rather the category can be described as one that is mostly built up of intangible factors that focus on achieving the required mindset to accept such technology. In addition to intentions and motivation, the category explores the role of stakeholders, by considering their beliefs and knowledge.

5.1.2 Technology Usage

The second category developed and nominated to represent sorted concepts is Technology Usage. This category was selected as it represented a range of concepts and resulting code related to participants beginning their usage of the technology. In exploring this proposed usage, participant viewpoints on system application and implementation, and issues that become relevant upon actual usage were identified via tangible concepts and codes.

5.1.3 Relinquishing Control

The final category developed to represent concepts is Relinquishing Control. This category was selected as it represented a range of concepts and resulting codes related to participants surrendering control and driving responsibility to the system. At this stage, the participants have accepted and are actively using the technology. In line with the IET (2015) levels of automation, this category discusses issues relevant to relinquishing further control and ultimately surrendering the driving task to the system. In exploration of this category, the concepts represent participant discussion on their probable concern and forecast of giving up control and issues relevant to this event. Each category will now be discussed in sufficient depth with a focus on its key characteristics and the code that contributes to the concept presence.

5.1.4 Intention to Use Category

This first category focusses on developing an interest, understanding and overall motivation in and around the AV system. Within this category, the findings are geared towards empowering participants and providing the required tools to mentally prepare users for the required shift towards AV technology. Popular theory around change and motivation point to this family of findings as being relevant when attempting to stimulate change and convert perception. The concepts that contribute to this category are as follows:

Stakeholder Involvement

Stakeholder Involvement refers to the need to engage users and stakeholders with the system at the earliest feasible stage. By promoting public engagement, stakeholders are made to feel as part of this change effort, developing a sense of ownership or involvement. By engaging stakeholders, their contributions can lie in the domain of system design, requirements engineering, user testing etc. This would ensure the human/user centred nature of the system would be maintained. A theme in the study was that participants were unwilling to entertain AV systems as they had not seen, touched or been in the vicinity of an operational AV system. From this, the need for tangible evidence through system display or continued research and presentation into system application was identified. In addition, public engagement would reinforce motivation and ensure stakeholder intention to use or engage with AV is not compromised, and in some cases increases. Furthermore, the method of introduction is also key to user acceptance. If the system was to be introduced in a top-down, autocratic approach, participants noted this would cause resentment and an early onset hindrance to potential acceptance.

System Awareness

The knowledge and understanding of each stakeholder is of paramount importance. Participants noted their current shortfall in understanding and how assumptions currently led their thought process with regards to AV systems. To allow individual intention towards AV system to develop, clear knowledge around substantial elements of the system is required. In developing their understanding of the system, stakeholders are then able to influence their intention and become inclined towards the system. Upon discussing the properties of the knowledge required, participants only discussed the characteristic of clarity as associated with this concept.

Stakeholder Belief

The belief around the system that is possessed by each stakeholder is considered by stakeholders as a key influence on their proposed usage. In addition to the above two concepts being relevant, a number of additional factors were discussed by participants. The user type that each participant assigned themselves to within the study is key in understanding proposed acceptance. In line with the Rogers (1964) model on diffusion of innovation, some participants described themselves as daring, extroverts and innovators, whereas other participants described themselves as introverts, being reserved, unwilling to change and disliking change. By describing their characteristics in this environment, the study was able to distinguish the variety of user types and how these would have an effect on their individual proposed acceptance (See Section 5.2 for further findings defined by user type).

In addition to the user type that is assigned to each stakeholder is the personal motivation associated with each user. Here, the study looks at a number of factors that either motivate or demotivate system usage. Participants spoke of their past experience with road transport, focussing on accidents, congestion, travel time and cost and how these influenced their motivation to adopt. By understanding the overall experience of stakeholders, the ability to embed change was noted.

The concluding code to stakeholder belief is the expectation a user has of the system versus the reality of what the system can offer. The expectation held by each stakeholder is motivated by their beliefs around the system and by the two not aligning. The probability of disappointment, disengagement, perceived over/under trust and disuse are high.
To ensure the alignment of user expectations and system offering, the community must ensure that each concept discussed, and the category as a whole, contains the correct knowledge, involvement and system association. This would not only have an effect on stakeholder intentions but on a larger scale, would ensure that upon actual usage, automation surprise or improper usage does not occur.

Usability Perception

Within the review of acceptance literature and the documentation of existing technology acceptance models, the theme of perceptions was prevalent. This was also the case within the study and three key perceptions of inquiries were noted from participants. There was an overwhelming interest in the usefulness of the system, the ease of use associated with the system and the learnability of the system.

5.1.5 Technology Adoption Category

The second category focussed on concepts related to actual system usage. Within this category, the findings are directed towards ensuring that users are comfortable in their adoption. This is done by raising their concerns, requirements and influences. It is expected that at this stage, the intention of the user is to use the technology.

Influencing Factors

The first concept within this category discusses a number of tangible influencing factors that stakeholders have discussed as imperative to early adoption and usage. As expected, events such as public displays and trials were discussed at length by participants as having the ability to instil confidence in users. As well as the confidence boost described by participants, the tangible evidence discussed in the previous category can now be utilised to develop stakeholder trust in the AV system. Furthermore, training was also cited as a much needed tool to establish proper usage. Participants also noted that an overhaul in legislation was required to introduce AV systems, and this was regarded as being influential to proper usage.

The concluding concept within influencing factors was the price of change. Described as one of the key influencing factors of usage, the discussion around cost centred on both the finances of purchase and maintenance. In terms of the cost of purchasing, participants highlighting this as including the cost to purchase a vehicle with such abilities or the purchasing of 'add –ons' for existing vehicles. Furthermore, a key concern for a number of participants was that it was only something that was available for high specification vehicles and would not be available for more affordable cars for a number of years. In terms of vehicle maintenance, a number of vehicle owners conduct minor maintenance of the vehicle themselves or use the services of a known mechanic. In a driverless environment, participants expressed concern around whether this was still a possibility or if the vehicle would require the services of a specialist, at an increased cost. Although the relevant legislation is not yet available, participants forecasted the inability to carry out maintenance of their vehicles, as this would be disliked by manufacturers and would cause issues surrounding liability and accountability. For example, if users attempted some work on their vehicle which inadvertently led to the failure of an AV component and resulting road traffic collision, the manufacturer would not be willing to accept liability.

System Implementation

Even though AV systems are considered as a natural evolution of technology associated with road transport, participants considered it as a revolution. This was cited in light of the current legacy system adopted and the drastic change that was affecting this sector. Participants discussed a number of issues in relation to system implementation. The first concept discussed was around an incremental introduction of the system to the road and to their individual usage. Participants were made aware of the varying levels of automation and spoke of the need to use and become confident with each phase before progression onto the next and higher stage.

In a connected society, AV system integration with existing technology is important. As platforms are connected and in car entertainment and interaction systems are integrated for seamless use, the ability of AV systems in this environment was questioned. With the upcoming internet of things and smart technologies set to advance society, being designed as an integrated system for seamless inclusion would increase acceptance and continued usage.

Automation reach and potential exploitation in light of accessibility were discussed as key implementation factors. Although this applies to a scenario where the system resumes full control without any driver input, it is cited here as an acceptance factor based on system implementation. In an environment where no user input is required, participants spoke of the ability to allow less abled users, younger users, those without licenses to use the AV system. Currently, this is regarded as a not a possibility; however, in a future environment acceptance and usage by alternative communities is a possibility.

Leaning on the topic of design, the real world application of AV system technology yielded resilient responses from every participant. The real world application of the system deals with the fear of this type of system being used on the road. Aside from the benefits it possesses, the downsides include the ability it has to distract drivers, regardless of the level of automation being operated in. Another fear is the unpredictability of the road network at present and how a computer system can negotiate with these scenarios. As the road network does not operate in a predictable fashion, with a number of hazards developing at almost each street or road, fear does exist around the identification and reaction to these unforeseen hazards. On a wider scale, this concept references the design of the system, alongside trust in the competence of autonomous vehicles and the associated fear that currently surrounds the driving task.

Usage

The concluding concept of this category of technology discusses actual usage of the technology. This concept was geared towards those stakeholders who would be in direct contact with the system.

In continuation of the incremental introduction discussed above, multiple expressions of having voluntariness in the form of a choice based system were made. This was discussed as being able to provide control to the user which would increase adoption and continued usage. The inability to do this, and the presentation of persuasive usage, would lead to resentment and long-term disuse.

The reason an individual drives is influential over their actual usage of AV systems. As the study invited participants who drove for a number of different reasons (social, enthusiasts, employment, commuting), the similarity between their intention to actually use was vastly different. Overall, participants who drive for employment feared loss of income due their role becoming operational rather than the actual driving task. Participants who drive as enthusiasts were against usage as they felt it removed the fun and danger element that they craved when driving as hobbyists. Participants who drove for commuting or for social reasons welcomed usage, given the timesavings it would create for them to do alternative things. Apart from participants who drive for employment purposes, all participants welcomed a choice based system of when to utilise AV technology. This was concluded as not each scenario of vehicle usage was for pleasure or alternatively, commuting.

Furthermore, the driving zone an individual is in dictates their desired usage of AV systems. Zones were introduced to participants as being urban, highway and rural. Generally, it was found that participants were unwilling to use the technology in environments with a high number of moving variables such as fellow vehicles, pedestrians, animals, congestion etc. It was found that the majority of participants were only willing to use the system and its features on the highway and in rural driving zones. As the task of driving is considered to be dynamic and applied in a number of different zones, non-usage in particular areas is hazardous to long term acceptance.

The concept of fear and system intimidation is activated only when actual usage begins. This is the negative emotion experienced by users when using and relinquishing control to a non-human system. Inviting the AV system to take charge of the driving can lead to a heightened level of fear and intimidation in those users who fall into the 'technophobe' category. It is not expected that every user would use the system by way of selecting the fully autonomous mode as their initial, preferred mode of usage, hence previous discussion in acceptance has been around incremental introductions and a choice-based system. By giving each user the choice to which level they want the system to operate at, slowly trust can build, regardless of the time taken, to a stage where they can comfortably use any level without fear, having built their confidence level.

5.1.6 Relinquishing Control Category

The third and final category selected to represent concepts is 'Relinquishing Control'. Set as the concluding category of the findings, here concepts are gathered that display findings around relinquishing control in higher stages of automation. Within this scenario, the system is expected to be able to function without any human intervention through the usage of intelligent behaviour. Additionally, with this change, the role of the driver changes from being charged with the driving task to now being an operator of proceedings.

Although participant view and market trends discuss that a fully driverless (Level 4 + 5) scenario is still a number of years away, it still forms part of the spectrum of driverless vehicle technology. The development of this category has focal influence from participants who are expected to directly interact with the AV system (drivers). Influence from the remainder of participants is provided in findings that relate to being in the vicinity of a vehicle that is in sole control of the driving task.

Accountability

The first concept within the category is accountability in terms of liability and responsibility. Although discussed previously, at this stage the sensitivity to this subject is heightened. Begrudgingly, participants accept that in every scenario, they are liable for the vehicle and its action; however, in a fully driverless situation, the sensitivity is heightened. The correct legislation governing the higher levels of automation should precede the technology itself. By ensuring strict enforcement and clear guidance on ownership and responsibility of actions and ramifications, each user would then be motivated to take the necessary precautions and employ the due diligence when using the vehicle. This would ensure that a situation does not arise where users do not feel responsible, and as such, reduce their concentration or concern regarding the vehicle in higher automation modes.

To facilitate the above, each participant expressed the need to employ clear responsibility indictors to assist in removing any confusion around who was responsible at any given time or to ensure users did not fall out of the automation loop. Users spoke of tangible features such as lights or sounds to assist with the indication of the division of labour.

Design

At this stage of automation, participants expect renewed support to be factored into the design that encourages, motivates and supports driver usage. Participants also expect a degree of transparency within the system, allowing them to understand the state of the system as well as its workings. In addition to system transparency, feedback is essential to aid understanding and allow the development of confidence and trust in the system. In short, participants expressed the need to understand the behaviour of the system at any given stage, and especially at automation levels 4 and 5. Participants also require decisional freedom of usage, expressing their wish to resume or relinquish control at their request. They do not wish to be influenced by the system or surroundings; they wish their comfort and discretion to dictate usage.

To support usage of the higher stages of automation, a wealth of code and literature points to the need to incentivise change. Like a loyalty shopping card, participants spoke of being rewarded for system adoption and continued usage. By rewarding adopters, a collective transformation can take place with monetary or asset gains encouraging acceptance.

As participants were introduced to the notion of automation surprise and falling out of the loop, they expressed concern around entering higher stages of automation if the design of the system was not efficient at facilitating this. Because their remains no established route from level 0 to level 5 (it could go 1>3>4>2>5, but also directly 1>5), participants become fearful of the learnability and comfort ability of adoption.

A concept that is primarily focussed on by those who drive for employment, but could also be modified to serve the wider audience, is the concept of replaced workload. With vehicle modifications and in car evolution, the nature of the driving task becomes such that drivers now adopt an observatory role. Many participants, especially those from a commercial background, spoke of their employers being unwilling to pay them a satisfactory salary if their role was primarily to monitor proceedings, as opposed to the actual driving task. Many assumed the workload would be replaced with another task of sorts, occupying the now 'free time' each user would have. The purpose of this concept is to highlight that by removing the driving task from the driver, a hole now exists in terms of defining their new role, what they can do and what they should be doing. The danger of attempting to increase employee productivity is that a task may be assigned that removes concentration and renders drivers out of the loop. In addition, dependent upon the actual allowed activity in higher stages of automation, participants displayed resentment with the system if it meant their workload would be increased, citing manually driving as being the easier of the two scenarios.

User Fears

Fear has arisen regarding the key reservations that participants cited when relinquishing control. As well as trust, the issue of competence trust was also highlighted. Participants discussed the fear of letting go, not due to their own trepidations, which were satisfied in the previous two categories, but due to their trust in the competency of the system. Whereas in lower levels of automation, drivers have a level of contribution to the decision-making and control of the vehicle, in the higher two levels, drivers become users. In this state, participants expressed fear around the ability of the system and if early versions of it had been designed to deal with the pressures of the road transport sector. This fear in ability, especially at this level, contributes to over/under trust, which in itself can cause mass confusion and represent a dangerous scenario for the vehicle and occupants to be involved in.

In contrast to the above, with proper usage and adoption, participants noted the adverse effect over reliance would have on their own skill levels in relation to driving. Participants felt an over reliance on higher levels of autonomy would result in a long term disuse of the system as the ramifications of using it would set in, resulting in it being considered unsustainable. This unsustainability is down to their own skill level decreasing, contributing to their inability to successfully control the vehicle, if required. In the field of aviation, pilots are required to have regular checks and training courses to ensure that the impact of fully autonomous modes are minimal and re-engagement and lower levels of automation still operate efficiently.

The concluding concept within this category is user wellbeing management, a concept that considers a method of alleviating fears, stress, trust and anxiety issues that will be associated with AV systems. Within this concept, participants expected the introduction of external support networks to assist users with relinquishing control, as well as any related AV system issues. Considerations were made to the providers of this system from manufacturers, local government, highways agencies etc. Given the relevant support, participants expected continued usage, as well as the attraction of laggards and late adopters in line with the Rogers (1964) categories.

The above concept concludes the category of Relinquishing Control and also concludes the first level of findings. At this first stage, three categories were presented that discuss AV system acceptance. In line with the question set and natural progression of each participant interaction, the categories follow a natural flow. Participants began by discussing their intentions and motivations to using AV systems, to relevant factors upon acceptance and usage and conclude with their fears and probability of relinquishing full control to the AV system, thus adopting a new role.

It is imperative to note that the categories have been sorted in this manner to improve understanding, readability and attempt to observe the primary path of discussion within interviews. Adoption of AV systems is not a linear process, with participants likely to revisit various concepts at regular intervals. For this reason, the categories are not presented in a chronological order and this iterative nature of AV adoption is evident with various concepts being presented in more than one instance across different categories.

The proceeding section will present a comprehensive analysis of the findings, exploring the associated implications, relevance to the community and understanding in light of existing literature.

5.2 Stakeholder Specific Findings

Whereas the above stage of the findings presented a collective view of stakeholders on the topic of acceptance with contributions from the majority of participants, this stage will differ. Here the aim is to present findings related to each participant or stakeholder group (car driver, motorcyclist, pedestrian etc.).

This range of findings will attempt to overlook presenting related to acceptance, as this will imitate what is discussed above. Rather, this stage will look to the variety of results related to external factors, the environment of AV systems, social issues and participant attitudes. The reason behind the division of findings into two separate sections is to allow maximum data extraction to occur. The analysis has been approached with two different objectives. The method of coding and knowledge extraction (grounded theory) has been identical for both sections with findings only being separated at this stage.

5.2.1 Car Drivers

The first stakeholder group within the study is car drivers. This stakeholder group is built up of participants GT 2, 4, 5 and 10. Although the majority of findings extracted from the car driver stakeholder community have been used in the previous section, additional findings are discussed here in relation to a number of social, environmental and personal issues surrounding potential users and autonomous vehicles.

Problem Space Awareness

Each participant who identified themselves as a car driver for this study truly understood and highlighted the need of the current situation on the road. Participants spoke about the regular danger when driving, the potential accidents they are exposed to, the concentration and skill required and the mistrust in fellow road users. Upon discussing the relevant dangers, participants found motivation in the need to change and the potential application benefits of AV systems.

Quality of Life

To contribute to the positive attitude around change, participants highlighted the effect of an improved driving experience and the impression it would have on their quality of life. With the associated benefits of AV systems contributing to an efficient, safer and stress reducing driving experience, the knock on effect on users would be vast. Users would spend less time in traffic, resulting in more time spent conducting personal affairs. The improved driving experience would also reflect on the mood of the user, with a reduction in the number of negative issues affecting them on their regular travels. Over a lifetime, it would be expected that AV system application would see a fall in road traffic collisions and loss of life, ensuring an improved quality of life for users and an overall improvement on the road traffic network.

In addition to the above, in an environment where the vehicle itself would carry the burden of most of the journey, users would be able to access locations further than they could hold concentration by driving themselves, improving their commercial and social capabilities.

Discussed briefly in the previous section of findings, but alternatively here are the assumptions that each participant held regarding the ability of the system. Aside from personal assumptions, the overlap between beliefs regarding the ability of the system is vast. As discussed in the literature, the perceived over/under trust that pilots held of aircrafts created inefficient usage and in some cases, life threating situations. If a user under trusts the system, then the true potential of the system is not being extracted, meaning users are not accessing the variety of benefits that is offered by the system. Conversely, if users perceive the system to do more than it currently does, or is programmed to do, this could result in collisions or related events as the concentration and vigilance level of the user is not at the required standard. This is evidenced in aircraft aviation, with events such as the Air France 447 crash being a manifestation of improper vigilance from the crew, over trust and lack of understanding from the pilots to react accordingly (BEA, 2011).

To some extent, this scenario is prevalent in discussions with car drivers in this study. A number of comments such as being able to sleep, read a book, watch a film, write essays all contributing to the perceived over trust held by participants. Believing the system can currently act of its own accord with users safely distracted in other tasks represents a serious misunderstanding of the system and the potential to cause accidents. Furthermore, a number of users discuss how they would not use it in the majority of urban zones and would treat the driving task as they would a legacy vehicle (a vehicle with no autonomous aids), representing a wastage of the system ability.

System Appearance/Vehicle Representation

On the social issue of the aesthetics of the vehicle, a number of issues were reported. A number of participants spoke of instances of AV systems they had seen in the media or on film. They described these vehicles as being generally smaller, not as visually appealing, not following automotive trends in terms of design and being too distinctive. When considering that a number of contributors considered their vehicle to be a symbol of wealth and status, widespread disuse could rise from the system appearance not being appealing enough. However, current iterations are early examples, and through development, vehicles may be normalised and designed to replicate existing/future vehicle manufacturer models. Furthermore, on the issue of symbolism, the associated cost implication is discussed and whether AV technology will only be available to the wealthy or whether people.

System Maintenance/ Past Experience

Participants likened an AV system to a software program and when considered alongside their existing experience of computer programs, participant attitudes were adversely affected. Examples such as crashing (e.g., ‘blue screening’) or large software updates are envisaged as associated problems of AV adoption. In most cases participants had at least one negative previous experience with IT related systems, so in every case participants were dubious and extremely cautious about surrendering control to an AV system.

5.2.2 Pedestrians

The stakeholder focus group of participants was the last entrant to the study. Represented by GT 11, the key focus of results from pedestrians was around the ethics of the AV system, misuse of the technology and issues concerning their close proximity to the system.

Ethical Consideration

The primary influence and concern held by participants was the ethical consideration held by AV systems. Many gave examples of two inevitable outcomes where an accident was inevitable but the choice remained on who the vehicle would collide with. In this situation, participants pondered who would decide on the outcome in the various levels of automation, vehicle or operator. The key concern here was around the decision-making system. Pedestrians mentioned how they could see a human driver, and could perceive their actions from facial expression, speech or actions. In an enhanced environment, pedestrians spoke of their inability to access this information and their failure to distinguish the decision-making process of the system.

Pedestrian Misuse

Pedestrians expressed concern around pedestrians misusing the system by way of testing its ability. In the event of an individual with malice intent running into a road expecting an autonomous vehicle to stop, participants forecasted the regularity and consequences of such events. The autonomous vehicle was described as a controlled entity, operating in an uncontrollable environment, amidst people with negative intentions. These individuals could be children being mischievous, adults attempting to re-enact 'crash for cash' schemes (purposefully inciting accidents for monetary gain) or people distracted by conversation, smart devices etc. The inability to control every variable in a pedestrian heavy environment would mean the ramifications of such events would restrict AV system exposure in such urban zones and probable disuse if such incidents became a regularity.

Trust- Proximity

The biggest trust issue for pedestrians was regarding the close proximity within which pedestrians would be interacting with autonomous vehicles. Considering themselves as the most vulnerable of stakeholders, pedestrians highlighted the lack of trust they felt when a vehicle was in touching distance. As this is usually the case for many pedestrians, the lack of defence or a shielding element for each pedestrian contributes to the lack of trust. This contributes to the urban zone disuse discussed in the previous finding. The ramifications of the lack of trust discussed in this concept is elaborated above in the concept of 'ethical consideration'.

Fear

In combination with the lack of perceived trust held by pedestrians, the concept of fear was discussed. Pedestrians described the two factors as being synonymous and by not trusting AV systems, fear developed as an influencer to disuse. Disuse in this scenario represents the refusal to adopt the usual process of being in the vicinity of a vehicle on paths, junctions, pavements etc. Trust leads to pedestrians being increasingly cautious around AV systems, but fear leads to participants deviating from their usual travel pattern and becoming somewhat reclusive, in order to avoid AV system interaction.

5.2.3 Motorcyclist/Cyclist

The stakeholder group of motorcyclists and cyclists was built up of GT 2,7,8 and 9. Contributions to the body of findings consist of issues surrounding stakeholder communication, driver and cyclist interaction, associated fears and motorcyclist worldview.

The Cosmopolitan Road

Split into two sections, the first half of this concept is related to the large number of stakeholders that currently use the road to achieve a variety of tasks. By speaking to a wide variety of users, it is now clear that an understanding between road users does not exist. Each discussed their interest based on their own ability, rather than understanding the need or objectives of their fellow road user. An example of this is the distrust and negativity that exists between car drivers and motorcyclists, with the car drivers in the study speaking of the dangerous manner in which motorcyclists ride and motorcyclists defining it as 'filtering' through traffic, a legal act. This misunderstanding transcends between all stakeholders and it requires attention before AV systems can be introduced. The second element of this concept is around potential prioritisation of types of road users. Participants of this stakeholder group expressed concern around the AV system only being designed or introduced with car drivers in mind, overlooking the interaction and negotiations that two wheeled riders would have to carry out with the system.

Unwritten Rules of the Road

Although not legislated, road users have defined a method of communicating with each other. This language employs a method of thanking each other and for giving right of way. In an environment employing AV systems, the need for such language will certainly reduce, ultimately being dismissed, due to its disuse. Cyclists feared this as they felt that this method of communicating is integral to their safe riding. Every participant spoke of their reliance on this method of communication, utilising it at least twice a day on their travels. In an AV environment, cyclists expected a system of sorts to take the place of this language, to ensure that at the least, a method of interaction still remains.

Worldview

The second concept relates to the worldview of two wheeled riders from their experience on the roads and their perceptions of a road transport system based primarily on AV technology. Participants spoke of how they felt the roads were already overcrowded leading to congestion and accidents. They forecasted that with people living for longer, as well as the younger population being able to access driving, the roads are evidently becoming increasingly congested. The accessibility options of AV systems the roads would see a further influx of vehicles, perhaps contributing to further congestion. Participants acknowledged the heightened efficiency of AV systems but still pointed to the increased number of vehicles that would be on the road network. In addition to the congestion issues, participants pointed out that, they perceived drivers as the defining cause of problems, because of their lack of concentration, bad driving and lack of awareness. Although this was not attributed to every driver, participants acknowledged that it was a problem they regularly saw on the roads and noted how AV systems would certainly remove a number of issues. This would increase driver safety, as well as having a direct effect on cyclist safety.

Furthermore, participants spoke of the bias that drivers had on the road, assuming themselves as the sovereign party on the road. By doing this, drivers lack respect of other road users, namely two wheeled riders. By adopting AV systems, cyclists pointed to the need for the system to be biased only towards efficiency and safety, thus rendering the platform of road transport as equal and accessible for every user, regardless of their mode of transport.

The last contribution to this concept is the Vision Zero theory of zero deaths on the road by a certain time, implemented by Swedish Parliament in 1997. Participants feared that if a theory such as this was to be applied in the UK, two wheeled riders would be then considered the 'rogue traders' of the road as they would then be the only party lacking any autonomic travel aids. In a scenario such as this, it could be perceived that belonging to this stakeholder group would be socially unacceptable, possibly leading to its outlaw. This mind-set follows the thinking that if AV systems prove their utility and their continued adoption breeds success, any road users not using AV aids would suffer as a consequence. Those on two wheels would be considered outdated and a potential threat to the now enhanced environment, potentially leading to their assessment and the aforementioned removal taking place.

Cyclist Fear

In continuation of the disconnect felt by cyclists, the issue of their fear was discussed. The overall emotion felt by participants whilst on two wheels was fear, but upon distillation, two contributing issues were disclosed. Participants spoke of an embedded mistrust that was instilled in them from peers or their personal experience on the road. Personal and previous experiences were influenced by what riders saw on the road, if they had suffered from an accident or media influence. The experiences discussed were generally negative, with advice from peers being similar. As well as negative in attitudes, participants spoke of how they were taught to ride defensively at all times, stifling their riding confidence, ability and mind-set when on the road. This was judged to have an adverse effect on the mental health of riders, with the negativity clouding judgement and affecting the appeal of cycling. In the long term, this would hinder the continued usage of two-wheeled transport.

Welcoming Factors

A number of welcoming factors have been discussed by participants that improve attitudes towards AV systems. By introducing AV systems to vehicular road transport, cyclists noted a number of factors that would benefit those on two wheels as a direct result of this change. The most obvious of which is the increased safety for cyclists in general. Most of those surveyed identified cars as being the biggest threat to their road safety. With the introduction of AV systems, participants noted that their safety and ability to safely navigate and complete a journey would massively improve. As a result of this, the appeal for people to ride bikes or motorbikes would increase. The benefits of this would be a reduction in congestion, due to a lesser number of vehicles on the road, a lower carbon footprint, a better mental state and the associated health benefits.

Another factor identified by participants as being dangerous to their safety whilst riding was the unpredictability that surrounds current driver mentality. Participants discussed how driving should be standardised in the manner of a ‘scalectrix’ track with all road users aware of each other’s action to a certain extent. It was unanimously agreed that the predictability brought forward by adopting AV systems would remove the current uncertainty, allowing cyclists to drive confidently and to their full potential.

Willingness to Learn

On account of the identified benefits of AV systems, participants collectively agreed that they were willing to do whatever was required to assist the introduction of AV systems. As the direct benefit to them outweighed the negatives, negatives that they believed could be solved with design and social developments. Participants did mention that car drivers were unlikely to have the same level of enthusiasm, especially as they would face the biggest change process of all.

5.2.4 HGV (Heavy Goods Vehicles) Users

The penultimate stakeholder group within the study was represented by HGV users. Represented by GT 4 & 5. A number of the findings from this stakeholder group have been inserted into the previous section of findings but those reported here focus on HGV driver attitudes, the quality of life, evolution within the cabin and the issue of trust.

