Design Fiction as an Approach to Stimulate the Adoption of Self-Driving Cars

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Abstract

Engaging with the future is an essential part of design, as design is about exploring, creating, and proposing something new. Design Fiction is a future-oriented approach, investigating the future through a combination of prototyping and storytelling. It can bring products not yet in existence to a concrete platform so that they can be examined. Therefore, Design Fiction can be classified as a service design approach that can address, visualise, raise questions, and explore specific issues at the beginning of the design process through its tools and strategies. This research conducted a deep investigation into the Design Fiction approach and found three features that correlate with the sustainable future studies: first, Design Fiction foregrounds questions of values and ethics; second, Design Fiction serves a rhetorical purpose within public discourses around the future; third, Design Fiction creates a safe space for engaging with vague futures. Therefore, Design Fiction is not about predicting the future or creating utopian visions that develop emerging technologies. Instead, it affords a means to explore the societal and technological distinctions of possible futures to better understand our present.

Design Fiction tools and strategies can be utilised as a technique to anticipate possible opportunities and challenges. The present research has employed Design Fiction strategies to investigate the adoption of Autonomous Vehicles (AV's). AVs are part of a critical shift that articulates a technological leap forward, proposing solutions to current transportation problems to change how people address mobility. Conversely, many drivers and passengers are unwilling to adopt new technologies, as it is not common for humans to have no control of the ambiguities around safety issues. Based on the above, the AV concept needs a new technique of communication to overcome the challenge of earning the trust of future customers.

As its vital contribution to knowledge and to accomplish the research aim, this project employed the Research through Design (RtD) approach, using Design Fiction as a tool to change behaviour to facilitate the adoption of AV's. The point of departure for the research is the following question: How does the employment of Design Fiction stimulate the adoption of Autonomous Vehicles? Design Fiction strategies provide a comprehensive understanding of the publics need to envisage the use of automation technology. Consequently, the present research proposed a new car design called Archer, and a Human-Machine Interface system called Intelligent Adaptive Ride (IAR), derived from the user requirements. This proposal reflects on the idea that Design Fiction has the immediate challenge of closing the gap between a vision and its material expression by situating the user in a shared conceptual space, allow them to explore, question, and engage with the potential future.

To validate this proposal, this inquiry has utilised a mixed research approach. A quantitative survey was conducted to reflect on the automation system concept and usage and the proposed prototype of Archer. Moreover, a Wizard of Oz experiment was implemented to examine the efficiency and acceptance of the suggested IAR system. This research utilised

IBM SPSS Statistics software to analyse the data to reflect on the research methods and hypothesis.

The results of this research found that Design Fiction tools and Strategies opened up a new space to envisage the usage of the automation technology, explore its impact and allow the potential user to reflect on what is preferable and desired to be seen in the future. The research strategy encourages future users to trust the automation technology, as they are involved in shaping its world and employment.

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List of Abbreviations

AV: Autonomous Vehicle

RtD: Research through design

HCI: Human Machine Interface

IoT: Internet of Things

Sci-Fi: Science Fiction

ABS: Anti-Lock Braking

CC: Cruise Control

NAVI: Navigation System

GPS: Global Positioning System

LIDAR: Light Dedication and Ranging

SAE: Society of Automotive Engineering

V2V: Vehicle 2 Vehicle

V2P: Vehicle 2 Pedestrian

V2E: Vehicle 2 Environment

UI: User interface

UX: User Experience

IAR: Intelligent Adaptive Ride

VOC: Voice of the Customer

NDRT: Non-Driving Related Tasks

IVI: In-Vehicle Infotainment

ADAS: Advanced Driver-Assistance Systems

HUD: Heads Up Display

IU: Intention to Use

T: Trust

ATT: Attitude Towards using the system

PU: Perceived Usefulness

PEU: Perceived Ease of Use

C: Clarity

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Chapter One: Introduction

1.1 Introduction

Design is a valuable tool to speculate and to raise debate about futuristic social and technological evolutions. However, visualising and tracking future technologies can seem like something straight out of science fiction; the implications can appear very vague and unfeasible. Therefore, the need to explore speculative design techniques and the role of fiction to examine and propose future objects has become a priority for designers and researchers as it helps define what their impact might be and present a range of possible alternatives for the future.

Design Fiction as an approach was defined by a science fiction author Bruce Sterling as "the deliberate use of diegetic prototypes to suspend disbelief about change" (Sterling, 2013a). Ever since, it has been known as a service design approach with the potential to address, visualise, raise questions, and explore specific issues at the beginning of the design process. Centring upon the idea of 'suspend [ing] disbelief about change' this research uses Design Fiction as a tool to investigate potential concepts that could contribute to the shaping of the future. This research utilises Design Fiction to explore some techniques that could expand the adoption of Autonomous Vehicles (AV's).

The present research started with an investigation of the Design Fiction approach as a branch of speculative design - discussed further in the literature review chapter - where fiction is the engine for exploring future objects and services. Indeed, the word fiction is usually correlated with something being untrue or unreal; but in fact, for researchers and designers, it provides the right platform for every idea to be discussed, prototyped, or even examined. However, not every idea, services or product is meant for use; some aim to raise awareness, to explore alternatives or in order to bring a product to life. Therefore, the purpose of each idea determines its nature and existence. Thus, the nature of Design Fiction, which will be explained further in this thesis, makes it the right tool to not only provoke the general acceptance of the technology but also to investigate when, how and why to trust the technology.

Autonomous Vehicles describe a technology leap that promises to improve mobility for many groups, including the senior population, non-drivers, and those with medical conditions. Conversely, there are potential users that are unwilling to adopt this new technology, as it is not common for humans to have no control, regarding the ambiguities around issues of safety. Hence, this research aims to bridge the communication gap between the technology and its potential user through Design Fiction techniques.

1.2 Justification for Research

Design Fiction as a service design approach has the potential to address, visualise, raise questions, and explore specific issues at the beginning of the design process. Centring upon the idea of 'suspend[ing] disbelief about change', this research uses Design Fiction as a tool to prepare and present potential concepts that could contribute to shaping the future. Therefore, this research utilises Design Fiction to investigate the adoption of Autonomous Vehicles, aiming to propose a useful strategy would locate the potential user in a fictional concept that could enhance their acceptance to the automation technology. However, utilising Design Fiction techniques is not to produce utopian visions that promote developing technologies but instead afford a means to explore the societal and technological distinctions of possible futures so that we can better understand our present.

Self-driving vehicles or Autonomous Vehicles are part of a critical shift that articulates a technological leap forward, proposing solutions to current transportation problems in order to change how people address mobility. Studies show that people generally have an optimistic stance towards Autonomous Vehicles (F. Becker & Axhausen, 2017; Howard & Dai, 2014). While Autonomous Vehicles have the potential to improve safety and enhance the quality of life, the populace appears reluctant to adopt the technology due to safety and control issues. The Autonomous Vehicles concept needs a new form of communication to overcome the challenge of earning the trust of its future customers since they determine the demand in the technology market as well as future investments in infrastructure. Therefore, reflecting on what it means Design Fiction has an immediate challenge of closing the gap between a vision and its material expression by using 'what if' scenarios that situate the user in a shared conceptual space. By presenting the generated design in different forms, such as images and

videos with different scenarios, improves our understanding of Autonomous Vehicles and raises a debate that could lead to enhancing our trust of the technology.

Design Fiction concerns the combination and manipulation of design and fiction, where design is a creative act to find solutions and fiction is an artistic technique to open up a discursive narrative space. Stuart Reeves, in his paper 'Envisioning Ubiquitous Computing', explains how Design Fiction has become popular in many profitable plans for the future, playing a conspicuous role in research studies and the shaping of potential technology (Reeves, 2012). It is indeed an exciting perspective, where Design Fiction is considered as an evocative means to enhance technologies growth (Kirman, Linehan, Lawson, & O'Hara, 2013) and a critical way to justify their exploration (Dalton, Moreau, & Adams, 2016). Hence, this research is investigating the automation technology through Design Fiction lens. A further study regarding this point will be addressed under the 'acceptance of Autonomous Vehicles' section within this thesis. Indeed, Design Fiction can be used as an instrument to familiarise the concept of the autonomous vehicle. This technique is not intended to deceive users but operates more as a creative act that sets them into a discursive space for a while and then lets them go. Therefore, the design experience has to avoid the ambiguity that pretends to be real, and the user has to 'suspend their disbelief willingly' (Dunne & Raby, 2013) to enjoy shifting their imagination into a new and unfamiliar space.

Design Fiction is employed in the present research instead of any other future-oriented approach because it raises far-reaching questions concerning the consequences of technological development besides prototyping. In particular, Design Fiction draws attention to the social aspects and implications of techno-scientific solutions, utilising the techniques of fiction to examine the future of objects to define what their impact might be in order to present a range of possible alternative futures. Blythe (2014) illustrates how Design Fiction proposes examining a distant future through scenarios based on the present, using the facts and constraints afforded by current technology. Design Fiction elements are made up of the narrative, the diegetic prototype, and the context, which can be employed together to present a particular narrative to envisage the future. Furthermore, the way these elements are combined and resonate with the users is a critical point in employing the method effectively and ensuring that any provocations and questions can be comprehended. It is

important to remember what Bleecker means when he states Design Fiction is about “creative provocations, raising questions, innovations, and exploration, making an effort to explore new kinds of social interaction rituals” (Bleecker, 2009). The intention of using fiction in investigations into the nature of the neoteric products and services is undoubtedly different from approaches in design, art, and architecture. Notably, in these disciplines experiments are taken to establish, validate or invalidate a rising hypothesis (Koskinen, Zimmerman, Binder, Redstrom, & Wensveen, 2013). However, locating the user in an unfamiliar space through Design Fiction is not for reproduction purposes but is more about raising questions and investigating the functionality of technology design.

1.3 Research Aims and Objectives

The present research derives its aims from the notion of "the paradigm shift" by Thomas Kuhn, which states that "People do not shift unless they have a vision of what it is they are shifting to" (Agassi, 1966). This research aims to employ Design Fiction strategies to stimulate the acceptance of driverless cars, by opening up a discursive space that allows the potential user to review the technology, raise questions and reflect on their use of it.

1.3.1 Research Objectives

- Identify what a Design Fiction approach is and how it can be considered a valuable tool to investigate future technologies to influence our understanding of design applications. To also describe how Design Fiction as a service design approach can address, visualise, and explore specific issues at the beginning of the design process.
- Investigate autonomous car technology and what challenges need to be overcome to proceed to the plateau of productivity. Then employ Design Fiction strategies to prepare and present the technology by centring upon the idea of 'suspend[ing] disbelief about change.'
- Develop a fictional prototype for an autonomous vehicle that fulfils the research process and purpose. Then, generate a context around this prototype to support the narrative that reflects the future vision and the product functionality by Design Fiction.
- Validate the efficiency of the proposed strategy to stimulate the adoption of autonomous vehicle technology by employing different data collection tools such as the survey and experiment.

- Evaluate how the use of Design Fiction within service design could help the acceptance of automation technology.

1.4 Research Scope

This research investigates the use of Design Fiction techniques to generate a visual language that bridges the communication gap that exists with the acceptance of Autonomous Vehicles. By utilising the fundamental aspect of fiction strategies, in particular principle of minimal departure,' this research will create a narrative that includes a fictional context and prototypes to manifest the concept of driverless cars. This encourages the critical debate by fostering the potential user to reflect on how such technologies could reshape everyday routines and cultural rituals associated with driving habits. This narrative is an open invitation for innovation and a catalyst to adopt new concepts.

The research does not intend to discuss the technical aspect of driverless cars, such as the artificial intelligence system, or the ethical and social issues resulting from using the technology. Instead, the research will focus on the design aspect as per the research aim.

It is essential to highlight that at times this research uses the term Autonomous Vehicles, Driverless Cars and Self-driving Cars. These terms refer to automation technology. However, this research refers exclusively to cars for personal usage, not to but this must be highlighted as the term 'vehicle ' which might mislead the research aim as it refers to all types of vehicles (buses, cars, trucks).

1.5 Contribution to Knowledge

This research intended on investigating the Design Fiction approach to enhance the adoption of future technologies. The point of departure was the research question: How the employment of Design Fiction can stimulate the adoption of Autonomous Vehicles? Design Fiction, as a future-oriented approach, investigates the future through a combination of prototyping and storytelling. It can bring products not yet in existence to a concrete platform for examining purposes. The trigger for this investigation is Bruce sterling definition of Design Fiction "to suspend disbelief about change." This study demonstrates that Design Fiction is a tangible continuation of the speculative design concept that enables designers to prototype physical objects, reflecting on how they visualise the future. It provides a space where

practitioners could drive their minds to visualise an object, giving it a tangible form and then constructs a narrative by placing the prototype in a new world for the audience to interact and raise a debate. Furthermore, this research interprets that Design Fiction is not about predicting the future or creating utopian visions that develop emerging technologies. Instead, it affords a means for investigating the societal, technological differences of possible futures so that we can better understand the present.

The evidence from this study found that extensive research has utilised Design Fiction techniques and some other methods to present new technologies; some have employed storytelling and what-if scenarios to shift the potential user into a futuristic world. These attempts have a set plan, aiming to provoke the debate and reflect their acceptance based on the pre-prepared elements. This research has employed the principle of minimal departure, where the viewer of a fictional world would locate their knowledge, experiences, even ideals into the actual world. This technique proposed autonomous technology gradually to the audience. Starting by visualising the current transportation system, then exploring the participant relation with this system, subsequent presenting the autonomous mode and how everyday travel could look in the future, concerning their travel habits, vehicle shape, and even the in-car interaction system.

The employment of the Research through Design (RtD) approach to establish 'how Design Fiction tools and strategies could enhance the adoption of AV's' was because the design Fiction approach does not provide a clear image of the kind of knowledge it could produce. Therefore, building meaningful experiments based on discourse alone is not sufficient. RtD is a combination of process and research ends; the results of this combination are always an artefact that serves the purpose and plays a significant role in defining new knowledge. By employing RtD, this research included traditional research tools and documentation to build the study understanding. Consequently, this thesis managed to reflect on their proposed artefact and improve it similarly to that of diagnostic design research methods.

Indeed, the experiment became an invitation to think of the automation technology in which the participants were not involved as a roleplay; they are instead a real play. Although different possibilities of expression enhanced the engagement of the participants, the narrative was utilised as a technique to anticipate opportunities and challenges. Following with questions, this intended to place the participants on a decision-making platform assumes

that the automation technology will be implemented soon, and the public perspective is crucially needed. Perceived usefulness of AV's is criteria where the consumers realise the benefits of using a particular technology, and eventually, it may influence their intentions to use it.

Based on the above strategy, the outcome knowledge takes a theory with practical general applicability and predictive ability. Consequently, it is derived that the Design Fiction platform allows the integration with other approaches to validate the proposed prototype, such as SUS and TAM, in the early stages of the design process without the concern of misleading the experimental concept. Hence, this approach has the advantages of encouraging the acceptance of automation technology and developing the proposed prototypes for futuristic use. However, to accomplish such results, it is essential to set the user requirements as the core of the design and implement a prototype that users could relate to and has futuristic properties to serve the research purpose.

1.6 Research Structure

1.6.1 Chapter One: Introduction

This chapter explains the purpose of the research and justifies the selected approach 'Design Fiction'. Moreover, it includes research aims, objectives, scope, and the contribution to knowledge this research has made.

1.6.2 Chapter Two: literature Review

The chapter provides a detailed review of Design Fiction notion, strategies, and implications. As well as it defines the difference between the selected approach and other future-oriented approaches. This chapter explores the kind of alternatives Design Fiction could provide and which future the research is deploying. Furthermore, it investigates the Autonomous Vehicles technology and what kind of challenges and requirements the technology has to overcome before it becomes out in use.

1.6.3 Chapter Three: Research Methodology

This chapter explains the used methodological design employed for this pragmatic study and justifies the philosophical assumptions, the research approach, methodological choice,

research strategies, time horizon, data collection and data analysis techniques. Furthermore, validation procedures, the summary and the links of the chapter were presented. Moreover, it provides an in-depth explanation of utilising Research through Design approach as a selective research method.

1.6.4 Chapter Four: Experimental Design

This chapter will describe the design stages of car prototype, User interface (UI) prototype and Design Fiction world-building in which both artefacts will be placed and verified through different techniques. This chapter will also reflect on what it means for Design Fiction having an immediate challenge of closing the gap between a vision and its material expression by using 'what if' scenarios that situate the user in a shared conceptual space.

1.6.5 Chapter Five: Results and Discussion

This chapter discusses the findings resulted from a survey conducted to verify the design prototype; an experiment to verify the user interface. The chapter will firstly explain the background information and the procedures adopted for the analysis. After that, the chapter presents the respondents' findings on how efficient the proposed concept was and how it contributes to enhancing the adoption of Autonomous Vehicles and suggest ways to overcome some challenges.

1.6.6 Chapter Six: Conclusion

This chapter presents the synthesis of the objectives, the contribution to knowledge, limitation, further research, and the final note for the study.

2 Chapter Two: Literature Review

2.1 Introduction

Design is a valuable tool to speculate and raise debate about futuristic social and technological evolutions. However, visualising and tracking future technologies can seem like something straight out of science fiction; the implications can appear very vague and unfeasible. Therefore, the need to explore speculative design techniques and the role of fiction to examine and propose future objects has become a priority for designers because it helps define what their impact might be and present a range of possible alternative futures. Julian Bleecker, an artist and technologist, argues that “there is no fact without also spending some time speculating in a fictional mode, asking the “what if...?” questions…. facts are facts and fiction” (Bleecker, 2009). Bleecker’s definition indicates that before they take their final shapes or form, facts must go through different trails in order to validate them. For designers have used fiction as a technique for both exploring alternative models for society and for criticising existing ones. By studying the role of fiction in idealistic applications in design practice, Design Fiction emerges as an inventive approach with which to explore and increase knowledge of the ways in which fiction could be used in design research and what differences fiction adds to these applications.

Design Fiction involves the appropriation and manipulation of design and fiction, where design is a creative act to find solutions, and fiction is a technique to open up a discursive narrative space. Simon (1996) as cited in Grand and Wiedmer (2010), contents that design and design research do not concentrate on the world as it already exists but rather attempts to develop a description of existing elements, processes, and activities to investigate a better possible future. To clarify what is meant by Design Fiction and design practices, and to reveal further details relating to design as the imagination and creation of possible future realities, Grand and Wiedmer (2010) state that the concept of Design Fiction "implies that the conceptualisation of design and design research as a practice and investigation field, which particularly focuses on the world as it could be, should be taken as the actual core for defining and practicing design research”. However, design methods bring inventive strategies to envisioning scientific research.

Over the last decade, the rise of Design Fiction has influenced the types of research with technology development and HCI research. The term Design Fiction was defined by science fiction author and futurist Bruce Sterling in his book *Shaping Things* (Sterling, 2005). Sterling aimed to distinguish between science fiction and Design Fiction from the "grandeur and credibility of science for its own hand-waving hocus-pocus" perspective (Raghavan & Ma, 2011; Sterling, 2005). Sterling's approach attempts to establish a deeper connection between science fiction and real life science; where Sci Fi explores alternative and possible diverse futures, and real-life science validates these alternatives and explain how to deploy these alternatives to build a real bond with the contours of the future.

The following parts of this chapter cover the notion and plausibility of Design Fiction; the employment of Design Fiction; the kind of future that Design Fiction is applicable to and why; the plausibility of Design Fiction; Design Fiction strategies; utilisation of Design Fiction as a technique to present new technologies, ideas, and services; how effective is Design Fiction as a technique; and why it is the right tool for the purpose of the present research. This research is cast in a descriptive, analytical, and critical way in order to provide a comprehensive explanation of different authors and researchers views, whether they had conducted academic research or industrial experiments that led to a new production of knowledge. This approach helps define the research gap and to investigate the potential solution for the research question.

2.2 Speculative Design Forms

In broad terms, design can be defined as a problem-solving creative act, more like a process of developing sufficient solutions that fulfil the need of the industry. Design is seen as a service practice because it focuses on the user experience and the quality encounter with the user is the key element to ensure success. Dejan Kršić, a graphic designer who has utilised design for advertising purposes, underlines that design represents a practice which distributes, analyses, and reproduces social meaning to meet the new social, economic, and technological conditions (Kršić, 2014).

To critically reflect on the development and role of technology in society, designers have to consider the role of technology in everyday life along with its implications. But the commercial aspects of design and the demands of the market are linked with a broader social context.

And design is used as a medium to focus on concepts, ask questions, and open issues to discussion, in which it becomes a more critical practice generating future visions and solutions. The researcher and educator Ramia Mazé states that critical design practice can be reflected through three different approaches: the first is about a self-reflection where designers question their own design practice; the second is about re-thinking the design disciplines based on an inclusive perspective; the third approach involves the design practice being steered towards broader social and political phenomena (Mazé, 2009). The previous classification of critical design practice does not exclude each approach from the other one; they most often supplement and entangle each other in practice.

On the other hand, design and critical practice generate deeper links in the interaction design field, a field that emerged from the accelerated development of digital technologies and is mostly associated with the design of digital services or products. The standard interpretation of interaction design describes it as a discipline that explains the way people are dealing with digital artefacts. From this perspective, as a design practitioner, Anthony Dunne defines critical design, as a practice that deals with the aesthetics of the usage of new technologies in the context of digital products (Dunne, 2007). Over the years, Dunne's definition has expanded due to his collaboration with Fiona Raby and included broader speculations on the cultural, social and ethical implications of new technologies (Dunne & Raby, 2013).