Evolution of Cabin Awareness

The first finding from this stakeholder group is around the awareness of technological aids for the driving task. Participants remarked how HGV cabins have evolved from previous decades to this one with current cabins treated to a number of technological advancements. This understanding and being able to see the advancements has made participants less sensitive to cabin changes and more inclined to accept AV systems, especially as they have already seen first-hand how technology eases the driving task. In some cases, participants likened themselves to being steering wheel attendants, a state usually reserved for higher levels of automation. From all the stakeholder groups consulted, the group of HGV users served as the most knowledgeable, most enthusiastic and most receptive of this particular change. The positive attitude, when explored, was found to correspond with the amount of time they spend on the road being higher than fellow groups and the collisions and bad examples of driving they regularly see. When questioned around attitudes overall, it was found that most HGV drivers tend to complain and lament about changes, before hastening to adapt to change and become resilient on their effort. It was concluded that their receptiveness to change and AV systems is based on the fact that most are employed to drive HGV’s and their attitude is based on their need to earn a living. This monetary need, as well as their experience on the road are two defining factors behind their motivation and positive attitude towards AV systems.

Quality of Life

The previous concept introduced the notion that most HGV drivers spend an overwhelming amount of time on the road. In some cases, a number of the participants were long haul truckers, meaning the majority of their working week, or sometimes longer was spent on the motorway or in its vicinity. When questioning participants about their current quality of life with a view to introducing AV systems as a dependable alternative, the following factors were highlighted. Many participants highlighted congestion and how it lengthened and delayed journeys and impacted on time-sensitive deliveries. It was discussed that delays led to HGV drivers losing focus and concentration in their effort to make up time. This waywardness was a contributing factor for incidents and mental stress, an unwanted factor, given the large-scale vehicle drivers were charged with and the potential it had for destruction. The identified root problem was congestion, a present factor for any road travel in the UK. Given the ability to reduce or eradicate this would have positive knock on effects for HGV drivers, ultimately reducing a key contributor for congestion, which is that of road traffic collisions involving heavy good vehicles.

Trust-Proximity

Like cyclists, HGV drivers also identify car drivers as the biggest hazard on the road, on account of their unpredictability. HGV drivers also seek a method of standardisation in driving to bring about predictability. This observation is made from the excessive time spent by HGV drivers on the road, rendering them as specialist observers of proceedings. From their elevated platform, HGV drivers point to bad decision-making, being distracted by technology and not abiding by road traffic laws and legislation as the key causes of driver distraction and driving issues.

Occupying Drivers/Operators

When questioning HGV drivers on the future of truck autonomy, the issue of fully autonomous trucks were discussed. In this scenario, participants were asked what they would do when the vehicle was in the highest level of automation. Some participants spoke of reading a book, some of going to sleep, others of varying recreational activities. In each case, every participant discussed a hobby or something personal, which was not work related. Although in a future state, this could be regarded as a possibility, the likeliness of employers allowing this was deemed as low. Although the role of the HGV driver will change as system adoption progresses, in a commercial environment, the employer would be looking to gain maximum work extraction from each of their drivers. This could mean a replaced workload for drivers, with their free time from driving being taken up by alternative tasks set by their respective employers. Although the legislation governing the driver/operator is not yet established, distracting drivers with additional workload could prove consequential, especially as drivers currently feel they are overworked. Any additional workload created by AV systems could lead to a refusal to adopt and long term disuse/resentment.

In continuation of the ‘overworked feeling’ felt by HGV drivers, participants discussed how their role expanded to more than just being a driver. They felt the responsibility they were charged with over their payload, schedules, managed breaks, cabin and trailer management and office communication rendered them as complete operators, with the addition of the driving task. Participants noted that any incoming system must be able to influence each part of the task and experience of a HGV driver, as only affecting the driving task would be insufficient. Rather, the AV system designed for HGV should attempt to have an impact on the complete journey, truly relieving the driver of a number of distracting duties.

5.2.5 ‘Other’ Stakeholders

The concluding stakeholder group of the study was represented by stakeholders belonging to the road network support sector. Within this group, stakeholders represented organisations that supported the infrastructure, safety and driver support element of the road transport network. The analysis and coding relate to this stakeholder group can be found at GT 1, 3 and 6.

Legacy System

The first finding from this stakeholder group is around the need to update the current legacy system embedded on the road network. Prior to the introduction of AV systems, participants highlighted the current problems associated with road transport and acknowledged that much of the congestion, incidents and mental strain was down to an outdated system attempting to operate in the modern era. AV systems were introduced and heralded as the required change effort to reduce problems across the spectrum of road transport and inject the required update of technology.

Further problems associated with the current legacy system fall into problems involving congestion, incidents leading to health problems and loss of life, rising insurance cost due to accidents, confusion surrounding accident liability, disconnect between stakeholders and system efficiency. This corresponds with the current problems identified by fellow stakeholder groups with each identifying problems with the current system that sets the foundation for change but also acts as the benchmark by which the new system will be judged.

In extension to the above, this stakeholder group concluded that the new system would bring in itself a number of teething and accompanying problems, similar to how the current legacy system has. Participants noted that by minimising current problems, the community could then go on to focus on the new problems attributed to the system as focusing on both current and new issues would overwhelm the phenomenon, possibly leading to its withdrawal or delay due to revision.

Infrastructure Management

In terms of findings related to the infrastructure in light of AV system implementation, participants expected street furniture to lessen. It was discussed that currently towns and cities are set up in a way that prioritises vehicles. Signs, roads, traffic light systems and road markings are present in much of the urban areas of the UK. They are seen as essential to safe driving and without them, chaos would soon ensue. The infrastructure is spaced accordingly to ensure a safe proximity is always maintained between vehicle to vehicle and vehicle to pedestrian. In an environment of AV systems, participant expected that the system would allow for much of the street furniture to slowly be removed, levying control and decoration of such urban zones back to the controlling party. In doing this, participant expectation is that such zones would become more attractive. In addition, participants expressed the requirement of vehicle being able to travel closer together, reducing the proximity barrier established, creating more space and further contributing to the attempts to transform towns and cities.

Information Overload/ Driver Distraction

On the topic of AV systems, participants voiced their fear around such technology distracting drivers from their primary task. Participants representing a road safety charity spoke of mobile phones, in car entertainment and iPods as being key contributors to accidents and questioned how a vehicle built up of state of the art technology would cope. They felt that with the addition of AV systems, vehicle interiors would be modified accordingly with an influx of screens and interaction options. The design of the system was questioned and the need to find a working balance between visible interaction technology and ensuring the user was aware of every process and action of the vehicle.

Risk Calculation

As discussed by pedestrians in the concept of 'Ethical Consideration', this stakeholder group was interested in understanding how risk would be calculated and then reacted to by AV systems. Participants acknowledged that in some extreme cases, drivers had to make rational judgment calls based on a number of inevitable, unenviable outcomes. In the case of driver demotion to operator, and in the instance of the system making the judgement call, participants were keen to develop an understanding of whether the system risk calculation in such situations mirrored that of a human or if it followed an alternative route. As well as assessing risk in such situations, participants discussed how risk calculation was a regular task conducted by drivers in everyday settings. Each journey undertaken required risk assessment of some sort, owing to the wider need to understand how the system would then assess such risk.

System Abuse

The collective stakeholder group discussed fear around system abuse and the ramifications of such actions. As the vehicle was able to function of its own accord without any human interaction, participants expressed concern that the system could be used for illegitimate activity, such as terrorism, theft, murder etc. As the vehicles weighed in excess of a tonne and could travel at high speed, they had the ability to be misused. The fact that each vehicle could remain unmanned contributes to the appeal of its misuse as the perpetrators could remain anonymous.

In terms of privacy issues, participants discussed that any data or information collected about user travelling must be anonymised and kept confidential. Although the data could be used to improve travel optimisation through forecasting, the abuse of it was identified in a number of ways. If the data was given to a third party, users could be exploited through targeted advertising. Furthermore, if unlawful access to user travel data was gained, it could be used to track users, especially those of a high profile nature e.g., government figures, army hierarchy, celebrities etc. Amongst the negative uses of data in this context, the above two represent two of the associated issues of data misuse and the need to provide prevention.

Participants understood that data collection through usage of AV systems was mandatory and had to occur, given its associated value. However, the stakeholder group spoke of the need to properly legislate and govern usage and management of data to ensure it is not compromised. The ramifications of abuse in this context could have a detrimental effect on continued system usage as well as the legal issues surrounding misuse in this context.

Unknown Future Behaviour

Society currently employs a well-defined list of acceptable and unacceptable behaviour in social, work and personal settings. Participants expressed fears that a shift to AV systems would represent a scenario where users would not be aware of acceptable behaviour in this setting. The proper behaviour would only become defined after multiple iterations of the system and trial and error scenarios. This deferral would cause issues stemming from neglect and misuse in the transitional period. To further explain this finding, the example of social media was given. As a young environment where there is a lack of ability to apply the decision-making and logic to a fellow environment, many do not know the appropriate way to behave in this medium. This results in their behaviour following offensive, racist or stereotypical lines for example. Until the environment of social media is thoroughly understood, a number of consequential issues will surround its usage and longevity. The case of AV systems in road transport is similar. As a new system, legislation and the relevant social issues require addressing as it matures. Failure to do this will result in a system that is misused, gains a negative reputation and does not grow into the environment.

Trust

The concluding concept discussed mirrors the findings from each fellow stakeholder group on the topic of trust. The difference from this stakeholder group is that they discuss trust in the present and future sense. Participants state that currently road users do not trust each other in any capacity. The trust between stakeholders is estimated to be below 10%, a surprisingly low figure, given the close proximity that all operate in. Although the figure is merely an estimation of the stakeholder group's own judgement, it represents an inharmonious environment that would not fully benefit from the adoption of AV systems.

Participants questioned whether AV system adoption would solve the trust issue or whether it would make users more cautious and less trusting of each other, and now of each other's vehicle. Participants followed the thought process that if trust did not exist currently, it would not exist in the future. Collectively, participants felt that the community must learn from current mistakes, understand present problems and solve these before making the change. Doing this would ensure that AV system adoption is done with no trepidations and participants are allowed to make the transition and initial implementation with relative ease.

5.3 Chapter Conclusion

Presented within this Chapter is an account of the findings developed from the grounded theory survey carried out with participants on the topic of autonomous road transport systems (driverless cars). The findings present a culmination of the pilot study and main study conducted with participants. The study set out to capture perception of the phenomenon from a concentrated stakeholder viewpoint and to assess how successful acceptance of such systems could take place. In attempting this, the results were developed and presented above in the following two ways:

- The first section of results focussed on presenting defining categories and resulting concepts based on the proposed adoption of AV systems. Within this set of findings, three categories (intentions to use, technology usage, and relinquishing control) were developed using grounded theory techniques and were used to collate relevant findings. The section discusses a number of factors, ensuing requirements, concerns and variables that, if satisfied, are conclusive to comfortably adopting AV systems from their inception, moving to their highest phase (Level 5- Full automation). Although input to this section was gained from each participant, those identified as car and HGV drivers contributed the bulk of findings at this stage.
- The second stage of findings discussed findings related to perceptions of AV systems as discussed by participants. At this stage of findings, participants were grouped into the stakeholder category they belonged to (car drivers, HGV drivers, motorcyclists/cyclists, other stakeholders). This stage of findings focussed on findings related to social issues, environmental factors, external pressures and legislation. This stage of findings supplemented the first stage as it provided context and an environment within which the findings of acceptance were embedded.

The next Chapter will discuss and analyse findings obtained from the grounded theory. The Chapter will consider the findings in light of existing literature and current knowledge on acceptance of AV systems. A comprehensive discussion of the study limitations, in light of the transferability and application of the findings, will also be presented.

Chapter 6- Discussion of Findings alongside Existing Knowledge

This chapter consists of an in depth discussion of the results outlined in the previous chapter. The key aim of the chapter is to discuss what the body of results offer in terms of exploring their construct alongside existing literature and developing recommendations for the AV community as result. The purpose here is to report on what the community and body of literature can learn from this research and how it can apply this learning to AV system implementation on UK roads, with a specific focus on public acceptance and usage. The results can be separated into two main areas. The first is the three categories and resulting concepts based on AV system adoption, as presented in Section 5.1. The second is the results relevant to each major road user type, as considered within the sample of the study, and as presented in Section 5.2.

6.1 Discussion of Results

Within Chapter 5, the results were presented in a descriptive level, as spoken by participants in the study and coded as per the grounded theory. The narrative will explore key findings of the study, and by way of analysis, deepen understanding around each one. This will allow for maximum extraction from the results through comparison with existing literature, contextualisation, assessing the impact of each and discussing the confirmatory or new knowledge each provides. It is expected that a culmination of the above would lead to a deeper understanding of AV system implementation within the UK road network.

In terms of the existing literature, the current understanding around AV acceptance can be found in Section 2.1, with technology acceptance discussed in Section 2.2, and stakeholder perceptions/attitudes in Section 5.2. This collection of current understanding will be drawn upon to identify confirmatory and new knowledge.

Three core categories were selected to represent the key challenges to AV system adoption. Each was selected as being able to sufficiently carry the concepts assigned to it. A discussion of the key findings of each category can be found below, with the addition of the chapter discussion.

6.1.1 Intention to Use

The first category of the findings represented knowledge related to the technology, motivation to use and technology involvement. This category is based on intentions and the persuasion of intention was set by participants as being equally important as the remaining two categories. This was because at this stage, participants were not inclined towards usage. The concepts discussed here would therefore be key in potentially convincing users to adopt the technology.

The concept of having the correct knowledge and understanding was highlighted as being integral to AV system adoption. It was discussed as being the overall concept that provided the required encouragement. Without sufficient knowledge and the required understanding of the system, the weakness of mentally interacting with the system or considering adoption was strongly highlighted. Within the literature, the Boston Consulting Group (2015) found that 27% of those surveyed stated they ‘did not know enough about the system’ in relation to AV system understanding. This represented almost a third of all participants (1845) and resulted in it being set as a key concern regarding the introduction of autonomous vehicles. The concern was related to the importance assigned to the knowledge by participants of this study and the negligence currently afforded to it.

The inability to understand the system can have lasting consequences in terms of long-term disuse and resentment of the system SMART motorways, for example, were introduced to UK roads in 2014 with the aim of using technology to manage traffic flow through variable speed limits and utilising the hard shoulder as a normal motorway lane. Pitt (2015) reports on behalf of an IAM (2015) study that drivers felt confusion and nervousness around the SMART motorways, with some not even aware of what they were. On an observational level, aside from minimal radio advertising and a number of TV adverts, the latest technological evolution to the road network was not publicised or displayed to the required level. The ramifications of this lack of knowledge and understanding around the system is 40% of participants in the IAM (2015) study lacking trust in the ability of the system to assist them if they had to stop on the hard shoulder. Additionally, Jolley (2017) reports that over four years, drivers have accumulated £526 million of speeding fines, because of the variable speed limits. Although the argument that raw speeding would have caused a portion of the fines, a healthy percentage of the fines and offending drivers would point to a lack of understanding and knowledge of the process by which SMART motorways, operate as the key reasoning behind their fine. For example, a lack of understanding of SMART motorways would lead to a disregard of the variable speed limit, leading to the ramifications discussed above. As well as this, drivers do not trust the SMART system, do not have faith in its ability and some perceive the system as being dangerous and incompatible to current driving standards (Jolley, 2017).

In an environment where drivers have adapted to AV systems, the consequences of not understanding or not having sufficient knowledge in a system would yield far worse consequences than receiving monetary fines. In that environment, this scenario would result in road traffic collisions and road user deaths.

The example of SMART motorways is a particularly apt example, as it represented a scenario of road transport network enhancement through technology exploitation. It also represents a system that requires user adoption and usage to ensure its operation. This is an almost identical situation to the introduction of AV systems, albeit with a different subject, but with almost identical aims. Whilst the introduction of AV systems would be more gradual and incremental than that of SMART motorways, the literature and the concepts developed from this study, point to a clear need for up-to-date, correct knowledge and understanding of the system by users. The importance of knowledge sharing and ensuring user understanding is informed prior to system delivery through to implementation is recognised. This will maintain a connection with the system, keep users in the loop, ensure they are aware of the system capabilities, contributing to the ability of beginning and preserving correct usage.

Schoettle and Sivak (2014) found that driver expectation of AV systems is high. Although participants were not questioned as to what had influenced their opinion, current perception is that it is not from the AV community or a reliable source, given that it does not align with current understanding of AV systems. Much of the knowledge and information about AV systems is currently being displayed on various media outlets, examples of which are Winkless (2017) and Finnerty (2017). Although there is discussion around the system, the flow of information must be factually correct and potential users must be aware of what specifically can be offered to them, helping to ensure that the reality of the system closely matches the expectations of the user. Society is currently plagued with the concept of ‘fake news’, which entails individuals being told news that is factually incorrect (Hunt, 2016). Within the confines and social media and smart devices, news items are spread relatively swiftly, with the source or content of a number of items not being checked for validity. In reference to AV systems and the discussion above, it seems news stories are already in circulation around the ability of AV systems, assigning qualities to it that are not true. This is influencing users to expect something that the system cannot offer, leading to user discontentment and possible disuse. The term ‘first impressions are key’ resonates in this scenario, with initial impressions of disappointment being situations to avoid.

Recent events involving incidents with Tesla vehicles and its autopilot mode highlight the potential importance of having access to this information. Golson (2017) reports how a Tesla driver had a road traffic collision whilst their vehicle was in autopilot mode. It transpired that that the driver had seven seconds to resume control of the vehicle when advised to by the Tesla but did not. Upon investigation, it was found that the driver was distracted from the driving task by a film they were watching, and therefore did not resume control when required to by the vehicle. Although, the small number of accidents by Tesla vehicles in autopilot mode is small in comparison to the millions of miles travelled, this episode represents an example of a user not being aware of the full capabilities of the system and or fully engaged with their own responsibility. Unlike traditional vehicles, where drivers are always driving, vehicles with autonomous properties require drivers to understand both traditional driving and the functionality associated with the autonomous system. Drivers are required to be fully aware of the capabilities of the system and their expectations should then align with these.

When questioning core values of each participant around innovation adoption and risk calculation, drivers adopt differing mind-sets and beliefs. Rogers’ (1964) model of diffusion of innovation can be applied to explain this range of beliefs. Rogers’ (1964) model has five categories: Innovators, Early Adopters, Early Majority, Late Majority and Laggards. In terms of sorting participants, it was clear to see from responses and interview narrative that some participants would quickly adopt innovations, some would want to see evidence, others would adopt slowly and some would wait until others had adopted the technology.

Given this spread of acceptance rates, implementation strategies would need to take uptake patterns into account. Acceptance of AV systems, displays traits that are similar to other events of technology acceptance, i.e. some uptake early, with others later. This cites the need for personalisation and the understanding of acceptance perception of a wide range of users. Although mass implementation would be most sensible, given the size of the market, manufacturers have the possibility to personalise adoption for different types of users. Manufacturers could offer drivers different versions of AV systems or different settings so that the various levels of automation could be introduced incrementally in response to user attitudes to adoption. A staggered introduction of different versions of AV systems would therefore suit the different types of drivers on the road. Drivers can currently purchase vehicles geared towards safety, high-speed performance, families etc. Given this choice, AV system capabilities and interfaces could be tailored towards the vehicle purpose and or the type of user purchasing them. For example, for the late majority or laggards, the interface can be more informative, more transparent and more involving to develop their confidence and understanding of the system. In a real world scenario, the late majority and laggards could be translated as families, who would be most risk averse to use AV systems. This ability to personalise the system to the user can be extended to users with learning disabilities. Although a baseline must be established to standardise certain processes to improve learnability, ensuring a user-centred design would increase acceptance and ensure continued usage. Furthermore, as mentioned in the findings, this is one tangible method of improving understanding of the system, especially as users have the ability to be able to relate to certain elements of it.

The concept of perceptions occupies the most confirmatory knowledge of this first category of Intentions to Use. In Section 2.2, a variety of technology acceptance models were presented. The models identify perceived ease of use (how easy the system is to use) and perceived usefulness (the extent to which the user will be able to use the system to achieve what they intend to) as two key elements of system acceptance. In this study, the ability to personalise the system to be able to improve system ease of use and usefulness were mentioned as being the method to satisfy the above confirmatory knowledge.

As adopting AV systems represents a significant change effort, Kotter's (1996) change model was considered in relation to the findings. This model emphasises the need for appropriate leadership and the correct procedures to lead the change effort. The steps of the model provided by Kotter (2016) are:

1) Establish a sense of urgency;
2) Creating the guiding coalition;
3) Developing the vision and strategy;
4) Communicating the change vision;
5) Empowering people to effect change;
6) Generating short term wins;
7) Consolidating gains, producing more change; and
8) Sustaining new approaches in the culture.

The first four points highlight the importance of establishing communication with the user, developing a guiding vision and coalition and establishing a sense of urgency. Kotter discusses the need to establish a guiding collation to lead users through a successful change effort. Drivers who identify themselves as the early innovators and the early majority can unofficially become change leaders through their early adoption and public display of usage. From the resulting publicity and public observance of their adoption, those who are late to adopt and fall into the final three categories of Rogers model can be encouraged and persuaded to change by the earlier adopters. As the majority of late adopters are cited to require evidence of successful application, the guiding collation are primed to sufficiently provide such evidence to instil change and adoption.

Lewin introduced the Force Field Analysis in 1951 with three key phases; Unfreeze, Change, Refreeze. (Lewin, 1951). The first phase (Unfreeze) is concerned with developing an understanding of the difficulties related to the problem. At this stage, the change leaders identify elements that will be affected by the change and try to develop solutions for them, ensuring no barriers of resistance remain. This is evident within the perceptions and concerns users face regarding acceptance. With an understanding of these perceptions recommendations for UK road implementation can be proposed. In thinking of the stage of unfreezing, the underlying factor is the ability to communicate with stakeholders about the change, about issues affecting them and about how the system implementation would benefit them.

In summary, a number of elements exist to bring about acceptance of AV systems. Public engagement was identified as having the ability to settle user concerns, meet user expectations and improve communication. In addition to AV acceptance literature, references were made to technology acceptance and change literature and how AV acceptance could be understood through these concepts.

6.1.2 Technology Adoption

The second category selected to represent findings on AV system adoption was Technology Adoption. Selected for its representation of findings relevant to actual adoption, this category deals with user concern upon system adoption, whereas the previous category represented findings that mentally prepared users, this one discusses a practical approach to adoption.

The first concept discussed in the category is influencing factors to use. Here participants discussed a number of expected tasks required as part of influencing them to use the technology. The factors involved training and public displays and trials (as methods to allow participants to see the system working) resulting in their confidence and usage being established. Although these factors were expected to be involved and are possibly already in progress in some cities, the discussion will look to the ramifications of overlooking them. The key warrant to this discussion was gauged from the comparison with literature from aviation automation, where in some cases the above were not established properly, demonstrated some inconclusive acceptance. The consequences of not implementing the influencing factors in the correct manner will also be discussed.

The road transport sector is being introduced to AV systems to help reduce congestion, driving accidents and general all round failure to the environment. This is almost synonymous with the reasoning behind automation being introduced to the aviation sector, with its introduction inciting multiple benefits in the area of safety and efficiency (Tarnowski, 2002).

As a result of this, observations, learnings and conclusions from aviation can be used to predict and influence the discussion of this thesis and the community around AV system implementation. In considering the above thesis finding of influencing factors, the following can be used to highlight how obvious processes of system introduction can sometimes be overlooked and the associated problems of doing so.

Wiener and Curry (1980) praised the benefit that automation brought to the field of aviation and how it reduced accidents overall. They went on to state that a new trend of accidents occurred, one where pilots did not understand the system they were interacting with. Furthermore, Abbott *et al.* (1996) found that pilots' lacked the current understanding of the function, limitations, levels and operation that the automation ethnology had. The study also found that the crew often misunderstood which level of automation the system should be operating in and did not have definitive knowledge on its application in certain situations.

Although Grabber (1999) and Boeing (1999) state that users of their products were always involved in defining high level requirements and human factors principles, evidence of this is not clear when considering initial failures of aviation automation. The behaviour of pilots would point to the fact that it was not actually a user centred design or approach to the matter. Although evidence of the human factors approach discussed by the above references is clear, the effectiveness of the approach can be questioned.

Wiener and Curry (1980) quote and the example of Air France 447 (2009) demonstrates how pilots became somewhat detached at the initial phase of system introduction. Technological advancements can be designed to carry out their task seamlessly if operating in isolation. In an open environment, the performance of the user is in equal proportion to the performance of the system and any shortcomings in their training or engagement would lead to a new set of incident issues, as highlighted by Weiner and Curry (1980). Although this reference is dated, it was created at a time when the aviation sector was being influenced by automation changes, much like the road transport sector is in the current day. Their quote displays that the technology can be developed to perform a task, in the case of aviation, it was designed and implemented as a complete overhaul of then current flying techniques. However, pilots lacked the proper understanding and training, therefore heralding aviation automation as the lead cause of new incidents, negating its progressive work on accident reduction.

The concept of influencing factors then, is not focussed on the nature of the concept itself, rather, the importance of its continued promotion and all round efficiency. If the early problems of aviation automation were to plague road transport, the number of incidents would be high, as drivers massively outnumber pilots. Lastly, frequent incidents and increased road deaths as a result of AV systems in the first phase of introduction would create resentment for the system and seriously hazard long term acceptance.

The next concept discussed within this category concerns the relevant legislation governing and supporting the usage of AV systems. Within the extant literature, the empirical study of Bjorner (2015) highlighted the need to update current legislation to explicitly include AV systems. Within the Casley *et al.* (2013) study, the importance of legislation was reiterated by participants. The analysis of this study discussed legislation in a different light. Here, the discussion ponders whether the relevant legislation will be user centred or geared towards protecting the system. Governance can be tolerant of both, but participants wondered whether agenda based legislation favouring the system would be initiated. By this, participants were referring to how legislation could be designed to protect AV systems and manufacturers in times of incidents, lending sole blame to drivers. Participants proposed that drafts of the legislation be made available to drivers with regular consulting and analyzing periods available to ensure the unbiased nature of legislation, with a focus on the right solution. Additionally, participants called for pilot studies of the system to re-enact particular situations and possible events involving AV systems, allowing legislation to grow organically from observation and simulation. This has been the case in Milton Keynes, where driverless pods were tested alongside pedestrians and urban traffic. Davies (2016) mentions how this allowed the community to begin developing the architecture that would be used to govern autonomous vehicles.

Moving onto the cost or price of change, adoption of AV systems was feared to be at a premium cost. Participants feared that it would follow market trends of being very expensive initially and with time, would reduce. Participants argued that because it was such a revolutionary system with such safety inducing properties, it should come at a subsidised cost, for promotion of acceptance. In some interviews, the concept of an AV system was likened to ‘a rich man’s gimmick’ fearing that the price would render it sustainable to only a select few.

As well as the cost to purchase such a system, be that as a complete new vehicle or an addition to an existing vehicle, the ongoing cost of maintenance was also discussed. Where participants believed that currently they could maintain their personal vehicles, questions arose regarding routine maintenance in an AV environment. As the software and radar system would require specialist attention, participants felt that if they were to attempt routine maintenance it could impact on the accountability of the system. For example, if participants were to attempt an oil change and inadvertently broke a sensor, any resulting incident that was not their fault would become their fault if the manufacturer became aware of their interference. As the design of AV systems on traditional vehicles is unknown, much discussion was made on whether it would be designed in complete isolation on a vehicle or whether it would be embedded and entwined with existing vehicle elements, with the later leading to the aforementioned issues. On the back of the above, if it transpired that the vehicle required regular specialist maintenance, the cost of this was questioned by participants. To remedy this, the concerns of the participants of this study would suggest that, in order to allow all users to take advantage of AV systems, a pricing structure that reflects each adopter must be implemented. Currently vehicles can be purchased at the low, middle and high price point to match the budget of users. In a driverless environment, the ‘add-on’ aid must also vary in its price, with the entry level package offering basic driving aids, moving up to the expensive option, offering a more comprehensive solution. For example, further radar range, higher quality of sensors, improved cabin interior etc. With a baseline established, each system should be able to offer mandatory processes, with the more expensive solution offering a number of optional extras. Doing this would match AV aids to the current catalogue of vehicles at different price points, and complete transparency on price and maintenance cost would ensure users were well informed prior to adoption. As well as this, the ability to have budget and luxurious packages would satisfy market and manufacturer demand.

Within the extant literature, the price or associated cost of AV system adoption was the most discussed theme. Although cost was discussed from a different angle, Casley *et al.* (2013); Howard and Dai (2013); Piao *et al*. (2016) and Fagnant and Kockleman (2015) found cost to be a key influencing attributor to whether users would accept AV systems or not. Although a price was not discussed, Piao *et al*. (2016) found that if the cost of driving in an AV environment were less than the cost to travel in a traditional vehicle, acceptance would certainly be encouraged by this. The findings here suggested that, price, rather than safety or features, was a determinant of AV system adoption. The findings of this study correspond with this, as participants of the study perceived AV systems as being a top down, autocratic system that was wholly designed for manufacturer monetary gain, rather than user benefit and sector improvement. Although this perception was not explored, it could be suggested that it is a barrier to adoption set up by disconcerted participants who do not welcome AV systems.