Speculative practice comprises or relates to a series of design activities with various purposes; these activities have a common ground which is using fiction to generate deeper links with the discourse on the proposed speculative project. For instance, design fiction is a sort of speculative design practice, and "critical design", is a place where the imagination meets the potential substances of the external world, according to (Dunne, 2008). Speculative design, as a discursive practice, relies on critical thinking and dialogue to question questions the practice of design, and takes this critical thinking towards imagination and visions of plausible scenarios. Different practices can fall under the speculative design categories such as critical design, design fiction, radical design, discursive design, adversarial design, vision concept design, transitional design, and many others. However, this research will focus on Design Fiction and critical design as more debatable genres under the umbrella of speculative design because they are more relatable to the research purpose. By speculating, practitioners and designers re-think alternative products, systems, and worlds. James Auger, a designer and

teacher, says that speculative design allows designers to: move away from the restrictions of commercial practice; employ fiction on future products or services to reveal the impact of new technologies on everyday life; and initiate a dialogue between experts and potential users of new technologies (Auger, 2013).

Though there is no commonly agreed interpretation of critical design or Design Fiction as fundamental categories of speculative design, these approaches share several similarities: they are not commercially oriented; they employ prototypes as the primary method of examination; and they utilise fiction to present alternative futures (Auger, 2013). Another practical approach that falls under the umbrella of speculative design is Vision Concept a futures study technique within the business context that helps designers step away from the constraints of the current marketplace and enter into a fictional world that allows future thinking. Certainly, the use of fiction has prominently emerged in recent attempts to become a resource for future-oriented approaches such as critical design, Design Fiction, and Vision Concept there is a need to explain how it becomes a resource for raising debate and which tools it uses to deliver its purpose. Therefore, this section analyses the different approaches that are presumed that they fall under the umbrella of speculative design in the design research landscape. Indeed, these approaches share a common ground when it comes to employing fictional narratives and props to present an idea, although they differ in the purpose and the timing of these ideas.

2.2.1 Notion of Speculative Design

Speculative design is an area of design research that focuses on ideas, and unreal products that are not assigned to be mass-produced, provides a space where the designer can use fictional worlds that are free from commercial constraints and allow them to challenge different ideas (Auger, 2013; Dunne & Raby, 2013). Indeed, through these imaginary worlds, designers facilitate "a dreaming process that unlocks people's imagination" (Dunne & Raby, 2013) - developing alternative visions and questioning ‘what if’ scenarios. Dunne and Raby (2013) demonstrate that speculative design generates objects that are more about the near future, and not placed in narrative space. Accordingly, speculative design is an approach that questions the practice of design by taking these practices into imaginative potential scenarios.

The production of new technologies or new products has opened a discourse regarding social interaction. And, whereas traditional design actually permits the status quo, speculative design envisages the future in order to understand and re-think the world of today. The fundamental concept is that by “exploring ideas before they become products or even technologies, designers can look into the possible consequences of technological applications before they happen” (Dunne & Raby, 2013). Speculative design is often based on the technique “what if?”, investigating the links between potential shifts in technological development and social relations, in which it is not only about engaging with a desired future but also dealing with the concerns regarding the emerging technologies in society.

The speculative design approach does not emphasise fulfilling the current and future consumer needs, but rather on re-thinking the technological future that reflects the intricacy of today’s world, opens space for examining and considering alternative possibilities and options, and imagines and redefines our present. By employing fiction and design as a medium, it drives thinking, raises awareness, questions, opens discussions, provokes action, and can suggest alternatives that are essential in today’s world. Auger (2013) states that designers who employ speculative design "use fictitious objects at the core of [their enquiries]", to provoke discussions with a broad audience (Mollon & Gentes, 2014). These speculative design proposals can function as: a form of thinking, questioning and imagining the very plausibility (Auger, 2012); as motivation, aesthetic exploration, speculation about possible futures, and impulse for change (Dunne & Raby, 2013); and as provocation and critique of the existing proposals of Design Fiction (Hales, 2013). It is important to note that Dunne and Raby’s approach aims to trigger debate about the relation between different objects, while for Auger debate is about the real use of the speculative objects and how the future user could react to these objects and further develop them.

The speculative practice may appear like a top-down approach at first glance, locating the designer at the centre of the process, allowing their vision, without the involvement or the influence of the target audience. Remember, one of the main goals of speculation is the embodiment of the public in the rethinking and dialogue on new technological realities and new social relations. Consequently, a sufficient speculative project is necessarily related to the research of a social context and is centrally directed towards the individual’s necessities and desires. The implementation proves that the speculative approach has the most potential

in multidisciplinary perspectives, where it fosters dialogue and generates a context in which the participants can simultaneously re-examine the boundaries of their views and discover links with the views of others.

Speculative design prototypes are most often inspired by science fiction; where it provides a space to create fictional scenarios, characters, and worlds which the audience or the viewer can closely recognise. Fictional worlds are an uncommon source of inspiration to designers in their practice of re-imagining the future. However, speculative design techniques, as described by the science fiction author and futurist Bruce Sterling (Bosch, 2012) are often part of the technological paradigm, more like confirmation for the technological improvement rather than questioning or being critical of it. By designing fictional worlds or products, we genuinely question the values and functions of the world we live in, as well as the expectations of its occupants.

Mazé (2009) indicates that design practices cannot be considered as being neutral practice, since there will be some critical or political issues, or even alternatives futures linked to the practice. Dunne and Raby (2013) maintain that speculative design can tackle large scale social and political issues, for instance, the alternatives to the existing capitalist model. In this context, Naomi Klein (2014) affirms that "the present domination of dystopian scenarios in literature and films lead to a view where catastrophic scenarios are unavoidable, which results in making us passive rather than proactive." Klein's perspective indicates that speculative design proposals should not be utopian or dystopian science fiction concepts of the future, but rather a discourse on what the future could be. This suggestion could be attributed to the explicit focus on the future, as the speculative design approach contributes to providing a stimulative framework for re-thinking visions on what is preferable and desired to be seen in the future.

Liam Young, a speculative architect, acknowledges that speculative fictional city prototypes and proposals can be considered as a point of departure for discourse and discussion about scenarios that we at present might desire for our future, which will "not just anticipate, but actively shape technological futures through their effects on collective imagination" (L. Young, 2015). Young adds that speculative design practitioners should cast themselves as a provocateur who encourages the debate, raises questions, and involve the populace on envisaging the future of their cities (ibid). This perspective proves that allowing the public to

decide what could shape their future will ease the transformation to adopt new technologies and seek the development that could make the future better. Further, according to CeArley, Burke, Searle, and Walker (2016) speculative design can function sufficiently in the real-world proposals, for instance, various companies employ designers to consider potential scenarios for future trends and research into the adoption of emerging technologies.

Though the speculative design approach can be classified as a traditional method as many designers practice it without using the term 'speculative design', according to (Dunne, 2008), there are some distinguishing characteristics to it that can be determined a basic framework of employing the approach. An example of a speculative design characteristics would be it continually interacts with other relevant practices, activities, and disciplines, and utilises any method that is accessible and appropriate for the project. Thus, the speculative design legitimately employs tools, techniques, methods, genres, and concepts such as fictional narratives, film dialogue, storyboard, experiments, games, and different types of media that are considered legitimate to achieve or enhance a debate about the future. For instance, the "Technological Dream Series: No. 1" by Dunne and Raby (2011), is a project where the speculative design approach was employed to dismantle the typical image of robots. The designed prototypes were aimed to harmonious with the contemporary home landscape in order to display an existential logic (see Figure 1). These robots imitate the sophisticated sensibilities of people. The technological interactions take place in strange but intimate forms, and they become needy and subservient to defeat the user's fear of them.

Figure 1, Technological Dream Series: No. 1

Indeed, speculative design practice is based on investigating, understanding, and observing the surrounded world and the social context, much as an attempt to articulate our needs, expectations, ambitions. However, some issues arise when practitioners endeavour to expand the horizon of observation to identify emerging themes or needs, considering that these themes differ from one individual to another and likewise from one community to another, because they require a standard vision that both covers them all and retains an open space for discussion and development. Therefore, the underpinning question is how to begin such a process when the design space is vague and has to meet wider audience requirements. The present thesis believes that the speculative design approach and practice provides an exceptionally stimulative platform for researching the space that shapes the present and the future.

The speculative design approach often employs tools imported from contemporary art. However, in contrast to the common artistic practice, the speculative design adopts a language that is recognised and understood by a broader audience and is not limited only to galleries and studios. In support of our perspective, a design critic and author Rick Poynor underlines that unlike artistic practices, the design is not declared as an artistic fiction out of hand and disregarded by companies, institutions, or policymakers (Poynor, 2005). The speculative design has a special bond with the new technologies and consumer society, so it claims significant media and social impact today. Therefore, novels, films, computer games, pop-culture forms, and many more are more effective platforms for speculative designs than galleries and museums.

While studying speculative design practices, there are two basic concepts to consider: firstly, speculation on plausible futures, where it generates scenarios of the future that critically challenge the concept of improvement, the implementation and usage of new technologies and their broader social implications; secondly, the design of an alternative present which refers to the creation of parallel desired technological entities. Thus, both concepts offer a rich narrative to question and criticise technological developments in contemporary society. These concepts and their implementation can include more comprehensive issues such as socio-political matters to ordinary and everyday activities such as interacting with a walking stick. Hence, unlike science fiction, in speculative design, there is a distinct link between the present and the imaginary future (Dunne & Raby, 2013). Therefore, when envisaging the

future, designers and practitioners must think about the different technologies and social relationships that could emerge from the current world; and also, must consider and question the assumptions and prejudice regarding the role of everyday services and products, and how do we set our preferences. Accordingly, the extension of the everyday tools and preferences for the future is what distinguishes and makes speculative design practices profoundly intriguing.

Dunne indicates that usually design activities essentially deal with designing relations, rather than objects themselves (Dunne, 2008), and that is why speculative design proposals can offer new speculative products and services or even new social rituals. However, the impact of a speculative proposal can be perceived by the audience, and how the artefact can rise and allow the debate of the potential scenarios of the future. The intended concepts develop and communicate in narrative or prototype, video, film, or other platforms that allow direct interaction and reflection. Such mediums can be classified under the term 'diegetic prototype', where they exist as fictional objects with different functions and purposes aiming to create the suspension of disbelief about change. Therefore, this emphasises that speculative design has different categories under its core, each with different purposes, but all provoking and enhancing the debate about the future.

The 'diegetic prototype' term was first used and invented by David Kirby (2010) to understand how cinematic depictions demonstrate future technologies to a broad audience, their implementation, validity, and how they can fulfil a potential need. Kirby (2010) clarifies that 'diegetic prototypes' have a significant rhetorical advantage compared to actual prototypes because, in the fictional world, these technologies are fundamental and have a distinctive function that helps fulfil a specific task. Therefore, diegetic prototypes encourage the analytical advantage of virtual witnessing where the narrative presents scientific and technological elements as consistent to reality, which is the core of the diegetic prototype that leads to real-world technological development and adoption. Hence as indicated before, speculative design practices derived from films, computer graphics, visual arts, and many other forms. The narrative and storytelling styles have considerable power and deep links in stimulating discussions and critical thinking. Speculative design scenarios and strategies provide an open discursive space that offers the opportunity for personal reflection and interpretation, activating the public on an emotional and intellectual level. Indeed,

speculative design scenarios are often unique, unusual, and they could be disturbing in a curious, desirable, and attractive way. However, if these scenarios and prototypes can provoke attention, emotions and encourage discussion, this means they succeed in communicating with the suspension of disbelief, which is the central core of speculative design practice.

Speculative design practices have the potential to become an active service design practice that investigates the future and links it with different social aspects; however, there are some concerns regarding the utopian image it could present, as it focuses on aesthetics aspects of the visual and narrative level, which could lead to separation from the real world. On the other hand, Cameron Tonkinwise, an international expert in design studies and transition design, underlines that speculative design provides many dystopian scenarios that are already found in the present time; this inquires the present role of the approach to suggest solutions for such mistakes in the modernist project (Tonkinwise, 2014). The purpose of each speculative design proposal can demonstrate where it leads; is it about raising a discussion for specific issues? or visualising the use of technology in the future? or does it aim to understand our relationship with future technologies? These possibilities help us to understand which speculative practice is appropriate to use. Therefore, a further explanation for each speculative design practice should take place. As mentioned before in this section, this research will focus on understanding the Design Fiction approach, critical design, and vision concept approach. The following section will investigate the Design Fiction approach and how it relates to diegetic prototypes and the suspension of disbelief.

2.2.2 Design Fiction

Design Fiction is described as a postmodern technique that opens a discourse about potential futures. To recognise 'the plausible and the preferable' that drive human curiosities to investigate and solve unanswered questions about the near future, Design Fiction uses fictional scenarios or props to explore and discuss human progress and the emergence of creativity. Eventually, this leads to an escalating need to keep up with increasingly rapid technological advances. Tanenbaum (2014) clarifies that there is some debate in Design Fiction over whether it is fiction about design, speculative design, or science fiction. Tanenbaum adds that the Design Fiction approach remains "somewhat ‘up for grabs" which

means Design Fiction proposals are ready to be taken further to investigate and communicate about possible futures through comprehensive narrative which will encourage the rise of new alternatives. Bleecker (2009) claims that Design Fiction is a fusion of design practices, science fact, and science fiction, this combination transforming the materialisation of ideas into something new. Bleecker's description justifies that Design Fiction is not realism, but a concept that is forward-looking, attempting to explore the new kinds of objects and technologies that are needed to help reimagine the world beyond storytelling. Bleecker acknowledges that science fiction is about innovation beyond the usual ubiquitous 'up-and-to-the-right', an approach which means disturbing the grid to anticipate alternative possible futures and provokes, raises questions, and explores possibilities. Reeves (2012) explains that the 'up-and-to-the-right' approach means there are various potential futures rather than one future that goes in one direction. Tanenbaum and Bleecker are both practitioners and their concepts have a common ground which is encouraging the use of new strategies relating to fiction.

Fiction is usually associated with something being untrue or unreal. Bleecker (2009) states that Design Fiction is a fusion of fact and fiction, but does that mean Design Fiction is real and legible? Is it speculating and extrapolating? A reflection on how things are, and how they might become something else? Or is it exploiting scenarios purely to provoke debates? (Sterling, 2013b) provides an explanation as to the difference between real and not real, stating that Design Fiction scenarios "are fakes of a theatrical sort", not intended to deceive people, but more of a creative act that sets the viewers into a discursive space for a while then lets them go. Likewise, Design Fiction objects are not real, because "real things are not entirely and permanently real", they are only an idea, brought into existence because they were buildable, profitable, and desirable in origin (Ibid). Sterling's concept regarding Design Fiction is so dynamic because it perceives this speculation to its extreme, enabling designers, engineers, artists, or stakeholders to actively speculate using prototypes and concepts that do not yet exist or are not yet real. Hence, for this new emerging design field, Sterling proposed a definition for Design Fiction as "the deliberate use of diegetic prototypes to suspend disbelief about change" (Sterling, 2013b). Sterling's definition has multiple meanings: "deliberate use" refers to something people do with a purpose; "diegetic" means the magical power that invokes the scene and draws attention to small details that enhance believability;

and "suspend[ing] disbelief about change" is a creative act that situates the viewer in a shared conceptual space. According to Sterling's definition and explanation, Design Fiction has three essential elements: the narrative, the diegetic prototype, and the context.

Bleecker (2009) investigated the concept of Design Fiction by combining Kirby's term and explanation of the diegetic prototype, and Sterling's concept of 'suspending disbelief about change', and his notion that "fiction follows fact". Bleecker explains that when an object or a thing is designed, it implies an ongoing thought about this object, considering that design connects the imagination with its material form. Thus, when the designed object is business or finance driven, it can move it beyond its current status towards another form that adheres to different principles and activities. Indeed, design can be conducted differently for each object or project, but outcomes should reflect this object's development and needs. As previously stated, a designed object can link an idea to its material form, and the process to get these forms or figures can include different stages such as ideation, speculation, reflection. Many of these activities would lead to emerging new needs and open the discussion door to verify these objects and seek the development of the existing objects. Bleecker questions the use of design for exploration:

> "If design can be a way of creating material objects that help tell a story, what kind of stories would it tell and in what style or genre? Might it be a kind of half-way between fact and fiction? Telling stories that appear real and legible, yet that is also speculating and extrapolating, or offering some sort of reflection on how things are, and how they might become something else?" (Bleecker, 2009)

Bleecker here establishes the link between design and fiction as an alliance of the paths of science fiction, art, and technology in order to envisage how the world may look in the future. By studying films such as Minority Report (2002) directed by Steven Spielberg, Bleecker aims to analyse the fictional prototypes within the movie. Such analyses emphasis on the speculative theory 'what if', that arises from the seeds of an idea until the implementation stage in the future. The idea of using the 'what if' premise is to provoke thinking of ways forward or taking an idea that exists in a raw state and thinking through what would happen

if it were circulated (Mulgan, 2013). Most methods of reflecting upon Design Fiction require either self-reflection, or a process of research verification , both of which engage users with relatively short fictions as part of the design practice (Dalton et al., 2016). While this affords insight into how Design Fiction work, the issue is that many new technologies are designed for a global market. However, the technology commonly used concerns projecting a distant future, and this is what provides some of the more insightful conclusions (Buttrick, Linehan, Kirman, & O'Hara, 2014). Today, many scientists, futurists, and designers are speculating about how they can form a deeper connection between science fiction and real-life science, whereas the emotional and imaginative superiority of sci-fi stories leads them to a wider understanding of the contours of the future. Science fiction has more imagination than science fact and almost certainly bridges the knowledge gap between fact and fiction. This knowledge has been circulated, and fictional ideas turned out to be real, and most importantly, desirable. Indeed, this progression brought many new devices or services which are smarter, faster, more accurate and present different uses, such as waving hands in the air to open doors or swiping fingers over the screen to read emails.

To follow, Auger (2013) endeavoured to actively speculate with different prototypes that are not real yet, as well as concepts that are never meant to become real. During recent decades, increasing attention has been paid to understanding how fiction can be a resource for design research. A number of researchers and themes have been established as being worth exploring using fiction either as a method, practice-based tactic, or a conceptual framework for encouraging the critical debate (Dunne & Raby, 2013); fostering people to reflect on how new technologies could reshape everyday routines and cultural rituals (Auger, 2013); or an open invitation for innovation and inciting of a new culture (Tanenbaum, Tanenbaum, & Wakkary, 2012). An example of employing Design Fiction strategies to present a new prototype is Helios: Pilot, Quick Start Guide designed by Near Future Laboratory (2015). The Quick Start Guide of Amazon Helios Pilot, is a 14-page booklet, that presents a basic guide to the concept of the fictional self-driving car. The booklet provides basic instructions for the user on how to operate the car and details some of the tasks it could fulfil, such as how the car picks up groceries, or how to activate the "Child Safe Mode" when the car taking your child to their football practice (see Figure 2).

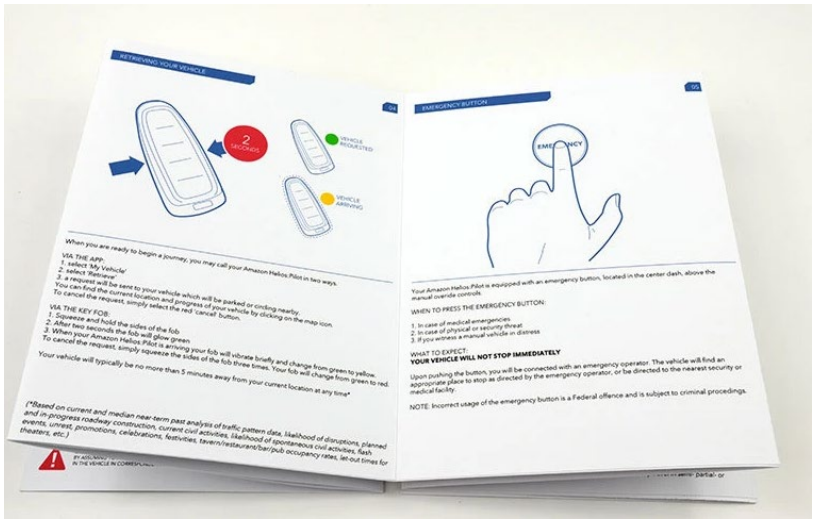


Figure 2, The Quick Start Guide of Amazon Helios Pilot

Sterling and Blythe's explanation focuses on the temporality of Design Fiction, where it affords a vision for the use of technology. However, Pasman (2016) has presents and explains the implementation of Design Fiction as a service design approach - where users' needs and requirements are in the centre of the design process and fundamental element for success -, which aligns with a previous concept that speculative design practices are trying to offer. Pasman adds to the theory of Design Fiction by explaining how it could be a new and innovative direction for service designers to investigate and establish new services in a contextually rich and comprehensive way at the beginning of a design process. Accordingly, it is convenient to say that Design Fiction does not focus on application, but on forming a rich discussion of 'what-if' scenarios between research groups or users affords an open invitation to ideate and explore possible future implementations. Dunne and Raby (2013) emphasise

that Design Fiction is concerned with progress, considering that progress means different things for different users and markets. However, Auger (2013), points out that Design Fiction implementation has a remarkable challenge typically invented and improved by individuals, who have varying educational backgrounds and experiences, who might have a very unconventional view of what a preferable future may mean for societies. Though this research agrees with Auger stance and considers it important to involve the potential user when designing for the future; (Doos, Packer, Ward, Simpson, & Stevens, 2016) had conducted a study to predict future health technologies within three to twenty years, aimed to emphasise the role that forecasting can play in rational decision making around emerging health technologies, but their research had excluded users from this process. The latter raises a concern about the credibility of the study results since the end-user shapes the market demands.

As Design Fiction affords a technique to visualise the future, so there are other future oriented approaches that deal with fiction, which are located under the umbrella of speculative design. As previously mentioned, these approaches have a shared base in terms of the emphasis on futurity, but with slightly distinct aims and structures. The following section will discuss the critical design approach as part of speculative design practices.

2.2.3 Critical Design

Dunne and Raby (2011) define critical design "as [using] speculative design proposals to challenge narrow assumptions, preconceptions and givens about the role products play in everyday life. It is more of an attitude than anything else, a position rather than a method." It can be understood that critical design is an implementation of speculative design, "a position rather than a way" (ibid). These fictions may be found in real life, or they may address cases caused by vague directions and their consequences in the future. Critical design offers an alternative vision of how things could be, rather than how things are now; this allows the audience to reflect "on existing values, mores, and practices in a culture [thereby] provoking new ways of thinking about the object, its use, and the surrounding environment" (Dunne, 2008). Furthermore, critical design enables designers to compose independent design proposals to criticise the existing state of affairs. The outcomes of this form of speculative design are "artefacts as an embodied critique or commentary on consumer culture [...] to

challenge the audience's preconceptions and expectations" (Dunne & Raby, 2013). The objects that resulted from this process aim to encourage people to question imaginatively; whether the concept of the proposed design, or its form.

The initial use of critical design practice was particularly inspired by the narrative quality and imaginary worlds of literature and film. Design and critical practice create debatable links with interaction design, a specialised field of design that emerged in the early 1990s as a result of the accelerated development of digital technologies (Arana, 2019). The classical definition of interaction design describes it as a practice dealing with the ways in which people connect via the products and technologies they use, i.e., with the design of our everyday lives via digital artefacts.

According to Mazé (2014) there are three different approaches to critical design practice: the first sees designers reflecting on and critically questioning their design practice; the second approach is based on a macro-perspective, re-thinking the design discipline as such; and the third approach, by contrast, the design discourse is directed towards broader social and political phenomena. Mazé points out that these approaches are not mutually exclusive, as they most often intertwine and supplement each other in practice. Referring to Mazé classification designers who can reflect on their role in the society, and be critical about different designs, they can provide affirmative design. Design is an ideological practice and an expression of the values interfered by designers and commissioned by society; though the design practice allows critiques; the critical design is the outcomes. Such a scheme presents alternative perspectives, where weakness and strength of design can be underlined, which positions critical design as an integral part of the design discourse. In contrast, (Poynor, 2003) argues that such activity does not lead to social transformation, because depth evaluation would draw attention and question the current assumptions about design.

Bardzell, Bardzell, Forlizzi, Zimmerman, and Antanitis (2012) classify critical design as a type of Constructive Design research, where design activity is a primary research activity that attempts to disrupt social and cultural norms. It is essential to point out that Constructive design research also known as Research through Design (Fallman, 2007; Frayling, 1993; Zimmerman, Stolterman, & Forlizzi, 2010), where design activity leads the research; it is the core methodology this thesis has utilised to demonstrate the research hypothesis, and a detailed explanation will be provided on Chapter three. As previously stated, design

experience in the form of designers' interpretations is evenly essential to the analysis and reasoning activities necessary to all kinds of research. Critical design practices can start with imagining future states of different technologies and how they can improve the current state of human existence.

There is some evidence to suggest that Critical Design as an approach to designing for Change, is a highly encouraging practice to enrich and expand our experience of everyday technologies. Dunne (2008) acknowledges in the conclusion of his book 'Hertzian Tales: Electronic Products, Aesthetic Experience, and Critical Design' that:

> *"Producing conceptual electronic products that encourage complex and meaningful reflection on inhabitation of a ubiquitous, dematerializing, and intelligent environment: a form of social research to integrate critical aesthetic experience with everyday life…. I hope in my approach I have retained the popular appeal of industrial design while using it to seduce the viewer into the world of ideas rather than objects. Industrial design locates its object in a mental space concerned with identity, desire, and fantasy and shaped by media.... Again, I hope this remains intact but is subverted to challenge the aesthetic values of both consumers and designers."*

In a nutshell, critical design proposes can be classed as provocative activities, that tend to obscure the norms and conventions impressed in the designs and their use.

Several critical design researcher and advocates have used the critical theory as an intellectual resource to defend and proof their scheme. Dunne (2008) has manifested ways to explicate symbolic systems; proposing critical strategies for exposing different structures; exploring relationships among design artefact features and qualities; and the influence of these artefacts from sociocultural context, since critical theory offers designers many resources to generate prototypes that encourage the public to debate about designs' participation from sociocultural norms and structures. Such method inspires designers and the audience to reconfigure sociocultural norms in more aesthetic critical ways and stimulate the desire for such designs.

Critical design literature offers several examples of its practices, but it does not talk much about how to do it. Koskinen et al. (2013) their book regarding 'Design Research through Practice' suggests that critical design practices can be conducted in three different platforms: lab, field, and showroom. In the lab platform, researchers conduct workshops with practitioners or designer to examine a question; then they tend to form on the outcomes by creating different versions of the same thing, this artefact investigates a broader unique interaction question to test if the generated hypothesis play out. In the field platform, design researchers utilise moderate versions of social science techniques to understand the current state of the artefact, then employ methods from design practice to produce new things that reflect a preferred state. Previous platforms have several sets of methods that design researchers can select based on their research design nature. However, the showroom platform, Koskinen et al. (2013) have a different term for the critical design; it highlights the theoretical influences on the practice and summarises how methods might be set together to complete a project.

However, much of the research categorise critical design as a form of design research and not only a form of design practice, which indicates that a set of described techniques and practices would allow other practitioners to pursue an alike approach. Though, regarding our previous stance, we are not suggesting that critical design should be represented as a formal methodology such as those found in scientific research, but rather a more relaxed framework that helps design advocates and researchers to select different methods that support a query, phenomena, or a question at the centre of their inquiry. Indeed, design as a practice has a long connection with making things a form of inquiry, generating solutions based on problem formulation and other strategies. Bardzell et al. (2012) aspire to describe critical design practice to account for both: prototypes or objects that create dilemmas or confusions among users, encouraging them to expand their interpretative boundaries or rethink cultural norms; the kinds of design processes and strategies that could lead to those genera of products. In the same extent, this thesis acknowledges that critical design is an open invitation to question how we adapt, do, and evaluate things around us, suggest a different direction of thinking as it might lead to a desired and better results; which would allow a reconfiguration of sociocultural norms and open the space for new objects to surface.

An example of critical design practice is 'Digicar' by Dunne and Raby (2013), an electric self-drive car concept, part of United Micro Kingdoms. Digicar is the primary form of transport for digitarians, in a fictional world that is constructed by market forces (see Figure 3). The car concept is not only for travelling space and time, but it provides a space to navigate tariffs and markets. This project considered as a lab platform example, aims to raise questions regarding the way that products and systems and services are made and employed.

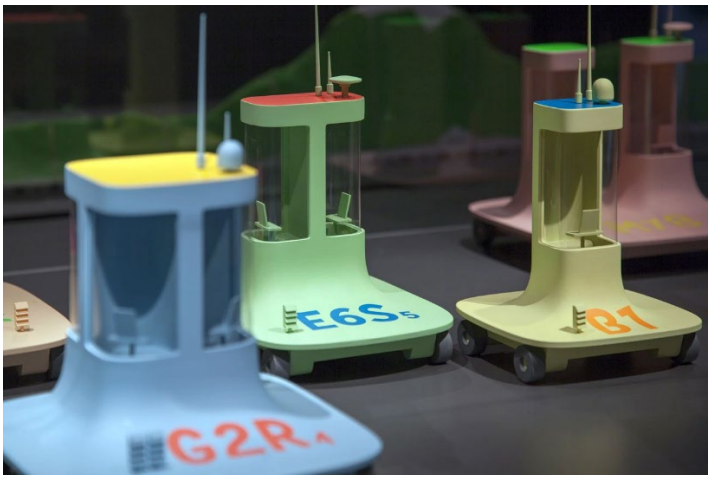


Figure 3, Digicar an electric self-drive car concept

The previous sections have described how the use of fiction and speculation can lead a new way of thinking and open up a discursive space about the future. Speculative design, Design Fiction, and critical design bring together the capacity to imagine and make concrete products not yet in existence, they have the potential to address, visualise, explore particular issue at the beginning of the design process, and to understand our relationship with future technologies for non-commercial purpose. However, there are other approaches that investigate the futuristic products for commercial purpose and would help companies and researchers to draw attention to what potentially can be used and how it can change our lives. The following section will explain Vision Concept approach as part of speculative design practices that derived by the commercial purpose.

Mejia Sarmiento, Pasman, Stappers, Lloyd, and Bohemia (2016), state that Vision Concept is a futures study technique that encourages organisations in the market to perceive and respond to change that could help to explore and discover new opportunities in the future. Vision concept allows companies to explore new technologies and envisage them to define a

possible, plausible, probable, and preferable future. As an active design approach vision concepts are part of a process that "support the company's strategic decision-making beyond the range of product development" (Keinonen & Takala, 2010). Such an approach allows designers, engineers, and stakeholders, through sketches, narrative or prototypes to exceed the limits of their imagination to bring about a new market trend. These outcomes always need to be presented in a high-resolution visualisation, since they aim to provoke the market to adopt the proposed idea for commercial purposes. Mejia Sarmiento and Simonse (2015) say vision concepts are "used by organisations to explore and present new ideas of the interplay between products and users in the future". Moreover, the resulting prototypes are usually displayed in commercial exhibitions where a broad audience can raise a conversation about the future regarding the company's proposal. Vision concept is a highly engaged approach aiming to draw the attention of different stakeholders to show the point they have reached with their technological exploration, and to build a debate about the future and what distinguishes it from other speculative design techniques used for commercial purposes.

Industrial firms must have a vision for the future and act within the current situation; this means they face a constant challenge to keep up to date with the technological evolution. For instance, Mercedes-benz (2020) presented a car concept inspired by Avatar film called *Vision Avtar*. This car concept presents four high-performance and near-wheel-built electric motors, embraces an incredibly agile implementation of a dynamic luxury saloon vision, and many other innovative technologies such as the so-called "crab movement" gives the vehicle a reptile-like appearance even in its movement (see Figure 4). *Vision Avtr* presents an example of how films and other mediums can be used as effective platforms for speculative designs. Further examples of how different car concepts were presented in films, and their designs inspiration will be discussed under the section Autonomous Vehicles on-screens.

Figure 4, VISION AVTR concept inspired by AVATAR film.

(Stokes, 1991) defines the vision term as "conditions as we would like them to be", this definition requires an investigation on the nature of new products development and what leads these developments. Similarly, to the previous discussed approaches, Vision Concept espoused the importance of sharing and reflecting different parties' visions, or as so-called by (Reid & de Brentani, 2012) a 'sharing process' where they suggest that vision development exists between individuals and other stakeholders. Nevertheless, various interpretations of how vision concepts explore the future through the embodiment of ideas and how designers share and lead the concept visioning process.

As described before, design as a practice is associated with exploring the future in different ways, where designers would act as futurists to meet the evolution needs; in the same context (Drucker, 2011) provides a scope to investigate what is possible tomorrow. Hekkert, van Dijk, and Lloyd (2011) claim that the vision in products is context-based and interaction-driven, which relies on the depth understanding of people's needs. Mejia Sarmiento and Simonse (2015) consider the development of vision concept from two prospects: deconstructions of the present; and the future design. In addition to the latter aspects, we add a third prospect; the lost futures describe the ideas that were not valid on their time due to their implementation or not accepted.

As previously stated, Mercedes-Benz recent car concept is inspired by Avatar film; this highlights the common tools that different branches of speculative design share with each other; which is the use of fiction. Science fiction has always provided us with a glimpse into what the future could hold. These futuristic worlds are always loaded with technology that seems far from reality, more like the stuff of dreams. However, too many technological fantasies have come true like mobile phones, driverless cars, holographic performances, and many others. In many cases, these technologies were inspired by science fiction films. Similarly, to Vision Concept approach, many researchers have employed films and television material to explain and investigate the future (for instance Bleecker investigation of Minority Report film where science fact and science fiction are knotted together), provide a critical view to the current technology and what kind of improvements are desired to be seen.

2.3 Temporality

To recognise 'the plausible and the preferable' that drives human curiosity to investigate and solve unanswered questions about the future, future-oriented approaches like speculative design, Design Fiction, and critical design use fictional scenarios to explore and discuss human progress and the emergence of creativity, setting its artefacts halfway between illusion and reality to provoke a debate. However, there is a need to understand 'how things might be'; what kind of alternative presents designers could envisage; and also "why things are the way they are" (Auger, 2013). Exploring alternative presents often provide a vision of what could be possible to adapt, and what are the 'lost futures' from particular moments in the past that can be reinvestigated by applying different ideologies and practices, through 'what if' plots; where it is used to question the factors that help establish a specific dominant technology. Thus, particular cases and decisions exploit some of the past encounters within a particular scenario to make it more believable. This section will demonstrate the timeline for the future-oriented approaches products/ services; and an explanation of the future, the present, and the past concepts.

2.3.1 Future

The future is no longer perceived as vague and inevitable, but rather as a wide range of possible and impossible scenarios. The futures cone chart is the best representation of the future concepts that could be discovered, adapted, or even eliminated for different products and services. The futures cone (Figure 5) chart as in (Voros, 2017) has been used to describe alternative futures by Hancock and Bezold (1994). This classification was initially designed by Henchey (1978), who presented four main classes of future (possible, plausible, probable, preferable). The future cone was developed and used widely (Bleecker, 2009; Coulton, Burnett, & Gradinar, 2016) to locate new technologies within different possibilities. Bland and Westlake (2013) explain different types of futures with their respective motivations as follows:

- Possible futures, cover the kind of futures that ‘might happen’, in other words, all prototypes we can imagine such as the ‘warp drive’ of Star Trek. Possible futures proposals involve transgressions of the accepted physical laws and principles.

- Plausible futures, present futures which ‘could happen’ as claimed in the current science of how things work. Plausible futures are derived from the current understanding of physical laws, systems of human interaction, causation, or processes.
- Probable futures, afford a vision of ‘likely to happen’ events and could be considered as a linear extension of the present or what is known as business-as-usual.
- Preferable futures, provide a kind of vision concerned with what we ‘want to’ happen. Preferable futures are quite varied and mainly emotional rather than cognitive and stem from value judgements which differ between people.

The future cone (Figure 5) classification opened up a door to construct stories about futures through designed scenarios that might be possible, probable, and preferable, as well as asking 'what if' questions to open up a discursive space. Coulton et al. (2016) have added the ‘impossible’ shades to the diagram in order to acknowledge that some proposals are outside the current scientific consciousness and most likely are considered as fantasy. In this research, the impossible futures are considered lost futures, as in the distant future they can be applied or implemented in different techniques with the right investigation tools.

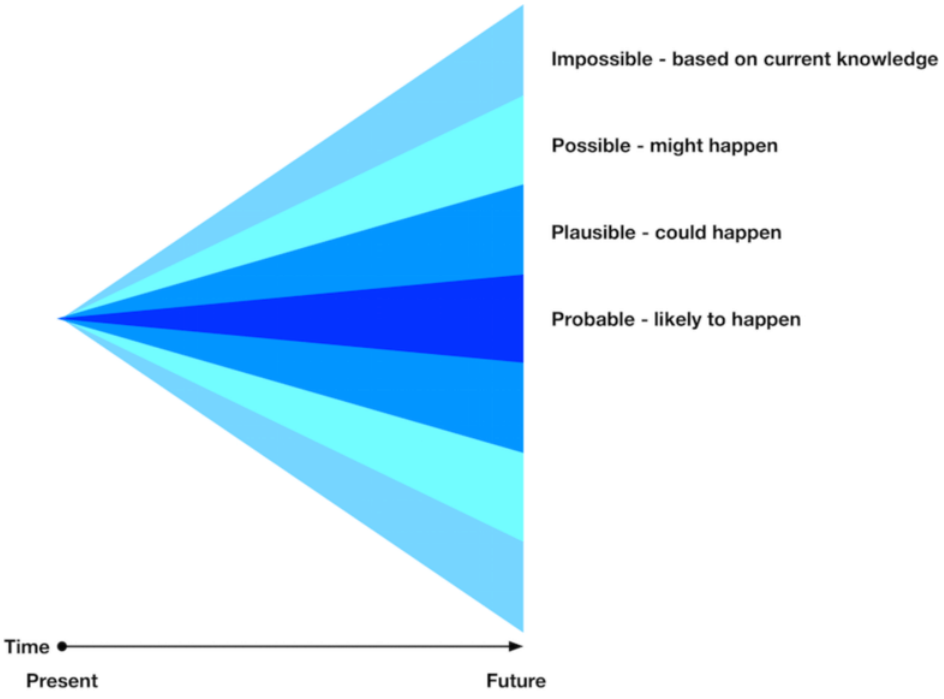


Figure 5, The Taxonomy of the future (Coulton et al., 2016)

Indeed, future-oriented designers must consider what type of futures they wish to imitate. While 'possible' futures include all potentials when recognising particular issues, plausible and probable futures debatably offer more conventional alternatives when attempting to raise

awareness, as they are frequently relevant to the current experience of the time. Preferable futures could be characterised as what we wish to happen and thus could be implemented within any of the three described futures (probable, plausible, possible). However, each future timing is related to these proposals: the preferable future notion is strongly linked with the critical design concept defined above, which has a common ground with speculative design regarding the prototypes they provide to facilitate discourse with a broad audience on future products. Bowen (2010) explains how the results of these discourses could lead to “elitist views of a 'better world' that society should aspire towards." Therefore, a 'preferable' future should raise a debate that designers address within the design profession in order to present an effective vision of the future.

The plausible future occurs by obtaining the right blend of factual reality from the present when envisaging the future (Lindley & Coulton, 2014). Indeed, to successfully accomplish this blending it is often valuable to trace the familiar elements of everyday use, as people have minimal experience of what they may stumble upon in the future as their expectations are usually formed by what they understand and practice today (Evans, 2011). Therefore, the concept of Design Fiction might be used as a technique to enable the recognition of what 'plausible and preferable' visions that trigger and drive human curiosities to adopt potential technologies. Although Design Fiction is still developing as a method of enquiry, a distinct aim is described by science fiction author Bruce Sterling in his speech at NEXT 2013 titled ‘Fantasy Prototypes and Real Disruption’ (Sterling, 2013a):

> "Deliberate use of diegetic prototypes to suspend disbelief about change… It means you are thinking very seriously about potential objects and services [to try to] get people to concentrate on those – rather than entire worlds or geopolitical strategies. It's not a kind of fiction. It is a kind of design. It tells worlds rather than stories."

Centring upon the idea of “suspending disbelief about change” this research employs design fiction as a strategy to investigate potential concepts that could contribute to the shaping of the future; afford a platform to explore the societal and technological distinctions of possible futures so that we can better understand our present. A more comprehensive classification regarding Design Fiction strategies and techniques is to class them under a plausible future because it draws attention to the significant aspects of the future objects, defines their

impact, and visualises these objects, leading to a range of desired futures Table 1, illustrates the difference between each future.

Table 1, Different types of futures

Possible: includes all potentials when recognising particular issues	Preferable: presents an effective vision
Plausible: presents a combination of the actual reality and the vision	Probable: offers conventional alternatives

2.3.2 Present

Everything beyond the present time could be considered as a potential future. This stems from the assumption that the future is indefinite, not fixed and open, which perhaps composes the foundational axiom of futures studies (Voros, 2017). Speculative design precisely investigates the trajectories of current technologies that have not yet come into common use to generate speculative presents or futures. However, alternative presents employ 'what if' scenarios to present a new vision regarding the actual technological development. These alternative presents could be acknowledged as the 'lost futures' from a particular period in the past and are often utilised to question the factors that help assign a specific dominant technology, and to direct the development of these possibilities. Gonzatto, van Amstel, Merkle, and Hartmann (2013) add that speculative design is about the current time in which the audience takes an action that is based on their past experience and reflects on their future decisions or choices.

The concept of an alternative present refers to the creation of parallel urban technological realities. These specific approaches offer a rich narrative potential for the questioning and criticism of technological development, but also of contemporary society as such. The issues dealt with can be exceptionally broad, from big socio-political topics to ordinary everyday activities. Future-oriented approaches can be utilised as a technique to anticipate opportunity and challenges. Auger (2013) presents different methods as ‘perceptual bridges’ between the audience’s perception of their world and the fictional element of the concept, looking through the connection between the here and now of real everyday products. This representation traces back the origins of the development of products until they become real. Figure 6, shows the Auger (2013) model of alternative presents and speculative futures. The left side of the

chart forms research and development work: the higher the line, the more it will become an emergent technology, but the longer and less anticipated its route to everyday life will be. The right side of the chart represents the future, where speculative futures rely on methods that focus on contemporary public understandings and a desire of the far or near future. These speculative design proposals open up a space to question and challenge existing cultural and manufacturing systems. As discussed above, 'lost futures' offer a guideline to both speculative future and alternative present, and more it can help to answer some fundamental questions such as, how these technologies will evolve, and how they could impact our needs and societies.