Like any technological advancement, adopters are most definitely aware that an associated cost of adoption exists. In a number of the studies discussed, participants assumed the cost would be high and so refused to accept technology. In some cases, participants may have listed cost as a more socially acceptable barrier to acceptance, rather than discuss their fear or alternative trepidations. The literature would have better serviced the thesis on this issue if actual cost implications were discussed or what participants expected to pay for such services. Within this thesis, the price of change and system maintenance was discussed, offering more insight into participant expectation on this importance acceptance factor.

Within this study, participants wholly accepted an associated cost implication, but discussed how if it was not excessive, the benefits of such a system would far outweigh any increased cost of adoption. The maintenance of the system serves as the more worrying concern for participants who at this point have accepted the system and are aware of the cost to adopt. The maintenance cost of the system and who is authorised to do such work were identified as unknowns, with road users' roles in maintaining their own vehicle identified as an area that would change.

The concluding family of concepts for this category discussed the usage environments of AV systems as decided by participants. As discussed in the results, the overwhelming majority noted the ability of the system to operate in isolation, but saw it fail when applied to the real world. Many felt that the AV system would struggle with the unpredictability of the roads, especially in built up urban zones. Participants felt the system would be most effective and safest when used on the motorway network, with no pedestrians or fellow unpredictable variables to cause interference. This viewpoint was shared across all participants, leading the discussion towards investigating competence trust and making viable recommendations on this issue.

From the literature review, only two studies discussed the issue of competence trust. In both instances, the issue mirrored that which has been discussed by this study. Although they do not specify a usage location, the literature points to the unease felt by participants of system operation in mixed traffic conditions. Although participants accept the technology and are using it on the motorway network, not using it to its full capacity represents a potentially dangerous situation of system under trust. The community must make efforts to ensure users are fully committed to the technology and its offering, rather than partially adopting the system, in subjective situations.

Although representation of participant under trust is preferable to trusting the technology too much, it still represents a growing concern to the community. To remedy this, tangible displays of system capability in varying urban zones are required to begin to convince users of the safety of application in each urban zone available. Seemingly, the best route for progression with users would be to mandate that initial usage of AV systems within motorway zones. In this, users would feel more comfortable as it is the zone they best identify with. Also, this would allow users to overcome any barriers, fears or concerns as they would be operating in the environment with a lack of variables that are currently influencing participant concern e.g. participants, animals etc. Upon doing this, and reaching an agreed milestone of miles travelled, the vehicles would then be allowed to operate under autonomous conditions in mixed traffic conditions, urban zones etc. In reality, it would not make much difference where users began their adoption, as statistics suggest that fatal/serious accidents are the same for both major roads, (motorway road) and for minor roads (built up zones, urban etc.) Accident statistics for the rolling year ending 2016 are 11,780 and 12,590 respectively (Gov UK, 2016) For this reason, usage could begin in either zone as both require some form of intervention, but the findings of the study suggest that users are more inclined to usage on major road zones.

This staggered introduction would follow the incremental method of introducing technology favoured by participants and extant literature, meaning participants would gain valuable experience in a non-intimidating setting, building their experience, understanding and trusting in the system.

The last finding associated with the usage environment of AV systems is pertinent to the reason individuals drive. As the sample was not restricted to one type of individual, rather it was open to individuals who as well as their defining feature for inclusion in the study, used vehicles for a number of different reasons. The reasoning behind why each individual drove differed between participants and it became clear that the reason they drove affected their intention to actually use.

Upon further investigation, it was found that those who drove vehicles primarily for work purposes (e.g., taxi drivers, delivery drivers, truck drivers) were sceptical of AV system replacing their role and would resist technology adoption. Their perception was that they would be replaced in their role by the AV system, leading to their unemployment. Although the success of AV could potentially lead to an environment where no drives are required, for the foreseeable future, AV systems still require a human operator/ driver.

As participants who drove for employment also drove for pleasure, they were wholly accepting of the technology in the social setting, just not in an employment one. Upon advising participants of their key role in an AV environment, some were still sceptical and requested job security in light of the evolution to road transport. It was concluded that legislation would need to be in place to specifically support those who drove for employment, ensuring that salaries and job benefits were not reduced or changed in light of their role evolving. An example of technology changing the market place, in specific reference to road cars is the introduction of Uber. Uber represents a massive technology shift in the way the taxi market operates, through its tap and ride app (Uber, 2017). This disruptive technology is resented by traditional taxi drivers and mass protests have taken place across major cities to its introduction (Benedictus, 2014). The resentment is due to Uber drivers not being subject to the same regulations as normal taxi drivers. Furthermore, the Uber pricing structure differs to that of a traditional taxi driver, attracting more clients, further affecting the income of traditional taxi drivers (Uber, 2014). This is a modern example of disruptive technology and the effect it can have on staple markets. In this case, technology has come to the road transport sector and has had such an influence that it has resulted in major city protests, physical altercations and multiple lawsuits. Given the popularity and ingenuity of Uber, those who chose not to move to the progressive technology, now complain about a loss of income. In the context of AV systems, the technology has the same ability to be disruptive, but as it relates to user values, rather than a commercial effort, it must be introduced with minimal intrusions on the system it will eventfully replace. By this, as AV systems come to market, the community must ensure that for late adopters, support and the current infrastructure remains until a point that it is no longer tenable.

Furthermore, with system progression, if it transpired that the role of a driver would become redundant, it is expected that employees would be offered alternative roles within the organisation internally. For those who class themselves as self-employed, the findings of the study would suggest that they would not adopt, as they would be free of employer pressure to do so. Although the study did not focus on the job role or job type of road car users, the general consensus around AV systems and driving employment was that the technology would remove them from their post.

Training was also cited as a key requirement and this would ensure that their job role and job performance would not be affected as a result of the changes. Although the literature on AV systems does not contain any direct research related to this concept, the wider spectrum of available literature yields the concept of technological unemployability. Technological unemployability is the displacement of humans as workers by machines (Attar, 2003). This means that technological advancements bring about new systems that can replace humans and do their task quicker, cheaper and more efficiently; this is the case with much of the factory industry. Smith and Anderson (2014) stated how robots could do the jobs of the human, and how this could lead to a class divide not seen since the 19th century.

An example of technological unemployability is the story of the Luddites. Founded by Ned Ludd, the Luddites were workers in the textile industry. Around that time, the textile industry began to evolve with the advancements of industrial machines, fearing their job would be lost, the Luddites began to break such machines in a bid to save their income (Bloy, 2005).

The findings of the study suggested that the issues presented above are a direct case of technological unemployability, especially concerning HGV drivers and drivers using their vehicle to earn an income.

The PEW Research Centre questioned 1896 field experts whether they thought AI applications (including driverless vehicles) would displace more jobs that it created by 2025. Quite interestingly, 48% saw a future where robotics displaced many of the blue and white collar workers. Further comments were around a vast increase in income inequality and a significant number of unemployable individuals. The rest 52% believed that even though robotics would overtake many of the human jobs, due to human ingenuity, a host of new jobs, industries would come to surface (Smith & Anderson, 2014).

Applying the research to this environment, a revolt against AV systems is not expected, especially given the level of exposure to technology that the majority of society has. However, participants do have real concern, given that they feel fear around unemployment and inadequacy. Nevertheless, as cited by Smith and Anderson (2014), even if AV systems progressed to a stage where they did not require a human driver, society would see such progression and technological advancements that job prospects and opportunities would be in abundance and the role of many, including drivers would certainly develop to a new stage. Furthermore, if legislation and governance take the standing of protecting the body of employed drivers, their position would be safe or if as expected, would progress.

The second category of findings discussed results pertinent to actual adoption and usage of AV systems. At this stage, users were mentally prepared for the technology, by overcoming personal trepidations. This section therefore, focussed on issues related to users physically using the AV system technology. The findings of the study and the discussion both suggest that participants are treating this instance of technology acceptance as if they would any other acceptance or change process. By this, the concerns and chronological placement of concepts follows that of extant literature discussed in this thesis.

Expected mentions and confirmatory knowledge was presented when discussing the need for regular training, trials and public displays of technology merit. These were cited as being able to then, positively influence user perception. Price was highlighted as one of the key influencing factors to users adopting the technology.

Furthermore, the issue of questioning the competency of the technology in certain usage zones induced the feeling of mistrust in users. Alongside this mistrust, fear in technological unemployability were the concluding concepts and deterrents to successful and continued usage. To remedy fear in usage zones, recommendations were made to begin usage in motorway zones to develop user skill and confidence. Upon this, users would then be prompted to use the AV system in mixed traffic conditions. This would settle any outstanding fear in the system and its ability. Lastly, amongst participants, discussions were made around the role of drivers in a driverless world. Concern was expressed around job loss and salary reduction in light of new roles and responsibilities. To protect users, recommendations were made to incoming legislation, prompting it to better protect employed drivers, although further research showed that even with job losses due to AV systems, the job market would be inundated with new job prospects due to AV system progression.

6.1.3 Relinquishing Control

The final category within the 'Adoption of AV systems' findings was pertinent to results that discussed the element of relinquishing control to the system. By the activating of this category, it was assumed that users would have begun adoption of the AV systems in the earlier stages discussed, but would now be attempting to move further up the available levels of automation. By this, users would be operating between levels 0 and 3 of the IET (2015) levels (Figure 31) and with continued usage, now have the confidence to attempt levels 4 and 5, fully driverless.

The first key finding in their attempt to do this is related to accountability. The exposure to accountability in previous categories has been minimal. The probable reasoning behind this is that in previous categories participants felt that they had control of proceedings in the driving environment. When encountering the true concept of driverless, regardless of actual proceedings, the onus in participant and eventual user mind-set is that control is being surrendered to the AV system in its totality. At this stage, participants felt that the onus of control was with the AV system but had trepidations that they were still cited as liable. These confused participants of the study and upon clarification, the following points of discussion became apparent. In the sole quantitative element of this qualitative study, participants were asked to select who they felt was liable for the vehicle in case of incident, 50% stated the manufacturer, 30% stated they didn't know, 10% cited the software creator and 10% labelled the driver as responsible. The difference in opinion is displayed here with confusion around which involved party is liable.

The issue of liability is discussed by the Department for Transport (2016) in proposals around legislation change in anticipation of AV system introduction. In extension of Highway Code 150, where drivers are required as a must to exercise proper control over their vehicle, regardless of interference from driver assistance systems, proposals were discussed. The proposal from the government is that minimal modifications will be made to current and existing liability, with the existing fault based approach being observed, as opposed to a new one. For example, if an accident occurred as a result of a defective vehicle, government proposals are that the driver and injured parties claim directly from the defective vehicle owner's insurance, even though the manufacturer is at fault. This current standard practice.

The vehicle Technology and Aviation Bill (HC Bill 143) presented to UK parliament suggested that insurers would be liable to settle costs of accidents caused by automated vehicles. Furthermore, users would be held liable if they failed to keep track of software updates or had made alterations (Parliament, 2017). The bill also suggested that insurer would then be free to contest manufacturers for liability and to recoup costs.

Between the government position on liability and participant opinion on the matter, a great difference exists. Whereas participants and various literature outlets believe that liability must be evolved and responsibility is now shared across a number of mediums, the government position is clear. Their stance is that the existing liability framework will still be maintained, with driver liability still being the key factor at the basis of the arrangement. Although the government position is still at the proposals phase, seemingly this will solidify as legislation is passed. Scope does exist to influence this legislation with the current proposals offering feedback form the public. To ensure that expectation is aligned, public consultations are being made and must continue to target drivers in an effort to manage forecasts and arrive at an agreeable endpoint.

In examining the liability standpoint, it does make sense to operate within the existing framework. Although each aspect of the liability framework and parts of the Highway Code will have to evolve to digest autonomous vehicles, in some cases this will only be cosmetic with grammatical change to cover AV systems. For example, Highway Code 150 discussed above will still be applicable to AV systems with only minimal extra wording required to represent driving in an AV environment.

The only criticism of the government standing in light of participant responses would be that rather than operating a two-tier liability framework (driver, insurer), a three-tier framework will be adopted. With the addition of the manufacturer, the insurer would then have the right to recoup costs from the manufacturer in the event of defective AV properties. Accountability therefore would also be expanded to include the manufacturer, as they would have an indirect influence on the autonomous mode of each vehicle. In any lesser mode, with mild driver input, liability should then remain in the two-tier.

Based on the above discussion, key amendments must be made to how car insurance is offered, the rhetoric that underlies it and the method in which risk, incident and rulings are measured. Insurance providers would be key in determining users of AV systems, potentially restricting usage to historically sensible drivers without conviction. By setting pre-requisites, insurers would have the ability to narrow down AV system misuse and negligence, whilst promoting usage to drivers deemed fit to operate such systems.

As well as this, insurers would be worst hit at times of incidents, with driver confusion serving to further hazard the process of denoting fault and delaying the process of recouping costs, claims and vehicle repair. However, to support insurers, participants of the study pointed to quicker turnaround times for investigation with on-board data recorders (e.g. 'black boxes') helping to determine the cause for incident sooner that eye witness statements, investigations etc. Also, with driver assistance, the number of variables that currently contribute to incidents would be reduced as operating in a driverless environment increase the safety of users and reduce the probability of incident, achieving the task it was introduced for.

To conclude on this concept, currently there is a difference in opinion around how liability should be designed in a driverless environment. The government believes that the existing framework would be satisfactory with minimal amendments, whereas participants of this study and in the literature believe that drastic change is required. On this issue, the government is observing the correct steps by appealing to drivers to analyse the proposals and offer suggestions/ alternatives to what it has produced. This process of involving potential users would ensure that the liability framework would eventually reflect the standpoint of both users and the government. As well as this, the thesis made a number of recommendations to include the manufacturer in the liability framework to assigning accountability to them. The concept was concluded by discussing the crucial role of insurers in managing the availability of AV systems, managing the eventual liability and user expectations. However, it was concluded that in an environment adopting AV systems, their task would be made easier as they would have access to on board data, sensors and reduced variables to determine fault from.

The second concept discussed within the category of relinquishing control was around the design of the AV system, in levels 4 & 5 of the automation scale. As users would be expected to relinquish full control at this stage, key concerns and expectations were cited by participants that fell into the environment of system design.

In line with the previous concept, the need for clear responsibility indicators was judged essential to the operation of AV systems. Applicable to each stage of the automation scale, but most critical in full driverless mode, this design requirement is key to maintaining user involvement and ensuring automation surprise or out of the loop situations do not occur. Abbott, McKenny & Railsback (2013) report that within their study of aviation incidents, it was found that 50% of the accidents hold the pilot as liable as they were out of the control loop. Within these incidents, the pilot was unaware of the current operation of the aeroplane and was unable to resume control where necessary or required. An earlier study by Abbott *et al*. (1996) found two key issues in relation to flight crew management of automation:

- Pilots' lacked the current understanding of the function, limitations, levels and operation that the automation ethnology had, this regularly led to automation surprise. This concept relates to one being surprised by technology displaying its normal function, highlighting the lack of understanding one has in the system. An example of the regular remarks from the flight crew were 'what is the system doing'; and
- The second key point was around the fight crew misunderstanding which level of automation should be used and also confusion around whether it should be turned on or off in unusual situations.

The above examples of confusion and possible weakness in design of early aviation automation displays the critical need to employ clear responsibility indicators. Whether conducted through physical system design e.g. lights, sounds etc. or carried out through mental stimulation e.g. understanding and awareness of system characteristic, this is a modest method of establishing proper control and employment of both driver and system.

The above also related to being able to establish meaningful human control over autonomy. In an environment where meaningful human control is subject to relinquishing control, three factors were identified by the UN (2014). Although targeted at next generation weaponry, their reliance on autonomy developed links to use the factors here. They are:

1) Informed decisions around weaponry usage;

2) User taking correct accountability for system usage; and
3) Weaponry designed and properly tested with the user also being trained to a satisfactory manner.

The above factors resonate with the discussion of this section, with the informed decisions taking the place of clear indictors and users taking accountability being discussed at the start of the section. On the issue of training and testing, the discussion for this can be found across the results presented at Chapter 5.

Furthermore, system transparency and feedback was highlighted as being contributing factors in developing human control and maintaining situation awareness. By transparency, participants referred to the system involving users and making them aware of its every action and reaction. If the system was to be designed to operate in isolation, without informing users, this would raise user suspicion and negate successful usage. The feedback system designed for the interface system is the single key factor in harmonising and maintaining a relationship between the user and the system, within each stage of automation that can be successfully used. Without it, a dangerous environment would surface, where users are attempting to predict system action, rather than being ready to resume control when required. For example, if a driver were to use the cruise control feature and not receive any feedback from the dashboard, such as symbols lighting up or reactive action when in operation, then the user would be trying to estimate if the system was in action or not, leading to their distraction of the driving task and road hazards. Simultaneously, in a review of trust in automation papers by Hoff and Bashir (2014), feedback and transparency were identified as key factors to build trust within automation. Although trust was not specifically discussed within this concept, within the wider category it has been and it can be expected that a number of concepts and resulting themes being analysed in this chapter are in some way off shoots or have links to developing trust in the technology.

In anticipation of a driverless environment and throughout initial usage of such a system, there was a strong expectation that a support network would be available for users. Within discussions, it was noted that the consensus was that support would be available for user fears, to allow users to practice their role in a driverless environment as well as ensuring a framework was in place to rehearse existing skills. An example of such a support network is like the phone access within prestige vehicles to an agent that assists drivers with directions, vehicle problems, general questions etc. On its foundation level, a system such as this should be available to coach users on the go and to ensure users do not develop a feeling of isolation due to their fear or trepidations of a driverless environment.

Furthermore, driving centres should be made available to users where they can practice driverless operation on simulation equipment, have access to experts to answer their usage or operational questions and be able to practice their existing driving techniques. Inspiration can be taken from the UK driving theory test, an emulation of the same would allow users to maintain their driving knowledge and practice their reactions and observational/ operational skills in this environment.

The latter was invited to be a requirement of such centres as participants expressed concern around skill degradation due to their perceived over reliance on the system. Curry (1985) found that over 80% of pilots surveyed had flew part of their flights in an attempt to maintain their skill level, fearing a reduction due to automation use. Although it would be expected for users to manually drive at times, having an extra layer of support for them to practice would instil confidence in users and reinforce continued usage with a benchmarked usage amount.

The penultimate concept within this category is around incentivising drivers into usage of the AV system at the higher stages of automation. Within the study, it was mentioned as to the possibility of incentives being made available to assist in promoting AV system usage. The FP7 Sunset (2011) discussed incentives in the process of change as being effective and a valuable asset to employ. When considering incentives in this scenario, the possibility exists to introduce a scheme that mirrors a supermarket loyalty card where users are rewarded each time they activate the higher levels of automation. In this scenario, drivers who have welcomed and adopted AV systems would receive a reward of some kind for initial and continued usage of AV systems. Doing this, and rewarding early adopters would help to set examples to those fearful of adoption. In addition, evidence of its usage would be prevalent to see, allaying any fears of members of the public. This would fulfil the criteria set forth by Rogers (1964) of ensuring clear evidence and system ability is established, not on biased media outlets or by manufacturers, but by actual drivers in a natural environment. This environment would begin the reduction of barriers to acceptance set up by users, be that from fear, mistrust or confidence etc. Another method of establishing introduction and long-term attraction would be introducing loss leader vehicle sales. A myth surrounding the Toyota Prius introduction was that each vehicle lost the company $20,000, but was still sold as it allowed the company to promote its hybrid technology and develop market share, and resulting public interest and adoption (Tellis, 2013). Initial Toyota UK sales for the single hybrid vehicle were 184 in the year 2000, rising to over 12,000 and multiple models in 2017 (Toyota, 2017). This radical method of introduction paid dividends for the manufacturer and the initial loss period led to a now healthy market share of the hybrid vehicle technology. Emulating this in the AV sector would require a substantial outlay, but would reward the community with early usage and evidence to grow public appetite, as well as projecting the required ethos of AV systems to the mass market. It would also specifically appease the late majority and laggards who required evidence of system utility. The findings of this study also suggested the concept of tangible trust, whereby participants spoke of the need to physically see system operation prior to trust, this would provide a fulfilment to that concept.

Furthermore, by inciting change through a reward structure, the fun element or ability to compete with others to reach agreed targets would allow users to gain invaluable, early experience, whilst removing the fear factor of driverless cars. Realistically, this method of inciting change would require data collection and sharing across a number of platforms, a previous concern for participants. However, at the time that a fully driverless system becomes available, the likelihood is that society will have extrapolated the full benefits of the internet of things and SMART cities will be in operation. At that time, it is possible that big data and cloud computing will see much data shared and each individual will most likely be in possession of an incentive card that also possibly is used as a travel card for driverless cars in the same way that an oyster card is a travelling card for the underground train. Furthermore, technological advancements could lead to a communal reporting system whereby autonomous vehicles submit congestion data and from this, trends and traffic flow /peak times can be identified, leading to a heightened understanding of the road and a better deployment of AV systems. This has traits that are similar to the Uber Surge programme that deploys vehicles at peak time and incentivises drivers to meet demand by raising prices and TomTom live traffic update and navigation (TomTom, 2017).

The concluding discussion within this category is around the replaced workload of users. As a number of the sample used their vehicle primarily for work related purposes, concern was expressed as to what their role would be in a driverless world. Participants were advised that they would serve as both driver and operator in a driverless world. However, participants discussed that in a future setting, with system integration improving; there would not be a need for driver interaction, rendering them as ‘passive driving supervisors’. In this scenario, concern was expressed around employers burdening drivers with additional tasks to accommodate for their now free time. It was expected that participants would be given additional jobs such as completing paperwork, calling clients and other manner of low concentration tasks to ensure the employer was getting best value for money from employees. If this was to be the case, participants felt that the higher levels of the driving automation scale did not suit them as it would result in one task being lightened for them, but another taking its place, creating extra work to carry out.

In an environment of austerity around finances and efficiency, employers would be seeking any means to improve workforce productivity, with AV systems creating a vacuum of potential free time within which to conduct other tasks. Although a trade-off between the two must be established, with future iterations of AV systems being such that drivers need not pay any attention to the road or driving task. In this environment, it would be expected that the role of the driver would organically evolve, with legislation and best practice negating their role and new responsibilities in light of their free time. Until such time though, employers must be advised of the criticality of the driver monitoring the driving task and intervening as and when required.

An exception to the rule can be classed for truck drivers who already discuss an overworked feeling as their responsibility transcends the driving task into managing their payload, their trailer and keeping communication with their base. However, proposals such as motorway platooning are taking place for truck drivers, which as expected, would change their role into one that is currently unknown. Presented above is the discussion pertinent to AV system acceptance, initially presented at Chapter 5. Key contributions from stakeholders allowed the development of the three categories of AV system adoption. However, a key focus was given to those who identified themselves as direct users of AV systems.

The findings were made up of participant perceptions, culminating their concerns and personal barriers to system adoption. As such, the discussion focussed on comparing these views to literature and making recommendations from a user perspective of various actions to facilitate implementation onto the UK road network. The findings provided the key perceptions, and in turn, the thesis presented the transformation process, allowing it to develop into a usable requirement.

Although the recommendations in the discussion varied, the underlying environment they were attributed to considered the design of the system, the method of introduction, the legislation surrounding proper usage of the system, the method to develop experience of using the system and the insurance considerations of using the driverless function.

Moving forward, the discussion will now consider the stakeholder specific findings introduced at Section 5.2. The second part of the discussion and analysis will consider the key findings relevant to each specific stakeholder, focussing on the key factors, attitudes and perceptions that define and distinguish them from the group of stakeholders considered in this study.

6.2 Discussion on Stakeholder Specific Findings

The thesis will outline key findings found as a result of grouping participants by their stakeholder type. Doing this allowed similar codes for stakeholders to be combined to allow a reporting of the key attitudes and concerns of specific stakeholder groups. Contributions from each were made to the first section of findings on AV system adoption, at this point, additional findings that are pertinent to the environment of driverless cars will be discussed. The list of findings this discussion is based on can be found in Section 5.2.

6.2.1 Car Drivers

The first stakeholder type to discuss is car drivers. Although the mass of the findings became the basis of the three categories of AV system adoption, the remainder have been discussed below.

The premise of each interaction with car drivers yielded an initial discussion of their understanding of the current problem space. Each participant understood the problems that are currently apparent on the road including rising vehicle numbers, expected congestion on each journey, rising costs of driving and regular road traffic collisions. As a result of their informed understanding, participants who identified themselves as car drivers in the study were well aware of the problem, which allowed them to cite the need for change and the fostering of an evolution. Like much of the change management principles, the ability to identify a problem or the need to change, is the first stage of actual change, where the admittance of a problem leads to the development of a solution.

However, even with a perceived need to change and an understanding of the associated problems of the road network, with some citing the problem as being due to the legacy system currently in place, attitudes towards AV systems are generally negative. Upon the instance of introducing AV systems as being the most probable solution to solve current problems, participant attitude towards this solution was generally negative. Although a number of participants spoke of its benefit and the associated benefits its introduction would have for the road network, the overwhelming majority did not share this view. This was in clear contradiction to the work of Fraedrich *et al*. (2016) who found that the worldview held by individuals towards the driving environment would correspond to their eventual attitude towards AV systems. In this scenario, participants understood the problem, the need for change and in some cases, the benefits of AV technology, but concluded with negativity towards the AV system.

In attempting to understand the disconnect between participant feeling and participant intention towards AV systems, further questioning within the study displayed that a number of factors were influencing participant attitude towards the adoption and usage of autonomous vehicles. When discussing if the system was fit for purpose, the general attitude was negative as participants felt it could not handle the unpredictability and pressures currently set forth by the road network. In addition, the fact that relevant legislation was not yet available, participant emotion around accountability further served to reinforce negative attitudes. It was identifited that participants found the idea of AV systems acceptable, but felt what was currently offered was not the right solution. From their limited knowledge, they felt the right derivative of AV systems was still a number of iterations away with current proposals being inadequate in terms of their offering and ability. Competence trust is a subsidiary of this discussion and is documented within the first section of findings, but here the narrative is focussed on questioning the whole environment of AV systems, rather than just its ability or actions.

The method by which participants have been introduced to AV systems then came into question. This was due to a need to understand what had influenced participant attitude and created a scenario where participants felt the system was unfit for purpose. It transpired that participant knowledge on the topic was gained from their own formulations, from TV and various other media outlets and hearsay. In this scenario, as participants were not being given information from an unbiased, peer-reviewed source, they were given partial knowledge on the topic and had formulated their own opinion. The danger of being in such an environment and left to develop self-opinion is that factors such as technophobia, technological unemployability, fear of change, loss of comfort etc. all become embedded within potential users, leading to their understanding of the problem but inherent negativity towards the proposed solution.

In a scenario such as this, it is imperative that the correct information is passed down from the relevant sources and is portrayed in a positive light, emulating the benefits of the system, rather than highlighting the associated dangers, pitfalls etc. More importantly, a change leader needs to be established to lead proposed users through this process; ensuring users can identify a leader and can resonate with the speech of the leader in their quest to adopt. In a real world scenario, the Transport Secretary, for example, can personify the possibility of a change leader with their role being highly vocal in the public eye attributing the change as being necessary, positive and being a successful alternative to the current model of road transport.

On the issue of AV system appearance, the aesthetics and design of the system were cited as a key influencer. Upon investigation, participants had been led to believe through film, TV and current AV system iterations that, upon introduction, AV systems would have a distinctive look, not synonymous with current vehicle design inspirations. Especially when discussed with participants who identified themselves as car enthusiasts or saw the vehicle as a symbol of wealth or presence, the expectation was that the vehicle would look extraordinary, unlike what they expected from traditional vehicle design.

It was found out that the overwhelming perception was that AV systems were not designed to be 'pretty' or to follow the design values of each individual manufacturer, rather they were designed as a single add on system for each vehicle, focussed primarily on safety, rather that style.

In reality, current examples of AV systems have been unusual, not best presented aesthetically and have not blended in with existing vehicles in terms of their looks. Although most of these are trial vehicles, unmanned drones, automated systems rather than autonomous, they have been visible to participants and the wider pool of users. This has caused resentment to the system based on its appearance and presentation. Willingness to engage and use has decreased as a result of this, however, it is the expectation that AV systems, upon their introduction, will be designed to align with each manufacturer values and stand out not due to its appearance, but its design. In some estimations, AV systems will be embedded within the traditional design of a vehicle, but with further developments, it is possible that they will outgrow what is currently the norm in vehicle design, catapulting a new era of vehicle design that is built around AV systems, rather than AV systems being perceived as an add on.