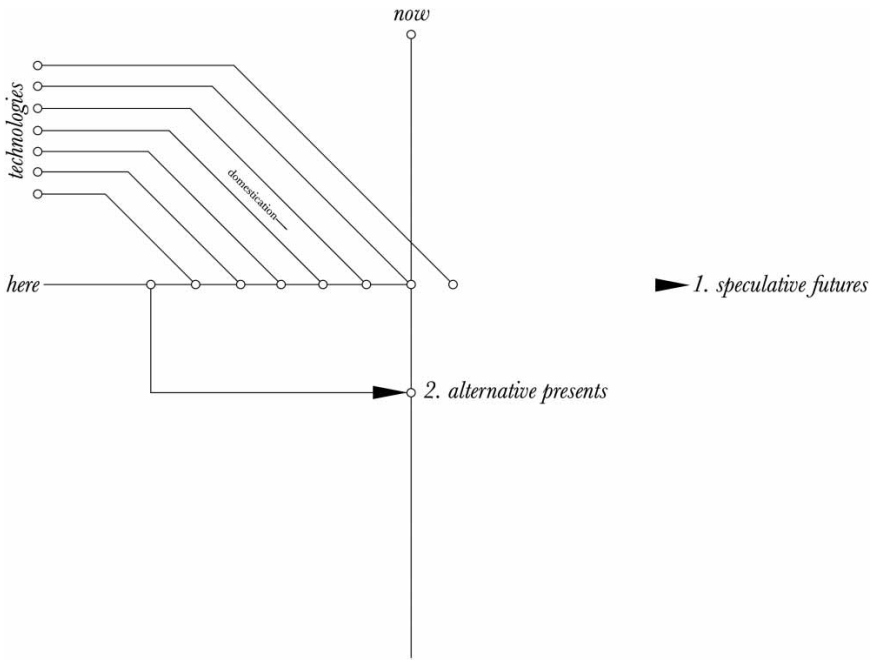


Figure 6, Alternative presents and speculative futures (Auger, 2013)

Despite the temptation to envisage the future, Gonzatto et al. (2013) state that "history lies in the past as a given, reality is restricted to the experiences of the present, and future is left to fictional speculations" and they interpret this relation as shown in Figure 7. Gonzatto et al. statement aligns with (Bleecker, 2009) perspective, "facts are facts and fiction" and with this research view and explained as follow; not all fictitious ideas can come to life on the time they were generated because some factors like the timing and the implementation tools allow the acceptance of some of these ideas. When an idea is considered invalid, this does not mean it cannot be used in the future, but the way to retrieve these ideas would allow new habits and needs to take place. In this research, we add to this concept that new circumstances and unexpected events can be a fundamental trigger to restore and develop the 'lost futures'. For

instance, the twenty-first-century global pandemic 'Covid-19' has urged the world to adopt Av's faster to accommodate social distancing regulations, where less human interaction would slow or stop the spread of the virus. Take into consideration that people are reluctant to adopt autonomous cars technology due to safety and trust issues (the implementation of the thesis conjecture), but as new needs have urged, and new reliance was added to encourage the adoption of AV's.

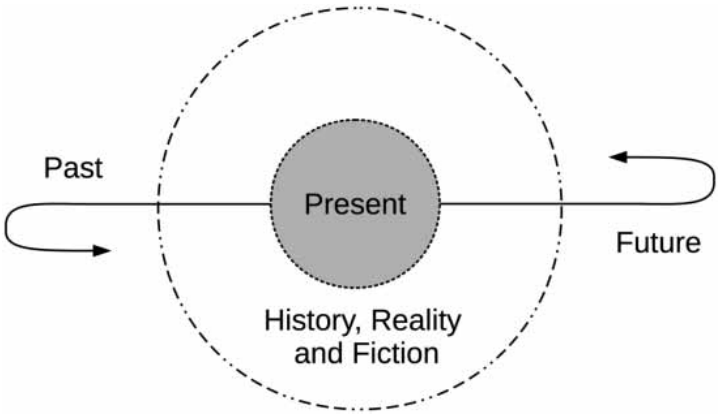


Figure 7, History as the possibility of redefining past and future (Gonzatto et al., 2013)

2.3.3 Past

Speculating about the future can guide rational decision making around the usage of emerging technologies and restrict investment in technologies that have limited long-term potential. Marshall McLuhan in his book, *The Medium is the Message* as cited in (Gonzatto et al., 2013) explains how the past can influence our present decisions, "We look at the present through a rear-view mirror. We march backwards into the future." As mentioned before, exploring alternative presents often means breaking existing timelines and highlighting the 'lost futures' from particular moments in the past by applying different ideologies and practices. In the film *The Time Machine*, 2002, directed by Simon Wells, Gore Verbinski presents an example of investigating the future in order to change the past. The film displays a social dilemma; the main character has raced 800,000 years into the future, where he realises that humankind has been divided into the hunter and the hunted. Such an example shows that lost futures are always under investigation since human curiosity would justify why these technologies have not worked in the past and how we can improve their vision to bring them to reality.

Furthermore, there is no universally accepted perspective of the past, nor the present, but rather there are individually constructed visions to create a particular reality (Law & Urry, 2004). It follows, when forming an alternative present or plausible future, it will assuredly comprehend the designer's perspective of the present and their experiences of the past. This in turn emphasises that future-oriented design approaches - whether Design Fiction, critical design, or speculative design - cannot be considered as neutral practices. Figure 8 shows how alternative presents or lost futures impact the shaping of future visions.

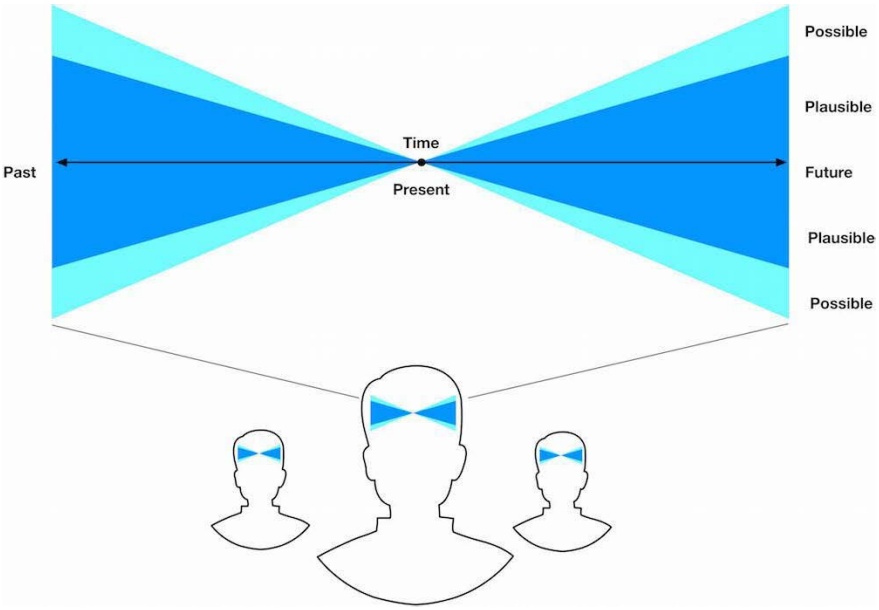


Figure 8, Lost future impact of shaping future visions (Coulton et al., 2016)

As was mentioned in the previous sections, each speculative approach has a particular characteristic that serves its aim, time frame, and the motivation behind each project. Speculative design precisely examines the trajectories of current technologies that have not yet come into everyday use to generate speculative presents or futures. The critical design concept aims to encourage people to question imaginatively; whether the concept of the proposed design or its form. The latter concepts intend to provide views of a better world that society should strive towards. In this quest, we tend to presume that critical design and speculative design are more about opening up discourse to understand and investigate futuristic or lost future products' social and technological impact. On the other hand, Design Fiction raises far-reaching questions regarding the consequences of technological advancements and open up space for new and different development to take place. These future oriented concepts encourage envisaging the future, in order to produce an image of

what could be our present. Table 2 highlights a comparison between each approach, time frame, and other elements.

Table 2, A comparison between each future oriented approach their design intent, and timing.

Approach	Design Fiction	Speculative Design	Critical Design	Vision Concept
Project	*Helios: Pilot, Quick Start Guide designed by Near Future Laboratory (2015).*	*Technological Dream Series: No. 1 by Dunne and Raby (2011)*	*Digicars, by Dunne and Raby (2013)*	*Vision Avtr, by (Mercedes-benz, 2020)*
Time Frame	Plausible and Preferable Future	Preferable Future	Preferable Future	Possible future
Motive	Connecting the imagination with its material form.	Question the design practice	To enrich and expand our experience of everyday technologies	To bring new trends and imagination to the market
Design Intent	Opens up a discursive space to discuss and reflect on the potential employment of the fictional prototypes	Re-thinks of future that reflects the intricacy of today's world	Encourages people to question imaginatively; whether the concept of the proposed design, or its form.	Explores new technologies and envisage them to define a possible, plausible, probable, and preferable future.
Manifestations	Fully working prototype	Non-working prototypes	Scale models	Fully working prototype, for commercial purposes

2.4 Plausibility of Design Fiction

As defined before deign fiction is a combination of design and fiction, where design represent the creative act of providing solution; and fiction meant to open up a discursive debate regarding these solutions and their possibilities on everyday activities. However, there is a need to understand the notion of fiction as the terminology is usually associated with something being untrue or unreal. Since fiction is generally regarded as an imaginative discourse, this section will present (Ryan, 1980)concept 'the principle of minimal departure',

as well as will highlight fiction strategies and where these strategies used effectively on Design Fiction prototypes.

2.4.1 The Principle of Minimal Departure

The principle of minimal departure, Ryan's theory is about addressing the use of fiction to explore the desired impossible world and how possible these alternative worlds could reach. Ryan presents a vision to investigate the different notions of plausibility and realness of Design Fictions namely occurrences where the purpose is not only to form a critical debate but to investigate the conditions that work towards implementing the diegetic prototype of the narrative. Using Ryan provides the following interpretation of Lewis' analysis of counterfactuals (Lewis, 1973) and possible worlds:

- There is *a* world where the predecessor holds and the con-sequent holds.
- There is a world *b,* where the predecessor holds, but the consequent does not.
- If world *a* differs, less than world *b,* from the real world, the counterfactual is true. If world *b* differs less, the counterfactual is false.

Lewis' investigation is concerned with the truth value of counterfactuals and subsequently possible alternative worlds. Counterfactual conditions being of the type 'if *a* has occurred then neither will *b*'. Ryan uses the analysis to the realm of narratives and how the reader explores the world created within the narrative. Ryan's differentiates between factual, non-factual, and fiction (Ryan, 1980). For the first two worlds to be applicable, they must be applied. The third world can differ from the principle but would require more interpretations of the possible image of the presented world. Ryan's definition of these principle worlds as the following: "This principle states that whenever we interpret a message concerning an alternative world, we reconstrue this world as being the closest possible to the reality we know." (Ryan, 1980).

Coincidentally with the plausibility given to a possible world, Ryan has constructed three basic statements about fictional narrative worlds (Ryan, 1980). First, the factual statement, in which the viewer describes the real world from an inside viewpoint, as it is presented around him/her as an audience. Second, the non-factual statement, in which the viewer articulates about an alternate world from an outside point of view. Third, in fiction, in which the viewer

represents a member of an alternate world, which said member speaks about from an inside point of view. The three statements can be combined and integrated into each other, creating narratives within narratives about possible worlds and alternate endings. Ryan continues to demonstrate how the audiences' awareness of the world serves to create an understanding of the possible or alternative worlds as they are represented in fictional settings. By the principle of minimal departure, the viewer of a fictional world would locate his knowledge, experiences, even ideals into the actual world. While this minimises the author's need to explain in detail how the prototype took such shape, it relieves the viewer possibility to create and unfold the world in their imagination. Depending on the viewer knowledge about the world, they can use these insights to expand the idea of the potential world with further details.

In this regard, there are three essential parts to Design Fiction: the narrative, the diegetic prototype, and the context. These elements cannot be understood or considered individually; Design Fiction entails these pieces be read together to present a particular narrative of the vision of the future. Further, the way these elements are combined and resonate with the users is a critical point in employing the method effectively and to assure as many provocations as possible and questions can be comprehended. Design Fiction is about "creative provocations, raising questions, innovations, and exploration, making an effort to explore new kinds of social interaction rituals" (Bleecker, 2009).

2.4.2 Fiction Strategies

Likewise, the concept of the principles of minimal departure, pastiche scenarios utilise fiction to investigate the interior 'felt-life' aspects of user experience and issues elevated by technological innovations. In the same vein, (Auger, 2013; Blythe & Wright, 2006; Dindler & Iversen, 2007), represent that fiction could be a precious resource for increasing user engagement and collaboration in the participatory design process. In the participatory design scheme, fictional artefacts such as games, alternate reality gaming (ARG), or story-making tools are often used as a part of a corporation design process. Hence, the notion of fiction is astonishingly far from the vocabulary and the discourse of participatory design, but it is obscurely understood.

The critical design approach has introduced 'value design', another fiction strategy, to invert the correlation between technology and social values in interaction design. Whereas technology is often futuristic, social values are likely to be conventional, representing the current societal conditions. However, the practical and mundane technologies are implemented to develop scenarios embodying fictional social or cultural values of how their usage could make a difference in everyday life states. Dunne (2007) presented a vivid example of a technological proposal that represents societal conditions; a wooden robot looks like an item of furniture. To operate the robot, the user must engage physically with this robot and make eye contact. Here, value fiction considers as a resource to provoke reflection if robots were to be combined into the domestic spheres of life, which suggest alternative design deals. Dunne and Raby (2013) claim that a physical prototype expands the perceptual of "the here and now while belonging to another yet to exist".

Auger (2013), says that careful management of the uncanny; is essential in making effective speculative design, despite if it is for an idea, product, or services. Due to the fact, people would not be able to correlate in a lack of engagement. Thus, this connection demands a bridge to link the existing timing and the fictional elements concept. Such participation could be implemented in observational comedy, psychology, horror films and illusion for the insights they endeavour into the human being understanding to provoke a reaction. Since fiction is a technique can serve different aspects, Auger and Loizeau (2009) suggest a project called "Afterlife Battery" where a battery stored with energy, that comes from the acid of the human body after death; this energy is an outcome of a particular chemical process. The project aims to integrate the discussion with the audience on how they would want their battery to be used.

Another approach for utilising fiction introduced by called Pastiche scenarios is considered a method for writing fictional scenarios. Instead of using personas, the designer borrows well-known fictional characters from novels or movies. This method enables the designer to evoke resonant contexts to place a new design or consider user needs. Pastiche scenarios rely on existing narratives to create more vibrant and resonant representations of users and technologies since rich and resonant interpretations have multiple views (Blythe, 2004). However, the used character features do not present the product functionality because they were initially designed for different aims. Still, their usage creates an ambiguity that (W. W.

Gaver, Beaver, & Benford, 2003) ay can lead to new insights and challenges. An example of utilising pastiche scenarios concept is (Blythe & Wright, 2006) attempt; they have borrowed 'Alex' character from A *Clockwork Orange* novel, by English writer Anthony Burgess. Alex is the central character of a brutal gang of criminals that have their language to communicate. Blythe and Wright (2006) employed Alex in a situation where he had to react against a new emergency protective device called the '*Cambadge*', a wearable lightweight webcam; used by elderly people to help them notify the police whenever they feel insecure or threatened in public space. By employing the literary technique 'stream of consciousness', Blyth and Wright's pastiche scenario provides us access to the inner feelings and thoughts of Alex and what victims needs to be aware of when confronted with a criminal of his type. Such a scenario reflects how such a device might be encountered by loyal users and those against whom it is used.

Pastiche scenarios offer us a 'deep character' that we perceive as we already know; these characters hold a much more productive potential for enhancing user engagement than typical scenarios, where personas somewhat flat and dull (Blythe & Wright, 2006). Therefore, this technique draws on fiction as a resource to investigate the 'Felt-life', which is the depth aspect of user experience, and the complicated social and cultural concerns raised by technological innovations (ibid).

Another demonstration of utilising fiction is narrative anthropomorphism. This technique describes an object, technology or animal given human characteristics or behaviour patterns to understand the complexity of a particular situation. Morisson (2014) illustrates an example of the unmanned aerial vehicle (UAV) called Adrona. Adrona presents a female character known as a killer drone. Such a discursive design approach aims to give voice and inner emotions to politically disputatious artefacts, thus permitting analytical and critical reflections. Another example of utilising anthropomorphised fictional personas is Rumina- a wi-fi enhanced bovine/ machine hybrid that roams unobstructed through a future city space (Morisson, 2011). One more classic conceptual example is *Animal Farm* by *George Orwell* (1945). It narrates the story of a group of farm animals who strike against their human owner, aiming for a better life where the animals can be equal, independent, and happy (Orwell, 1989). *Animal Farm* presents a vision of how the masses rebel against a government and their socio-economic dilemma. Indeed, what makes Rumina, Adrona and their kin of

anthropomorphic form an impressive artefact is the allowance of the rhetorical tools, such as irony, to engage and react through the anthropomorphic persona, which allows multiple divergent points of view in a cooperative research process.

Likewise, Dindler (2010) introduces a concept that utilises fiction as a resource to create a debate called 'fictional space as design space', inspired by Kendall Walton 1991 concept 'game of make-believe. Dindler explains that fictional space is formed through make-believe games, in which props act as a catalyst for the imagination. For example, seeing a fast car and imagining yourself inside it, then imagining this car is James Bond one; this car has extraordinary features (Knutz, Lenskjold, & Markussen, 2016); thus, the fictional space presents through chained narratives (ibid). Also, if we imagine the flying cars in the Harry Potter film are genuine in a particular fantasy world, and we place ourselves inside that world. Dindler (2010) demonstrates that the generation of a fictional space recognises when the participants are practising make-believe games via props.

Knutz et al. (2016), add to the vision by imagining that car is James Bond one, or to support generating a fictional world by way of illustration, all the flying vehicles in Harry Potter film are actually in that particular fantasy world (ibid). As fictional space is presented through chained narratives, (Dindler, 2010) illustrates that the generation of a fictional space recognises practising games of make-believe via props. Therefore, the fictional space emerges when participants engage in a game of make-believe when they can relate to the right props that provoke their imagination. This approach is close to Bruce Sterling definition of Design Fiction, 'the deliberate use of diegetic prototypes, as these prototypes mean to invoke the scene and draw attention to small details that enhance believability and engagement.

The last technique of employing fiction to establish a debate is 'fictional reframing of social innovation' by (Emilson, 2015); it is acknowledged as a method for questioning the baseline of design for social innovation and sustainability. Emilson implies that "seeing something's as something else" is a metaphor that allows the viewer to perceive an unfamiliar situation by shifting familiar experiences to a different realm and thus generate a new perspective on the world, this is known as "generative metaphors". It is often about the diversity of stories in a particular situation, that implicit generative metaphors become noticeable.

In brief, according to (Väänänen, Pöllänen, Kaipainen, & Vartiainen, 2017), design for social innovation mean "a new idea that works in meeting social goals." Social innovation is known as an act of creatively change the authentic assets and represent these assets in a new way. Thus, social innovations have always existed, but within social development, it will become more common in the near future as growing challenges of the continuous economic change and the urgent demands transition toward sustainability. Moreover, the nature of social innovation itself is also improving, resulting in new and until now, improbable possibilities (Selloni, 2019). Emilson (2015) proposes 'dark and soft fiction' as two strategies for transforming the debate on sustainable improvement; the 'soft' intimates a reconnection" with the organic part of life and humans as part of nature." Whereas 'dark fiction' implies realism without deceiving unreal or false futures. Indeed, the societal scale aims to open a 'design space' where narratives could form and inspire design (ibid). Therefore, fictional reframing of social innovation has a common ground with the recasting of societal utopias since, both approaches are authentic, achievable and have concerns regarding social values (Wood, 2017; Wright, 2010).

Following the fiction strategies, this study establishes that each strategy represents qualities that may trigger specific forms of participation which would invoke a debate. Table 3 offers a comparison between each strategy and how they individually contribute to the debate.

Table 3, Fictional strategies and their contribution to the debate

Fiction Strategies	Contribution to the debate
Perceptual Bridge, by James Auger (2013).	• Connect the unusual speculation with personal experience in order to appear convincing • Aims to invite the audience to envisage the future proposals
Value Fiction, by Anthony Dunne (2007).	• Reverse the correlation between technology and social values • Aims to inspire dialogue regarding visions, emotions, and beliefs about the future
Pastiche Scenarios by Mark Blythe (2004).	• Investigate inner felt life through fictional character as a possible user

	• Aims to provide an experience for the audience that they are already familiar with
Narrative Anthropomorphism, coined by the Greek philosopher Xenophanes (Pomering & Frostling-Henningsson, 2014).	• Utilises fictional characters, narrative, or objects to engage with some technological barriers. • Aims to facilitate critical reflections and collaborative explorations by employing relatable prototypes for participants.
Fictional Space as Design Space, by Christian Dindler (2010).	• Create props to support producing fictional truths. • Aims to involve participants throughout a game-of-make-believe, facilitated by props.
Fictional Re-Framing of Social Innovation, by Anders Emilson (2015).	• Inquiries about the basis of design for social innovation and sustainability. • Aims to trigger socio-political reflections and national debate in a group of participants.

2.5 Design Fiction: Strategies and Tools

Knutz and Markussen (2014) suggest a strategy to understand Design Fiction as an advanced theory for testing alternative designs for society or criticising existing ones. They explain that Design Fiction can be accorded five criteria:

1. "What if scenarios" as the basic constructional principle of Design Fiction
2. The manifestation of critique
3. Design aims
4. Materialisations and forms
5. The aesthetic of Design Fiction.

Accordingly, Design Fiction does not pretend to predict the future; it acts as a service to aid an audience to be responsive to the discourse on the future.

Design Fiction is a future-oriented approach aims to distinguish and develop the perceived range of possible solutions by extending the design spaces; and engage the public audience

for future making scheme. The concept of Design Fiction has emerged to such a degree that it is now sit alongside with other modes of future-oriented design approaches such as speculative design and critical design. It is essential to consider how it is different from the speculative design of Anthony Dunne and Fiona Raby (Dunne & Raby, 2013), which is itself an outgrowth of Dunne's earlier concept of critical design (Dunne, 2007). The characteristic that sets Design Fiction apart from these approaches is found in a way it explicitly concerns itself with diegesis. In cinema, diegetic material exists within the world, by example *Her* movie (2013) directed by Spike Jonze; it is accessible to the characters within the story world. Non-diegetic content, in contrast, is available to the viewer but is not a part of the fictional world on the screen. Title sequences, for example, are often non-diegetic. Sterling invokes Kirby's concept of diegetic prototypes, while also attending to their importance in communicating scientific agendas to the broad public. Thus, when Kirby describes diegetic prototypes, the key point is that they are situated inside an imaginary narrative world.

Design Fiction is employed to raise far-reaching questions concerning the consequences of technological development besides prototyping. In particular, Design Fiction draws attention to the social aspects and implications of techno-scientific solutions, utilises the techniques of fiction to examine the future of objects, define what their impact might be and present a range of possible alternative futures. Blythe (2014) illustrates how Design Fiction proposes examining a distant future through scenarios based in the present, using the facts and constraints afforded by current technology. However, these "possible worlds" are established through "cognitive estrangement" (Raven & Elahi, 2015), or signs that convey to the viewers that they do not perceive their current time and place.

In this regard, there are three essential parts to Design Fiction: the narrative, the diegetic prototype, and the context. These elements cannot be understood or considered individually; Design Fiction entails they be read together to present a particular narrative of the vision of the future. Further, the form these elements are combined and resonate with the users presents a critical point in employing the method effectively, and it ensures that any provocations and questions can be comprehended. It is important to highlight what Bleecker meant on his statement about Design Fiction as "creative provocations, raising questions, innovations, and exploration, making an effort to explore new kinds of social interaction

rituals" (Bleecker, 2009). The intention of using fiction in investigating the nature of the futuristic products or services is undoubtedly different from it in design, art, and architecture approaches. These disciplines experiments are held to establish, validate or invalidate the rising hypothesis (Koskinen, Zimmerman, Binder, Redstrom, & Wensveen, 2011)

2.6 Operationalising Design Fiction

A critical function of Design Fiction is in highlighting the values and intellectual commitments associated with new technology. Blythe (2014) provides an engaging and playful example of this when he takes the infamous "Sal" story from Wieser's seminal ubiquitous computing paper 'The Computer for the 21st Century' and rewrites it in the voice of several different science fiction writers including Douglas Adams and Philip K. Dick (Blythe, 2014). In revising a canonical scenario from ubicomp, Blythe can reveal several rhetorical capacity and function that were hidden within the initial "neutral" voice that Weiser used to portray the story of Sal living inside her computationally saturated world. Through this act of literary ventriloquism, the presence of pervasive marketing systems and oppressive surveillance apparatus is brought into view. Blythe uses techniques from literary theory and science fiction to force readers to grapple with the ethical issues hiding inside of a future vision that has dominated HCI discourse around ubiquitous computing.

Design Fiction sets its artefacts halfway between illusion and reality to provoke a debate. *Minority Report* (2002) directed by Steven Spielberg, presents Design Fiction as a design practice that re-imagines, draws attention, raises questions, prepares, and presents new ideas. The movie offers an unusual image of the year 2054, including the structure of its imagined world, and the advanced technological objects used in that time. Inspector John the conductor the character played by Tom Cruise, uses multiple directories to solve future crimes by looking over videos showing snippets of the future (Brooks & Pollock, 2018). Wearing distinctive gloves, the character performs a series of hand motions, while standing in front of a translucent screen, and responding to gestures, allowing him to skip videos at the sweep of his hand, or pause when he makes a "timeout" signal. These particular details contain intensive combinations of compelling visuals to enhance realism, allowing the audience to follow the gestures carefully to develop a fuller understanding of the narrative, of what is being manipulated, and how fragments of clues are set side by side. The purpose behind

showing what is being manipulated is to realise that what is unreal as a creative act situates the viewer inside the scene. The presented technology is so appealing that companies wondered how this approach could succeed, draw attention to itself and become legitimate. With the logic of Design Fiction, the motion interface of *Minority Report* presents and prepares its audience for new ideas inside our real world. The movie introduces a simple way to understand both the technology's use and the purpose behind it.

Science fact and science fiction are knotted in *Minority Report*, Design Fiction is presented within various cinematic techniques and literary mechanisms. Dalton et al. (2016), explain that Design Fiction depends on 'literary mechanisms' to reach its goal. These are: framing a time and place different to the present; permitting the viewers to see the narrative from a neutral perspective (J. O. Young, 2019); placing "the unfamiliar in the state of the familiar" Thus, this narrative content provokes a discursive space between these new ideas (technology, scientific facts) and the scientific conception of the viewer (ibid). Sci-Fi films endeavour to make viewers believe in the images they are seeing, utilising a familiar technology in a fictional way that helps to create the link between fiction and reality, and so enabling the plot to progress (J. O. Young, 2019).

A Digital Tomorrow is a Design Fiction video produced for 'Curious Rituals' by Nicolas Nova, presenting a vision about gestures, postures and digital implementations that stereotypically emerge with the use of digital technologies (mobile phones, sensors, computers, etc.) Nova, Miyake, Chiu, and Kwon (2012). The project offers many regular activities that have been combined with the devices to smooth out utility, such as motion gestures to interact with a car and make calls, although the project manifests unusual actions, such as when smart devices are charged by rotating them in a circle in the air. The project aims to visualise the future of rituals and gestures based on Design Fiction videos that speculate about their evolution and emphasises the function of such gestures. Accordingly, this project highlights 'mechanical imperfection' concept according to (Lindley & Potts, 2014) of how the devices can make mistakes and indicates things will not get any better in the future since voice recognition works just as poorly here.

Sterling (2013b) describes Design Fiction as a creative act that sets the viewers into a discursive space. It is important to clarify that this discursive space refers to the creation of functional objects whose essential aim is to communicate debatable ideas. These ideas raise

awareness and understanding of substantive issues of psychological, sociological, and ideological consequence (Tharp & Tharp, 2009). However, *Uninvited Guest* by SuperFlux (2015) is a Design Fiction project that explores the flipside of the extensive presence of digital gadgets in our lives and our connection with them through film. The project focuses on the idea of a connected home, where fictional smart objects help to improve the quality of life of an elderly man by monitoring his day-to-day activities. These devices constantly track the man's every move including his eating habits, exercise, and sleep routine. This constant tracking gives rise to tensions, and it becomes an inconvenience rather than being helpful. The film not only shows the power dynamics between technology and its human users, but also remarks on how technology changes communications and relationships between people.

Design Fiction can be utilised as a technique to anticipate opportunity and challenges. As mentioned before, Auger (2013) presents different methods as 'perceptual bridges' between the audience's perception of their world and the fictional element of the concept. A key method Auger uses is called 'Verisimilitude: Design Fiction or design faction' that simulates the 'what if' schemes. Whereas the speculation can take the viewer far away from the here and now, making the proposed design idea seem unreal, the solutions provide range of possibilities that fiction may provide to make the vision feels real. 'World Without Oil (WWO)' is a form of 'what if' method, a fictional issue meant to shed light on a global oil shortage, presented an alternate reality gaming (ARG). The imaginative crisis aims to hear from the people by enabling a shared environment and thinking about a common future. The narrative in WWO starts by sharing information about how this issue might affect the daily life of the audience, by example gas prices rose which caused chaos. Where such details help to draw attention, the participants are not involved as roleplay; they are instead a real play. Although different possibilities of expression enhanced the engagement, the participants were free to express their reaction in the way they found convenient, as if the fiction of the game is real. After absorbing the dilemma, the participants did not just think about change, and what their lives would look like, instead they started to make it real.

As future's fiction implications and solutions emphases on visualising progress, of far-reaching questions and technological developments, *the Museum of the Future: Machinic Life*, in Dubai, is an exhibition investigating the future consequences of current advancements in technologies and artificial intelligence on communities De Bernardi and Gilli (2019). The

museum's notion concerns how advanced intelligent machines could emerge to improve our bodies and minds, rearrange our social engagement, and conduct social and economic systems in the future. From human growth to emotive machines and hyper-intelligent decision-making, seemingly, the 'now' is automatically accelerated. The museum presents real products and services from the present that suggest pathways to potential futures. Unusual fictional prototypes are presented in the exhibition for personal use. The *Personal Augmentation Spa* is a prototype presented through virtual reality devices, where the participant can experience a body modification, as a common usage in the future. This prototype suggests a range of physical, cognitive, and social instruments shortly be on the market. Another artefact called *Caring Machines* explores how artificial intelligence would involve an improvement of our mental health, help us relieve stress, and provide elderly care. This device depends on reading our emotions, observing our routines, then employing the results to take better care of us. Furthermore, *Algorithmic Management* is a super intelligent computer; algorithms will be capable of understanding, solving, and managing complex and sophisticated scenarios in the future.

Indeed, *The Museum of the Future* has utilised design for debate to understand emerging technologies and to explore the social-cultural and the ethical impacts they have. The museum triggers controversy about whether if it is a form of Design Fiction or speculative design. The museum could present both approaches, as they have a shared base regarding the emphasis on futurity, and both are about the 'prototype'. However, speculative design has a different characteristic, it generates objects that are more about the near future and not placed in narrative space, while by contrast Design Fiction builds a prototype within a story world to create a discursive space that would raise questions, exploration, and innovation. This research investigates the museum of the future concept as a Design Fiction example, this claim is according to design rules formulated by Hiroko Shiratori in her article *'Unusual Objects from Japan'.* Shiratori argues that employing fiction in design practice needs to present a kind of physical or interaction function; should be humane and comprehensive; it has to be believable, contemporary, and desirable (Coles, 2016). Design Fiction involves the appropriation and manipulation of cultural forms of design as a creative act to find a solution. Fiction as a technique aims to enhance discourse, and answer fundamental futuristic

questions such as, how will these technologies evolve in the future, how will they impact our societies?

Design Fiction has opened design to theoretical and artistic methodologies that can be used to explore past, present, and future studies through fiction. *Game of Drones* by Lindley and Coulton (2015), is a project that aims to investigate a potential future employment of drones for public use and develop a program for promoting Design Fiction as a research method. Coulton, Lindley, Sturdee, and Stead (2017), emphasise the enormous potential of Design Fiction by covering both “how drones helped us develop a Design Fiction, and how Design Fiction helped us highlight wider issues related to the design of a drone-based system.” While the drone’s usage is expanding for commercial purposes like Amazon’s Prime Air, and Facebook’s Internet Drone, this project is about investigating a "drone-based gamified civic enforcement system" in the UK, to understand what the technological and legal challenges for such technology are. Coulton et al. (2017) build a story world with various details to unpack the ethical and societal questions relating to such a system’s adoption. All the following elements have contributed to enhancing the believability and the desire to have a real system: parking zones; dog fouling areas; the official UK font for road signage; and charging stations. After presenting the project, (Coulton et al., 2017) illustrate that their participants seemed to believe that this project is real because it describes how powerful technological visions of the future are to those shaping futures. Therefore, Design Fiction is not about predicting the future or creating utopian visions that develop emerging technologies. Instead, it affords a means for investigating the societal, technological, differences of possible futures so that we can better understand the present (Coulton et al., 2017).

Design Fiction raises far-reaching questions concerning the consequences of technological development. In particular, Design Fiction draws attention to the social aspects and implications of techno-scientific solutions, utilises the techniques of fiction to examine the future of objects, define what their impact might be and present a range of possible alternative futures. Design Fiction employs objects and devices in the ‘real world’ to observe how they might be used and how people might react to these new objects. Like Sci-Fi, Design Fiction often reveals more about current reactions, attitudes, and behaviours than it does about the far future. While experts are producing advanced objects for the public, technology

must be adapted to how the public behaves and learns from them to develop these objects. Scientists have agreed that the global market not only needs to understand where people are today, but what type of technology that the public needs, and could drive new desires. it must be noted that the previous cases like Uninvited Guest, WWO, and The Museum of the Future succeed to provoke and raise questions not only because Design Fiction acts as a service to aid audiences to be responsive to the discourse. But, because they are issues affecting the audience personally, and their everyday life.

Design Fiction concerns the combination and manipulation of design and fiction, where design is a creative act to find solutions, and fiction is an artistic technique to open up a discursive narrative space. Stuart Reeves, in his paper 'Envisioning Ubiquitous Computing' Reeves explains how Design Fiction has become popular in many futuristic profitable plans, playing a conspicuous role in research studies and the shaping of future technology (Reeves, 2012). It is an exciting perspective, where Design Fiction is considered as an evoking medium to enhance technologies growth (Kirman et al., 2013), a critical way to justify the exploration of different technologies (Dalton et al., 2016). A further study regarding this point will be addressed under the 'Acceptance of Autonomous Vehicles' section within this thesis. Indeed, Design Fiction can be used as an instrument to defamiliarise the AVs concept. This technique is not intended to deceive users but operate more as a creative act that sets them into a discursive space for a while then lets them go. Therefore, design experience has to avoid the ambiguity that pretends to be real, to perform a full experience and the user has to 'suspend their disbelief willingly' (Dunne & Raby, 2013) to enjoy shifting their imagination into a new and unfamiliar space.

Coulton, Lindley, and Cooper (2018) proposed three different products in *the Little Book of Design Fiction for the Internet of Things,* in which Design Fiction is employed to understand how the internet of things will help articulate the contours of our future through everyday products. Indeed, Design Fiction expands the question of how 'what-if' scenarios provide a space for exploring and prototyping possible futures in design practice and research. Hence, there is a need to answer critical questions concerning the relation between fiction and experiments, such as: how to prototype the future through experiment; why the future should be negotiated through exhibited products; and how would Design Fiction influence

the hype cycle for futuristic products and services. Table 4 shows the three different elements of Design Fiction (The narrative, the diegetic Prototype, and the context) projects that have been stated in this section.

Table 4, The three essential parts of Design Fiction previously mentioned projects.

Project	The Narrative	The Diegetic Prototype(s)	The Context
Minority Report by Steven Spielberg, (2002)	Uses multiple directories to solve future crimes by looking over videos showing snippets of the	Distinctive gloves, touch screens, drones, etc.	The way the actor interacts with the fictional prototype provides particular details containing intensive combinations of compelling visuals to enhance realism and how fragments of clues are set side by side, allowing the audience to follow the gestures carefully to develop a fuller understanding of the narrative.
A Digital Tomorrow by Nicolas Nova	A documentary of current advanced technologies and their digital gestures in a book format and a film speculates about their evolution.	Mobile phones, sensors, computers, etc.	Exploring the gestures, postures and digital habits that are occurring in the digital every day, such as recalibration of a smartphone doing a horizontal eight sign with the hand, swiping of wallet with RFID cards in public transports, etc.
Uninvited Guest by SuperFlux (2015)	An elderly managed 70 lives on his own; his children send him smart devices to track and monitor his diet, health, and sleep from a distance.	Smart objects: Fork, walking stick, bed sensor, medicine container	Explaining the authoritarian feel and concerns around smart devices and connected environments humorously and humanely; explores how to work with the implications of the demographic shift that will be experienced in the next years and decades.
World Without Oil (WWO) by	An Alternate Reality Game (ARG) uses the real world	Alternate Reality Game (ARG)	Outlining the overarching conditions of a realistic oil shortage, inviting players to

San Jose, and Ken Eklund	as a platform and employs transmedia storytelling to deliver a story altered by players' ideas or actions. It aims to spark dialogue around solutions to a near-future global oil shortage and the alternatives.		imagine and document their lives under those new conditions.
The Museum of the Future, Dubai	Presents real products and services from the present that suggest pathways to potential futures.	A technology-themed museum	Utilising design for debate to understand emerging technologies and exploring the social-cultural and the ethical impacts they have.
Game of Drones by Lindley and Coulton (2015)	Drones that located in different stations aim to enforce the laws related to parking offences and dog fouling in a small UK city.	Drones, and docking stations	Covering both “how drones helped us develop a Design Fiction, and how Design Fiction helped us highlight wider issues related to the design of a drone-based system.”
the Little Book of Design Fiction for the Internet of Things by Coulton et al. (2018)	Design Fiction is employed to understand how the internet of things will help articulate the contours of our future through everyday products	Polly: The world’s first truly smart kettle, Allspark: Sparking the Internet of Energy, and Orbit Privacy: Opening doors for the IoT	Expanding how 'what-if' scenarios provide a space to explore and prototype possible futures in design practice and research, how to prototype the future through experiment; why the future should be negotiated through exhibited products; and how would Design Fiction influence the hype cycle for futuristic products and services.

Design Fiction would provide a near-future world that explores the possibilities and consequences of today's emerging technology. Autonomous cars technology is an emerging technology that promises to bring a safe, adequate, and accessible transportation system to all kinds of users. However, the populace appears reluctant to adopt the technology due to safety and control issues. Consequently, the autonomous technology concept needs a new form of communication to overcome the challenge of earning the trust of its future customers since they determine the demand in the technology market and future investments in infrastructure. Therefore, reflecting on what it means, Design Fiction has an immediate challenge of closing the gap between a vision and material expression. This research will study and investigate how Design Fiction tools and strategies can be utilised to enhance the adoption of autonomous vehicles. The following sections will illustrate the automation technologies, why it is essential to be prepared for the adoption, and the potential user needs to implement this technology.

2.7 Autonomous Vehicles Overview

For a long time, automobiles have played a fundamental role in our lives, providing many benefits to society by being a source of innovation and economic growth. Mom (2012) states that automobiles could be considered the fastest-growing during the last century. This evolution was, however, not inevitable, or smooth, and nor was it particularly beneficial. The World Health Organisation reported that around 1.25 million people die every year due to road traffic collisions. Casualties from road traffic accidents are the highest cause of death among people between 15 and 29 years of age, with 20 and 50 million people experiencing non-fatal injuries worldwide (WHO, 2018). Figure 9 shows the total number of reported road accident casualties in the UK. Further, low and middle-income countries have recorded more than 90% of road traffic deaths (Jackson & Cracknell, 2018).

Since this progression, innovation within the automotive industry has brought significant technological advances, leading to safer, reliable, more affordable, and cleaner vehicles. Henry Ford introduced the moving assembly lines; changes within the industry have been incremental and evolutionary (Hu, 2013). Therefore, the automobile industry initiates to have a revolutionary change with the potential to reshape the competitive landscape and the way we interact with vehicles and the futuristic design of the roads and cities.

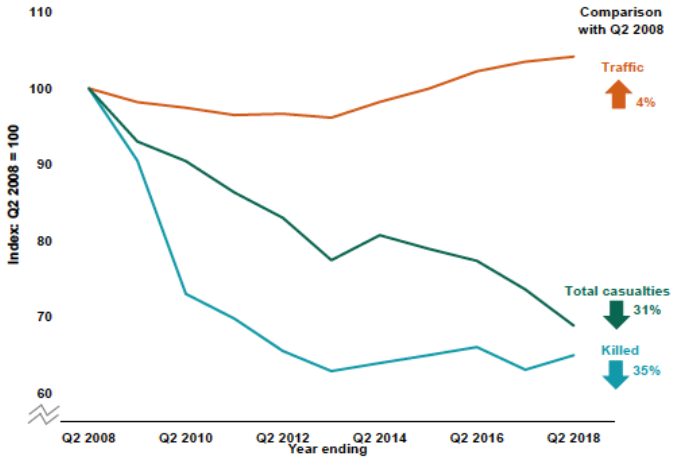


Figure 9, Number of fatalities and road casualties (Transport, 2018)

Sequentially, the automotive horizon has accelerated and provided an extraordinary initiative that depends on the consumers, needs, and preferences, leading to future transportation. The National Highway Traffic Safety Administration states that AV's are "vehicles in which operation occurs without direct driver input to control the steering, acceleration, and braking" (NHTS, 2011). In this kind of vehicle, the driver is not required to constantly observe the roadway while operating in self-driving mode. However, this definition assumes that the vehicle will always have a driver, where this assumption is not essential in the current experiments; autonomous technologies can perform all of the standard functions for a vehicle to run safely from A to B without any user on board at all.

Many major automotive manufacturers, including General Motors, Ford, Mercedes Benz, Volkswagen, Audi, Nissan, Toyota, BMW, and Volvo, are testing driverless car systems. In 2009, Waymo, the Google self-driving project, began testing its technology, ever since various companies participated in the field to provide the technology and take the lead of the market. Appendix A demonstrates market analysis for the most leading companies testing a self-driving car and their proposal features. Many autonomous car technologies can be found in most recent vehicles, such as an Anti-Lock Braking System (ABS) and Cruise Control (CC). These functions already have many advanced features that could take over the driving process. However, this technology maintains a specified distance between conventional and autonomous driving. Appendix B will justify what distinguishes the functionality of the autonomous vehicle from the conventional ones.

Various researchers argue that self-driving cars can improve safety and enhance the quality of life (Lutin, Kornhauser, & MASCE, 2013; Schoettle & Sivak, 2014). Conversely, many drivers and passengers are unwilling to adopt new technology, as it is not common for humans to have no control regarding the ambiguities around safety issues (Schoettle & Sivak, 2014). Moreover, this technology determines that the truly transformative benefits are only realised once the public adopts self-driving vehicles (Howard & Dai, 2014). Indeed, the usage of AV's is not restricted to enhancing the general acceptance of the technology but to investigating when, how, and why to trust the technology. This progress is contingent on the intuitive user who shapes the market's demands (Yang & Coughlin, 2014). Hence, Design Fiction would provide a near-future world to explore the possibilities and consequences of today's emerging technology.