6.2.2 HGV Drivers

The second group of stakeholders discussed within the findings were HGV drivers. Like discussed in the previous section, HGV drivers contributed a number of important concepts to the categories of acceptance. The remainder of their discussion is presented below.

HGV drivers had the most positive attitude towards the notion of accepting and using driverless vehicle technology. Upon investigation, it was concluded that this was the case due to two key influencing factors. The first being that each HGV driver, on average, spends more time on the road than a person using their car for domestic or commuting purposes. As most HGV drivers drive as their employment, their exposure to the road is heightened as they travel on a daily basis. This exposure has meant that each HGV driver is more aware of the current problems facing drivers, and as a result sees the need for change. Where it was brought to light in the previous section (6.2.1) that car drivers understand the need for change based on their experiences of the road, this is strengthened with HGV drivers. To contribute to their positive attitude of AV systems, past experience is signified here as a key influencer of their current attitude. Within the literature, prior experience was highlighted as being a key influencer of attitudes, as understood from various literature sources (Agarwal and Prasad, 1999).

Alongside this, HGV drivers generally do not use heavy goods vehicles for their personal use, and this particularly influenced attitude. Within the second category of adoption, the reason an individual drove was highlighted as a significant influencer on their proposed adoption. Upon analysis, for the comfort of job safety and to ward off technological unemployability it was concluded that users would have to adopt without a choice, with failure to do so leading to potential unemployment.

As with any initiative launched in the workplace, failure to take advantage of such changes would result in the professionalism and commitment of the employee being questioned. With an initiative, as integral to the job role as AV systems, failure to take advantage would result in the job role becoming untenable and the employee being unable to complete their job duties. This would then become grounds for dismissal or the seeking of an alternative career. For this reason, given that the change is due and the need to adapt will possibly become mandatory, due to the safety and financial remunerations of AV systems, HGV drivers of this study are positively inclined towards the acceptance of AV systems. Regardless of personal opinion, due to their understanding and experience around seeing the current problems associated with road transport and the enforced need to accept AV systems, based on this study, participant attitude was highly positive towards the acceptance and usage of AV technology.

An alternative viewpoint to understanding current attitude can be linked to the technological advancements made to HGV cabins over the last number of decades. When the issue of design was discussed with participants, the evolution of the current cabin was a popular topic. Many HGV drivers discussed how the cabin had been subject to a number of technological advancements, in some cases rendering HGV drivers as steering attendants. The benefits of such changes to the driving task were praised by participants, in many cases comparisons were made to cabins from the 90's and early 2000's, with the current ease of driving being in stark contrast to older cabins without this technology. Due to this exposure, and the physical experience and understanding of how technology can assist them in carrying out their driving task, participants are more inclined towards further technological improvements. The majority of the participants noted how they currently felt overworked, especially as their job role was more than just driving the HGV, for them, any form of technology that would mean a reduction in their physical role, which would almost certainly be welcomed. In determining the positive attitude of participants, this is one probable cause of it. In applying this thinking pattern to car drivers, the first iteration of AV systems to vehicles would be received by a probable minority as discussed in this study. With evidence of its success, it is expected that the second iteration of AV system implementation would result in a higher success rate with participants with acceptance being increased due to the tangible evidence being displayed and the benefits clear to see.

As well as considering AV systems for HGVs, the consideration of AV systems within cars was also discussed with HGV participants. When considering the impact of AV systems for vehicles, HGV participants noted the need and perceived benefit of this. From all stakeholders using the road, car drivers were identified by HGV drivers as most probable to cause incidents and neediest of driverless technology. This was identified within the study with the remainder of the road user groups nominated car drivers as neediest. When exploring this perception, HGV participants spoke of their experience of seeing car drivers as breaking the majority of road traffic rules through erratic driving, use of a mobile phone, displaying behaviour that would suggest substance abuse, not paying proper attention to the driving task and not executing their responsibilities to the best of their capabilities.

The extent of HGV participant mistrust of car drivers was evident in their mutual agreement that if AV systems were solely applied to cars, and not HGVs of any kind, then the maximum benefit of driverless vehicle technology would be achieved. From October 2014 to September, the number of 'killed or seriously injured' casualties were almost double for road cars as it was for any other road user type on UK roads (Department for Transport, 2016). Although AV systems are set to affect all road user types, the findings suggest that in the instance that it is car drivers that require AV systems the most and in turn, would be most positively affected by it. In a scenario such as this, where HGV drivers distrust car drivers, this represents a dangerous situation, especially as all are operating in such close proximity. This competence trust in the ability of car drivers would mean that in any given scenario, HGV drivers are focussed on and have a fear of what the driver is doing, rather than concentrating and executing their own driving task responsibilities. The number of registered cars on the UK road network is around 30 million, with HGV at 6 million and motorcycles at just over 1 million (DfT, 2016). This figure displays that on average, cars are a much safer method of travel, but perceptions of them remain. This is possibly due to HGV drivers and motorcyclists seeing road cars more than they would see any other road user type. Added to this, their possible bias would influence them into perceiving road cars as being the most dangerous method of travel, ignoring the statistics of their own road user group. Nevertheless, the fact remains that road cars cause the most accidents regardless of averages; hence the mistrust exists and in some cases, is warranted.

In considering the above discussion, although the listed statistic identifies road cars as causing most incidents, a key contributing factor is the increased growth of cars each year, whereas the number of HGVs is declining. In addition, since 1994, the number of vehicles on UK roads has increased 34%, with only the UK registering double-digit growth from the major EU markets (Department for Transport, 2014). Currently, the number of cars on the road outweighs any other road user type and is constantly rising, possibly explaining why the most incidents are attributed to this group. As of March 2016, 30 million vehicles were licensed to drive on UK roads; bringing AV systems to this mass market would directly affect and reduce the number of incidents on the roads, as well as improving safety of all stakeholders (Department for Transport, 2016).

At this point, it is key to assess whether any other road user types list car drivers as the most offending party and neediest of AV systems. To conclude, HGV drivers, within this concept, state that those most in need of AV systems are car drivers. This point is not stressed by them because of the number of vehicles on the roads, but rather through their experiences in observing the irresponsible action of car drivers and the resulting incidents this then causes. However, the fact that they would see more cars than HGV's and could potentially be sympathising with fellow HGV drivers would see this influencing their perceptions.

The issue of legislation supporting liability and accountability was also popular in the responses of HGV drivers. In extension of the liability discussion in Section 6.1.3, where it was discovered that government proposals to address liability legislation in light of AV systems was minimal. It was found that with minimal updates, current legislation was sufficient to support liability, with the manufacturer, expected by many, not set to be involved in the process of incident and fault detection.

Upon discussion of liability with HGV drivers, serious concern was detected in this discussion. Participants noted the due diligence they paid to the driving task, given the potential damage that could be caused by a HGV. Unlike a car that could cause limited damage, heavy goods vehicles weigh around 44 tonnes, leading to the potential to cause mass destruction. Due to this, participants pondered over the situation of a HGV incident where the vehicle was in driverless mode. Here, the driver would have had minimal influence over the driving task, with the vehicle possibly malfunctioning and leading to a road traffic collision. Within this scenario, participants had multiple concerns. The first, like car drivers, was that current legislation would not serve drivers well in this scenario, with the need to include the manufacturer in the liability framework (Section 6.1.3). Secondly, participants displayed real fear in a situation of this sort occurring, with the primary fear being in how it would affect their mental and physical capabilities and secondary fear in the inability to execute their duties because of this. Although situations such as the above could occur, it would be then down to AV system manufacturers to design their systems in a way to minimise the effects of such. The decision logic required for different accident scenarios would need to be implicit in considering the associated prioritisation and ethics. In addition, this would have to differ for different vehicles types e.g. HGV's would require a different primary path/ethics blueprint to that of road cars, given the damage potential of each.

Although participants discussed the issue of liability and its legalities, their principal concerns resonated that of extreme fear and probable guilt. In this case, participants felt a sense of defencelessness, and cited such an event occurring as the end of their career and probable resentment of AV systems. Considering recent terror attacks across UK and Europe where large vehicles have been used to mount walkways and run over member of the public, a malfunctioning driverless HGV would act in a similar fashion. Heavy goods vehicles are effective tools of destruction and if participants felt they were liable for incidents that killed similar amounts of people, the associate mental consequences of this would be severe. To remedy this, as discussed earlier, adopters of AV systems require protection from certain consequences arising because of AV systems. Participants require protection from road traffic collisions where the responsibility was levied more strongly in favour of the AV system. In addition, participants require more protection from the resulting liability and accountability if such incidents are to reduce extreme mental and physical stress. The feeling of exposure expressed by participants in scenarios of collision can only be remedied by ensuring that legislation is user centred, with a focus on ensuring the fault-based approach of incident management is biased towards user protection when inclined to do so. This approach should not discriminate against any level of automation, with legislation expected to cover the range of automation levels.

6.2.3 Motorcyclists/Cyclists

The third stakeholder group discussed within the specific findings were two wheeled riders. Within this group, key contributions were made from motorcyclists as well as those who rode bicycles. Although these two road user types were not actively using AV systems, their interaction and experience with traditional vehicles as well as their forecast on the benefit of AV systems to them was invaluable.

In a trend appearing to be synonymous to that of HGV drivers, the participants of this stakeholder group displayed the same level of motivation and positive attitudes towards AV systems. Although here, the motivation and attitude in question was not for the usage of AV systems, but rather its introduction and embedding on UK roads. In attempting to understand the exuberance of this stakeholder group, discussions turned to the values of motorcyclists. It was found that in their fear of the unpredictability and concentration of car drivers, motorcyclists and cyclists were taught to ride with an embedded mistrust of car drivers. In addition, their riding style was manoeuvred to take on a defensive position, ensuring they always yielded, were always visible and had run off space in extreme circumstances. Being taught to ride in such a manner severely affects concentration, as rider's state they regularly focus on the action of the car driver, rather than on their own task. This mind-set was synonymous across riders and it was found that the introduction of AV systems could potentially end this negative mind-set, given the standardisation that would be brought forward with driverless driving. Like HGV drivers, two wheeled riders felt that car drivers were the biggest cause of problems on the road and were neediest of AV systems. Their reasoning for this was synonymous to that of HGV drivers (Section 6.2.2). From this study, three major road user types have now listed cars as the ‘rogue’ user type. This identification leads the thesis to consider the possibility that if AV systems were to be implemented, a number of the concerns and current problems would eventually disappear. As the thesis is not representative of the views of UK road users, it is not possible to hold drivers liable for current problems, but within this thesis, it is possible that car drivers are seen as the most blameworthy for the current road situation.

Furthermore, on the issue of participant mind-set, it was noted that AV systems would allow riders to begin expressing themselves and applying their full skillset to the riding task. Without having fear for the action of car drivers, participants expected an increase in their freedom to ride as they wish, in turn reducing accidents that are partially or fully down the fault of the rider. Added to this would be the previously ascertained point that AV systems would definitely reduce road car accidents, ensuring three of the major road user types would see a reduction in accidents where they were liable. The reduction in road car accidents could potentially be as high as 90%, according to Bertoncello and Wee (2015). This figure could be slightly higher with Maynard, Beecroft and Gonzales (2014) mentioning 93% of accidents were down to human error, with the ability of AV systems to take away these accidents entirely.

Within this concept, one that involved rewriting rider values, standardising road car actions, reducing overall accidents and improving rider freedom and mind-set, was where the key triggers for positive participant attitude were found.

The remaining concepts of this stakeholder group build on this, discussing both positive and negative concepts that arose as a direct result of the above discussion. The first concept discussed was around the increased appeal to trade four wheeled means of transport for two. In a society that was reliant on AV systems, with evident benefits, the appeal for cycling would increase. Currently, a barrier to acceptance of cycling is that is unsafe, especially in urban zones. People fear cycling and riding motorbikes due to the behaviours of car drivers and the vulnerability they feel in the presence of road cars. This vulnerability leads to cycling in some cases restricted to a hobby or in rural zones with little to no vehicles passing. However, in an environment adopting AV systems with safeguards and reassurances being made to ensure road cars and vehicles do not touch, the appeal for travelling in this way would increase. With mass acceptance and usage of cycles and secondarily, motorbikes, the road network would see a reduction in vehicles, resulting in reduced congestion. As AV systems would also be contributing to lessen congestion and traffic, physically removing vehicles from the road would allow for further reduction in congestion. In league with this benefit would be a smaller carbon footprint and a collective impact on the pollution levels created from the now vacant vehicles. As well as the environmental and social benefits, each adopter would personally gain from this change. As cycling costs are minimal in comparison to road cars, each user would have vast monetary savings. From this cardiovascular activity, each user would be healthier as well as enjoying a better mental state.

It may come across that the above discussion is not progressive for AV systems, with recommendations being made to move to alternative means of transport. However, as AV systems would be introduced to an environment with multiple types of users, its effect on promoting cycling as a means of transport would form part of its appeal and perceived acceptance. Given the system will not operate in isolation in a standardised environment, with many alternative means of transport available, the findings of the study suggest that AV systems would have a direct, positive impact on each of them. This has already been the case with truck drivers, now it is appearing to align with two wheeled riding also. If it transpired that AV systems would solely benefit car drivers, its acceptance and usage would be short term as conflict would undoubtedly arise with fellow stakeholders and transport means. This is a contributing reason to the varied participant base of this study, ensuring the above is true, and confirming this. Any situation where it becomes apparent that AV systems would not benefit fellow stakeholders, the reasoning behind this was explored, yielding either a justification or a set of recommendations.

On the negative issues that would come about because of AV system introduction, participants pointed to a communication breakdown between stakeholders. Part of the current role of all stakeholders is that they have developed a method of communicating with each other to ensure the safe passage of each vehicle in an interaction situation. For example, motorcyclists rely on expressions, hand movements and eye coordination of car drivers before they proceed at junctions or are given right of way. The Highway Code 104 states that riders should '*watch out for signals given by other road users and proceed only when you are satisfied that it is safe'.*

In line with the Highway Code, communication between stakeholders is imperative. Users have extended the Highway Code and have manipulated it to form a universal language between each other that has allowed the safe progression of each driving task. The language has now become established and is vital for any stakeholder who is operating in this environment. The problems that transpires as a result of this is that due to the language having such a presence currently and not being legislated, its role in a driverless world will be questioned.

In an environment reliant on AV systems, the need for such a language would become defunct. It would be unlikely that this unlegislated language would survive the legacy system update and this poses a problem for two wheeled riders. The need for this language is justified, especially when considering the rider fear, vulnerability and inability to judge vehicle action. For this reason, the reliance is defensible and an alternative solution is required to take the place of this method of communication. No studies have been found to have collated and assessed each individual action that warrants movement, but one is required to initially identify each component of the language. Upon doing this, wasteful or unnecessary movements must be discarded with only suitable movements being enhanced for analysis. In a driverless environment, suitable alternatives must be designed to emulate such a language that has been developed organically because of stakeholder needs during the practical execution of the driving task. The value of a language developed in such an environment must not be ignored and the importance of designing an alternative is imperative. Most probably, this interaction between car drivers will not be a key requirement for AV system users.

Much of the design discussion has identified methods of interaction using sensors to gauge the presence of another AV system and from this, suitable proceedings can be pursued. Interaction between an AV system and a non-AV entity such as a motorbike or a bicycle represents the key communication framework opportunity. Through identification of each action and public consultation on the issue, the community will then face the task of ensuring that non-AV entities can still maintain the perceived high comfort levels they expressed earlier in this section. Whether the original language is incorporated into the highway code or that drivers still maintain the responsibility of adopting the language or AV systems are given an add on to carry this responsibility, it remains to be seen. The key is to ensure that drivers do not relinquish the responsibility of maintaining contact or shouldering the onus of communication with their fellow road user. It could transpire that in a driverless environment, drivers lose concentration and break the communication cycle with fellow road users, essentially rendering them out of the loop, extending the discussion to the danger of AV systems and autonomy in general. Overall, a need exists to introduce a set of protocols whereby AV systems are equally observant of road events, as users are. For example, newer cars are now being fitted with blind spot detection systems, role once fulfilled by users. In addition, further examples could relate to overtaking scenarios on motorways whereby AV systems recognise that motorcyclists accelerate relatively faster and yield sooner to allow the motorcycle to pass. At traffic light situations, AV systems could delay their set off for a few seconds if it transpires that a cyclist is by their side and is preparing to set off. What this would mean is that through observation, AV systems would adopt a set of protocols that mirror best practice and driving ability set forth by road users, in consideration of the diverse range of road users.

The second negative concept surrounding AV systems form the viewpoint of two wheeled riders or non-AV entities is how the concept of Vision 0 affects non-AV entities. Vision 0 was a 1994 multinational approach to road safety developed because of a Swedish approach to road safety thinking. The initiative set out with the ethos of no loss of life because of a road traffic collision is acceptable (Vision Zero, 2017).

In an AV environment, a key aim of the community is to reduce road traffic collisions. To do this, vehicles supplemented with AV qualities would contribute to a safer driving environment, given the technological enhancements. By vehicles, the thesis is referring to road cars, large vehicles and heavy goods vehicles. In essence, any vehicles with four wheels is subject to enhancement through AV qualities. It is expected that non-AV entities (motorbike, cycle) will not be subject to any AV improvements. As a result of this, the fear held by participants is that in such an efficient environment where safety is determined and governed by AV systems, ultimately yielding 0 deaths, non AV entities will be considered the ‘rogue’ traders of the road. As rogue traders, non-AV entities would slowly be phased out and considered outlawed, in respect of their presence and actions. Although this is currently not the intention of the community, with the forecasted success of AV systems in this controlled environment, the uncontrolled elements (motorbikes, cycles) could potentially see a continuation of incidents involving them. This would begin to raise suspicion from the community with the most convenient solution being to remove such entities from the road and enforce usage of road cars or public transport using autonomous technology.

In conclusion, the discussion seems farfetched. The possibility of the above occurring is low; however, if the success of AV systems is established and the current problems with riding remain, the above could become a reality. Here, every person adopting a means of transport would only have the choice of using a vehicle of some sort, with two-wheel method of transport only accessible off road for pleasure etc. Therefore, a vehicle would carry out commuting and social requirements of historic riders whereas hobbies and desires would be fulfilled off road by their two-wheeled cycle. This is reminiscent of the method in which horses are currently used. Historically, horses were used as vehicles are used now, but in the current climate, they are generally used for hobbies or for sports purposes. In the same way that riding a horse on every road type is highly impractical and dangerous, the same thought process can be extended to two-wheeled riding in a future setting.

It could be argued that this kind of scenario should be brought forward, with the road network only adopted by a single type of road user. In an environment such as this, the relevant governing organisations would have the opportunity to standardise and monopolise the road network into a safer and more predictable routine. Furthermore, with AV systems at the heart of the transformation, a real opportunity would come about, where the network, vehicles and infrastructure could be updated in a method that would be biased towards AV systems, with no concern or safeguarding needed in place for non-AV entities. This would yield time and monetary savings, as well as creating a more efficient system with maximum infrastructure dedicated to its continuous running.

Until such time, or until the introduction of such radical thinking, each road user has the freedom to express their travel in whichever way they feel. Users are free to choose their transport and the method in which they travel. The findings of the study suggest that the success of AV systems should not lead to the downfall of its alternatives. Rather, by observing best practice and pursuing consistency through AV system usage, naturally, alternative means of transport will benefit. By observing AV systems and the method in which 21st century road car travel operates, non-AV entities should then understand their role and adjust their driving accordingly. In doing this, AV systems would set a benchmark, which others would then follow.

In the long term however, it is possible that either technology or redundancy will extend to non-AV entities that are occupying the roads in the near future. This is the natural order of progression and the process by which technology operates.

6.2.4 Pedestrians

The third section of this discussion on specific stakeholder focusses on pedestrians. As the group potentially most vulnerable to AV systems, pedestrians represented an insight into the thought process of being near driverless technology with little to no protection.

In contrast to the stakeholder groups discussed previously, pedestrians of this study did not highlight car drivers as the cause of problems or vindicate them as being the contributing factor of their concerns in regards to the road transport environment. In addition, minimal discussion was made to the actual problems surrounding their interaction with road transport or the environment in general. It was judged that this was due to them approaching the context considering themselves and the impact of AV systems on them, rather than the impact of AV systems on society.

The ethical consideration or decision making of AV systems dominated discussion in the study. Pedestrians discussed how they could resonate with human drivers, as they loosely followed the same thought process. In an environment adopting AV systems, pedestrians expressed their concern of being able to translate or understand the behaviours of the vehicle. With this lack of understanding, they spoke of their inability to react to or be prepared for the action or possible reaction of driverless vehicles. Current understanding between pedestrians and motorists is largely developed, through adoption of the unlegislated language discussed above, through road traffic laws and through judging actions. In a future environment, although AV systems would yield to the road traffic laws in place at that time, the latter two points of understanding would be slightly skewed, causing fear to pedestrians. Pedestrians gave the example of a malfunctioning AV system that had to collide with two inevitable outcomes a child and a pensioner. Pedestrians highlighted which they believed they would collide with, but questioned whether the AV system would differentiate and employ a similar ethical standing as them for prioritisation. This fear transpired to multiple examples of the system operation in a real life scenario, echoing motorist questioning of system ability on the concept of ‘system application in the real world’.

Although collision avoidance is manifested in AV systems with an aim to reduce such occasions from happening, the possibility of their occurrence still exists. Pedestrians regularly voiced the vulnerability they feel when interacting with vehicles, as they have no apparent barrier in place in some locations. In remedying the fear felt by pedestrians regarding AV systems, it is imperative to ensure that as well as drivers being in the loop, pedestrians also are. In extension to the clear responsibility indicators discussed by motorists, pedestrians should also be made aware of the mode of automation currently in execution by a vehicle. As well as this, pedestrians must be well informed around the character, nature, action and reaction of AV systems. This is all in a bid to improve the line of understanding between the two parties, ensuring that pedestrians do not feel a foreign entity is in operation on the road. Rather, it is an evolution of the traditional road car that they currently understand, with additional characteristics to improve their safety. Further to this, the AV system itself must be designed in a method to identify vulnerable pedestrians such as those using wheelchairs or the visually impaired. Whether done through radar or sensor on the two parties, this would ensure that the system changes its actions accordingly. The bigger picture here is that not every pedestrian is the same. Whereas with fellow vehicles, each car, with the exception of emergency vehicles can be largely treated as identical in terms of interaction or engagement rules. In interaction environments with pedestrians however, the vehicle must be programmed to adjust its actions, such as being defensive around children playing or cautious when nearing less abled pedestrians, the list is not conclusive. However, if this method was designed and implemented, accounting for generalised stereotypes and observational data, it would largely improve acceptance and interaction between pedestrians and road cars.

The consequences that have been forecasted if the above is overlooked is a massive shift in the action and travel of pedestrians. If it transpired that AV systems were not designed with equal attention paid to pedestrians as well as car drivers, the travel pattern of pedestrians would shift from its current state to a sheltered, state of fear. From operating in close proximity with vehicles, utilising the infrastructure currently designed around roads and highways, pedestrians would not frequent these and would find alternative means to travel to their destinations. This would leave urban planners with unused walkways and congestion of pedestrians on rural, off road pathways. This would then require new walkways to be designed, with a total overhaul of current understanding of pathways and pedestrian routes. Essentially, this would equate to non-acceptance of AV systems, as pedestrians would refuse to be in the presence of AV systems whilst in operation. The long-term ramifications of this would require mass infrastructure development, as well as the possibility of more vehicles on the road as pedestrians decide to use AV systems, as a safer option than walking. Reduced cardiovascular activity would have a detrimental effect on the long-term health of pedestrians.

The importance of the relationship between pedestrians and AV systems is manifested in the above concept discussion. It can be concluded that the relationship between an AV system and motorist is equally as important as it is with AV system and pedestrian. The associated lack of protection and the feeling of vulnerability highlight the need to develop an association between the two that promotes safety and understanding. It was forecasted that the responses of pedestrians would be proportionate to that of cyclists as they both aired a level of vulnerability. It has emerged however, that pedestrians can be classed as the most vulnerable based on assessing attitudes towards and aptitude of AV systems. Interestingly, fear in using AV systems was not expressed by participants, part of the discussion mentioned usage of AV systems as an alternative to being a pedestrian, given the increased safety. The overwhelming fear was only when considering themselves as pedestrians in the presence of active AV systems, and the associated vulnerability of this episode. To conclude on this concept, the primary purpose of AV systems is not to impose on any of its fellow road user types. As many different stakeholder groups frequent the road network, this is a factor that must be respected and coded into the ethos of AV systems to ensure it embeds in, rather than attempting to overtake.

The final concept discussed pedestrian misuse of AV systems. Although only applying to a small minority, by stepping into a new environment of technology, the possibility to cause malice and deceive AV systems and associated organisations existed. In one instance, younger members of the public could run out in front of AV systems in a competitive environment. By expecting the vehicle to stop on demand, individuals could use this situation to create dangerous games to entertain themselves and others. Although the premise of the vehicle is that it will stop before any injury is sustained, continued issues such as this could frighten and dispirit motorists from sustained usage of driverless modes. Recommendations on this issue would be to use dash cams, a tool that is currently being exploited by motorists to help prove liability in case of incidents and to maintain their overall safety when driving. Sales of dash cams were up 918% in the year 2015, with many insurers citing it as a key tool in the fight against intentional compensation claims and offering premium reduction to dash cam users (Christie, 2015). The findings of the study around adoption at Section 5.1 found participants were wholly in favour of system integration and were more likely to continually use AV systems if it aligned with their current in car and general driving related technology. This deterrent would be one example of such integration.

Furthermore, with schemes such as crash for cash, which involves crashing road cars intentionally because of exploiting a compensation loophole, such acts could potentially be recreated in an AV environment. As the AV community would be young, with an updated policy, this is the perfect breeding ground for criminal exploitation. Allowing such events to occur would gravely damage the public purse, as well as insurers and all those with financial interest in AV systems. Although a proactive approach is much more suited, it is impossible to fathom every element of AV system introduction and by allowing criminal entities to exploit the field, this is an organic method of overcoming every loophole until a position of strength is achieved. Though this is an effective method of achieving a robust legislation set to underline AV systems, it is still one that leaves the community open to attack and possible embarrassment. Thorough research, field observation, simulations and a thorough understanding of every possible context of AV system implementation and usage is required prior to the higher stages of autonomy being introduced to the market.

6.2.5 Other Stakeholders

The other stakeholders of the study were built up of organisations supporting the facilitation of road transport. Within this final stakeholder group, stakeholders had various roles accounting for infrastructure management, road safety support and accident charities. In the majority of responses, the narrative was focused on discussing the bulk of what was gleaned from the rest of the participants. This was testament to the somewhat management role being adopted by these support stakeholders, that they had an awareness and estimation of the views and perceptions of those they represented. As well as this, a number of additional discussion concepts were found within the grounded theory analysis.

Participants discussed the negative influence of mobile phones on motorists and how these devices distracted from the driving task. In some cases, the devices led to the motorists falling out of the loop of the driving task and having a road traffic collision. The severity of this distraction is such that the UK government recently doubled the penalty of using a phone whilst driving, to deter motorists from doing so. This represents the thought process of legislation in regards to technology distracting motorists and the associated dangers of it.

In a driverless environment, it is expected that technology will be prominently involved in the interface and display of vehicle interiors. In addition, the technology is such that it will require driver involvement to ensure its safe operation. The danger here is that whilst attempting to negotiate the technology, motorists could fall out of the loop, representing a scenario synonymous to that of mobile phone usage. Although the need for such interfaces is imperative, given the concepts of system transparency and regular feedback discussed in Section 5.1.6, governance is required to ensure maximum clarity and minimum intrusion.

In a capitalist society, it may transpire that to beat off competition, manufacturers begin to evolve their systems to offer more than their rivals do. In the real world, this would mean systems offering more than what was required, in a bid to entice customers through large, complex systems. As mentioned earlier, it is imperative to ensure that a baseline and some form of logic is applied to this technology. This would ensure that although some flexibility and leeway is afforded to manufacturers, consistency in design and layout of the technology is mandated through research and simulation learning. This ‘best practice’ will evolve with the environment, but will maintain learnability and consistency for the AV environment. Although vehicles will eventually become autonomous, they will at least still require some form of interaction from users. Interestingly, unlike other products brought to market, AV systems will have many instances and interactions, which will make learnability of the system an increased task. By normalising systems and ensuring each version of the system is easy to use, motorists will require less time to learn and interact with the system, increasing their focus and concentration on the driving task. As well as maintaining the safe operation of AV systems, this concept discusses themes that are echoed by key acceptance literature, such as that of the ease of use and learnability (Davis, 1989).