2.7.1 History of Transportation and Human Adaptation

Transportation inventions have changed the face of the land and the human being evolvement, every day we are being transported into the future. Whoever invented the wheel could never have known what a big hit it was going to be. Indeed, every human could walk or ride their ox; different mediums could transfer humans, goods, animals from A to B. It is believed that the first time a human being used the wheel for transportation was in 3500 B.C., an ancient human-invented roundtable for shaping the clay and made circle pots out of clay, that simple wooden wheel was about to go places until our time (Herbst, 2005). Humans travel for different survival purposes, such as finding food, hiding from animals, and other dangers. Old Romans were considered the first people who travelled for leisure; wealthy Romans travelled to their summer villas and farms (Šnajdar, 2020). Travelling and crossing borders to extend territories and explore different cultures encouraged the ancient civilisation to develop networks and routes to make the travelling experience better for humans and animals.

In the 17th and 18th centuries, many new modes of transportation were invented, such as bicycles, trains, motor cars, trucks, aeroplanes, and trams. The transfers that automobiles have recorded could be considered the fastest during the last century. Nikiforuk (2013) illustrates that automobiles and tractors needed only 50 years to replace animals from public transport and farms throughout North America. However, this transition was not inevitable

or smooth, nor was it particularly beneficial. Will Rogers have abbreviated the description when he said, "you never heard of a horse going broke betting on people" (Yagoda, 2000). In 1906, the first car was designed with an internal combustion engine; other transportation forms such as boats, trains, aeroplanes, and automobiles were based on the internal combustion engine.

For many centuries, human curiosity and imagination worked as an engine for different innovations. Over eras, humans tried to fly like birds; wings were made of feathers or light wood and attached to arms to attempt to flee. The results were often disastrous, but they never stopped; these attempts were a motivation to keep developing and trying to fly like a bird. The fiction about flying like birds never stopped and eventually became a reality; in 1902, the Wright Brothers had developed a sustained and powered aircraft (Gibbs-Smith, 2013). Planes such as Lancaster and B-29 were designed, and British pilot De Havilland Comet flew the first commercial jet airline (ibid). In 1914 first commercial flight took place with much ceremony and circumstance; about 3,000 people paraded to watch as the first ticket was auctioned off; Just before the flight, Percival Elliott Fansler, the man who thought up the idea of commercial flying, said, "what was impossible yesterday is an accomplishment today, while tomorrow heralds the unbelievable" (Reilly, 1996). To date, several studies have investigated the early stage of inventing aeroplanes and flight technologies; yet there was no clear explanation of why and how people adopted the technology. In this research, we hypothesised that what encouraged people to adopt travelling by plane is due to three factors as follows:

- Curiosity and imagination, as mentioned earlier, humans tried to fly like birds; Ryan's theory addresses the use of fiction to explore the desired impossible world and how possible these alternative worlds could be. Therefore, turning fictitious ideas into reality encouraged this adoption.
- Safety assurance, the first aeroplane was an airboat (it lands over the water) with a top speed of 64 mph, flying no higher than 50 feet over the water, can take one passenger beside the pilot. How the aircraft operate was publicised to prove the efficiency of the design and development of the technology.
- Publicity stunt, the inaugural flight took place in public where people could observe the whole journey, including a technical error. For instance, halfway through the trip,

the engine misfired, so the pilot had touched down in the bay, adjusted and took off again (Reilly, 1996). The fictitious idea from science fiction novels such as the War of the Worlds by English author H. G. Wells became a reality. Indeed, presenting an idea through media platforms (such as illustrated books in the 1900s) played a significant role in enhancing public desire to bring the mentioned artefacts to reality.

Media tricks and Sci-Fi films provide a rich library of fictional devices and technologies that encourage the audience to envisage how the future could look alike. Starting as early as the 'Star Trek' series, mobility caused humans to change all the expectations, lifestyle, and other aspects of life. In Star Trek, mobility was possible not only in the world but in space, even from one world to another. Hence, it motivates people to explore space research and convinces them of their potential. Regarding the technological developments, this was not somewhat new compared to the steamboats and the coal engines, merchandise, and the trains to mobilise the human. The spaceship connection and the *'Back to The Future*' exemplify the ideas such as DeLorean designed for the film and later became 'real' via the locomotive at the end of the film. It is unavoidable for the individuals to keep themselves out of the wave while all the betterment is on its way and huge masses are affected.

As mentioned previously, the beginning of modern humanity is usually related to the invention of the wheel, making mobility possible. Like aircraft innovations, trains were classed as fascinating of all the great inventions of the industrial revolution; the railways had the most impact, travel over distance was a significant undertaking. Trains are connected carriages that run on rails; in 1804 first train trip took place. The train was powered by steam mainly fuelled by coal, wood or oil, moved coal from mines to rivers, and carried 70 people over 10 miles (Lepage, 2017). For centuries, as the first steam train rolled over the railways, industrial development brought bullet trains. This train could take thousands of passengers at incredible speeds, and freight trains could transfer substantial goods to the whole world. Indeed, trains enabled us to develop our civilisation with unexpected consequences that nobody expected. While all the railways, as mentioned earlier, came a long way, none were explicitly used for human transportation. In 1807 the Mumbles and Swansea Railway became solely passenger-based, consequently going down as the first-ever passenger rail service in history books (Lepage, J. D. G, 2017). It was initially constructed as a quarry railway for limestone and running between Swansea and Mumbles; construction began on this horse-powered railway

in 1805. This novel idea was swept across Britain and eventually led to developing first steam power, then electric.

The adoption of trains was a consequence of the human need to travel far and explore other cities. Christian Wolmar (2019) states in his book 'A Short History of Trains' that lack of mobility was a significant hurdle to economic and social development; in the absence of rapid transportation, people could perish within only a few hundred kilometres. The slow transit of goods by horse and cart or along rivers and canals meant that food and drink supplements had to be consumed within a short period. Limitation to travel has social and local restrictions. For instance, newspapers were inaccurate since they were full of old news. It took months for people to receive the fate of loved ones at war. In addition, the concept of time was different before the railways as the sunrise and set regulated daily life. However, the arrival of railways has changed everything. One of its significant impacts was forcing countries to standardise their time measurement both nationally and internationally. The railways created the structured day, in another word, they made the 'nine to five' routine (Wolmar, 2019). Besides the time and distance concept, social changes have followed. People were no longer tied to the land; indeed, they could work far from home, work for standard hours, and expected to do so for a wage. Hence, towns and cities have become more extensive than they would previously have been. Access to long-distance travel in relative comfort at reasonably low cost changed people horizons and opened up their imaginations. What had been impossible became a routine.

Like any other transportation, Sci-fi films tremendously envisaged trains, bullet shape trains like Shinkansen were seen in different movies before they became a reality and everyday transportation medium. In 1927 Metropolis film showed suspended railways, with exceptional stations and travelling with high speed; this visualisation indicated that human life in the future would be more organised and civilised. Currently, Elon Musk's Hyperloop is anticipated to be the new genre in public transportation; it drives travellers through a nearly airtight tunnel at speeds nearing that of air travel. In 1964 Athelstan Spilhaus began a comic series called Our New Age to speak about the Russian Sputnik satellite (Johnston, 2020). His work aimed to get children interested in the sciences while reading their Sunday comics - (Auger, 2013) identifies this approach as observational comedy: rooting the speculation in the familiar. - However, Spilhaus probably never intended on predicting the future. Still, his vision

of the trains of the future carried some uncanny similarities to today's Hyperloop; for instance, calling it an "exotic wheel-less train" capable of "travelling at hundreds of miles an hour" (Johnston, 2020). The design of the train even resembles a lot like those of the Hyperloop.

Indeed, learning new technology that has a foundation in science fiction establishes a link between what is desired to be adopted and how. Yesterday' lost futures' -presented in the Vision concept section- are becoming today's possibilities. The excellence of science fiction is that it can perform as a guide that those in the present can use to explore a path to the future.

2.7.2 Autonomous Vehicles On-Screen

Throughout time, cars became a means of simple transportation, proof of wealth. Car manufacturers were competing to develop different models, colours, and styles. Car's producers tended to give their car a personality, as it reflects a status symbol. Over the past century, many films presented supercars, such as James Bond, Bentley, and later Aston Martin; Blade Runner 2049, Peugeot; and Batman, Lincoln Futura, a superficially modified concept car. These cars were famous as much as the leading actors; they represented the seeds of the future vision. These bizarre cars had a certain charm and persuasive power over the adoption of cars as a personal transportation body. Thus, it is essential to understand how the use of automobiles within the films made some models and styles very famous and created trends, how the promotion of these trends affect the latest models and the desires of mobility.

Self-driving cars are becoming a real prospect with each passing year. Companies like BMW, Toyota, Volvo, Tesla, and many others are racing to take the lead in producing an intelligent vehicle that can get from A to B safely and without the need for human involvement. This technology has captured the imagination of Hollywood and filmmakers since the sixties. On-screen cars have been represented through predictions of future technology, supernatural energies, or working with people responsible for developing Vision concept prototypes. This section will present examples of AVs in films to understand how the self-driving car concept has evolved and been portrayed in movies. Since the 1920s, the self-driving car concept has existed, intending to amaze crowds at public events like the World's Fair.

Humankind has been always after the better and more practical innovations; some of the lost futures mentioned earlier became a reality throughout time as used tools were changing and evolving. In 1960, AV's appeared for the first time on-screen, as the technology began to develop beyond basic radio transmitter commands and publicity tricks (Bagloee, Tavana, Asadi, & Oliver, 2016). The 60s and 70s experienced the actual appearance of AV's on-screen as various filmmakers utilised tricks such as hidden cables to help guide AVs around tracks. Yet not all prototypes were life-sized Scalextric. Indeed, this evolvement escorted the actual car manufacturer race to develop genuine automated vehicles. The film industry impact on manufacturing development cannot be overlooked, such as Aston Martin providing a supercar for the James Bond film series and Dodge R/T Charger in the Fast and Furious series; nor the fiction to open up several discourses and possibilities.

Referring to some of the fiction strategies mentioned previously in this chapter, examples of AVs in films will be further underlined. For instance, the narrative anthropomorphism strategy could be seen in Herbie the Love Bug films (Figure 10). The film series started in 1963, introducing a Volkswagen Beetle, a car with feelings and characteristics as humans created by Walt Disney. Herbie the Love Bug had a mind of its own, capable of driving itself, and a serious contender in auto racing competitions. The car was not only presented as a hero, but it also had a humorous character. According to Johnston (2020), this series proved that it was not only humour or sentimentalism that engaged people with the autonomous concept but logic and power. Indeed, the trick behind the Herbie wholly depended on the humour and the technical substructure of the car. The Love Bug was equipped with different engines to allow a more realistic effect; a Porsche Super 90 engine, breaks, modified transporter engines with big-bore cylinders, early type 3 dual-port heads, and dual carbs. The horsepower of the cars ranged from 40 horsepower 1200cc engines to soaped up engines over 2000cc. Certainly, a particular logic in fiction works effectively to facilitate critical reflections and collaborative explorations by employing relatable prototypes for an audience.

Figure 10, Herbie the Love Bug, the autonomous Volkswagen Beetle 1963.

Another autonomous car prototype with the proper purpose as the 'fictional space as design space' strategy is KITT from Knight Rider, 1985. The film presented the car as a mechanical superhero instead of an actual actor (Figure 11). KITT was an autonomous car that was capable of functioning better than a spaceship. Not too far from Herbie the Bug, humour and sentimentalism were strongly presented at the scene, but logic and power were behind its attraction. The artificial intelligence concept showed KITT's self-awareness, hardworking, protective, dedication, and almost indestructible. Indeed, the Knight Ride film aimed to involve the audience throughout a game-of-make-believe facilitated by props. The car- KITT was introduced in a black 'Pontiac Firebird Trans Am' devoted to maintaining justice, high virtues, and dedication in society. Unlike Herbie the Bug, KITT demonstrated a more mature and sophisticated form and provided an elegant perspective ready for challenges. In 2012 and 2013, KITT was featured in the General Electric company advertising campaign, "Brilliant Machines", building the campaign around famous robots from various films and TV series[1]. One advertisement showed KITT racing a GE diesel-electric railroad engine that hauling a freight train[2]. The employment of fictional objects in the Knight Ride film created props that represent desired fictional truths.

Figure 11, Knight Rider KITT, 1985.

[1] https://www.youtube.com/watch?v=MwNIyloRtdo
[2] https://www.youtube.com/watch?v=M6tAgUcuNN0

The 80s and 90s Sci-fi vehicles were full of gadgets and superpower features. For instance: DeLorean DMC-12 in the film Back to the Future, 1985, the car was able to fly (Figure 12); similarly, Spinner in the Blade Runner 1982, was a 1972 VW Super Beetle, the car could recognise its owner's voice and can be driven along the ground like a typical car using internal combustion and was able to land and take off vertically through 'anti-gravity' engine and fly using jet propulsion. With many examples of these autonomous vehicles, the current industry provides a similar feature for everyday use. Similarly, according to the company founder Elon Musk, Tesla's Cybertruck design was inspired by 'The Spy Who Loved Me'. The Flying autonomous taxi in Dubai can carry one passenger weighing 100kg (220lbs); the traveller selects a destination on a touch screen. As technology take a massive leap from government labs to the R&D departments of mainstream manufacturers, a rapid need has risen towards adopting the technology for everyday use. Therefore, further investigation is needed to understand what drives potential users' adoption intention of autonomous vehicles and how? In this research, we believe that Design Fiction tools and strategies can lead to a better understanding of the concept of the autonomous car and enhance their adaptation.

Figure 12, Top left: DeLorean DMC-12, Back to the Future film; top right: Spinners, Blade Runner film; bottom left, Tesla Cybertruck; bottom right: The Flying autonomous taxi in Dubai

2.7.3 Self-Driving Levels

For many decades automobile industries development has recorded different stages for vehicle driving levels. Level 0, where cars have no automation, everything was controlled by mechanical means, up to the promising stage Level 5, where the vehicle is fully autonomous in all environments and stages. Figure 13 shows the six levels of automotive automation. As

mentioned before, the AV's dramatic changes will address a world in which travel is affordable or accessible. Driving towards different destinations could be an experience that passengers or drivers could utilise their time to do any activity while the car is driving itself. However, in order to change our current state of travelling to the one futuristic car is promising, there are many technical, societal, and regulatory barriers that we should overcome to adapt to the revolution of Autonomous Vehicles. The present research intends to provide a visual language that bridges the communication gap with the projected adoption of AVs for level 5.

Figure 13, Autonomous vehicles Levels adopted from (SAE, 2017)

2.7.4 Acceptance of Autonomous Vehicles

Furthermore, Design Fiction can interact with the viewers through possible world theory, which demonstrates by (Markussen & Knutz, 2013) that might be impossible to comprehend in the present. While there are many ways to adopt AV's, the Hype Cycle survey provide open space to investigate this adoption. The Hype Cycle was developed by the Gartner organisation (see Figure 8) to explore various technologies' life cycles, help the market, and define the best time to adopt or acquire new technology. Gartner divides the hype cycle into five stages as follows (Dedehayir & Steinert, 2016):

- The technology triggers the earliest phase of any new technology where it gains attention within groups and media.
- The peak of inflated expectations: within this stage, the technology can reflect unrealistic expectations. At this stage, most technologies collapse.

- The trough of disillusionment is considered a critical stage for every product when the technology, application or solution is no longer recognised or selected by groups and media. The present research calls this point 'the crack', where the product could either vanish or survive to move on to a different stage.
- Although on the phase a technology might fail to accomplish expectations, the slope of enlightenment, with some industries continuing to adopt it if productivity and utility are determined.
- The plateau of productivity: the technology is stable, widely accepted and adopted.

According to Gartner, in 2017, autonomous car technology passed the "peak of inflated expectation" (see Figure 14)and began moving towards the "trough of disillusionment" stage in which negative assumptions will take place (Panetta, 2017). The present research calls this point 'the crack,' where the product could either vanish or survive to move on to a different stage. An increase in negative coverage has already started when an accident involving an Uber autonomous car allegedly struck and killed a pedestrian. Consequently, Uber and Toyota have suspended their autonomous car testing. Furthermore, AVs are the only technology past the inflated expectation peak that has more than ten years until the expected time to reach the plateau of productivity. Based on the above, the AV's concept needs a new technique of communication to overcome the challenge of earning the trust of future customers, as they form the demand in the technology market and future investments in infrastructure.

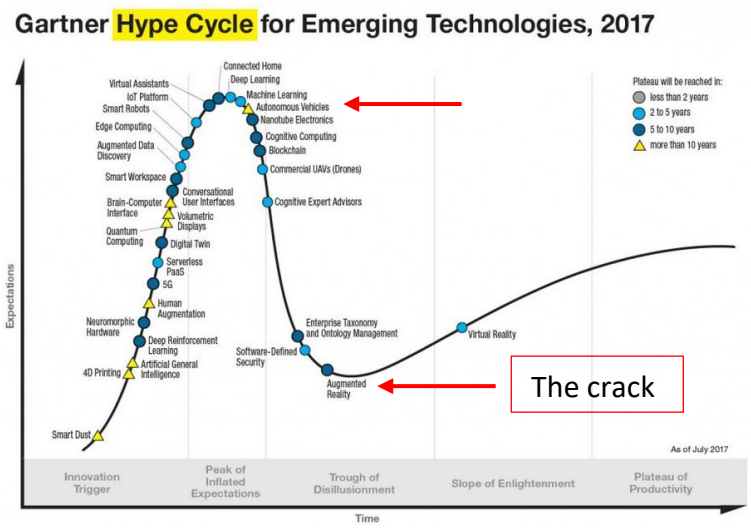


Figure 14, Gartner Hype Cycle for emerging technologies (Panetta, 2017)

Although the paradigm shift of road transport with entirely automated cars appears to be

nearby, there are some technical barriers, future human-machine interactions and connecting data, security, and safety concerns. Therefore, individual, and societal acceptance is considered an essential factor when introducing driverless vehicles. Automated driving has hardly been investigated beyond technical questions targeting the user, such as the interior structure and the machine interface. Though, different cultural studies and humanities researchers are investigating: how driverless cars can be embedded in the transportation network (Muller, 2017); reviewing relationships between people and automated systems, both theoretically and empirically (Ekman, Johansson, & Sochor, 2017); and how future driverless car passengers perceive the new technology (Creech et al., 2017). This research investigates the user requirements for the interior design of the car to design a user-oriented car that fulfils their need and enhance the adoption of autonomous vehicle technology. In addition, it is essential to consider the human-machine interface for the futuristic user to propose a new interface that meets the acceleration of the pace of everyday technology, such as mobile phones and tablets. The following section will illustrate an explanation of the user requirements and the in-car interface design.

2.7.5 User Requirements for the Autonomous Technology

Autonomous vehicles technology promises to enhance safety, decrease the need for infrastructural investments, and create more sustainable and green energy. Indeed, many companies are already testing their technology on the street and promising to have it in use shortly. Google has launched its project 'Waymo' in 2009, and its car has completed more than 300.000 miles in autonomous driving mode (Google, 2020). The 'Drive Me' project by Volvo placed too many AV's on the streets in 2017 (Volvo, 2016). Many other companies joined the race to provide AV's that meet customer requirements, safety levels, and control concerns. However, since the passenger is no longer a driver, this situation inquires new spatial orientations regarding the interior structure, interface system, and even the activity that could be practised inside the car.

Though, it is unlikely to study the efficiency of other companies' driverless car concept because these companies only release conceptual proposals, a wide range of studies have investigated the user need or vision of self-driving cars. Pettersson and Karlsson (2015) Have conducted a study to investigate user expectations of AV's; and presented a new method

called "Setting the Stage". This method requires placing the participant in a prototype, simulating the car's interior design with the possibility of rearranging its sitting structure. Indeed, the user expectation during the session is relevant to the individual's view of different user scenarios (Pettersson, 2017). In the experiment, the participants had an active role when re-placing the seats, which encourages further reflection on their vision of the future as it provides a simple and open design space. Pettersson and Karlsson's study has explored a new method to understand user expectations about AV's, which would improve technology adoption and acceptance. Such methods succeed to obtain a detailed insight into how the user envisage the driverless car and reflect on how autonomous technology would change the kind of activity the user might practice while driving.

A similar study by Jorlöv, Bohman, and Larsson (2017) aimed to gain knowledge about user preferences and attitudes towards seating positions and activities inside an autonomous car; the focus in the experiment was safety responses for long and short rides. During long trips, participants prefer to have a car interior structure that would allow them to rotate the front seats to a living room position. Meanwhile, shorter journeys for one passenger, the participant prefers to keep the forward-facing position and allowance of seat adjustment to a further relaxed position. Although the adjustable seating position and reclined seats would not meet the current safety requirements, participants believed that these regulations would be more flexible and allow more freedom in the future. Jorlöv et al. (2017) have utilised (Pettersson & Karlsson, 2015) method 'Setting the Stage' to conduct their experiment in order to open up the space to think about the future and explore the user expectations for further studies.

In their research, Filo and Lubega (2015) proposed a potential design structure that employs the 'Body & Trim' prospect; focuses on the functionality of the future autonomous car. Their experiment aimed to provide the most suitable design that meets the user needs, is convenient with the limited volume space in the car and meets safety requirements. Filo and Lubega (2015) design proposal was performed at the department Body & Trim at Volvo Cars and driven by the company concept "designed around you." The research core was around the question, "what will people do in a car when they no longer have the responsibility of manoeuvring it?" Such a question raises a new research opportunity created by the timeslots; this time can be used to do different activities, affecting the user's need for a new structure

to practice these activities. Therefore, Filo and Lubega (2015) surveyed the futuristic car's customer needs and vision, analysed the market, and justified the kind of segments the car could have from the safety recommendations aspect and body component perspective. This project's futuristic nature helped identify the user need, whether with the material component or how the passenger could utilise their time while travelling. This scheme encouraged the user to imagine themselves as the user of tomorrow technology and enhanced their desire to have such technology shortly.

On the other hand, excellent communication between vehicle and passenger accommodates when to trust or not to trust the automated systems. In this context, the automated system needs to convey the sense of intentions awareness, the ability to flexibly switch control at any time or even to give instructions about how to drive within the passenger's comfort zone. Affording such a result is through a comprehensive human-machine interface (HMIs), also known as user interface (UI), which present an effective communication platform with the end-user. An outstanding UI should provide a visual presentation that tells its functionality, how to use those features, and why are these functions are fundamental in the object/service. Therefore, a comprehensive UI leads to an immersive user experience (UX), more safety, and more efficiency while travelling from A to B. For drivers, a fraction of a second can vary between getting into an accident and driving away safely. Studies show that it takes up to 8 s for a driver to regain situational awareness and more than 3–4 s for reaction time. During this time, the possibility of a collision is significantly increased (Wright, Samuel, Borowsky, Zilberstein, & Fisher, 2016). While recent car technologies propped with safety features like backup cameras blinking and sensors, different types of driver distraction impede the ability to spot hazards and react in time. For example, the use of mobile phones has become a necessity for many people. Evidence explains that the distraction caused by mobile phones can impair driving performance in many ways.

Commonly, drivers operate cars, and at the same time, they would be engaged with another activity; therefore, the need for technologies that assist the user became more urgent. In 2005, Honda and IBM presented a leap into the future, the first voice control system in cars called *Acura* (Homden, 2019). Consequently, the voice control system has provided enormous support to the driver with different tasks such as making calls, setting reminders, managing shopping lists, or even editing the work schedule. Indeed, this growth was parallel

with other innovative technologies, such as mobile phones; the interaction with built-in information and entertainment systems; however, some drivers treated it more as a side feature likely to cause more harm and increase the risk of driving. Therefore, the need for a novel interaction system inside the car became a priority for different companies and created various opportunities for designing an efficient and attractive in-car interface. This interface has to reflect the way the user perceives the driving experience.

Over the last decade, driverless cars appeared like a science fiction fantasy genre; currently, too many companies tested fully AV's on real roads among other human drivers with only occasional human intervention (Markoff, 2010). This technological shift demonstrates that intelligent systems are capable of performing efficiently in cars. However, it does not seem easy to shift from a hundred years of driving habits to an automated system, neither encouraging people to sit back and relax while the car is taking over the driving task. To successfully implement new technology (Verberne, Ham, & Midden, 2012) investigate psychological factors that significantly contribute to the acceptability of autonomous technology. This technological engagement is relevant across areas ranging from primary driving control to assisted functions to navigation, information services, entertainment, and even games.

It is important to understand that what people engage with depends on how it meets their ongoing activities and whether they realise its potential value (Makri & Blandford, 2012). The design of systems that support active engagement will ideally take account of people's practices and contexts and their interests. Good design can facilitate productive interactions with information. Moreover, the passengers need to operate the car in the way they want to be driven to maintain a high level of trust and comfort in the car. This communication can be verified through visual, auditory, and haptic approaches. The subtleties of the many possible scenarios and actions while riding the car can be too detailed and intricate to express via visual aids adequately. While auditory communication in urgent situations can improve the feedback, care must be taken with the amount of presented information to ensure the passenger is not overwhelmed; it could take away from the conveniences of autonomous driving (Dey & Terken, 2017).

2.7.6 The Impact of COVID-19 on adopting Autonomous Vehicle

In December 2019, a new virus was reported in Wuhan, China, known as Covid-19. Therefore, countless changes have been forced all around the world as a response to the pandemic. The transportation industries have been highly impacted by this virus, as social distancing became a 'must' to avoid spreading. Thus, transportation industries are investigating how changes in consumer behaviour may affect the adoption of AV's. As societies worldwide have changed to a more home-based living and working environment, the need to transfer goods and services without human interaction has become a priority than ever before. While COVID-19 may have interrupted the improvement of AV technology and restricted consumer purchasing of new vehicles, it has increased the potential of adopting this technology in other spaces. The need for AV adoption by logistics businesses, delivery companies, and the food services industry might provide the manufacturer and other AV shareholders with the market need to move AV technology to the next stage. Indeed, as staying healthy means staying far from other public citizens, the appeal for adopting AV's trucks and robotic food delivery appears more appealing than ever. As COVID-19 sets the human side of transporting goods into the spotlight, various logistic companies recognise the need to implement autonomous systems in real-time. As the Covid-19 pandemic has spotlighted the human factor of transporting goods and shipment of goods, many workers had to quarantine for 14 days to reduce the risk to others; fewer workers mean a delay in delivering goods and services. Unlike humans, AV systems can operate all day and night. Indeed, autonomous technology promises to provide an adequate and accessible transportation system that meets public need. The autonomous technology concept needs a new form of communication to overcome the challenge of earning the trust of its future customers since they determine the demand in the technology market and future investments in infrastructure.

This chapter has reviewed different studies regarding the AV's concept and what kind of development this technology needs to shift the user to fully AV's. The following chapter will demonstrate the method this research has adopted to accomplish its purposes.

3 Chapter Three: Research Methodology

3.1 Introduction

This research has utilised a combination of qualitative and quantitative methods to investigate and justify the use of Design Fiction to enhance the adoption of Autonomous Vehicles. Multiple research analyses have been conducted to understand the different layers of research, such as research philosophy, approach, methodological choice, and research strategy. The selected methods used to fulfil the research aim include four primary stages that reflect on the research through the design view of conducting research. Therefore, the purpose of this research is to design an experiment that helps validate the research hypothesis. It begins with a background investigation into formulating a research question (catalyst for research) and then generating an artefact that requires validation.

3.2 The selection of Design Fiction

The literature review chapter has defined the notion of Design Fiction as an approach to present and prepare futuristic products/ services. The present research aims to utilise Design Fiction tools and fiction strategies in particular, principle of minimal departure (the use of fiction to explore the desired impossible world and how possible these alternative worlds could reach) to investigate the autonomous vehicle concept. The trigger for this investigation is Bruce sterling definition of Design Fiction "to suspend disbelief about change." In practice, design fiction is a tangible continuation of the speculative design concept that enables designers to prototype physical objects, reflecting on how they visualise the future. By referring to Sterling definition, "the deliberate use of diegetic prototypes to suspend disbelief about change," it is recognised that Design Fiction is both a discipline and a method a designer or researcher drives their mind to visualise an object, giving it a tangible form and then constructs a narrative by placing the prototype in a new world for the audience to interact and raise a debate. Therefore, design fiction connects upon a 'diegetic prototype', along with the context a designer decides to present within 'cognitive estrangement' that facilitate the temporal difference in one's perception of current time and place. By the principle of minimal departure, the viewer of a fictional world would locate their knowledge, experiences, even ideals into the actual world. While this minimises the designer/researcher need to explain how the prototype took such shape, it relieves the viewer of creating and unfolding the world

in their imagination. Depending on the viewer knowledge about the world, they can use these insights to expand the idea of the potential world with further details.

Design Fiction depends on the 'diegetic prototype' with the ability to generate these suggestions. The audience may thus suspend their disbelief and consider the work as fiction. As mentioned before, the story elements must also present a particular logic to be effective. However, if technology is ambiguous or unfamiliar to the audience, it must follow a set of governing rules. The viewer must not be suspicious of the design or the presented technology. Furthermore, the scenario that focuses only on technological superiority may lose its critical value because it will not provide Design Fiction's provocation. Therefore, the proposed technology must show its social potential, so the viewer can imagine their engagement if it becomes a reality.

Therefore, this research employed Design Fiction to investigate the adoption of Autonomous Vehicles. AV's technology is a promising technology that would enhance mobility for different users and sort too many concerns the current transportation system. In the research, we hypothesise that Design fiction will help provoke the general acceptance of autonomous technology and provide a vision of how, when, and why to trust the technology. The primary component that guarantees the success of this development is the final customer since they shape the market; therefore, Design Fiction would provide a near-future world that explores the possibilities and consequences of today's emerging technology. The current participants are not the drivers or passengers of the future cars, and the future users do not yet understand the requirements of the current seniors. Designing for a target group from the future is a challenge that the Design Fiction approach would help overcome. Most importantly, to open up a discursive space regarding the AVs through Design Fiction is not enough to seek the desired change. Indeed, the proposed prototype should be validated through statistics since this research aims to change behaviour concerning the AVs concept.

This thesis has had employed Research through Design (RtD) approach to establish how Design Fiction tools and strategies could enhance the adoption of AV's. The design Fiction approach does not provide a clear image of the kind of knowledge it could produce, as it allows a discourse that could differ from one to another. However, building meaningful experiments based on discourse alone is not sufficient; therefore, this research relies on

Frayling (1993) to consider the multidimensional and reciprocal relationship that research, art, science, and design have with each other. According to Schön (1987) RtD concept is about a "designerly way of knowing", which justifies the uses of RtD instead of the standard research method. Frayling (1993), as cited in Grand and Jonas (2012), explains the difference between research for art and design, research into art and design, and research through art and design, and also explains research in art and design as follows:

- Research (with a big 'R'): Production of new knowledge
- research (with a small 'r'): Pre-existing knowledge

Frayling's classification of design research:

- Research **into** design (big 'R'), represents a pursuit of new knowledge about the practice, as opposed to actually doing the practice; this kind of research is theoretical.
- Research **through** design (again, big 'R'), refers to the production of knowledge resulting from a design/making process.
- Research **for** design, refers to contextual research that has been conducted to support the design and production of a design artefact (it is the only category that refers to research with a small 'r').

3.3 Design Research

To further build a comprehensive understanding of the RtD approach, there is a need to explain what research means. Frayling (1993) demonstrates that research could be interpreted as a systematic inquest into X to identify communicable knowledge. According to (Chamberlain et al., 2012; Oakley, 2002) research, is systematic because it attempts to answer questions and integrate findings; the task description defines the research goal. Hence, knowledge is a justified true belief, which means findings must have a foundation that can be objectively demonstrated (Fantl & McGrath, 2002). Therefore, design research aims to study and investigate 'design' and to connect that knowledge and findings (ibid).

Archer (1995) as cited in (Chamberlain et al., 2012) classifies research into five categories and claims that in practice, any research could include more than one class. These sequent categories as follows:

- Fundamental research, a systematic inquiry conducted in order to generate or investigate general knowledge, without any specific application.
- Strategic research, a systematic inquiry utilised to fill gaps in fundamental research, in order to narrow gaps within potentially useful applications.
- Applied research, a systematic inquiry with the aim of reviewing or extending knowledge, for the use of a particular application.
- Action research, a systematic investigation into practical action, with the aim of testing or inventing new knowledge, ideas, or forms with which to present communicable knowledge.
- Option research: systematic inquiry led to provide evidence for decision or action.

Indeed, turning to the kind of outcomes based on the above categories, knowledge takes the form of theory that has useful general applicability and predictive ability. Vermaas (2014) states that design theories often present a combination of descriptive and prescriptive outcomes. Theories can, firstly, describe design practice such as actions and structures; secondly, prescribe these actions or structures for future usage (Tomiyama, 2006). An alternative embodiment, theories in prescribing design practice, determines design from non-design. Thus, prescriptive design theory shifts to be descriptive when a tool is described and adopted. Hence, theory building is an essential aspect of any research, which can develop courses of action in the future. Friberg (2010) argues the classical distinction of "traditional research" versus non-traditional research through design, adds there is "a complex and extensive field of different research practices." Further, Friberg declares that theories are built not merely to know formulations, but also to understand their potential practice. Such theory corresponds with (Frayling, 1993) definition of RtD as an example of using X to study X.

The design field includes different categories from the arts, engineering, and technology. Design research has various implications and purposes; where research can be conducted in numerous ways, design can demonstrate research in many different ways. Design research directed by academic goals proposes scientific outcomes, whereas design research captures a design vision and forms a prototype. This research needs to define the linked connection between design and analysis, locate the designed artefact in the research landscape, and serve the purpose of Design Fiction. This section will explain how design and research

together work to utilise the design research landscape. While designers can demonstrate their work purpose as research, academic researchers could find it challenging to understand the illusion of design. Designers might not use the standard analysis to formulate their work purposes, as theory is usually not actionable to address human needs.

Research as defined by (Cross, 2001; Grand & Jonas, 2012; Schön, 1987), is a systematic investigation that discovers new facts, analyses existing theories, resolves new or existing problems, demonstrates new ideas, or introduces new theories. It is essentially correlated with the quest of knowledge, particularly in the science and technological disciplines (Chamberlain et al., 2012). Design, in contrast, refers to the act of planning and delivering a course of actions to others, within the creative investigation of a particular field. Charles Eames, as cited in (Lunenfeld, 2003) represented design as "A plan for arranging elements in such a way as to accomplish a particular purpose best." The notion of "design research" blends the characteristics of design and research, to present significant knowledge through purposeful design. (Fallman, 2007; Koskinen et al., 2013; Taura & Nagai, 2011) articulate design research as the investigation of design and the process of generating knowledge through the design practice. However, as research design is used in different disciplines, there is a lack of understanding of this approach in standard academic research (McKenney & Reeves, 2018). (Krippendorff, 2007) argues that design research presents a contradiction, as its strategy is not evident to everyone, and could lead "naïve users into thinking of it as a kind of research similar to what reputable scientists do." Therefore, design research requires a broad understanding of the cultural distinctions and contextual variations across subdomains of research and design.

Design research approaches are broadly adopted. However, research on design and research through design are the only approaches that engage effectively in the "designerly ethos" according to (Cross, 2007). Whereas traditional research strategies like design through research, and design of research, are less adopted as researchers consider them deeply scientific, regardless of their effectiveness at improving research practice (ibid). Faste and Faste (2012) classifies research through two axes: Scientific vs practice-based, and theoretical vs empirical (see Figure 15). The first aspect of the diagram is the horizontal classification: scientific vs practice-based. The left side of the diagram manifests basic research, where topics like mathematics, physics and biology are found, these disciplines considered as

systematic activities, which aim to expand knowledge of primary and replicable principles for understanding the physical world. The right side of the diagram represents design-related activities known as practice-based research (Zimmerman et al., 2010); scientific and experimental subjects alongside with arts, humanities, and applied engineering are eligible for this type of research. Therefore, design research belongs more to the practice-based research section. The second aspect are the vertical values: theoretical vs empirical. This diagram addresses a clear degree to which a field of research is listed on directly perceived empirical experience and theoretically derived prior knowledge. The scientific research stands to define modern industrial design, regarding intuitive and non-intuitive techniques, it reveals where art and science are blended in solving design problems (Cross, 2001). Design science emerges from the inquiry of the universal application of natural science strategies to formulate a conventional design method.

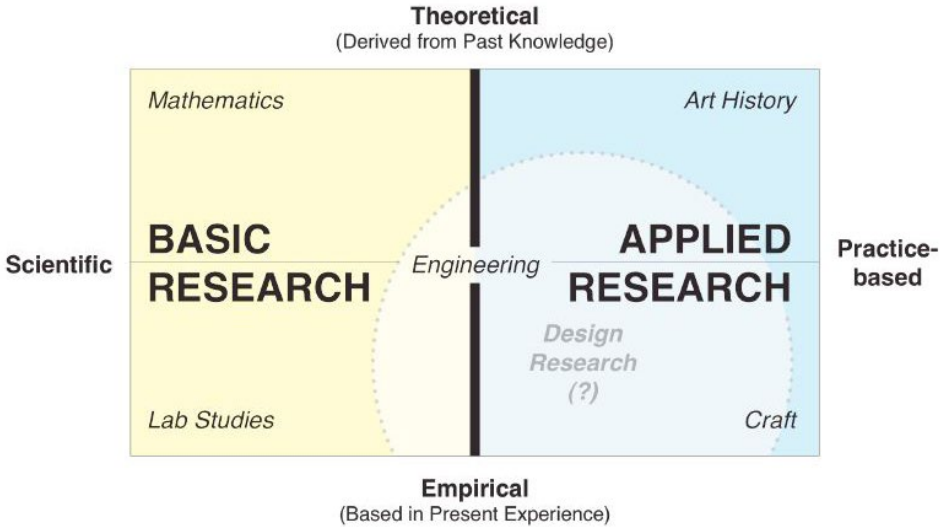


Figure 15: Research classification (Faste & Faste, 2012).

According to (Simon, 1973) design science is research that attempts to investigate new solutions to resolve problems, to explain the investigation process, and to develop the problem-solving process. Broadbent (2003) claims that the positivist approach falls into design science since it challenges the process of defining a solution. Rittel and Webber (1973) as cited in (Crowley & Head, 2017) call it "tame problems" by adding some aesthetic content which enables the issue to be characterised, analysed and planned. However, Rittel and Webber adopt a rational system perspective which ignores the psychosocial aspects of solving problems. The science of design means that design is the core of the scientific investigation,

as mentioned above, "systematic enquiry into X to discover communicable knowledge" (Frayling, 1993).

As previously explained design research develops different ways to conceive of activities or practices, which depend on the multitude of reasons design practitioners are engaged in research. Such engagements incorporate inspirations, evaluating current solutions and strategies to similar issues, distinguishing user requirements, predicting the potentiality of an idea, or even examining possibilities of using certain concepts in a particular experiment with diverse materials. Generally, the data outcomes of the research are used to guide the design process, as they directly influence how the designer could instigate the result. For instance, Polly: the world's first truly smart kettle, by (Coulton et al., 2018) is a fictional prototype that serves the Design Fiction concept and explicitly represents a design research strategy. Coulton and his team present an affordable and familiar kettle and employ a research approach that conveys what features the kettle has, proposes some visions about how it would work, and what it might be like to use it. Such an example demonstrates that while the results of design research practices are always new knowledge, the experimental results might not necessarily be applicable for broad usage or adoption, as there are many ways that design can demonstrate research through practice. Representing a set of design activities as design research without any additional considerations leads to results too vague to be meaningful for sensible delivery.

However, design research approaches fall into three different categories:

- Empirically oriented design research, which relies on direct observation of the physical world through qualitative research, in order to detect user requirements (Perks, Cooper, & Jones, 2005).
- Design research that focuses on the practice of design, in which designers engage in a repetitive prototyping process, to define the proposed artefact applicability and usability. This approach is often used in trials, experiments and participatory co-design sessions (Sanders & Stappers, 2008).
- Speculative design approach practices, where precise probes and interventions into cultural and social discourse and practice have a role in leading the discussion and generating knowledge (Auger, 2013).

As the previous discussion has demonstrated, design research is usually considered as part of research practice from a scientific aspect, and as part of design processes by designers; both views have their practical merits. While technologically-driven research domains often tend to reflect on design as a -kind- of research; on the contrary, science is an example approach, out of many, to the practice of design (Holmström, Ketokivi, & Hameri, 2009). Scientific research employs legible and replicable methods; where design research is often not replicable and outcomes hard to determine. Design research determines intrinsic human needs that could be hard to generalise, employs alternative methods to resolve challenging concerns, which enhances the desire to accomplish meaningful impacts in a way that is difficult to adjust with traditional research methods. Hence, while it is understandable to frame design research as a division of design, it is also unrealistic to acknowledge such practices as research in any conventional sense. The previous statements are stemmed from standard research steps where investigating background, and research objectives guide the research process.

3.4 Design Research Categories

As classified in Figure 1, research has two aspects: scientific, and practice-based; design research is mostly located on the practice side (right), and partially on the scientific side (left), and each side has it is own practical merits. In the conception of (Faste & Faste, 2012) , it is suggested that design research is not a subclass of research; rather, research is a kind of design. This assumption relies on the idea that practice is the big umbrella of conducting research, as scientists practice research exactly the same way as designers to define or prove a new or existing theory. Unlike research which includes only certain aspects that meet standard categories, design research provides a creative space that allows various design strategies to take place, become conventional and raise new unconventional methods and replace them. Therefore, the stance of (Faste & Faste, 2012) classifies research as a subclass of design practice, and the proposed strategies are actually unconventional methods which were not considered for the research. This reversal of performing research in the field of design, allows practitioners to employ and view their artefacts through academic ends. Though design research constitutes a limited proportion of its practice; design within research standards has additional limitations. To overcome this dilemma, (Candy, 2011) considers research, as an integral part of creative practice, which allows a broader range of conventional

outcomes. The creative practice blends the act of creating something novel with the fundamental research processes and techniques relating to a given discipline of endeavour, whether art, music, design, engineering, or science (ibid).

Design research has different categories that reflect the various kind of activities that the researcher is expected to perform; each has a distinct usage and purpose across research strategies. These categories are design through research, design of research, research on design, and research through design (Laurel, 2003).

3.4.1 Design through Research

The researcher presents activities in a conventional way and considers research alongside these design activities. This category reemphasises framing research as a kind of design, which makes research the engine of the practice. The nature of this research unequivocally studies natural and technological aspects to advance human knowledge (Denyer, Tranfield, & Van Aken, 2008). This type of design research is compatible with the research practices of other traditional fields of research. Thus, research practitioners are considered design researchers despite their awareness that they practice design.