The second discussion concept focusses on the unknown future behaviour in the environment of AV systems. Introduced as a two-stage discussion with the legalities of an unknown future environment discussed in Section 5.2.5, here the narrative focusses on the social expectation and rules surrounding AV system adoption. As this is an evolution of a legacy system, considerable developments will be implemented to advance the sector. Due to this, an established behaviour is not accessible, only what users expect is required of them. The example of social media gives a strong example to support this discussion. With the arrival of social media to the mainstream, users did not know how to conduct themselves on this platform, with many assuming that the online platform rendered them free of any responsibility or accountability for their actions. As a result of this, many faced convictions and jail sentences on account of their online speech, with their main defence statement being they were unaware of the rules of social media or the correct behaviour, given the revolutionary nature of the platform. In the context of AV systems, this is a minor concern, with the legalities dominating discussion. However, the issue remains to developed acceptable behaviour in this environment. This important factor is to highlight to users that rather than this being a revolution, AV systems are an evolution over a well-developed system and surrounding. This would ensure that the mind-set of users is influenced to approach the system as they approach driving in the current context. This would have lasting impression on their behaviour, attitude towards the system and awareness of the safety critical task of driving. If the opposite was to occur, and users enter the environment, perceiving it to be totally new and revolutionary, adaptation time will increase, affecting the safety of the task. As well as this, users could begin the development of their own language or nuances to using AV systems, reminiscent of the concept discussed in Section 5.2.3. Although in traditional driving, the unlegislated language can be argued to be very useful, in

AV systems, it is imperative that users abide by manufacturer guidelines, without any personal innovation. In the long term, subjective influence over the system may become acceptable. In the short term however, given the unique nature and safety criticality of its operation, using the system objectively is mandatory.

The concluding concept for this stakeholder group discussed the presence of problems in the current variation of road cars and the possibility of their existence in a future setting. It was understood that a number of problems contribute to the current, failing legacy system in place. Participants' highlighted that if these problems were not resolved or reduced in some capacity prior to the introduction of AV systems, it would be unhelpful to introduce the technology as embedded problems would still be present. It was argued that AV systems were coming to market to improve the driving task, with a secondary aim of solving current problems that are hindering the driving task. A number of the problems identified by participants centred on issues such as substance abuse, driver distraction, mistrust of fellow road users, lack of driving skill etc. As these were problems of the motorist, rather than the vehicle or road network, participants felt that if these were not solved, the introduction of AV systems would be futile.

Efforts to introduce AV systems should be matched with efforts to reduce current problems. This would allow the progression of the vehicle, as well as the motorist. Renewed efforts to educate incentivise and convert offending users would see a revitalisation of the driving task, further contributing to the overhaul that is expected with AV systems.

The above represents the final concept discussed for the 'other' stakeholders and the final discussion piece of the chapter. At this stage, all key findings either have been discussed, with various recommendations made, for their introduction, or is some cases, reduction. The thesis will now move to concluding on the lessons learned from this discussion chapter.

6.3 Chapter Conclusion

At this stage, the discussion of findings is complete. The aim of this chapter was to discuss key findings that had been manifested because of the grounded theory study application to the dataset collected from participants of the study. Whereas Chapter 5 introduced the results of the study, this Chapter prepared and presented discussion around a practical implementation of each concept to accelerate findings from their current state to physical, actionable outcomes.

To summarise on the discussion of findings presented in this chapter, two sections constituted the main body of the dialogue. Firstly, the thesis discussed the three categories that were understood as the key categories and resulting concepts related to AV system adoption. Each category was discussed in depth, highlighting key findings and making recommendations to ensure each was practically implemented to guarantee progression and consistency in AV system usage. The first category approached AV systems from a mental standing and discussed a number of mental blocks and concerns held by participants. The second category discussed practical concerns that were addressed which would stimulate actual usage of the system. Within the final category, it was expected that participants had accepted and were using the technology but were faced with a sizeable task in relinquishing full control to the system. The final category therefore, discussed tangible methods of assisting users to access the higher levels of automation, through settling fears and establishing proper legislation and control barriers. Overall, the first segment of findings discussed user perception of what the key adoption issues were and developed recommendations on how each could be satisfactorily met.

The second segment of findings constituted a discussion that saw participants grouped into their respective road user types. Doing this allowed the discussion of commonalities between participant perception on issues around the environment of AV systems, social concerns, legislation, legalities and the associated ethics of AV system uptake. Any concept that formed part of the second section of findings was judged incompatible with the first section of findings. Rather than discounting these findings and adopting a one-dimensional approach to presenting findings, the two stages were introduced so as to ensure maximum extraction of findings was taking place.

Moving forward, the next chapter will analyse core components of the discussion elements of this chapter to assess the impact, transferability and generalisability of the findings, discussion and recommendations made. As well as this, the chapter will also analyse contributing mechanisms of the thesis on a whole, such as the methodology, sample and literature review.

Chapter 7- Critical Evaluation of Methodology and Impact of Results

Within this chapter, an in-depth analysis of core components of the thesis will be presented and attempts made to fully explore and understand the knowledge that has been gathered. This chapter will discuss and analyse the results, evaluating their impact and credibility, and identifying where they may lead to future opportunities. The selected methodology and sample of this study will also be analysed, considering their strengths and weaknesses, together with the limitations of the study.

7.1 Research Output Analysis

The first stage of the analysis will explore the research output developed through this study. This will be done through the Charmaz four-stage evaluation metric (2006). The Charmaz (2006) metric offers adopters a set of four criteria that are designed to thoroughly assess each element of a grounded theory study.
The four criteria are as follows:

5. **Credibility**
    - Has your research achieved intimate familiarity with the setting or topic?
    - Is the data sufficient to merit claims?
    - What evidence exists to support the research?
    - Do the categories cover a range of observations?

6. **Originality**
    - Are the categories fresh, do they offer new insight?
    - Does the analysis provide a new conceptual rendering of the data?
    - What is the social and theoretical significance of the work?

7. **Resonance**
    - Does the grounded theory make sense to participants and/or people who share their circumstances?
    - Does the analysis offer deeper insight about their life and world?
    - Do the categories portray the fullness of the studied experience?

8. **Usefulness**
    - Do the analytic categories suggest any generic processes?

- Does the analysis have the potential to spark research in further categories?
- How does your work contribute to a better world?
- Does the research have the potential to offer interpretation that people can use in their everyday world?

7.1.1 Credibility

The credibility of the research is based on the rigour of the evidence collection and processing. Within Chapter 2, this study presented collated research regarding the current knowledge on AV system acceptance. To assess its impact and importance this knowledge was categorised into themes, with commonality within research papers used to evaluate its importance to the field. To complement the literature on AV system adoption, the thesis documented literature on general technology acceptance to establish a baseline understanding of the environment, together with a section on current attitudes towards AV systems. The latter was a later addition as it was concluded that participant discussions on AV system adoption always leant on the individual participant attitude, so to ensure the analysis of participant attitudes had a reference point, this literature review was included.

Within Chapters 5 and 6, further literature was referenced to substantiate claims and support discussions. Literature in the fields of change management, aviation automation and statistics from the UK government were used to provide evidence to make claims within the findings and confirm portions of the discussion.

Within grounded theory application, literature plays a key role in supporting data collection and analysis. Literature was used in this study to confirm knowledge and to allow claims of new knowledge to be made. The introduction of literature within grounded theory studies starts with data collection and ends at the close of the study, this helps avoid bias through the influence of academic research before the data collection process. Previous discussion of bias limitation can be found at across Chapters 2 & 3.

In terms of the evidence that supports data construction, Chapter 4 displays a multitude of examples of the various coding procedures applied to data in the construction phase. As the grounded theory employs a number of processes to develop data, these have all been displayed within this chapter. Evidence was documented from the early phases of data collection in the form of transcription and field notes. This evidence continued through the coding, memo, and categorisation phase to ensure the reader had a thorough understanding of how grounded theory connected with the data. The coding process of three separate participants is documented within at Chapter 4 (Techniques). The importance of providing evidence of methodology usage is imperative, especially in grounded theory as the approach employs various tools to develop the voice of participants into the eventual concepts and categories that are presented as findings.

The process of theoretical saturation (collecting data until no new themes emerge) allows familiarisation with the data as knowledge on it develops. By participant GT10, saturation was reached, with subsequent data containing the same themes that had arisen from the first ten participants. At this point, a conclusive understanding of the environment was available and was able to state that sufficient data had been gathered to begin meriting claims and confirming existing knowledge. Finally, as the research was able to confirm almost all of the key points denoted within the literature of Chapter 2, at this stage, a thorough understanding of AV acceptance was gained.

In summary, two kinds of familiarity were found within this study. Firstly, the study itself found familiarity with the topic through constant data comparison, extant literature influence and confirmatory/new knowledge. Secondly, familiarity with the study was found through strenuous manual transcription, theoretical saturation and the completion of a thorough discussion and analysis.

One criticism made of current knowledge around AV acceptance through this study is that previous findings were categorised in a single format – studies do not identify differences between participants through categorisation. Separating participants by their road user type for example (the approach taken in this study), yields further, and more nuanced, understanding. By adopting this approach, the thesis has been able to report a wide range of observations from different perspectives. On the issue of reported results, the thesis can report results in the format of "truck drivers found trust to be…", rather than "a number of participants found trust to be…". This method of categorising participants by stakeholder type adds value to the results. Further research opportunities for each road user types can be identified more easily, and with this segmentation, academics interested in specific road user types can access results that are more relevant.

The collected data confirmed existing knowledge and yielded new insights. Participants echoed concepts that were prevalent in popular literature such as perceptions linked to current acceptance literature and the importance of understanding change and burning bridges (as discussed in change management theory). In these cases, the findings were confirmatory. Knowledge around legislation, system design and interaction are under reported in current knowledge and therefore new knowledge has been identified in these areas. As this new knowledge is based on the findings from small representative stakeholder groups, generalisability cannot be claimed. Further examination through larger quantitative research studies based on the findings identified within this study could then lead to generalizable findings. Grounded theory studies by their very nature focus on development of understanding rather than producing definitive empirical results and therefore this limitation is to be expected.

The foundations and development of this study have strong links to relevant literature, as is the premise of grounded theory application, and therefore there is the possibility to extend these findings to related areas. The first area to consider would be technology acceptance itself. Removing the context of AV systems, there is the possibility to apply learning from the three categories of acceptance to general technology settings where human interaction with the technology is required, where technology usage questions the values of its adopters, where system control is required or where the role of the adopter changes because of technology adoption. As a range of new technologies beyond autonomous vehicles becomes increasingly autonomous in their operations, this study provides both an approach to analysis and a range of findings, which could assist future researchers with their studies. The difference between the findings of this study and the original technology acceptance model show a greater complexity in the factors influencing technology acceptance in autonomous vehicles. The original Technology Acceptance Model (Davis, 1985) had six defining factors for acceptance. This study, if it were to be developed into a model, would have over 20 factors. User emotions, vulnerabilities, fear and trust for example are highlighted as influences in autonomous vehicle acceptance, but there appears to be no reason why these factors would not also affect acceptance of other current technologies. Reviewing technology acceptance models based on the factors identified within this study therefore represent another area for future research studies.

To summarise the discussions regarding this criteria, new knowledge has also been identified which can be utilised by the academic community, vehicle manufacturers and those involved in the topic for further testing with their respective participant bases (See Chapter 8).

7.1.2 Originality

Relevant factors and concerns around AV adoption from a user perspective have been identified (Chapter 5) together with categorised findings based on road user types. This is the first study of its type, a grounded theory study in the area of autonomous vehicles, which summarises stakeholder perspectives. Another study exists, by Lee, Lim, Kim and Kim (2016) that studies driver experience through assuming a Wizard of Oz approach. However, that study had a key focus on UX and HMI, not similar to that of this thesis. It also has originality in its findings, highlighting a key failing in current research in relation to categorisation of stakeholders and highlights the benefits that can be gained from this approach. It also therefore opens up new research directions based on these original contributions. Charmaz's (2006) categorisation of criteria also covers significance of findings under the criteria for originality, and therefore the remainder of this section will summarise the significance through the contributions made by this study.

The study provides a comprehensive discussion, definition and context for each factor outlining how it relates to the field of acceptance from the respective stakeholder perspective. A set of recommendations to address deficiencies within each factor is presented, which support progression towards autonomous vehicle system implementation on UK roads. Discussed alongside each category and concept in Chapter 5, the various recommendations have been collated in response to participant fears and concerns around acceptance and usage of AV systems. Aside from the theoretical implications of the study, the study therefore has a large social relevance too. Given the nature of the work, its attempts to create a scenario whereby users can comfortably adopt AV systems represent a crucial social issue. Wiener and Curry (1980) found that aviation automation brought with it a new trend of accidents, having solved historic accident trends that were plaguing aviation at the time. By creating relationships and familiarity between different stakeholder groups, the transition to autonomous vehicle technologies can be both smoother and more effective. Another key contribution of this study is that it highlights the need for better dissemination of information regarding AV systems, both to address a number of current misconceptions, and to have a direct impact on user perceptions and attitudes towards AV acceptance.

In terms of increasing understanding amongst researchers, schematic representation allowed the creation of a number of diagrams (See Figure 28 & 29) to represent visual memos. The purpose of written memos within grounded theory (See Figures 24-26) is to investigate relationships between concepts and categories. As well as having the written instance of each memo, the methodology allowed the inclusion of a visual element as well. The process of creating diagrams involved soft systems conceptual modelling (Checkland, 1972). The conceptual model allowed the thesis to combine findings from each participant and to create a unique reference point for findings related to each road user type. This effort proved invaluable through the analysis process and set out the map for the presentation of findings. Both the approach and its findings are valuable support materials for researchers conducting future studies in this area.

7.1.3 Resonance

The study makes sense to participants on a number of levels. An overall understanding can be gained, given the simplicity of output presentation. The majority of the results are in a qualitative, text-based format. As the results are all text based, and only employ domain specific terms where necessary, they can be easily translated. By observing results, participants can also verify and identify which findings resonate with them. The only non-participant element of the study is the use of extant literature on the topic of AV systems. However, as the literature is related and is based on the outlook of participants, individuals accessing the study would be able to relate to findings that have an element of literature incorporated.

On an individual level, participants who identify themselves with any of the road user types that had been investigated in the study can access this concentrated knowledge also. As this portion of findings is exclusive to each road user type, familiarity and a heightened understanding can be developed on this level also. This would be more so than the findings related to AV system acceptance at section 5.1, as that is general overview of the acceptance context.

In terms of insight, the study must be able to offer participants more than they currently understand about the topic and context. As with many fellow qualitative studies, the starting point was the data collected through participant interviews and perception. This voice was analysed to assign understanding. Participants were able to speak about their viewpoint; however, in some cases they were not able to explain sufficiently why they had these viewpoints. This study employed literature and a rigorous analysis procedure to enhance understanding around perception and develop concepts related to acceptance. As participants had different levels of understanding and knowledge of different components of the system, this study was able collate these viewpoints to represent a universal point of understanding on the topic representative of all participants. This understanding provides clear understanding of future requirements regarding AV acceptance addressing the issues raised by each stakeholder group, both in terms of AV acceptance and the associated social and environmental issues.

7.1.4 Usefulness

The key reasoning behind attempting to investigate user perception of the AV systems environment is to use this and extant literature to forecast technology acceptance of this topic. By using the grounded theory to do this, the study was able to collate knowledge from prospective users and advance current understanding in the field, rather than pursue extant literature to predict acceptance in this fashion. The grounded theory allowed participants to express their subjective opinion on the subject area, expressing what they felt was important and required attention in the pursuing and introduction of AV systems to market. This contributed to a better world, another criterion of Usefulness through the following measures.

The first contribution made by this thesis is by extending current understanding around acceptance of AV systems. As discussed by academic scholars cited in Chapter 2, there is an overwhelming need to extend what is currently known about AV systems ahead of its introduction in the near future. Within the topic of AV systems, human factors and understanding around acceptance are currently key topics that have not been exhausted in their understanding and require further research (Rosenzweig and Bartl, 2015). Current literature supports the technical development of AV systems (91.2), rather than research on human factors (1.3%) (Rosenzweig and Bartl, 2015). This thesis helps to fill this gap in knowledge, contributing both confirmatory and new knowledge.

The study also contributes to the engineering requirements for future AV system development. Perceptions, concerns and potential acceptance factors were identified and recommendations or requirements to address these were identified. Discussed in Section 6.1 & 6.2, the requirements generally identify how best to design AV systems from a participant perspective, how legislation can be updated to reflect the changes to the road network, how AV systems can be introduced effectively within the context of the journey of acceptance from level 0 to level 5.

As well as the theoretical benefits to the AV community and possible identification of further research opportunities, practical factors also exist. By identifying approaches, which can ease the transition for users to AV system acceptance this study, is useful for both AV system manufacturers and for policy makers. Further discussion around the utility of this research can also be found in Section 1.5. The criterion of Usefulness discusses the possibility of future work that is warranted as a direct result of the work of this thesis. A complete section on future work and opportunities can be found at Section 7.3 and 8.3.

In summary, the application of Charmaz's (2006) metrics demonstrate the validity, applicability and originality of this study. The validity of findings is demonstrated through the strong participant base employed for the study, the rigorous analysis procedure and the influence of extent literature to confirm knowledge. The applicability of the study highlights its utility in academic research, system development and policy. The originality relates to the methodological approach and treatment of results, both of which have utility to future research studies and indeed have led to new areas to explore.

7.2 Research Output Weaknesses

A number of weaknesses are identifiable in correspondence to the study itself. In introducing the weaknesses identified, they do not affect the thesis validity, rather they highlight opportunities for further research to refine or extend the current work.

The first identifiable weakness associated with the study is the inability to test findings within the confines of the grounded theory. Unlike quantitative studies, the grounded theory provides no method of validating results. This is because currently, the findings do not carry any statistical factors that could have been subject to factor analysis or numerical confirmation. By approaching the topic from a qualitative standpoint, the finding is text based; rendering any processes of testing or validation a challenge. The grounded theory and the qualitative method of study provide various metrics that allow analysis and dissection of results, applications of these be made at Section 7.1 and 7.5.

It is key to note however, that the aim of the study was to capture perceptions and discuss adoption because of this, with no mention of statistical analysis to contribute to the study. Even so, the lack of testing can be acknowledged and renders the findings of the thesis as potential hypotheses to test. This is a trait of the grounded theory (Charmaz, 2006), and a point further discussed in the grounded theory introduction at Chapter 3.

To remedy the deficiencies created by the void of testing, the study had to employ strict guidelines around the development and presentation of results. Any concept that survived to the final presentation of results was contributed to by more than one participant or participant group. It was not the case that final concepts were created because of the analysis of one participant. Multiple mentions or discussions were required to validate findings as being reliable and worthy of assimilation into findings. In addition to this, the coding process required comparison between findings to ensure participant discussion was relevant to the topic, in line with the values of fellow participants and developing constructs within the analysis process. Lastly, where possible, findings were instantiated by literature to confirm their validity. This was done through association with current literature on relevant topics, thus creating the reputation and validity of developed findings. This process was only applicable to confirmatory knowledge, and this set of findings was distinguished from potential new knowledge, which was reported as testable hypotheses and findings subject to further development.

Although the presence of a rigorous test procedure would have further complemented the results, it was not possible due to the aims and adoption of the grounded theory. Much of the literature employed a quantitative approach to exploring adoption of AV systems and a clear opportunity for further work exists in adopting statistical analysis techniques, discussed in Section 7.3.3. Nonetheless, by adopting a qualitative approach, confirmatory and under reported knowledge have been identified, highlighting the benefit of this approach.

The second weakness associated with the study is the inability to present the results as representative of the market or wider body of users. Within grounded theory, sample sizes are usually modest, as the methodology intends to achieve its aims through the employment of a smaller sample (Charmaz, 2006; Glaser and Strauss, 1967). Within the confines of the study, proper application to and adherence of grounded theory principles does yield a robust research effort. However, as the pool of users that could potentially adopt AV systems in the UK is in the tens of millions (DfT, 2016), a strong argument can be made that the majority of current research studies pertaining to AV systems are not representative of the relevant stakeholders. Within the literature, for each of the studies listed, the highest sample size is 5000. This is within the work of Kyriakidis *et al.* (2015) who administered a 63 question survey to their sample across 109 countries (See Section 2.1.2). Currently, the aim of this thesis and research in genera is to establish a well-developed understanding of acceptance in the UK, in light of the domain specific factors on domestic roads, prior to considering an international market. From the extant literature currently considered, none can give a definitive explanation of AV system acceptance; each only contributes its acute understanding, with identification of further research opportunities.

This is most likely a contributing reason as to why each of the authors listed, discuss the need for further research into the field, through their comprehensive assessment of current understanding. This is not solely a trait of the qualitative studies; it extends also to quantitative studies operating in the environment too. However, amidst this weakness, this study and the wider world understand the implications of these smaller studies. As the field is relatively recent, with knowledge and understanding of AV system adoption still in its relative youth, the aim of this study is not to be labelled as representative. The key aim is to employ smaller studies, in some cases qualitative, to develop an insight into the topic, gather subjective perceptions and intentions, deepen topic understanding, leading to the development of tentative knowledge. Upon the culmination or possible exhaustion of this, the strategy should then shift to mass sample studies.

7.3 Research Output Opportunities

7.3.1 Data Interpretation

A key trait of the grounded theory is that the study must be grounded in the data that it has been collected in (Glaser and Strauss, 1967; Charmaz, 2006). This is a central tenet of the grounded theory and Moss (2016) describes this data as being the subjective view of participants. In applying grounded theory analysis methods to the data, an objective standpoint was assumed; however, a certain degree of subjectivity is associated, especially when dealing with data of this sort, in a constructivist environment. For data that is confirmatory, an objective standpoint is established. Similar in the case of deriving code, which is done from the data, rather than through a set of pre requisites employed by the study. Subjectivism, therefore, does play an intimate role in the analysis of data (Ratner 2002), and in some cases, the finished study is partially influenced by the researcher and their pre conceived interest and opinion in the topic. This is not a criticism of the study, but an indication of the effect of an individual researcher on a qualitative study. This represents an opportunity for the data to be coded, categorised and presented by an alternative researcher or group of researchers. Through this, the method of interpretation and difference in translation can be gained. The grounded theory itself provides a comprehensive structure for data collection, but not a complete overview of how apply the procedure in differing contexts. This is left to the discretion of the adopter. In the case of this study, by providing the transcripts to fellow theorists, it can be expected that the majority of the concepts discovered by this study can be categorised, especially that which is confirmatory. However, the findings that are underreported and the recommendations that are specified because of that knowledge will possibly differ, providing an alternative research angle. As well as being a method of validating findings, to ensure no bias or exaggerations have been developed from the data, this method would trigger further data extraction, unlocking the full potential that can be derived from the data.

7.3.2 CAQDAS Methods

Extending the coding procedure discussed above, a number of qualitative data analysts employ software programs to code their data. Although computer assisted qualitative data analysis (CAQDAS) is generally used on large data sets, it would again provide an alternative set of finings to this study (Adu, 2015). For the purpose of this study, CAQDAS tools would have benefitted the study through speeding up the time required for analysis and providing an advancement on the complexity of data analysis (Wong, 2008). This study however, employed a manual approach to analyse and present data. This decision was taken to ensure intimacy with the data was maintained. The ability to build and maintain familiarity with the data was the driving factor behind manual coding. However, reminiscent of the previous opportunity, CAQDAS methods would represent an alternative method of approaching the topic and presenting a set of related results. In addition, the subjectivism element would be removed with objectivity upholding the integrity of the results. Furthermore, bias or researcher influence would be minimised, appeasing research ethics in that respect.

7.3.3 Quantitative Analysis Techniques

The previous opportunities discussed methods that alternate from this study, rather than extend it further as a true opportunity. The most immediate opportunity that requires maximum attention is to infuse the findings of this study into a quantitative approach. Quantitative methods focus on statistical analysis of data collected through mediums such as polls, questionnaires etc. with a view to generalising data across groups of people to explain a particular topic (Babbie, 2010).

By utilising a statistical approach, and by accessing a wider sample, the study would begin confirming knowledge gathered by this study or help make informed adjustments. Creating a questionnaire or survey on the results of this study would allow users to score or rate findings, based on how they resonated with their individual perceptions. High scoring factors would lead to the retaining of successful concepts and low scoring factors would result in concept modification or potential discounting. This approach would mirror that of user testing and by accessing a large enough sample, claims of strengthened validity and representativeness could then be made. Additionally, structured equation modelling could then be implemented to assess the strength of factor connections.

7.3.4 Stakeholder Specific Studies

The next opportunity has been developed from the findings presented in the second section of results (5.2). The diversity on the stakeholder set led to a section on the results that was solely concerned with the different perceptions of various stakeholders. Here, the viewpoint concerning specific road user groups was categorised and presented as relevant perceptions of each road user set. Although similarities were found within the respective data sets, overall, each road user group had specific concerns, advice and fears in relation to their association with AV systems. As each group would be interacting with AV systems on different levels, it was expected that a diverse data set would be collated. For this reason, the opportunity to conduct standalone studies with each road user groups exists. Doing this would allow the gathering of a concentrated view of each road user group. The work of this thesis, in Section 5.2, has proved the scope of such work, with a multitude of data being gathered from each stakeholder. A future piece of work that created an empirical study around each road user group, ensuring the aims, questions and topics were specifically focussed on the respective stakeholder would yield a developed understanding of the spectrum of stakeholders in relation to AV systems.

For the long term, this would mean that all parties of stakeholders would be serviced, with the findings of each expected to influence the environment of AV systems. For the purpose of data analysis, themes that extended across stakeholders could be satisfied and discounted, with only the outstanding themes from each requiring attention. Overall, this method of dividing stakeholders from participants into their road user groups presents a structured method of investigation and research into AV system adoption. It ensures that all parties are consulted and an informed understanding that considers all those in contact with AV systems will be developed.

7.3.5 Model Development

One observation made of the first Section (5.1) of findings, was that the possibility existed to develop a conceptual model to represent AV system adoption. The findings are assimilated into three categories (Intention to use, technology usage and relinquishing control). As the categories are structured as such, they represent a possible chronological model for the acceptance of AV with intentions preceding usage, which in turn precedes further automation. The categories therefore can be seen as a conceptual model, or as a technology acceptance model of AV systems. This would then follow the ethos of popular technology acceptance models such as the original TAM (1989), TAM 2 (2000) and TAM 3 (2008).

Although, in this context, it is expected that adoption would not be linear, with users revisiting earlier stages and concepts as they move up the levels of automation. This positon was taken through participant interaction as it was noted that participants dealt with the various level of automation in a different manner, with some pursuing natural progression onto the next phase, with others raising concerns or requiring the fulfilment of certain criteria before progression. In the current context, the results can be assimilated into a static model, which would possibly represent a primary path through system uptake, but not a dynamic one that would represent the true nature of user adoption. The development of a dynamic model would require the use of simulation equipment or the employment of AV system prototypes designed to emulate each stage of automation progression. Being able to observe potential users in this environment would yield an understanding of actual usage and the method of automation progression adopted by a sample of users. Through analysis and evaluation, this would allow the study to create a model that would be representative of how users would possibly adapt to and maintain usage of AV systems. Employing an approach such as this would be reminiscent of the work of (ward) who conducted field-testing with a sample of users to forecast usage of advanced cruise control systems.

7.3.6 General Knowledge Extension

The concluding opportunity associated with this research and the wider community is the general research opportunities that are required to further service the environment of AV systems. The key advice highlighted within the literature review was that further research is necessary, from both a qualitative and quantitative standing (Section 2.1.3). The relative youth of AV systems and the knowledge gap associated with its adoption has created a niche area that requires knowledge population. The majority of the studies listed provide a high-level view of adoption, a generalist response to the need for understanding. Alongside the existing literature, the requirement is to begin developing a deeper understanding of AV systems that would yield a representative understanding and a thorough outlook on the matter. By obtaining this, system introduction can be accelerated, in a safe and considered environment.

The term general is used to describe the characteristics of the research required for this study. Upon results presentation in this study, it was noted that the set of results yielded were very diverse, with a number of areas and topics combining to provide a complete overlook of AV system adoption. For this reason, it was judged that adoption in this context is multi-disciplinary and not confined to one area of knowledge. The discovery of such means that for a conclusive understanding of AV system adoption, the community must conduct research in a number of key disciplines (trust, change, attitudes, usage etc.) to attain an exhaustive understanding on the matter.

As the grounded theory process is heavily reliant on researcher action and influence, especially in this case of individual research, the opportunities were heavily influenced by opportunities related to this. Proposals were made to alter the analysis method by inviting an alternative researcher to conduct the grounded theory from the process of open coding to categorisation. In addition, CAQDAS techniques were advertised as being able to provide an alternative view on results. These methods were selected as they had the ability to provide further extraction of results, whilst allowing confirming of the original concepts identified by this study. This could serve as a low-level method of testing and validation on results, ensuring researcher influence or bias did not lead the compilation of concepts and categories.

In terms of opportunities that truly extended this study by utilising its findings for further exploration were to use the categories from the first section to develop a technology acceptance model. This proposed model would be specific to the field of AV system acceptance, would contain all the concepts requiring satisfaction prior to consenting acceptance, and maintained usage. Further proposals were also made to divide and populate road user groups with a focus on developing multiple studies focussing on each road user group to achieve an exhaustive understanding on the perception of each. The benefits of doing this have been introduced at a high level by this study as each road user group cited a variety of concepts that required satisfying prior to their interaction. Possibly the key benefit in relation to this opportunity is that each stakeholder group will be consulted, ensuring the stakeholder centred approach of the system, rather than solely addressing car drivers, and overlooking the rest.

The most urgent opportunity however, is related to the introduction of quantitative analysis to this study and its findings. Doing this would allow the validation of both confirmatory and new knowledge as relevant to the community and the discounting of knowledge deemed irrelevant. Although it is anticipated that the latter would not occur, the possibility of ranking concepts into their respective importance classification would provide the community with further utility. In addition, any form of statistical analysis would serve to strengthen the defence and further application areas of this study, contributing to its overall longevity and relevance.

7.4 Transferability of Research

In extension to the opportunities discussed above, this section will explore the value that could be obtained in the transferability of the finding and research principles to sectors other than this one. To support this discussion, chapter 6 built on the findings of chapter 2 and spoke of how current technology supersedes existing technology acceptance literature, so requires domain specific acceptance understanding to service it. This is the belief of this thesis and is evident in the research conducted for this environment. When comparing the acceptance knowledge gathered by this study, and compared to a general technology acceptance model and literature, a number of factors are synonymous between the two. However, it is also clear that a large number of domain specific issues do exist and require identifying, such is their ability to halt or deter successful acceptance.

For the above reason, and when comparing modern acceptance models (TAM 3, 2008) to legacy ones (TAM, 1989), it can be understood that modem day acceptance is vastly different to the technology it is replacing and different episodes of technology acceptance have different requirements and needs. The work of this thesis has explored a modern day instance of technology acceptance to a specific domain. Because of this, various transferability opportunities exist, for both the findings and the research principles. A selection of these are discussed below.

The utility and transferability of the finding themselves may be to a limited environment as they are highly specific to the field of AV systems in road transport. In fellow transport, situations that currently involve human drivers/operators, these findings would prove useful in displaying the range of perceptions that exist prior to implementation, allowing concerned potential users to have some information to relate. In addition, system creators or commissioners could use the findings of this study to forecast issues they would face when attempting to harmonise human-computer interaction. A certain portion of the findings also discuss design, legislation and experience requirements, a knowledge set that would prove useful when attempting to predict such requirements for state of the art systems. Although autonomy has long been involved in the transport sector (aviation, trains), it is possible that major technological upgrades in driverless pods, HS2, truck platooning and any avenue currently unknown would allow the commissioning of this research for steering purposes. In the short term, the value and exposure of this thesis should remain within the environment of road transport; such is the need within this sector for knowledge development and application.

In considering transferability of the research principles, its ideology and process, the following areas can be subject to transferability on this sense. In healthcare, where users are expected to interact with an artificial intelligence medical system (Oakden-Rayner, 2017), this study can support a multi user study to understand the issues of interaction and usage. In addition, as the technology is state of the art, and something not seen by users, acceptance of it can also be ascertained by applying the principles of this study. In weaponry and warfare, issues of autonomy in relation to legalities, ethics, human interaction and public perception (Carafano, 2014). An engaging study that adopted the principles of this research would allow the capturing of public and user data on the mentioned issues and wound eventually yield valid recommendations to satisfy or overcome the issues presented.

Lastly, variants of the word SMART, such as SMART homes and cities are set to further invest in societal improvements, with technology set to become more prevalent in daily tasks (Bell, 2017). Although the introduction technique is likely to be incremental, with participants becoming acclimatised to the technology upon its introduction, rather than vice versa, it could be considered unnecessary for such a study. However, as noted earlier in this section, state of the art technology challenges users more, requires a higher level of behavioural shift and is exploitative in a way that is unparalleled by current day technology. If it transpired that to comfortably introduce this, user engagement would be required, again the principles of this study could be applied to collect the relevant data and apply it to the design, refining or implementation phase.

Overall, this section briefly discussed the transferability possibilities of this research, focusing on its values as a research tool and on its findings. On the findings, it was noted that it would be possible to transfer into fellow transport sectors, given the domain specific nature of the technology. In the wider world, technological and autonomy improvements in a number of sectors were highlighted where the principles of this research process around the multi user sample and grounded theory could be utilised. What remained clear throughout this section is that due to the disruptive and highly specialised nature of incoming technology, existing acceptance understanding could only provide a generic response to the need to study it. Rather, it would be necessary to apply studies such as this to those areas to learn the unique issues that are prevalent for their respective users.

7.5 Methodology & Sample Analysis

Chapter 3 provided a comprehensive overview of the methodology adopted within this study, whilst Chapter 4 discussed how it would be utilised for this specific application. As discussed in the study, the constructivist version of grounded theory, initiated by Charmaz (2006) was selected as the primary methodology to achieve the aims of the thesis. The following discussion will outline various points of analysis related to researcher experience in applying the grounded theory. The section will draw on the experience of using the methodology and how it benefited or limited this particular application area.

As discussed briefly in the previous section, the grounded theory does not provide a comprehensive set of analysis tools to survey studies that adopt it. For this reason, metrics from the wider qualitative family were sought to analyse the work of the study. The CASP qualitative checklist was selected to operate alongside the Charmaz (2006) metric in the complete survey and analysis of the study.

Introduced in 1993 to meet the challenge of evidence based medicine, the current day format includes many peer reviewed checklists and metrics to provide critical appraisal. Amongst the list, the qualitative checklist stood out as the tool required for the needs of this thesis, with a set of ten questions designed to make sense of and assess the validity of qualitative research (CASP, 2014).

An application of the checklist can be found below.

1) Was there a clear statement of the aims of the research?

A clear statement of intent, defined by a collection of aims and objectives can be found at Section 1.2. As well as this, an analysis of whether these were satisfactorily met by the study can be found in Chapter 8.

2) Is a qualitative methodology appropriate?

Chapter 2 highlighted how the majority of current understanding on AV systems has been developed through the application of quantitative research. This was identified through the documentation of current understanding at Section 2.1. In observing the development of knowledge on the topic, it seems that pursuing a quantitative methodology would only yield saturated knowledge that already exists. This is because public knowledge on AV systems is limited to approaching the subject with an identical approach to that which currently exists would not yield anything indifferent. Rather, this study proposed a qualitative methodology in the grounded theory as it felt that it could build on the current quantitative knowledge by expanding the understanding around findings of those studies. This has been evident in this study with the already known knowledge facing further extraction to develop conclusive understanding of each point. Examples of this can be found in chapter 5 where rather than stating that ‘x is affecting participants’ the study has been able to delve further and explain ‘why x is affecting participants’. This would not have been possible with a quantitative study, as they do not have the framework to digest deeper insight. Rather, quantitative surveys are useful for confirming knowledge or selecting between a limited numbers of outcomes.

For the long term however, the thesis is proposing a return to quantitative techniques to confirm the work of this study and to allow it to reach a wider market, increasing its representativeness.

Section 3.1 of the thesis introduced the grounded theory as the methodology of choice to fund the aims of this thesis. This selection was made in light of considering alternative qualitative and quantitative methodologies and arriving at the conclusion, that each was not sufficient to meet the aims of this thesis. The grounded theory has served the thesis beyond expectation. It has been comfortable in collecting, sorting and analysing the subjective perception of participants and being able to derive from it, usable knowledge. This knowledge was then subject to literature comparison, as well as comparison within itself to develop refined knowledge that is presented in Chapter 5. This simplified process, expanded at Chapter 4, displays how the grounded theory served as a sufficient vehicle to achieve the aims of this thesis and develop knowledge of value for the community.

3) Was the research design appropriate to address the aims of the research?

In the unique case of this study, two stages of justification were required. The first stage was to justify the usage of the grounded theory against alternative methods and this can be found at Section 3.5. The second stage is to justify the adoption of the Charmaz (2006) constructivist version of the grounded theory and this can be found at Section 3.4.

4) Was the recruitment strategy appropriate to the aims of the research?

Section 3.8 gives an in depth overview of the sample and participant selection. Snowball sampling was selected as the sampling strategy to recruit the required participants into the study. By working individually, the study was unable to access the required participant for study, as an awareness of each did not exist. Through adopting snowball sampling, the study was able to capitalise on certain referrals and from this, access individuals and organisations who then became participants within the study. Although all referrals were acted upon, not every referral became part of the sample. As the sample size of grounded theory is historically modest (Charmaz, 2006), certain criteria was developed by which each candidate was measured. This ensured that researcher bias did not interfere with selection, that successful participants had the required knowledge to benefit the study and that a balance existed between the different types of participant, ensuring no one road user type enjoyed an unfair advantage in numbers.

To achieve the aims of the research, the study attempted to recruit a sample that represented the road network. Whereas much of the extant literature recruit's participants without stereotyping, this study attempted to recruit participants based on a number of defining factors. It was determined that the participants would be differentiated by the method of transport they used for the majority of their travel. This led to the categorisation of the following road user types; motorists, motorcyclists/cyclists, HGV drivers, pedestrians and infrastructure organisations. This method of developing the sample base was adopted as it meant that the study had the employment of a sample that was representative of the stakeholders who would encounter AV systems. In addition, to extend knowledge around AV system acceptance, rather than solely attracting car drivers, the study invited participants who would be directly and indirectly linked to AV systems. This guaranteed that the viewpoint of all road users would be gathered and presented, previously not done by the academic community and the targeted development of results through clear participant identification. The aims of the research were to capture perception of AV systems, and the cosmopolitan sample of this study ensured this occurred. If the study attracted only car drivers, one type of perception would be gained, which could be critiqued for being too narrow and one-dimensional. By assuming this sampling approach, the study now has the ability to report acceptance and perceptions from multiple viewpoints, increasing the value and validity of reported findings through a multi-dimensional and representative sample.

Upon participant confirmation of interest, each participant was provided with a form outlining the purpose of the study, his or her individual role, some background information, possible interview questions and a section concerning interview ethics. This form served as the catalyst in providing an overview of the study, ensuring participants understood and conformed to the requirements of the study. A signed copy of the ethics form (appendix 3) confirmed individuals as participants in the study.

5) Was the data collected in a way that addressed the research issue?

The method of data collection within the study consisted of three key tools; semi- structured interviews, focus groups and forum use. The initial project plan only accounted for the use of semi- structured interviews; however, the opportunity arose to conduct the latter two and given the success of one to one interviews and constructivism, it was decided to investigate constructivism in light of forums and focus groups. This change was documented in the thesis and it was found that grounded theory supported the use of 'mixed methods' to gather data.

As mentioned above, interviews were conducted in a semi- structured nature with the location being one that was comfortable to the participant, usually in a location common to them. A topic guide or question list was created (see appendix 2) and this was used as a start point or a reference tool in each interview. However, participants were encouraged to deviate from this list and to explore areas they considered relevant, given it was their perceptions being recorded.

Saturation is a key milestone narrated by the grounded theory as it signifies an ending to the data collection procedure. Within this study, saturation was reached at the penultimate participant (GT09). However, due to the schedule of the final forum being arranged prior to saturation, the study extended the collection process through to GT10. This evidence displays the key findings from all participants in a chronological order and as this display progresses, it can be visually seen that the new findings decrease and recurring patterns increase.

6) Has the relationship between researcher and participants been adequately considered?

An active role was played in the study, from formulating questions to leading proceedings in the interview setting and contributing to data collection. This is in line with constructivist grounded theory (Charmaz, 2006). Given this active role, the possibility of bias influence existed on a number of levels. The following measures were adhered to, ensuring these unwanted associated did not occur.

The snowball sampling method was key in allowing bias avoidance within the sample recruitment stage. As the study relied on referrals for potential participants, no bias existed in the presentation of participants. The possibly of bias existed once referrals had been made, with the ability to influence which referral would then become a participant in the study. For this study, participants who were identified as subject experts would have provided data of the highest quality. This would have eased the analysis process and yielded a set of results that were extremely complimentary of the study and would have presented it in a positive light. This was avoided, with participants sought that had a mild understanding of AV systems and a strengthened understanding of their own road user field. Also, with the provision of a 'Research study explanation form' (appendix 3), the expectation of study participation was given to individuals through this document; with the study only ensuring each individual met certain criteria prior to their inauguration. The criteria were made up of ensuring no participant was a subject expert, that each participant represented a road user type and had an opinion or interest in AV systems.

In terms of the interview setting, participants were asked to provide the interview location if possible. In the case of forum meetings, organisation members were prompted to designate a meeting place. This was key in maintaining participant comfort in their surroundings and using this comfort for perception exploitation. Furthermore, a dress code was deemed too formal, with both parties approaching the meeting in an informal fashion.

The questions that were used in the interview setting were dynamic with regular evolvement taking place. Earlier participant interactions influenced the question set, based on question performance, level of response and participant discussion. If a question did not lead to an extended discussion around AV systems, rather it operated a closed question; it was either modified or discounted. By operating in this manner, as the study moved towards the latter end of participants, all questions had been moulded and were developed because of earlier interaction and feedback on question performance.

Lastly, within interactions, as mentioned earlier, researcher contribution is encouraged in data collection scenarios. Within this particular study, contributions were made by encouraging participant response, providing objective information, clarifying points for participants and introducing literature where required. The subjective view of the researcher was avoided as it was found to be in favour of AV system implementation and this viewpoint could have possibly spoiled data collection and influenced participant forecast. Also, as the subjective mind-set of the grounded theorist was in some cases, extremely different to that of participants, the possibility to create bias within participants though social expectation existed. For this reason, contribution was limited to that which is listed above. By adhering to this, the ability to influence participants, data or the overall study was minimised and the data collected from participants was valid, as it was free from bias, influence or social expectation.

7) Have ethical issues been taken into consideration?

A comprehensive overview of the ethics associated and adhered to by this study can be found at appendix 1. This section covers adherence to the relevant legislation for data management, participant consent and anonymity and the rights of all concerned parties.

8) Was the data analysis sufficiently rigorous?

An in depth description and commentary of grounded theory application can be found at Chapter 4 (Techniques). Here, the study provides a comprehensive overview of how the techniques of the grounded theory were utilised to develop understanding from a position of transcribed data to the eventual categories presented at Chapter 5. Chapter 4 displays the stages of analysis adopted within the study to achieve this development. By adopting a constructivist approach to the grounded theory, the relevant approaches to coding, analysis, memo completed and concept categorisation were used. The process highlighted at Figure 13 displays a methodology flow chart, and this process was administered to each data set derived from every participant. The examples of Chapter 4 differ in their content, however, their construct and presentation is uniform, in line with the strict application procedure of the grounded theory on gathered code. Further evidence of strict application can be found at appendix 4, where further examples of grounded theory application is displayed. The Charmaz evaluation tool discusses whether the data is sufficient to support findings and this discussion can be found at Section 7.1.

9) Is there a clear statement of findings?

Chapter 5 displays the two sections of findings derived from the study. Chapter 6 provides a comprehensive discussion of the findings. Given the nature of the grounded theory, the findings are usually sizeable and as such, require extensive space for presentation an equal for their discussion. In addition, analysis of the results can be found at Section 7.1 and 8.2.

10) How valuable is the research?

The primary discussion of this question can be found in the usefulness Section 7.1 of the next chapter.

7.5.1 CASP Application Summary

By applying the CASP qualitative checklist to the analysis of this chapter, the thesis was able to confirm the inclusion of core components. As well as this, core features such as the research design, sample and sampling method were analysed to understand their impact on the study, any unwanted variation and if sufficient evidence had been provided for each. It can be expected that a yes answer and sufficient evidence for each question posed by the checklist would result in a successful research study.

In some cases of the checklist, the discussion around questions was extensive, and in others, it was short. The reason for this is that the discussion and analysis of some components is exhaustive at this stage with no need for further discussion. Also, as some components are not dynamic i.e. they do not change from pre study to post study as they are applicable in their static state across the study, they require no further discussion e.g.

ethics. In some of the questions, such as that of the sample, an extensive discussion has taken place discussing the challenges presented by the CASP on that particular component.

7.6 Methodology and Sample Limitations

Although discussed briefly within the weaknesses, a number of limitations associated exclusively with the methodology and sample were found during the study. By this, during application of the methodology to this subject area, a number of limitations were encountered that restricted the thesis. Although at this stage, the methodology and sample both performed sufficiently to warrant the claims and stature of the work, by documenting the limitation, the ability to have progressed further can be noted.

A major limitation of the grounded theory is that it does not provide a testing metric within which to assess the quality, value and claims of the results. Currently, upon completion of the analysis process, the reader is presented with categories and concepts that are related to the subject area, otherwise known as tentative hypotheses (Charmaz, 2006). This means that, in their current form, findings are soft results that require further validation or extension to reach their end. This could potentially be translated as an incomplete thesis, lacking the final stage of validation, prior to reaching its end. The merit of being able to properly test results would be an increase in the thesis value and a reduction of unwarranted variations.

However, to gain a true insight into user perception of AV systems, whilst overlooking the validation element, the grounded theory has served as the ideal tool of exploration. It has provided the scope to sufficiently extract qualitative data and analyse it in a method to report on potential, relatable findings. As cited by Glaser and Strauss (1967), & Charmaz (2006), the role of the grounded theory is not to provide the outcome; rather they state it is to develop a working theory, tentative hypotheses, that creates the foundation of required knowledge.

Lawrence and Tar (2013) attribute the grounded theory as being the precursor for further investigation, with its usage being suitable in areas such as this, with limited current knowledge. Importantly, this study has acknowledged this limitation and the effect it could have on the thesis, if the findings were preserved in their current state. However, as Lawrence and Tar (2013) mention, the thesis has identified alternative methodologies to verify and in some cases, extend the qualitative propositions made by this study. In qualifying this outcome, the thesis has settled this limitation and created a niche within which to conduct further research and add further value to current understanding of AV systems.

The second limitation is the suppressive role of literature within grounded theory application. Prior to study commencement, the Glaserian (1987, 1998) and Charmaz (2006) both champion the process of avoiding a pre study literature review as it stifles creativity or leads theorists down well documented, linear paths of understanding. Glaser (1998) continues this theme by stating the premise of the grounded theory is the unpredictability it develops and how this will lead the theorist down avenues not expected, to new findings. The danger of a premature literature review is primarily the fact it may be misleading, create bias in the collection and analysis process, as well as being wasteful.

The problem with the above was that it limited the ability to engage in conversations on the topic with participants and supressed the ability to truly contribute in a constructivist environment. During participant interaction, the data collector is expected to be the definitive source of knowledge on the respective topic, and by avoiding a pre-study literature review, this estimation of their position is not fulfilled. Fortunately, a pre-existing interest in the topic of AV systems was present and this was sufficient in participant discussion, leading to the rich data and discussion reported within the transcripts and analysis process. Without this understanding, it would have been challenging to understand the quality of data passing through the study, hard to truly commit to snowball sampling as it would not have been explicit which of the participants were truly serving the study and as mentioned earlier, an environment of constructivism, a central tenet of the Charmaz (2006) approach, could not have been sustained.

This is a key limitation of the grounded theory, although it comprehensible why the theorists have set it so. Given the exploratory nature of the grounded theory, and true exploration occurring without a ‘blueprint’, certain adjustments would embed it properly, without risking the participant interaction situations.

Given the benefit of the initial literature review, which understood current trends and media opinions on the issues, design methods were consulted on how to involve literature, without bias. Many different elements were considered; however, the one that came out on top was to employ two man teams to conduct grounded theory studies. In doing this, two types of roles were discussed;

- The two researchers each have separate roles, one would conduct the literature, monitor proceedings, informing and refining process where required, and the second researcher would work through the grounded theory as usual. This method would ensure that the second researcher could not apply any bias to the study as they had no extant knowledge on the topic and the first researcher would only intervene where required, providing just enough knowledge to complete the task at hand, without providing a full picture or solution.
- The second method would involve both working together in a kind of 'pair-programming' environment where each validates and comments on the work of the other. This would help to not only remove bias, but also a wide range of associated issues, such as improving the coding procedure, the ability to compare and contrast data analysis findings and a greater influx of literature addition etc.

As the grounded theory comfortably worked in the favour of this thesis and the many other efforts that have applied it, changes to it are unnecessary. The issue of the literature review, although still contested, is not down to the fault of the theory; rather it is reliant upon the skill level of the grounded theorist. The correct training and experience are the tools that assist in ensuring bias does not play a role in any study and it is this level of skill that determines the inclusion of bias, not the position or time of introduction of the literature review.

7.6.1 Sample Limitations

The issue of the representativeness of the sample has been discussed previously, but is not considered a limitation, or even weakness associated with the sample. Rather, that is a weakness of the study, and a trait of the grounded theory. The strengths and benefits of this particular sample base have been discussed extensively at Section 3.8. The following discusses the current limitations identified that concern the sample.

Within the sample, concerted efforts were made to include stakeholders who represented each of the major road user groups associated with AV systems. However, the inability to attract and employ participants who represented the emergency services community served as a limitation of the sample. Although efforts through referral and approach were made to stakeholders such as the police, this did not result in their participation. Involving participants who would be managing and enforcing correct usage of AV systems would have provided further depth to the data set and their perception, including governance and legislation would have provided utility, especially when considering the results of earlier participants. A scenario could have been envisaged where members of the police could have considered the results of earlier participants with a view to observing how it differed to their perception, especially situations involving misuse and the legalities of AV systems. In addition, members of law enforcement could have described how implementation of AV systems would translate to them in their role, further analysing implementation on public roads.

In a future scenario, conducting a study, satisfying the above would provide a valuable piece of work on the topic. Rather than a varied sample, focusing specifically on law enforcement, with interviews occurring with staff at different grades, an understanding of the legalities and governance surrounding AV systems could be gained, with a practical overview of how such a scenario would look. A study of this nature, however, would have to be deferred until the relevant legislation by which they would act would be in place. Upon this, by addressing the above limitation, further efforts to expand understanding within the community and satisfy AV system legality implementation exist.

The concluding limitation of the sample was participant inability to physically see and use AV systems. To no fault of participants, AV systems are not currently available for public consumption; hence, the ability to interact with them is non-existent, which affects their responses. During the study, it was noted that as expected, participants are structuring their responses around their perceptions of AV systems, discussing the topic subjectively, though their influence by research or the media. Given the ability to use AV systems, the responses of participants would have been more reliable, as it would have been based on actual usage, rather than forecast.

This limitation was acknowledged prior to inducing the sample in the study, and was recognised as a limitation, rather than a weakness. This is because currently, this is the extent of understanding from users, and is not grounds for dismissing their perceptions, especially as it has provided utility in recommendations made to potential AV system implementation. The entire extant literature on AV systems is currently based on participant perception, so this limitation is still observing current practice and is using the available tools to extract maximum knowledge about the subject, prior to its arrival. In this isolated context, it can be considered a limitation, but when considering in the wider context, this limitation is not as such, rather, it is the status of the topic.

7.7 Chapter Conclusion

Within this Chapter, attempts were made to extend understanding and analyse core components of the study, including the methodology, sample and characteristics of the findings. As a conclusive discussion on the findings and their potential application was discussed in the previous chapter, at this analysis stage, the utility, objectivity, weaknesses and associated opportunities were analysed.

Charmaz's (2006) evaluation metric and the CASP (2014) qualitative checklist tool have been used as the basis of this chapter to evaluate the quality and rigour of research that has been conducted. For Charmaz's (2006) evaluation metric the four key evaluation criteria (Credibility, Resonance, Usefulness, Originality) were applied to the study and the findings explained in relation to these criteria. Limitations, weaknesses and opportunities arising from the research were discussed, with a range of future research opportunities proposed. Finally, the CASP (2014) qualitative checklist was also used as the basis of the analysis of the research methodology. The checklist enabled all criteria to be explicitly considered within the study and appropriately addressed. Additionally, limitations associated with the methodology and sample were discussed with accompanying commentary on how to limit their influence or reverse their effect.

Moving forward, the study will now look to conclude on this research study by considering the implication of the findings for the implementation of AV systems on public roads. As well as this, the study will look to introduce the higher-level limitations and opportunities linked to this field of study.

Chapter 8- Conclusion

This Chapter will provide conclusions that have been identified during this research. As well as this, the Chapter will look to finalise understanding around the learning and findings of this thesis by presenting a concluding discussion on driverless vehicles implementation on public roads.

Early sections of the Chapter will discuss how each of the objectives presented at Section 1.2 have been satisfied. This section will allow the documentation of overall activity of the entirety of this thesis.

Given a large set of results was developed through application of the grounded theory, the Chapter will move to presenting the key analysis and recommendations of the study. Doing this will provide detailed context to the findings of the study and will further highlight their utility and the necessity in their study. Alongside the research extension opportunities discussed at Section 7.3, the conclusion Chapter will assess the opportunities that are available to the AV community, and what value can be added by adopting them.

8.1 Aims and Objectives Assessment

The aim of the study are provided in Section 1.2 are:

The aim of the thesis is to develop categories of acceptance that support successful uptake of driverless vehicle technology across a range of stakeholder groups. This aim will be achieved through the following research objectives:

- To review current literature on autonomous vehicle acceptance, identifying existing knowledge gaps to assess the need for further study of this topic;
- To undertake a grounded theory study to capture perception of, and attitudes towards, autonomous vehicle acceptance and usage;
- To present findings, deriving from the grounded theory study and reviewed against existing literature, which supports autonomous vehicle acceptance and usage by a range of road users; and
- To recommend areas of further research, through identification of opportunities presented by the research through its output and analysis.

The following sections present a brief overview of the research undertaken in this thesis in regards to each objective.

8.1.1 Objective 1

Chapter 2 carried out a literature review of current understanding of AV systems, specifically focusing on the areas of acceptance and attitudes. Within the literature related to acceptance, theoretical and empirical studies were discussed to gauge what the community currently understood in relation to acceptance of AV systems. This allowed the thesis to identify areas of further research (See Section 2.1.2) and the commissioning of this study, as well as listing literature that would be used in comparison with the findings of this study to display (See Chapter 6). This also extended to the literature on attitudes towards AV systems and this knowledge was used to compare with and understand the findings related to specific stakeholders. As these findings were of a higher concentration and looked past general acceptance factors to developing an understanding of why stakeholders had particular perceptions of AV systems.

To complement the above research, general technology acceptance was discussed, by way of introducing popular technology acceptance models. This gave a general introduction to technology acceptance that covered a chronological timeline of technology introduction from the first technology acceptance model (Davis, 1989) to more recent understanding (Ghazizadeh *et al.*, 2012).

8.1.2 Objective 2

To collect data and employ a framework of coding and analysing data, the grounded theory methodology was implemented. Within this framework, the Charmaz (2006) variant of the grounded theory was selected as most suitable to service the aim of this thesis, given its focus on 21st century social research (Charmaz, 2006). An introduction and justification to the grounded theory is discussed at Chapter 3, with a practical application documented at Chapter 4.

8.1.3 Objective 3

Discussed on the previous page, the findings were presented twofold. One, findings presented through categories of acceptance, relevant to those who would actively use AV technology. Additionally, the second stage of findings discussed acceptance factors and specific concerns of the majority of major road user types, as well as including direct stakeholders, the bulk of these findings were related to those indirect stakeholders who would be near the AV technology during its operation.

8.1.4 Objective 4

Given the fertility of the field, a number of opportunities became apparent when studying the literature, considering the limitations of this thesis and attempting to contextualise this research and current understanding in the wider environment of AV systems. The conclusion chapter described this thesis as a ‘working’ thesis in that it is not conclusive on the topic of AV acceptance; rather it is a continuation of existing research, and progresses understanding through its qualitative approach, in a largely quantitative biased environment. Because of this, an number of recommendations and further research opportunities, both related to this research specifically and the AV community have been developed (Chapter 6 and 8). This is in addition to the results of this thesis, which themselves also require further study and validation.

8.1.5 Summary of Assessment

This section reintroduced the aims and objectives of the research study to assess the execution of activity and the extent to which the aim and each objective had been met. By listing, the overall activity of each component and the majority of chapters that make up this work, the justification for and delivery of each objective could be made. The Chapter will now present the concluding discussion that takes into account the entirety of this research effort and aims to succinctly present its understanding on driverless vehicle implementation on public roads, with a particular reference to public acceptance.

8.2 Driverless Vehicle Implementation on Public Roads

This section will present key findings of implementing driverless vehicles on public roads.

- The results of the study suggest that proposed users of AV systems would accept the technology in the same manner that they would accept any other piece of technology.

- When exploring perceptions of the ability of AV systems, it was found that the estimation of AV systems was higher than the actual capability or status of the technology. In a minority of cases, estimates were negative towards the technology, and associations of under trust were made with the technology. Upon exploration, it was noted that much influence was taken from media outlets or speculation on the matter from unverified sources. For the community, this represents a dangerous situation. As the technology is state of the art, and is considered highly disruptive to society, participant interest will be growing in the topic, with a requirement for correct, reviewed information available on the topic.
- Personalisation in service is key for user acceptance. Although compete personalisation is not possible, given the likelihood of AV system adoption by the masses, a degree of personalisation, or various levels of personalisation can still be implemented. For example, uptake patterns differ within users. In an AV environment, the technology must be marketed at different price points to attract custom from across the spectrum, not just at the higher or lower price point.
- The last discussion of personalisation in service discusses the interfaces available to users. Modern vehicles such as Audi offer users full digital dashboards, also known as virtual cockpits (Audi, 2017). This digital approach to cabin design differs from the traditional static design of existing vehicle and as such, can be highly personalised. As well as being appealing to a wider range of users, thus increasing acceptance, this would greatly influence the safety of safe AV system execution, with users fully understanding and being comfortable with the technology.
- When considering technological innovations that have been attached to road transport, such as ABS, cruise control and other technology that have implemented change, the process of their introduction was praised by participants. Technology has usually been incrementally introduced, with major updates usually introduced at alternate intervals, rather than simultaneously. This ethos should be extended to AV system implementation, with levels of automation introduced at different intervals, allowing users time to acclimatise and adjust to each stage.
- The technology must have ‘submissive’ characteristics and yield to legacy systems in scenarios of conflict or progression. This would ensure that proper respect is afforded to the legacy mode of transport, with an understanding of concepts such as ‘unwritten rules of the road’. In the long term, this would allow AV systems to be implemented with minimal resentment and would promote long-term acceptance, as the technology would not be considered in a negative light, given its introduction technique.

- Alongside an incremental introduction of the technology, the results of the study suggested a staggered uptake of the technology in terms of their allowance for its usage. Every participant of the study spoke of only feeling confident and comfortable in using the technology on the motorway zone. Participants noted the fear and lack of trust of using the technology in urban zones, given the unpredictability and higher number of moving variables involved.
- Regardless of manufacturer or AV provider, participants agreed that a degree of consistency must be applied in vehicle design. In the same manner that current vehicles have similarity in their symbols and features, this was a requirement for AV systems too. Through regulating the design process, the fundamental usability principles of AV systems can be learnt and retained by users in an environment that would transcend manufacturers.
- In considering the exterior of the vehicle, the consensus was that versions of AV systems that had been viewed by participants were not in line with current vehicle design principles. Participants expected a slight variation in design to account for the technology, but overall spoke of the need for vehicles to adopt physical attributes, similar to current vehicles on the market. This would maintain the ability to adapt to the technology with relative ease, given the ability to relate to the vehicle.
- In considering the overall ethos of driverless vehicles; the ability to maintain the driving task whilst incrementally removing responsibility from the driver until the vehicle is self-sufficient, the key recommendation from participants was to provide them with meaningful human control. This recommendation was developed from considering the drawbacks of automation within transport, as observed in aviation
- The final recommendation of the study in considering the design of driverless vehicles is the need for it to identify and classify different pedestrian types. The road user group of pedestrians rightly identified themselves as the most vulnerable of stakeholders near driverless cars. As such, the need to identify pedestrians, especially the different types (less abled, children, vulnerable, elder) was classed as imperative to gain acceptance from pedestrians.
- Presented above are the recommendations developed by the study for the AV community. The recommendations were developed from the work of Chapter 6, where literature and study findings were combined and placed in the context of progressing AV system implementation on UK roads. As a result of this contextualisation, the results of the study; user perceptions of AV systems, were further developed and given societal utility, as well as the earlier reported theoretical utility and significance discussed in Chapter 7.

Moving forward, the last section of this discussion on AV system implementation on public roads will attempt to combine the findings, learnings and literature presented and considered within this thesis. In doing this, the thesis will present a final overview of AV system implementation, with a special focus on public acceptance and the associated implications of this thesis on the wider AV community.

- It must be considered that even with minor pushback from road user groups; overall, AV technology is welcomed by each group consulted. When consulted, each participant understood the need for the technology, amidst current failings and legacy system issues.
- The literature review (Chapter 2) suggested that to introduce AV systems onto the public roads, the blueprint of existing literature could provide a strong foundation. When analysing participant data, it was concluded that the framework of accepting AV systems, was very similar and in the same chronological order as the work of the original technology acceptance model (Davis, 1989) and of Lewin (1951).
- The issues raised by participants were mainly around the ability, pricing strategy and individual role they played in an AV system environment. Overall, it was found that participants currently lack the actual knowledge to sufficiently understand, and therefore negotiate with the system. Many cases of over/under trust were presented at a perceptive level, with misinformed participants believing the system could offer them more or less, than what it actually could.
- Fears about the role they would play also surfaced, especially when engaging with participants who identified their vehicle as a primary source of income. When exploring their line of inquiry to arrive at their particular assumption, it was found that speculative or biased media sources were informing participants, as they were unable to access the relevant and correct information.
- When considering the road user groups affected by AV systems, the results of the study would suggest that car drivers stand to benefit the most from AV system instruction. As well as the external benefits of a reduction in pollution and congestion, less street furniture, increase social mobility etc. They would feel internal benefits from being the direct recipients of the system.
- The safety element of AV technology is possibly the most important factor for the collective stakeholder base. When exploring the reasoning behind regular road traffic collisions, current perception from participants in the study is that it is down to driver error.

- Motorcyclists and cyclists both stated that they had to ride defensively and were always cautious when in the presence of the vehicle, suggesting this hindered their ability to safely ride, as their concentration was not on their own transport. It was suggested that through AV system implementation, and an overall improvement in the driving and conduct of vehicles, motorcyclists would be able to focus on their own riding task, thus improving the safety and execution of their road user group.
- The results of this study suggest that the motorcyclists and cyclists group displayed the highest levels of motivation and willingness towards the introduction of AV systems. Unlike pedestrians, who were motivated for change, but not trusting of AV systems, this group recognised the value that could be added by the technology in progressing safety of vulnerable road users and an unbiased road network that was equally accessible to all manner of vehicle, regardless of individual prejudice.
- To gain public acceptance of AV systems, the cost of uptake served as a key barrier. The cost at point of sale and cost of maintenance have been identified as holding the strongest opposition and possible threat to AV system uptake. The utility and features of the technology are nearly as important as the associated cost, but given that the technology is an optional purchase, the price must align with current expectation.

8.3 Future Work/Opportunities

At Section 7.3, the thesis discussed research opportunities related specifically to extending the work of this study. The research opportunities discussed alternative methods of data interpretation for further data extraction, substitute analysis techniques, and further avenues of data collection/exploration.

Within the opportunities discussed at this section, the thesis attempted to explore opportunities that were not exclusive to the specific work of this study, but rather to the AV environment. Through the execution of this thesis, a number of opportunities have been identified that would progress understanding and accelerate AV system introduction, with a focus on public acceptance. Within this section, areas for future work are presented.

8.3.1 Simulation Work

In 2016, attempts were made to incorporate the use of simulators in the study, but due to geographical and licensing constraints, this was not a possibility. Once criticism of the study is that it is highly speculative, as none of the participants have yet interacted with AV technology past levels 1 and 2. Although the data quality has been judged high, the inability to assess perceptions after interaction has meant the ecological validity of the study can be judged as being low. However, as highlighted is Section 2.1, this is the current norm in literature on this topic, with progression expected as publicly accessible models become available.

Preparatory scoping and development of understanding prior to system introduction is valuable as highlighted by the work of this thesis and the extant literature at Chapter 2. Although capturing perceptions is useful, to further understanding of the technology, the use of simulators would massively improve the ecological validity of participant response and would represent the most of what is currently available. In the absence of actual technology to test, simulators would offer participants life like scenarios and settings within which to use the different levels of the technology.

Testing with simulation can be conducted in a number of ways, given the creativity that can be applied to a simulator. A selection of scenarios or test methods are as follows:

- Scenario based testing could see the user presented with a number of different scenarios with their action and reaction being matched against the action and reaction of the system;
- Given the ability of the system to appear in different levels of automation, the importance of understanding driver re-engagement is of paramount importance. Simulating this scenario would help to understand the role of human and machine in the environment of trade-offs and the most comfortable method of this situation taking place;
- A more sensitive and potentially controversial method of testing could be to examine the decision making process of the user in comparison to the programmed decisions of the system. Within the study, many of the participants spoke of their concern in regards to how the system would behave in potentially sensitive scenarios. Discussed briefly in the code of ‘ethical considerations’ one of the key hindrances that affected users in their conscious decision to relinquish control to the system was

their inability to identify how the system would behave in scenarios such as accidents, unexpected variable presence and changing weather conditions. Although sensitive, especially when considering situations where the vehicle would be presented with two inevitable outcomes, employing the use of this test type would inform users, making them aware of system characteristics. Undoubtedly, this would ensure each adopter of the system does not suffer from automation surprise. Given the fact that current community efforts are geared towards creating a code of practice, this would be a beneficial method of assisting in this task, as it would simulate real life situations and the preferred method of action. It would also allow users to influence and give feedback on this standardisation, ensuring their involvement and a user centred approach; and

- The above scenario based testing could see application to the consideration and design of liability or distinguishing the responsibility of each party (vehicle and user) at any given time. This opportunity was established upon the results of the study regarding liability in a range of scenarios with the responses varying from 50% (manufacturer) to 10% (driver). This gulf in nominating liability and in the majority of cases, to the wrong party displays the confusion that exists from a user perspective and the need to educate and set out the clear standards from a governmental/administrative position;

In employing the use of simulation equipment and conducting a variety of the scenarios described above, those concerned with AV systems can benefit from this life like situation as it would further the knowledge known around the system. By emulating the behaviour and characteristics of the system, users are afforded an interaction with the system, and this would help to uncover any hazardous issues that may come about upon interaction;

As responses would be based upon usage, rather than perception, the depth and quality of any study conducted at that time would be improved, providing a revised version of this study and furthering the knowledge not only of the scenarios above, but also the categories described in the study.

8.3.2 Culture/Location Specific Studies

The work of this thesis primarily targeted participants who live and would most probably use or interact with AV systems in the United Kingdom. This decision was taken when considering ease of access to participants and logistics. As a result of this, the interest, response and resulting findings are based on potential usage and interaction on UK roads. . However, one participant spoke of acceptance being potentially higher in the United States due to the road width afforded to each vehicle being much wider, resulting in increased user comfort. This contributed to the development of this opportunity of applying this same data collection process in different cultures and locations. The importance of this is clear, especially as AV technology is not solely limited to UK roads, but given legislation change, could be targeted at a global market. In the UK context, participants raised issues around fear, the price of change, a need to engage. This may not be the case for those looking to adopt in the United States. In its current form, the model is culture specific to the UK and applying it to another region/country would be an ill fit, given its application being based on the UK market. The value of understanding and pre-empting potential issues that would delay or halt public acceptance is evident from the work of this thesis. Extending it to a foreign market would serve to inform the providers of that environment into specific issues to consider.

In doing this, a range of models, each with the ability to be cross-referenced with each other can be built. This would extend the available understanding of technology acceptance from the angle of varying cultures/geographical locations.

8.3.3 Field Tests

Ward *et al*. (1995) were early testers of vehicle automation and assessing its impacts on users. Their study tested the effect of cruise control on mental workload, arousal and stress. Within this study however, a physical system was available to test with, strengthening the understanding and validity of participant responses. As has been discussed, the speculative nature of this study has been enforced due to the inability of accessing AV technology. However, it is now evident that in 2017, vehicles are becoming available with low to medium autonomous properties, such as lane assist, steering assistance, radar controlled acceleration/braking etc. In the immediate future, it would be wise to emulate the work of Ward *et al*. (1995) and attempt to conclude on the effect and attitudes towards AV systems prior to and post usage. This would allow the community to understand participant feeling in relation to the technology and their experience upon using it, helping to refine the experience, design and usability of the product. Studies such as this would promote public engagement, begin to develop public confidence, align expectations and continue the development of user centred systems. In the long term, by implementing an ethos of learning in low to medium autonomous properties, a refined framework can be established that would allow for the testing, refinement and modifications of the higher levels of automation, as well as inspiring the additional benefits mentioned previously.

8.3.4 Interaction and Communication

In the execution of the study, a number of questions remain that require answering. The thesis was able to broadly discuss and provide recommendations for a number of issues. However, key areas were identified that were pivotal to the success of AV systems, and were currently underreported in literature. As AV systems would be introduced in an environment with other AV systems operating at different automation levels and alongside non-AV systems, interaction and communication is a key issue highlighted by the study that requires attention. Aside from the need to articulate interaction and communication to users, the study of this issue is imperative to the safe operation and longevity of AV systems. The community must be aware of the disruptive nature of AV systems and as a result of this, the need to identify and account for external factors. One of these being the study of the environment and those entities expected to interact with AV systems and the design of such a framework to accommodate this. The results of this study would suggest that as well as the need for users to understand their own role and system operation, it was equally important for them to identify and understand how to negotiate with other AV technology, regardless of level and non-AV technologies.

8.3.5 Liability Study

Although extensive discussion around liability has already taken place in the study, the question of liability in the higher levels of automation remains. The results of this study suggested that participants would be willing to accept liability the lower levels of automaton, but not the higher. This would suggest that participants believe that the more control that is taken from them, the lesser the responsibility that is assigned to them. Currently, opinion is subjective on this issue, although the work at Section 6.1.3 is cited as saying the liability framework could most likely remain as it is. The perspective of participants, and possibly the wider general public can be understood, given the paradoxical nature of still holding responsibility, even whilst in a ‘driverless’ vehicle. However, further study must include stakeholder engagement, simulation work, field tests and engagement with insurers to ascertain the boundaries, responsibilities, accountability and governance when considering liability of AV systems. As well as settling issues around liability, this study will present solutions for additional issues in this context. By specifying the liability framework, the community can settle the role of each driver in the levels of automation, as the responsibility afforded to them in each levels will have a direct connection with the liability framework. In addition, as highlighted in this study and by wider speculation, members of the public have stated they feel they can do a number of things in their vehicle, if they were relieved of the driving task. These include watching TV, socialising, working etc., distracting drivers from the safe operation and usage of the vehicle and technology. As mentioned earlier, by implementing the correct liability framework, safeguards would be established to stop users from committing such acts, as they would feel responsible and charged with driving or monitoring proceedings. Situations such as those described above would then be classed as occasions of misuse, and could potentially be treated in the same manner as using mobile phones while driving are in the current market.

8.3.6 Data Owner/Usage

A wider topic that requires further study is the regulations and facilitation of data created by AV system technology. As the vehicle would essentially be 'connected', it would develop data, where previous legacy vehicles did not. Data collection in this environment would be essential to the safe operation of AV systems, to support in instances of collisions and to determine the value of AV system, through comparative statistics. As this stream of data would be state of the art, it would require regulating and managing to ensure its value is preserved, and to safeguard against misuse. Alongside protection of the data, issues would be raised around how it would be used, who would have access to it and whether opt-out initiatives could be established. This would be important, as the data would track personal information and travel details. Data such as this has its benefits, especially for GPS services and road/traffic planners, but if not governed correctly, could be used for advertising and monetary purposes. Also, vehicles would be more prone to remote access and hacking, being used like drones for illegal acts such as terrorism, robbery etc.

Further regulation would have to consider who the owner of the data would be and their preference for its usage. Overall, the possibilities associated with this big data would be endless. Through analysis, true cost, efficiency and safety savings could be established via driver trends and incident patterns. The possibilities of data exploitation would provide as much benefit to the public as the technology itself would. However, safeguards and regulations must be established to protect users and the technology itself from misuse and malpractice.

8.3.7 SMART Cities

Alongside the state of the art nature of AV systems, fellow evolutions are set to cause equal disruption to society. The upcoming SMART cities and associated intent of things would proceed AV systems and are set to change the demographics of towns and cities (Macauley, 2016). It is expected that within the implementation of these phenomenon, AV technology is set to play an active role. Speculation has placed AV technology as taking on the guise of a taxi service, with owning vehicles being impractical and outdated and a ride hailing system being the norm (Forbes, 2016). A system such as this is expected to be driverless and the AV technology is focal to the facilitation of wide ranging SMART city plans. As well as this, the upcoming internet of things is set to propel AV technology into not-thought-of territories, with Neiger (2016) expecting 250 million vehicles to be connected to the internet by 2020. One can see the rapid development and innovation that can be exploited with the addition of internet; such is its effect on existing markets such as PC's, smartphones, smart homes etc. Although the exploitation through association of the two is expected, it is currently unknown.

To this end, further study is required at a later stage. This work should consider the role of AV systems, upon not only its arrival, but also how it could evolve with arrival of technology in different sectors. The work would mostly be speculative and assumptive, but would allow the community to lay foundations of understanding to the evolved potential and continued development of AV systems, in light of environmental and technological changes.

8.3.8 Grounded Theory/ Soft Systems Methodology Infusion

Alongside grounded theory usage in this study, techniques from the soft systems methodology were also used to progress the analysis work. Given the reported success the thesis achieved in this mix, the only recorded literature attempting to combine the two is Durant (2005). The reasoning behind using the two in conjunction in this study came from noting that both share a commonality of the nature of their inquiry and their inductive approach of problem solving. In reference to the advantage of using both methods in conjunction, Durant (2005) reported that the new strategy offered a more holistic explanation of the data as it was examined from the viewpoint of both parties, furthering the understanding and connection with the data set.

The key application of the SSM to this thesis was the thought process in which the SSM views the problem space as being unclear and how it applies an investigative process to make the situation clear. The second application of the SSM, a more tangible one, was the use of conceptual models in conjunction with the memo phase of the grounded theory to further explore the analysis phase of the study. By conceptualising the analysis process, rather than solely adopting a written analysis, maximum extraction was able to take place from the data.

Although applied, the use of the SSM and the grounded theory was only minimal with one philosophy and one technique of the SSM introduced to the grounded theory. In a future piece of work, not at the behest of any specific situation, further application of the two in conjunction could potentially yield an approach that applies the strongest features of the two approaches to solve the 'hard system' or to generate a substantive theory.

In trying to understand the reasoning behind why they are not used more often, one can look to the schools of thought in which they reside. Whereas the grounded theory is generally a social science method, every exposure and the underlying teaching received around the SSM was from an information systems point of view. As discussed in the thesis, the two do not generally mix, and this could be an obstacle to a potentially viable solution to a variety of situations, such as the one of this thesis.

8.3.9 Summary of Future Work/ Opportunities

In addition to Section 7.3, the work of this section expanded on the opportunities available to those operating in the environment of AV systems. The relative youth of AV systems is evident when considering the vast opportunities that have been noted as result of this thesis and of general observation. Upon the completion of this thesis, a number of key questions arose and these have been addressed in the section, especially around the role of AV systems alongside further innovation and change.

The legislation surrounding the usage of driverless cars is a fundamental tenet of the technology that is under reported in literature. The thesis and background literature both questioned the liability and data policies that would be established alongside AV technology. Participants of the thesis regularly discussed liability and the results of the study suggested that disparity exists between what are the proposals around liability and what participant expectation currently is. Alongside this, the data collection/sharing issues are of equal importance. The need to collect data is imperative to the safe execution of driverless cars; however, the value of this data is high and must be protected, given the opportunities that were discussed for its misuse.

The most immediate opportunities that must be exploited are around the need to implement field tests and/or simulation work. As discussed above, this activity would allow further data analysis and a depth of understanding of user/system interaction that could not be recorded by the speculative nature of this thesis and the extant literature at Chapter 2. As AV technology bridges closer to the public market, it is imperative to secure methods of bringing both parties closer together to find common understanding and any variation.

The overall theme associated with the suite of opportunities identified is that a state of urgency should be adopted by the AV community. As the major evolution of this sector approaches, the number of opportunities highlighted display that a possible shortfall in understanding may greet the technology on its arrival. The work of this thesis has displayed that possible users are enthused around the technology, have an aptitude to support its introduction and require a level of support that they do not currently need with vehicles. By adopting this urgency, each section of work can be satisfied and the best possible foundation can be established prior to the introduction of autonomous vehicles.

8.5 Thesis Summary

The reaching of this section represents a significant research effort that has shaped my career from a predominantly IT/Business background to now considering complex issues involving people, attitudes and perceptions. Becoming a student of knowledge of these topics allows a technical background to give due diligence to the most important factor of any system.

When this research effort began in 2013, public perception of this topic was that it was one of personal interest, rather than academic. Generally, attempted discussions of driverless cars was no taken serious with the consensus being that the topic belonged to Hollywood, rather than a PhD. In five short years, the progression of autonomous vehicles has been vast, not in the community as this was an expected evolution, but within the public. The AV community, manufacturers, academics and all aligned have placed considerable effort and resources into driverless cars and are now at a stage of offering low to medium autonomous properties on a number of their vehicles. However, the greatest change has been in public perception. This period has softened the user palette and converted speculation into a possible reality. The key advice of this thesis is advice that has been conveyed at multiple junctures throughout this report, the importance and continued need of public engagement and work on human factors to solidify the relationship between user and vehicle.

In considering the overall offering brought by this thesis to the community, a multi-level contribution can be noted. At a high level, the thesis reports on the issues, requirements and fears brought forward by participants on their journey of accepting and using driverless vehicles. On a second level, the thesis reports on the specific concerns as presented by each stakeholder group and discusses how best to engage each road user group, both directly and indirectly. On the third level, the thesis presents recommendations to the AV community and society in general on how best to achieve public acceptance and technology introduction, upon consideration or results and extant literature.

The results were spit across three level, as this is the complex nature of modern day system acceptance and the need to consider not only the direct user, but those in its environment are necessary. In addition, as highlighted by the results of this thesis, in comparison to existing technology acceptance literature, the complexity discussed above translates into more concepts to consider before acceptance can be reached. Although the results reference a large amount of extant literature, a number of domain specific factors come into play that highlight the need to study technology innovation and introduction in this manner. Furthermore, it may not be possible to transfer the results from this study into another similar scenario, but the principles and fundamentals of this study around how data is collected, the sample type and results presentation can be. In a modern day society where seemingly automation is set to play a key role in the wider transport sector, in warfare weaponry and in the medical sector, the opportunity to exploit this process and encounter further research opportunity outside this sector is evident.

In definitive terms, the thesis set out to understand current user perception of autonomous vehicles and use this to steer understanding of how it is perceived and the acceptance of it. By using the data collected under the teachings of the grounded theory and by refining this data through comparisons with current understanding, the thesis has been able to deliver what it intended.

On the one hand, this paragraph represents the end of a significant piece of work and research journey for the author. On the other, this work has many associated limitations and opportunities that have come because of its completion, displaying not the close of this important issue, but rather a beginning.

“The seekers of two concerns are never satisfied; the seeker of knowledge and the seeker of the world”

(Hadith reported by Al Hakim)

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Appendices

Appendix 1- Research Ethics

The nature of this study required specific detail around ethical consideration. As participants would be involved in the study, various measures were taken to ensure their privacy and sensitivity was respected and adhered to at all time. In addition to this, as primary data would be collected, processed and analysed throughout the study, a number of measures, as discussed below were employed to maintain anonymity, data safeguarding and adherence to legislation.

The study was in adherence to University of Huddersfield (2017) code of practice for research. Due to the study involving participants who at times spoke of sensitive issues, a rigorous code of conduct and an adherence to the relevant ethics was followed. Adapted from the work of Patton (2002) the following is a manifestation of the ethical guidelines Patton sets out for researchers to consider and follow when embarking on a research project.

The applied code of ethics is as follows:

- **How will you explain the purpose of the inquiry and methods to be used in ways that are accurate and understandable to those you are researching?** Prior to study induction, participants were provided with a 'research study explanation form' (See appendix 1). The form contained the purpose and background of the study, a representative number of sample questions, the role of the participant within the study and how data would be processed. Furthermore, the form also highlighted participant rights and a consent form containing all relevant ethical guidelines and commitments. (See Figure 9)

- **In what ways, if any, will conducting this research put people at risk? (Psychological, legal, political, becoming ostracized by others?)** The nature of the study is such that the data recorded from participants does not have the potential to become hazardous or cause any risk to participants. Even though this is the case, to avoid participants becoming excommunicated by others in light of their perception, participant anonymity was maintained throughout the study. Lastly, participants were reminded of the anonymity of the data and also their rights in reference to answering questions and also terminating the interview.

- **What are reasonable promises of confidentiality that can be fully honoured?** The Data Protection Act and University of Huddersfield regulations were both abided to during the collection, handling and storing of data. Collected data was anonymised and tagged throughout its handling, ensuring traceability of all elements and also protecting the participants of the study. Up to date anti-virus software and multiple copies of the data were always maintained to ensure the security and protection of the data. The location of data and access to it were only known and made by the data collector. Upon thesis completion, collected data and backups made were destroyed.

- **What kind of informed consent, if any, is necessary for mutual protection?** Along with the initial explanation form, a participant consent form was provided. This form required the filling in of a short ethics questionnaire, ensuring they understood their rights and also a signature to approve the meeting. Failure to answer each ethical and commitment statement with a 'Yes' resulted in participant disqualification from the study.
- **Who will have access to the data? For what purposes?** During the empirical study phase, the data was accessible only by the interviewer. Any collected data was anonymised and assigned an ID code, thus hiding the true identity of the participant. This theme will continue to the publishing stage. Transcripts will be available only to the participant they belong to. Participants were advised that data access was time sensitive as data was destroyed upon thesis completion.

- **Who will be the confidant and counsellor on matters of ethics during a study?** All ethical advice required for the study was provided by the Research office and supervisory team at the University of Huddersfield.

- **How hard will you push for data?** In a co-construction setting, the interviewer and participant/s will together form the reality, subject area and resulting data of the study. Although the researcher will lead interaction and participants will feel encouragement to pursue answers, at no point will they feel pressured to answer or continue discussion. Participants were reminded that the answering of questions was optional and termination of the interview was at their discretion.

Upon invitation into the study, each participant was provided with the research study explanation form mentioned previously. With regards to ethics related information on the form, three key sections were included:

- **'What data is needed/ Your rights'-** A sample list of questions was provided to each participant, contributing to their knowledge of what would be discussed in the meeting. Participants were reminded of their rights in relation to participation and anonymity and also the commitment made to storing data in relation to the Data Protection Act of 1998.

- '**How will data be used**'- Each participant was also given a brief introduction to the research methodology and given an example of how the data they provided would be used for the benefit of the study. Reiterations were made at this point to each participant in that they could withdraw at any time if they felt uncomfortable with any part of the process.

- **'Participant consent'-** Concluding the work on ethics was the participant consent form. Designed to summarise learning and to repeat the commitment of the study, each participant was required to confirm each ethical statement and sign the form. This would then be countersigned and the individual would then be confirmed as a participant in the study. Failure to fully complete the form with a 'YES' answer resulted in their incomplete application and resulting termination. (Figure 9)

Participant Consent Form	
Respondent Checklist	Please circle as appropriate
I can confirm that I have read and understood the explanation form and have had the opportunity to ask anything about the research study.	YES/NO
I understand this is a voluntary exercise, I am free to withdraw at any point before, during and after the study, without reason.	YES/NO
I understand that I am charged with answering whichever questions I like, declining any of the questions is my prerogative.	YES/NO
I have read and understood this study is following the values of the Data Protection Act, my name will not be published anywhere, my identity will be kept anonymous and any data I do provide will be stored and managed according to the Act.	YES/NO
I agree that whatever discussion I have will be used as part of an analysis procedure that could lead to findings being shared in future projects	YES/NO
I agree to have my voice recorded as part of the interview (once transcribed, recordings will be destroyed)	YES/NO
I give my consent to take part in this study	YES/NO

Participant Name: Date:
Participant Email Address: Participant Signature:

Researcher Signature Date:

Appendix 2- Possible Interview Questions

The purpose of the following questions listed below is a set of questions and justifications defined by the researcher to use as a guide for the interview process. The questions have been set forth to gather user perception around the proposed system, considering topics such as trust, usage, attitudes etc. The questions have been designed to trigger discussions on the actual deliverable of each question, comes upon the discussion of an unrelated topic, rather than the one initially asked of the participant. The questions were used as a foundation to trigger discussions, with deviations from questions encouraged and pursued. Please Note: This list is not substantial, with each passing interview, questions are added and removed.

Topic	**Questions**
Opening Questions Driving Experience Driving Personality	-How long have you been driving for? -Tell me about your driving experience to date? -On an average day how does driving help you? Why do you drive? -Are there any alternatives you could consider to driving? -Do you prefer adopting the role of a driver or passenger? Why? -Do you see driving as a passion, enjoyment or a method of convenient travel? Why? -Do you spend much time in traffic? Find yourself planning your day around it? -Have you ever had to drive a long distance when you had something important, say some work to be getting on with? -Have you ever been subject to anything unsavoury/incidents/accidents while behind the wheel or in a vehicle? Drive for Business/pleasure?
Road Transport Problems	-From your view, the current problems with road transport are? Is it getting better or worse? -In your view what would improve the road transport situation What emotions, if any do you feel when coming across an accident Have you ever lost anyone or had someone injured due to this? How did that feel? Have you ever been late or missed something important with traffic or congestion being the sole responsibility of this? How did you feel?

	Do you trust your fellow motorist? Do you think we could be more efficient and kinder to the environment?
Self-Managing Vehicles	-What, if anything do you know about computer assisted driving or driver aids in general? What do you think of lane assistance, cruise control, systems like this? Your experience with them? -How far-fetched does a driverless car sound? -What do you currently know of this phenomenon? If a car was driverless, what could you be getting on with?
External Variables	-Apart from a new car system, which other external variables would affect your decision e.g. infrastructure, training? -What else could influence you to use, not use? Does social network play an influence on people's decisions? How big a role would the media play in propelling a technology like this or tarnishing it? We know how you feel, on a whole how would people you know feel about using it?
Perception	-How would you personally benefit from a car that removed you as a driver? -Do you see these systems being able to help your day to day life? -What if I told you that planes didn't need a pilot and your flight was controlled by a computer? How would you feel? -Driverless cars or pilotless planes? Why? -As of now, what was your perception of this system, what was your perception of planes, until I told you nobody flies them, they only monitor? What do you think of planes that fly themselves or trains that manage themselves; chances are you must have sat on one of them? How would a car differ to a plane, would it be more dangerous, given traffic and that kind of stuff? How do you ascertain if something is worth giving time to? E.g. is it worth the effort? This is how it would help the environment, what do you think? -What influences a person's perception? -How easily is perception changed?
Learnability	-What challenges do you generally face when adopting new technology? Have you previously ever adopted life changing technology? What is the hardest element of learning something new?

Attitudes towards	Do you think the massive role computers play in supporting humans can be increased in any way? The next big thing? How would your attitude change if the tests all came back correct? Would that be a powerful acceptance factor or a strong public backing? How would your attitude towards it change given a bad experience with it How's that different to your attitude if it was a car you were driving was involved in an issue Now that you have heard everything, how is your attitude towards this system?
Trust	Before you put your life in the hand of another what would you require? What do you need to see before you trust something? Is trusting humans and trusting technology the same? Many argue that it is? Do you know what over trust and under trust in this area are, how do you feel after I've told you?
Structure/process	-Who does the responsibility fall on if the systems do fail? -Who in your opinion would control it? -Would you treat failure of autonomic systems the same as you would treat human failure? -The government has not regulated it as they're waiting for public engagement, what help do you think the public can offer? -Do you think it would have to be mass introduced or do you think it would work alongside?
Usage	How would you feel in regards to adopting the technology or it being enforced on you?
Ease of use	N/A
Usefulness	-How easy do you think a complex system like this is to use? -In terms of management and overseeing of a system as such, in use, how hard do you perceive it to be? -A uniform, consistent system, would different people find it harder or easier to use, Should that stop the system performance?
Behaviours (pre ending?)	-When it comes, which I believe it will, will you use it? -What if it is more expensive than what you currently own? But better?

Ending	-At any point, do you think I didn't explain anything properly or anything you feel I have missed that would give a deeper insight into your perspective? Anything else? -Before today and our discussion did you know much about this emerging system? -Is there anything you are unclear about? -What advice would you give to manufacturers/ governments on the implementation of such systems? Is there anything you would like to ask me?

Appendix 3 Research Study Explanation Form

'Autonomic Road Transport Systems'

A Grounded Theory Research Study Explanation

Mohammed Amin Mayat

University of Huddersfield, UK

Research Title

Autonomic Road Transport Systems: A Road User Perspective

Researcher Background

The researcher, Mohammed Amin Mayat, is a graduate and current PhD student at the University of Huddersfield, England. Past research efforts of the researcher have been into trust and E-commerce and most recently, graphical design patterns. This research effort forms the empirical study of the current PhD effort to investigate user perception of autonomic road transport systems, with the involvement of the grounded theory approach as the primary research method.

Researcher Contact Details

Before you read on, if any you have any questions at any point, you are free to contact the researcher about any queries you may have or any issues regarding anything in this document.

Mohammed Amin Mayat
+447872124040
u0854009@hud.ac.uk

Research Aim

Autonomic road transport systems are an area of increasing interest amongst research communities. Following its successful use in the aviation industry, the socio-economic benefits of intelligent and autonomic road transportation are now being explored, in particular assessing areas such as reduced congestion and the associated economic benefits, reduced pollution, increased safety and reduced healthcare costs. This work focuses on user perceptions exploring issues such as trust, required behavioural changes and psychological repercussions.

The current knowledge on the topic is minimal and unconvincing, with regards to the user, no attempt to unite user and system have yet been attempted, this study will attempt to do that using the primary methodology (grounded theory approach) to form a theory or an understanding about this currently hazy topic.
This thesis, part of a wider working group labelled ARTS (Autonomic Road Transport Systems) working under the umbrella of COST (European Cooperation in Science and Technology) has been commissioned to form an inter disciplinary coalition aimed at rapidly developing new ways of designing road transport systems which implement the use of autonomics as a driver/vehicle aid.

Grounded Theory Approach Use in this Study

The research method observed by this study is the grounded theory approach (Figure 1). This method provides a variety of tools that allow for a collection of qualitative data that is focused on experiences and perspective, the latter of which will be the primary focus of the study.
The following points are a brief summary of how data will be collected and utilised in line with the guidance of the research method:

- The researcher will enter the field of study and create a set of questions (a sample set can be found further in the study) these question form the basis of the study and will be used in an interview process with respondents.
- A sample group of 20 will be generated; this will form the respondent group.
- A coding phase that will seek to highlight and focus on key words or phrases that will allow a dissemination of the data, upon the road of the interviews, codes that are similar are gathered together and placed into categories.
- Any categories or analysis faces constant re-analysis as new data is fed into the study, memo usage acts as a form of iteration to ensure all findings, observations and theory reflect the data captured, in doing this the final theory will most certainly be grounded in the data it is a product of.

Most studies aim to compile a comprehensive literature review to understand their chosen field, however in using the grounded theory, researchers are encouraged to begin their journey with little reading or a very restricted literature review in a bid to avoid pre-determined ideas or bias. The use of existing literature will come into play as a secondary stage, reviewing it will allow a comparison between what has been discovered and what is already known will allow for

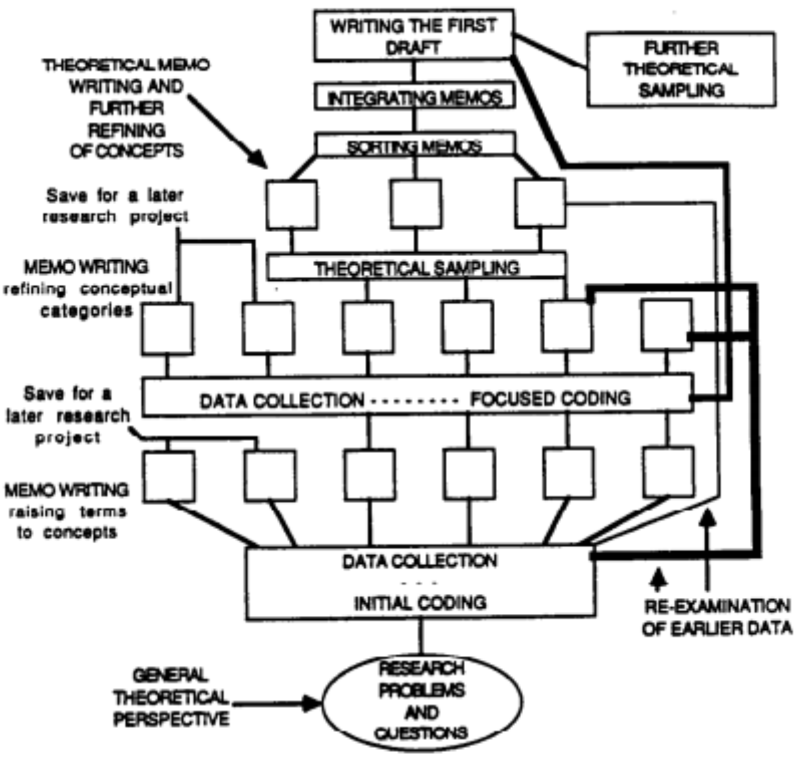

Fig. 1. Research levels in the grounded theory method.

emerging categories to be immersed and integrated into the theory.

What data is needed/ Your Rights

Upon your conscious decision to partake in this study, you will be asked to provide your consent using the form provided in this document.

Having consented to the study, you will be asked to partake in an interview as per the requirement of the grounded theory approach; the topic will follow a general guideline of discussing autonomous road transport systems with the minor inclusion of other topics if required.

Any data collected will be treated in line with the Data Protection Act (accessible at: https://www.gov.uk/data-protection), this means the researcher will collect, manage, store

and publish data in line with the required legal regulations, protecting and anonymising participants of the study.
Each question is optional; you will be charged with dictating which ones you would like to answer when they are presented to you. However, if you feel distressed or concerned at any point throughout the interview, it is your right to leave without giving a reason or notice. Figure 1 highlights the roadmap of the grounded theory as mentioned in previous chapters, you will realise the significance of your role within the study. As can be seen, the data you will provide will play a recurring theme throughout the study and will form the initial foundations upon which the theory is built.

How will the data be used?

Each interview will be recorded, notes taken and upon completion of the interview, the recordings will be transcribed, converting voice to text, easing the coding process. Answers and discussions between the participant and the researcher will form the fruitful codes the study is searching for, any response the participant does provide will be anonymised, and names, dates or locations will not be published alongside the data, ensuring the protection of each participant.
Your data will be matched and considered alongside approximately 19 other interviews in a process of triangulation whereby each set of answers will be compared with each other to find trends and patterns that will be scrutinised with a rigorous analysis procedure.
If anything should arise that the researcher is unsure about, you may be contacted regarding this to maximise clarity in the study, if you are unwilling to be contacted, this also can be stated.

Participant Consent

The document until now has been a learning process for you in your role as a participant of the study. The researcher has attempted to outline the aims of the research study, the intended research method for data collection and various other sections that build up a picture of the study. Following on from this, the researcher will provide you with a brief form to check you understand the study, your role as a participant, your options as an individual and finally, your rights over the information you may or may not provide the researcher with. If, for any reason you feel you cannot sign the form or have any concerns with anything you have read or anything that is required of you, please email the researcher with the details provided as soon as possible to clear up any confusion. Lastly, if after the interview, you feel any distress with regards to your responses, any of the questions or even your role within the study, please get in contact with the researcher so a feasible solution can be sought out. If you are happy to participate in this study, please circle as appropriate the answer you most agree with in the form provided, sign, date and fill out the form and return to the researcher (u0854009@hud.ac.uk) as soon as possible. A signed copy will be provided to you for your records.

Participant Consent Form	
Respondent Checklist	Please circle as appropriate
I can confirm that I have read and understood the explanation form and have had the opportunity to ask anything about the research study.	YES/NO
I understand this is a voluntary exercise, I am free to withdraw at any point before, during and after the study, without reason.	YES/NO
I understand that I am charged with answering whichever questions I like, declining any of the questions is my prerogative.	YES/NO
I have read and understood this study is following the values of the Data Protection Act, my name will not be published anywhere, my identity will be kept anonymous and any data I do provide will be stored and managed according to the Act.	YES/NO
I agree that whatever discussion I have will be used as part of an analysis procedure that could lead to findings being shared in future projects	YES/NO
I agree to have my voice recorded as part of the interview (once transcribed, recordings will be destroyed)	YES/NO
I give my consent to take part in this study	YES/NO

Participant Name: Date:

Participant Email Address: Participant Signature:

Researcher Signature Date:

Sample Interview Questions

As mentioned previously in this document, the research study will take the form of an interview with likely questions surrounding the title and aims of this PhD topic. As a guide to the participant, a set of sample questions have been provided below to give an understanding of how the interview will take place and the constructs of it, with regards to the questions. To reiterate, all questions have been set out as optional, participants can either seek to gain clarification about the meaning of the question from the researcher or can choose to skip any particular question.

Please note: As the interview process begins, the question will become more refined and focused, with this in mind, this document and the sample set of questions will be updated at various stages of the data collection process.

- On an average day how does driving help you?
- From your view, the current problems with road transport are?
- Do you trust your fellow motorist?
- What, if anything do you know about computer assisted driving or driver aids in general?
- How far-fetched does a driverless car sound?
- Does social network play an influence on people's decisions?
- What challenges do you generally face when adopting new technology?
- Is the prospect of trusting humans and trusting technology the same? Many argue that it is?
- What advice would you give to manufactures/ governments on the implementation of such systems?
- Before today and our discussion did you know much about this emerging system?

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Examples of completed Consent forms-

Participant Consent

The document until now has been a learning process for you in your role as a participant of the study. The researcher has attempted to outline the aims of the research study, the intended research method for data collection and various other sections that build up a picture of the study. Following on from this, the researcher will provide you with a brief form to check you understand the study, your role as a participant, your options as an individual and finally, your rights over the information you may or may not provide the researcher with.

If, for any reason you feel you cannot sign the form or have any concerns with anything you have read or anything that is required of you, please email the researcher with the details provided as soon as possible to clear up any confusion. Lastly, if after the interview, you feel any distress with regards to your responses, any of the questions or even your role within the study, please get in contact with the researcher so a feasible solution can be sought out.

If you are happy to participate in this study, please circle as appropriate the answer you most agree with in the form provided, sign, date and fill out the form and return to the researcher (u0854009@hud.ac.uk) as soon as possible. A signed copy will be provided to you for your records.

Participant Consent Form	
Respondent Checklist	Please circle as appropriate
I can confirm that I have read and understood the explanation form and have had the opportunity to ask anything about the research study.	YES/NO
I understand this is a voluntary exercise, I am free to withdraw at any point before, during and after the study, without reason.	YES/NO
I understand that I am charged with answering whichever questions I like, declining any of the questions is my prerogative.	YES/NO
I have read and understood this study is following the values of the Data Protection Act, my name will not be published anywhere, my identity will be kept anonymous and any data I do provide will be stored and managed according to the Act.	YES/NO
I agree that whatever discussion I have will be used as part of an analysis procedure that could lead to findings being shared in future projects	YES/NO
I agree to have my voice recorded as part of the interview (once transcribed, recordings will be destroyed)	YES/NO
I give my consent to take part in this study	YES/NO

Participant Name [redacted]
Participant Email [redacted]

Researcher Signa [redacted]

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[redacted]

Appendix 4- Coding Examples

For further evidence of grounded theory application, this appendix presents the coding procedure of three participant groups. This is in extension to the three already presented at Chapter 4. The coding listed here relates to participants GT05 (a professional drivers' forum), GT09 (a cycling organisation) and GT10 (car enthusiasts network). The examples are not conclusive on each participant group, they are a representation of each.

Open Coding

GT05

Words of Participants	**Open Coding**
There is more to driving than just the enjoyment or otherwise of the actual driving	Why do people drive Driving Reasons- pleasure, work related, income Driver Types vs adoption of technology
Most drivers don't do the job from choice but necessity, the need to earn a living and keep a roof over their family's head.	Why do people Drive Driving Reasons The need to drive This driver understands that a driverless vehicle would render them useless? Role of the Driver in a driverless world A system so advanced that it requires no driver is far away but still a possibility
In the 45 years I was driving I saw vast changes in the equipment I was provided with to enable me to do my job. Yes most of them were improvements, others not so. (Thinking of cab phones here) The lorries I started with were under powered, noisy, uncomfortable and difficult to control.	Users are aware of the introduction and progression of automation Its clear to see the benefits of automation and the help it brings from a user, however they do say not all of them help Evolving Changes in the cabin Automation has been grouped within 'improvements'

I have seen improvements to cabs, from wind up windows, power steering, decent windscreen wipers, heated mirrors, air suspension seats, radios, sound insulation and they even put beds in them now. The engines have gone from loud and slow to refined and powerful.	Old vs new encapsulates the changes that time has brought about, not all automation related, but all improvement related, some of which automation fall in.
Much of the strain of the job has gone away due to innovations of cruise control,	Generally used on the highway, this innovation has given user the freedom to partially relax…. Highway automation which seems a certainty will further remove the strain and allow for more than partial relaxing Systems take away strain/stress… this is important in a close proximity situation Role of the driver Even without automation, lorries have improved so much so that they are currently considered state of the art, modernising the driver to become an operator of a driverless truck seems the next step
Modern day drivers are very much more steering wheel attendants than their earlier counterparts although many, like myself, have evolved with the changes. But you can never do away with a driver (or attendant) all the time.	Role of the Driver here is summed up as a steering wheel attendant which is defined as the only role they really have Automation has creeped up and taken away much of the strain of operating a big vehicle However, it is imperative from their knowledge as a driver that a driver is

	required at all times, even if their role changes Trust
Will it ever get to a point where as a driver I would say enough is enough?	Regarding accepting changes that take away the feel of driving This broadens to the area of control, and enforced change
To be honest I don't know. With the latest trucks I drove I used to joke I only need someone to steer the thing and I could spend all day in bed.	Role of the Driver (Trucker) The need for driving
The tiny back street delivery point where you've had to inch past streets of badly parked cars, the muddy farm yard miles from the nearest decent road, the tightly packed distribution yard built for 20 trucks but holding 40 as well as the stacks of badly placed pallets. – these are areas you need driver intervention.	System Application in the Real World Role of the driver- Driver Intervention Stages of Automation Lorry driving is not just about the journey, drivers encapsulate lorry driving as a number of other tasks which require their intervention.

GT09

Words of Participants	Open Coding
"following the news as an enthusiast"	Every participant so far has mentioned the news as the primary tool for information, this has to be addressed Information has to stem from the correct source
"it has the potential to make cycling much safer" **"will reduce anxiety for cyclists"**	Associated benefits of system Knock on effect to surroundings Solving current problems

"I think the roads will be more spacious, enabling more walkways and cycle way"	Associated benefits of system Knock on effect to surroundings Lasting effect
"Optimisation for autonomous cars will create space and proximity issues with pedestrians and cyclists wanting space between them "	Interesting point, however this would change the infrastructure drastically, which is not the point of these systems
"autonomous vehicles will enable more vehicles to travel on roads and for more miles"	Seen as a bad point by many, not so much by this participant, part of ARTS is to inject efficiency into the road systems network, allowing more cars will only serve to bring a new wave of issues.
"communication between cars and non vehicle road users is currently hard, will autonomous vehicles make it harder?"	
"safety is the biggest problem with our roads" -fatality rates	Identification of current problems
"we have a perceived need for more infrastructure for safety"	This is not true, some may perceive this to solve our problems, more roads and signs cannot fix what is the biggest contributing factor to the current problems.
"an established system that allows vehicles to recognise cyclists would massively reduce stress"	Associated benefit of system Something needed to win over the cycling community The wider picture of not just having a car issue to solve but the bigger picture within which it operates
"at the moment we rely on hand signals between people a lot, will that social construct be transported to ARTS systems?"	This is a very interesting point, social issues such as this and the exercise one will most definitely be considered and discussed

GT10

Words of Participant	Open Code
“I understand the benefits but personally I wouldn't have one”	Unwanted system unwillingness to change Lack of understanding
“So long as there exists an option to buy a vehicle to drive yourself , even only on the weekend I think it will work and has my vote"	Participants point to a system that can be turned on or off, one where they exercise decision making on usage and activation.
“Despite the stress of driving, I love it”	Driving Scenarios vs Driving Reason Vehicle Representation
“i would also be worried about who would be in fault when accident happened, man in car or manufacturer”	Ownership and Responsibility have become unclear, can be liked to social media usage possible lead to system misuse What is the liability framework in this instance, does it mirror that of the existing one?
“in theory in a platooning situation they would work, because they're all the same” “once you add the human element it becomes chaos/hell”	Human error and judgement
“i work it IT and we all know anything with an electrical pulse can crash and switch off of its own accord"	technology trust/ reliability Paranoia- User Wellness management

"driving is not something that interest everyone and some just want to get their destination, for them it would be perfect"	Driving reason Motivation to use willingness to change
I worry of their ability to detect danger, on a Sunday we drive down a residential street and we know a kid might jump out of nowhere so we drive alertly and accordingly" "does it know this order it just drive at 30 because it only knows that" "they are meant to be safer than normal cars so why does the google car look like a fortress"	system application in real world dealing with unpredictability Design / Aesthetic issues

Axial Coding

GT05

Axial Coding	**Concept Development**
As mentioned, usage is navigated by the purpose and reason one has to drive. One who frequents the motorway is possibly more inclined to a system of this type Links between reason for driving vs zone vs usage	Driving Reasons vs adoption of technology DR vs Z =usage
One who drives for a living such as a lorry driver, may feel this is one advancement too far as it sounds like they are not needed anymore, Feeling inadequate	Role of the Driver System intimidation
Users are aware of the introduction and progression of automation	Understanding Automation benefits

Its clear to see the benefits of automation and the help it brings from a user, however they do say not all of them help Evolving Changes in the cabin Automation has been grouped within 'improvements' Old vs new encapsulates the changes that time has brought about, not all automation related, but all improvement related, some of which automation fall in.	Progress of Automation
Generally used on the highway, this innovation has given user the freedom to partially relax…. Highway automation which seems a certainty will further remove the strain and allow for more than partial relaxing Systems take away strain/stress… this is important in a close proximity situation Role of the driver Even without automation, lorries have improved so much so that they are currently considered state of the art, modernising the driver to become an operator of a driverless truck seems the next step	User Wellbeing Management Understanding benefits of automation
Role of the Driver here is summed up as a steering wheel attendant which is defined as the only role they really have Automation has creeped up and taken away much of the strain of operating a big vehicle	Role of the Driver n a driverless world Change Management- Truck Drivers

However, it is imperative from their knowledge as a driver that a driver is required at all times, even if their role changes	User wellbeing Management Understanding the technology
Regarding accepting changes that take away the feel of driving This broadens to the area of control, and enforced change	System Intimidation User Change Management Tradeoffs between H & C
Lorry driving is not just about the journey, drivers encapsulate lorry driving as a number of other tasks which require their intervention.	System Application in the real world. Role of the driver- Driver Intervention examples More than Driving

GT09

Axial Coding	**Concept Development**
Owning the knowledge and sharing it accordingly is key to this area. Every participant so far has mentioned the news as the primary tool for information, this has to be addressed Information has to stem from the correct source	Correctness of response Flow of knowledge Public Engagement
With the ability to positively impact on fellow elements using the road network, this system will see success. If it has the ability to reduce stress for cyclists, what benefit will it have on the human?	Addressing external factors/fellow road users Success factors
This comment possibly is wayward at this stage, the infrastructure is unlikely to change much.	Infrastructure changes Trust Issues

This could be translated as this participant believing in the efficiency of the project	
Interesting point, however this would change the infastrcuture drastically, which is not the point of these ssytems Initially people will feel unsafe, testing will settle this and actual tangible viewings of this system at work	Trust Issue Power of time Tangible need
Seen as a bad point by many, not so much by this participant, part of ARTS is to inject efficiency into the road systems network, allowing more cars will only serve to bring a new wave of issues.	Role of Driver Efficiency of system
Implementing the rules of the road correctly will men communication is not needed to be made	Clear Indications of system System Design
This is not true, some may perceive this to solve our problems, more roads and signs cannot fix what is the biggest contributing factor to the current problems.	Infrastructure Changes Perceptions
Owning the information flow is key to the persuading or managing perception and expectation	Flow of knowledge Correct sources of information
Associated benefit of system Something needed to win over the cycling community The wider picture of not just having a car issue to solve but the bigger picture within which it operates	System Design System usefulness
This is a very interesting point, social issues such as this and the exercise one will most definitely be considered and discussed	Rules of the road Unwritten

GT10

Axial Coding	Concept Development
knowing the benefits and being unwilling to change leads to a possible dislike and also change prefer current methods could be a factor of change, an unwillingness to change	Change Management
driving is stress but some users overlook that issue stress can be linked to certain situations, you may love driving at certain times (perfect scenarios) and feel the stress at particular times- congestion, long motorway journeys	Driving Motivation
confusion around liability, could lead to possible non acceptance	Ownership and Responsibility Liability Incident Management
participant seems to think the human element in automation causes issues, kind of like problems we currently have	System Introduction/Implementation
reliability of technology will always be at the back of someone's head. look at aviation since computer assistance came in a severe reduction of problems has come about, rendering commercial aviation as the safest mode of travel.	User Wellbeing Management Trust System reliability

having the choice or the control to select and not being fed the system allows some to believe in its benefit and its adoption	Choice based usage zones vs usage System Introduction
understanding computers is the understanding that things wrong, but even then the benefits still outweigh the negatives if driving it will overcome	system fear user wellbeing management
not many believe in the systems application onto our roads, they always talk of a residential scenario, its weird. its not that hard to deal with this unpredictability, a range of sensors can do the job perfectly.	system application scenario based usage

Memo's

GT05

Role of the Driver

More often than not, participants of this nature use their vehicle for work related purposes. This is an interesting area to consider with multiple codes and themes being linked to this area. **SYSTEM INTIMIDATION** is the first area I uncovered in speaking to participants, the second linked area is **GRADUAL RELINQUISHMENT OF CONTROL.** I build this story here by first stating how participants begin their story by mentioning how they began their journey in noisy, loud and hard to use machines, with automation and technology advancements in the cabin users welcomed these advancements and this contributed to **USER WELLBEING MANAGEMENT.** At this current time, users have gradually relinquished control to various systems in the system but this current proposition is one that will undoubtedly intimidate them. Imagine you were working as a cleaner for a multinational corporation and you heard on the grapevine of a cleaner less system coming in to do the job of the human, naturally you would feel intimidated, anxious and fearing for your job security.

We know that their job is safe, however their role will change, but they don't know because of a lack of **UNDERSTNADING AND KNOWLEDGE** regarding the system.

System Application in the real world and driver intervention

As an experienced trucker, they are aware of the differing situations they are faced with every day, when confronted with questions around **SYSTEM APPLICATION IN THE REAL WORLD,** users strongly and unanimously agreed that the system would struggle. One participant mentioned that drivers would be needed at the start and end of journeys, but bits in between they wouldn't be needed (DRIVING ZONE vs USAGE). Here, the topic of DRIVER INTERVENTION popped up and the elaboration that in particular zones, where unpredictability and common sense went hand in hand, driver intervention would be needed because the system simply couldn't control or safely navigate through these trying circumstances.

GT09

CHANGE

People have the inclination to not change, we are very stuck in current ways so it seems harder to propose change in this environment. it is obvious this would be key.. but change is influenced by many things and it is up to us to figure them things out.

Driving Reasons (linked to usage)

People, especially car drivers drive for a multitude of reasons, each driver can drive for up to x number of reasons so it becomes a very dynamic environment… the reason we drive dictates our usage of this kind of system e.g. in the morning I commute to work so I will use it in the traffic ok, in the evening I go for a blast on the countryside roads because my car is powerful so I use manual control, this is linked to USAGE. why they drive linked to if they would use, or maybe their motivation in the system.

Some people do point blank refuse it but people would, people don't want to change the smallest of thing like the brand of ketchup, why are we surprised that they outwardly and initially reject something like this.

VEHICLE REPRESENTATION is also an interesting point here. like we read about ownership psychology, cars sometimes are symbols of wealth, sometimes as workhorses and sometimes no symbols that is also linked other above.

LIABILITY- OWNERSHIP AND RESPONSIBILITY

Consumers are confused about liability, they mention they don't know who is in charge of any failure.

Because a risks till exists in the early stages insurance still needs to be involved in the driving process. however it will be less used o the price should decrease on it.
risk and fault still exist but as mentioned the more the machine takes over, the less the human will be involved with the process, thus removing accountability to a degree from them.

SYSTEM DESIGN- human error and judgement

In theory, participants believe that the system can be designed to work in certain conditions. Here the notion of the human brings about the word chaos. this participant believes that you can design this but introducing the element of the human in the equation causes the problem.

you can't move a human from a manual car to a car with cruise control for example and except them to be the best driver.

USER WELLBEING Management / technology trust /System Fear

constant paranoia an fear is not how we want the system to be perceived or accepted.. people talk about computers and how they crash, teaching people bout the benefits rather than the drawbacks can counteract this. but without proper knowledge fear is the key thing that will float around in a persons head with regards to the system. if their perception is that then system acceptance will never come about.

System Need/Urgency-

a real understanding of the true failure is the single catapult that'll give the urgency needed. interestingly one person has really personified it with their statement about us looking back and not understanding how we pet people die