3.4.2 Design of Research

Design activities are conducted and designed by the researcher in order to evaluate the experimental designs. Similarly, to formative design research, design of research activity has the same foundation in the scientific convention, and often used to plan out a design process. Research activities are consistently designed, which reflects a certain aspect of the previous category 'design through research' and can be effectively acknowledged the deliberate 'design of design' according to (Creswell 2002). Therefore, design is the core of the research process. Design research practises on this category defines the intent of the designer performing the research activity.

3.4.3 Research on Design

Research on design, is a process whereby researchers develop a design prototype and examine it, by studying the design workspace, or forming experimental variables to change design behaviours and results, thus exposing relevant design process knowledge. Using this discipline, designers improve their practice, while design research performs the critical role

of monitoring design processes to enhance the efficiency of a presented design method or strategy. This type of research is known as diagnostic design research, as researchers concerned with improving design practice can reflect directly on the process by studying the practitioner environment, and the kind of variables that influence design outcomes (Kuehl & Kuehl, 2000).

Research on design can validate the efficiency of assigned design practice, such as prototyping dynamics (Dow et al., 2011). Although the analysis of design activity permits patterns in the relative progress of some activities to be verified and determined; research on design has limitations as to what can be practically analysed. However, research on design plays an essential role in legitimating and establishing design methods in a scientific district.

3.4.4 Research through Design

With this approach, designers design elements as often, but take into consideration the research results, besides casting tangible outcomes, and the new knowledge they have gained among their practice. RtD is a combination of process and research ends; the results of this combination are always an artefact that serves the purpose and plays a big role in defining new knowledge. RtD operates as research, whether deliberately or not. Faste and Faste (2012) define it as embedded design research. The produced knowledge is obtained in the cognitive processes and the outcomes artefact in the experiment. What distinguishes RtD practice is the ability to include traditional research tools and documentation, thus allowing practitioners to use research in order to understand the subjects they are investigating. Consequently, designers can reflect on their proposed artefact and improve it in similar ways to that of diagnostic design research methods. RtD is the research method adopted for this thesis to operate and investigate the use of Design Fiction to enhance the adoption of Autonomous Vehicles, and to provide a well-designed prototype that reflects user needs. This standard research process could help to generate new knowledge. The following sections provide more details about the notion and the use of research through design.

3.5 Notion of Research through Design

RtD has been widely used as a substitute for research into design as it helped researchers like (Blythe, 2014; Lindley, 2015) who are investigating Design Fiction to answer fundamental

questions about the foundations of design-based enquiries, the purpose of utilising a prototype, and the value of designing digital artefacts in research. These questions arise to identify the distinction between what is known as standard research design and the original purpose of research through design. Herriott (2019) says that "the "designerly way of knowing" implies a difference in how something is known that comes from finding out about it in a specific ("designerly") way."

Zimmerman et al. (2010) define RtD as a research strategy that applies methods and processes from design practice as a legitimate method of inquiry, where the earned knowledge can be implicit, residing totally within the resulted artefact. In addition it is argued that theory building is the weak phase of RtD (ibid). Grand and Jonas (2012) attempt to distinguish between research through practitioner action and research in the scientific tradition; science research and practice are often seen as acts that belong to and are defined by a particular context, to reflect upon it from a more neutral or objective point view. Consequently, RtD can be interpreted as a means to connect theory and practice, according to (Bang, Krogh, Ludvigsen, & Markussen, 2012) RtD forms the possibility of design based on design practice such as creatively making an object in order to gain knowledge.

Classifying RtD as practice-based research strategy, Schön (1987) remarks that RtD is usually concerned with advancing a practice and the nature of the practice, his view stemming from the understanding of the reflective practitioner and involving the practitioner's strategies. Stolterman (2008), indicates that RtD offers many services such as reflection in action, participant research and action research. Therefore, RtD enables researchers to rely on designerly activities to approach and understand complicated cases and provide an explanation for situations that are not suited to other methods of inquiry. Archer (1995) demonstrates that there are some circumstances when the most competent option is to shed light on a hypothesis, a principle or material, function or process; to form or build an understanding of something or enact something or test it. W. Gaver (2012) explains that RtD is not generalisable or repeatable, that it has ambiguous claims, that may create useful quality sometimes and sometimes not.

RtD, as (Forlizzi, DiSalvo, Bardzell, Koskinen, & Wensveen, 2011), claim lacks clear standards and expectations for what "good" design research is; and thus would benefit from some

actionable criteria for bringing accuracy in the critique of design research. Therefore, the RtD community must develop guidelines, descriptions, and protocols for the approach activities, in ways similar to other approaches (Zimmerman et al., 2010). Indeed, such a process depends on developing RtD as a conventional research methodology that can generate consistent and rigorous theory (Ibid). Accordingly, conceptual contributions should provide a certain level of extensibility and verifiability in order to include theory designers who could apply this theory to practice (W. Gaver, 2012; Zimmerman & Forlizzi, 2008), and fill the part that RtD as a subbranch of design research is occupying in the science research sector (Figure 1). W. Gaver (2012), has utilised RtD in HCI (human-computer interaction) research, where he acknowledges, along with (Forlizzi et al., 2011; Wiltse & Stolterman, 2010; Zimmerman et al., 2010), that while design practice has become more common, some questions have been raised about the nature and standards of RtD. These inquiries revolve around the desirability of combining research methods, strategies and outcome in HCI. Zimmerman et al. (2010) demonstrate that HCI research readily allows contributions from RtD if it has an acceptable form of practice, outcomes, and evaluations; if these contributions are coming from the improvement of extensible, systemic approaches to theory development. However, (Stolterman, 2008) claims that the tendency for design to generate 'ultimate particulars' poses problems when developing generalisable theories.

Accordingly, RtD is not a standard or formal research approach; instead, it is a foundational concept for proposing inquiries through the practice of design. Hence, RtD has been subjected to multiple articulations, and consequent interpretations depend on the purpose of the research and contrasts drawn between the variety of design research practice in the different working cultures and contexts of academia and industry. This leads to a consideration about how RtD should operate.

As design activity is used as a means to study the nature of design; this raises a question around the epistemology, how we know what we know. Schön (1987) suggests that epistemology of practice is "based on the reflective practice of design". Schoen's theory focuses on what could be known with how it is known. In response, according to (Herriott, 2019) the researcher must remark that "that knowledge exists in mind and not in an entity (a text is a representation of knowledge)." Though each method has a piece of particular technical knowledge, it is not equivalent to the epistemological differences (ibid). As stated

in (Schön, 1987) study of the "epistemology of practise implicit in the artistic, intuitive processes" design is a concept that operates within the problem, and knowledge must be communicable to count as such. Therefore, this takes the study back to the question of how to make knowledge communicable.

3.6 Research through Design Process

Utilising design artefacts in research is a debatable process which raises essential questions about the various approaches to design research and legitimate forms of knowledge production. RtD usually involves the production of a design artefact, which is the core of the research process. This section will present the process of translation from the research question into the design brief, to the initial prototype production, back to the question, back to the prototype; this process continues until the design artefact is relevant as a tool for research or is tentatively discarded. Indeed, in terms of Design Fiction, the produced artefacts do not serve a utilitarian purpose but implement a clear perspective about their use and the experience they invoke. These artefacts as an example are like an 'idea' with lots of creative proposals. The idea may possibly never leave the paper, but when it does become a 'concept', different levels of independence, forms, and debates could be identified.

3.6.1 The Purpose of Design Artefacts in the Research Process

With the different approaches to operating design research, the discussion on function and characteristic has a similar way of operating. When assembling an artefact, the purpose is to generate guidelines, and the focus is on the process of design. The produced artefact can be considered as an object that has been built over the research process. For example, a bird or an aeroplane, are items that could be analysed by employing natural science methods, and without any attention, to the purpose of these items, or intention for adaptations (Simon, 2019). However, when the process of design is an essential part of the research, and the artefact is not in existence; the artefact is primarily invented in accordance with the research scope and question. Though the RtD approach employs the artefact as a source of generating knowledge and analysing data, it does not need an external object to build the theories. Indeed, it is essential to highlight that if the design and the prototype are inextricably linked, then the design artefact created within RtD is interpreted in the light of its subject (Kroes, 2002).

3.6.2 Research Question to Design a Prototype

Several distinctive qualities characterise the aim of developing and presenting experiments in design for scientific research. They are less practical and more conceptual; they usually include several phases of clarification; targeting a particular audience who are interested in research products, instead of object usability. Therefore, employing the RtD approach establishes several inquiries such as, how the research question could be translated into design briefs, and these design briefs interpreted into tangible prototypes. Hence, it is essential to clarify that as the main impulse for this research, the Design Fiction approach in definition emphasises the term 'diegetic prototypes,' to explain how the audience might understand and relate to these prototypes, which creates discursive space, raise questions, and investigate innovations.

3.6.3 Standard Research through Design Process

This section will describe the process of transformation from the research gap or question, into a design outline and then into the prototyping stage. This section will cover different design and research decisions made along the process until the last phase, an evaluation of the process from research and a design perspective.

The first model to be described is research *into* design process. When the aim of the research is planned, the designer/researcher begins the research by investigating the background to the research, which leads to a research question, further investigations leading to developing the primary object to an appropriate subject. Following this, the researcher selects an object, or a process or a combination. This type of strategy, which could be quantitative and/or qualitative, leads to new information on the object and its design process. Based on the outcome findings, a theory is modified, or a new theory is introduced (see Figure 16).

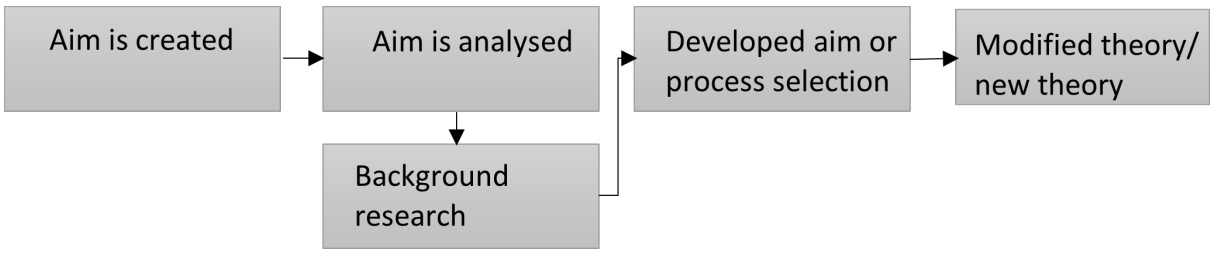


Figure 16, Research into design process 'A'

Another process to run research into design, is when background research is confined to establish a research gap/question. An experiment is conducted, which leads to the production of new data. This data should then be analysed, and the results lead to a new or modified theory (see Figure 17)

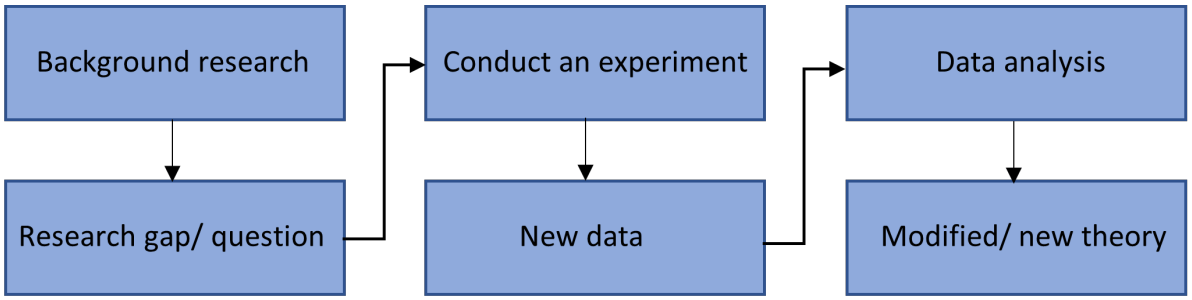


Figure 17, Research into design process 'B'

RtD is not restricted to traditional research outcomes, and as part of practice-based research, it enables designers to improve and reflect their design research practice in techniques similar to diagnostic design research methods. However, design process knowledge is rooted in the internal toolkit or environment of the practitioner, and in the external world as a result of the produced designs. Therefore, RtD enables the enhanced representation of future design action through knowledge distributed through more apparent means than that of traditional research. Indeed, prototypes are presented as supporting evidence for interpretation by their target audience, forming a critical discourse between the proposed concept, designer, and the environment to which the artefact is targeted, which corresponds with the main approach guiding this research, Design Fiction. Mäkelä (2007) follows "an artefact can embody a greater range of roles: as an object made by an artist researcher during the process of research, it can also be seen as a method of collecting and preserving information and understanding." The combined knowledge in the designers' activity not only reinforces design research, but it also plays an active role in the distribution of knowledge across all forms of experience.

Therefore, Figure 18 visualises all design research categories, to build a better understanding of each research/ design process and what is derived by research on one hand, and on the other hand what is derived by design. Design through research; researchers perform activities that would conventionally be considered research regardless of their awareness that their activities are designed. Design of research, in which the design activities are routinely performed by researchers to plan and evaluate their experimental designs. Research on

design, wherein researchers study design practice in the workspace, thereby revealing relevant process knowledge. In addition, we have research through design, in which designers design things, with the results of prototype or process leading to shaping tangible outcomes, and thus, new, or modified knowledge.

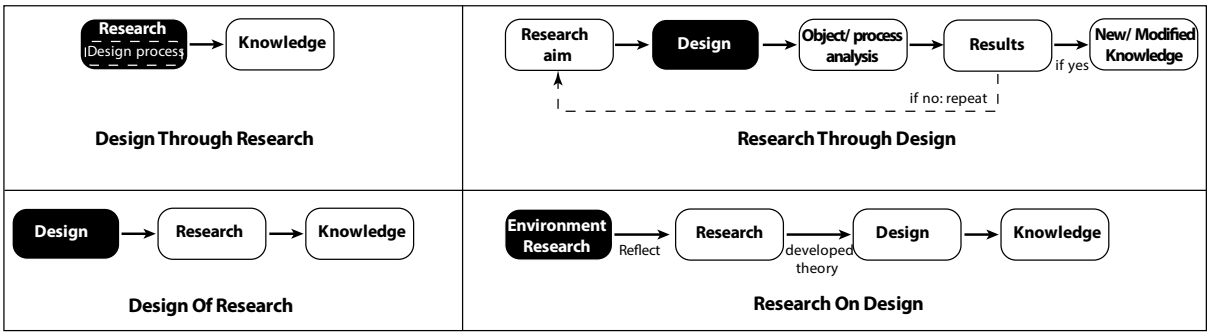


Figure 18: Design research categories process

To further explain the use of RtD, (Coulton et al., 2018) present an example of designing an artefact around the concept of an IoT called 'Polly' the world's first truly smart kettle. The designed prototype seems mundane and similar to existing kettle designs but aims to investigate the ethical and privacy concerns that connected objects would bring to the potential user. To do so, Coulton and his team built up a fictional world that utilises Design Fiction props, in order to make the design narrative more relatable and reflect a certain level of believability and reliability. The primary purpose of this framework is to invite the audience into the world and let them explore and reflect their views on the product. Indeed, this world has certain elements that (Coulton et al., 2018) call 'entry points' which aim to enhance the reality of that virtual world. A detailed explanation of fictional world design and the entry points will be highlighted in the 'Experimental Design chapter'. Coulton et al. (2018) visualise the research process as shown in Figure 19, which depicts several artefacts coming together to form the design investigation, thus forming a reciprocal prototyping relationship between the artefact and the world; consequently, it generates new knowledge and achieves the purpose of the project. Figure 20 provides a supplementary explanation of where the above project has run a research background and reflects on the design process.

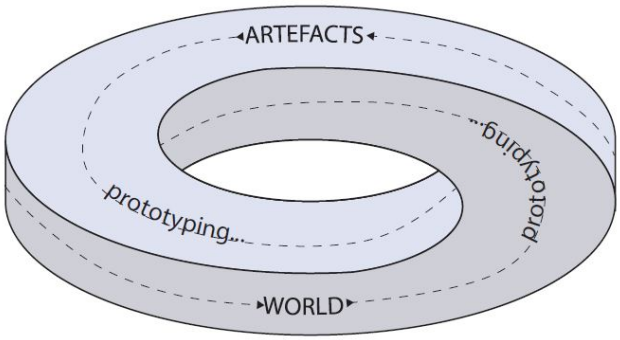


Figure 19: Polly the kettle prototyping relationship between the artefact and the world (Coulton et al., 2018)

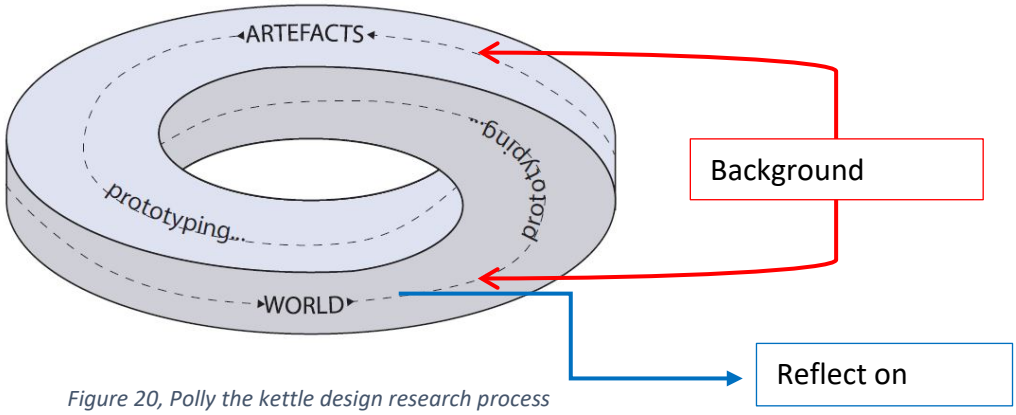


Figure 20, Polly the kettle design research process

In the same vein, (Lindley & Coulton, 2015) employ RtD to contribute knowledge about the Design Fiction approach on their project 'Game of Drones'. Being a relatively new term with only a handful of texts referring to Design Fiction approach, the corpus of literature on the subject is not sufficient to build meaningful rhetoric based on discourse alone. The Game of Drones project intends to highlight the advantage of using drones by commercial providers subject to pilots holding an approved Drone Pilot Proficiency Certificate. This project considers the broader societal and ethical issues of technological futures in which drones might be widely adopted. As well as the effectiveness of Design Fiction in addressing such challenges. The outcome of this project generates new knowledge about the kinds of futures people really want. Lindley (2015) suggests a framework to proceed with the investigation of Design Fiction, as shown in Figure 21, relying on Frayling's classification to declare the multidimensional and reciprocal connection that research, design, and science have among them. This framework explains the need of proposing a prototype, and the process/route a research background could be conducted in order to generate new knowledge.

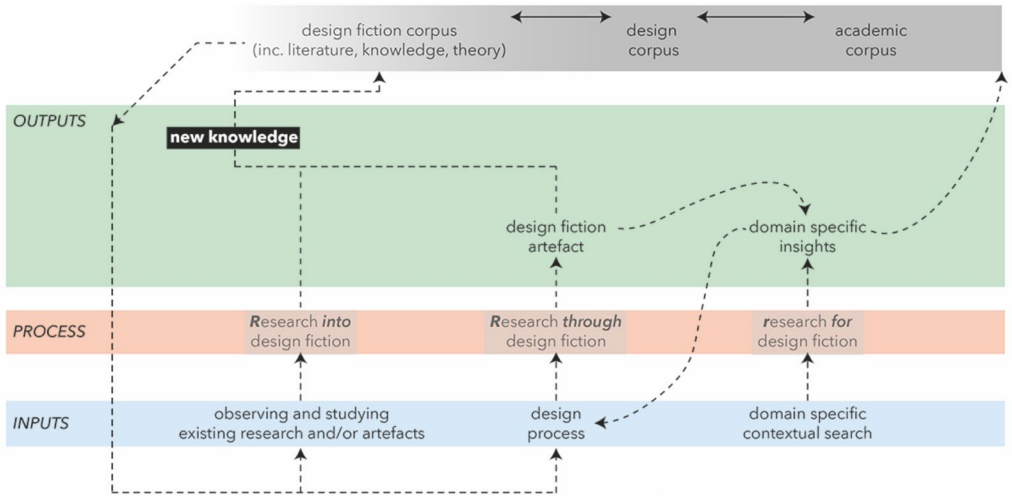


Figure 21: Different categories of Design Fiction research (Lindley, 2015).

As defined above, RtD attempts to discover knowledge through doing design work. Another example of research by design is iFloor, "an interactive floor in Aarhus, Denmark. An interdisciplinary project designed by researchers from architecture, design and computer science, this project aims to bring interaction back to the library. This kind of practice produced knowledge that can be implemented elsewhere, as the researchers constructed an object and made new discoveries. (Koskinen et al., 2013) believe that a 3d or CAD model would not have the same impact as the interaction activity has brought to the scene in which debate was enhanced and exceptional new knowledge produced.

The previous examples have common ground between them, in designing an artefact to produce knowledge; hence, this production requires a catalyst to drive the design process. Therefore, this process starts with background research that involves defining the state of the art and formulating a research question (catalyst), subsequently the designed artefact generates data which could be both quantitative and qualitative; thus, leading to a new or modified theory. The creation or design of the experimental object brings design research or research through design to the production. Yet, this statement does not contradict the previous investigation of what research design is, and how to conduct it, rather it supports (Frayling, 1993) explanation for conducting a systematic enquiry into X to explore communicable knowledge. Consequently, any modification added into the structure, requires more experiments or repeating of the process until the desired result is reached. Figure 22, simplified RtD process. The following section will highlight the research design, specific methods of data collection, analysis, and interpretation.

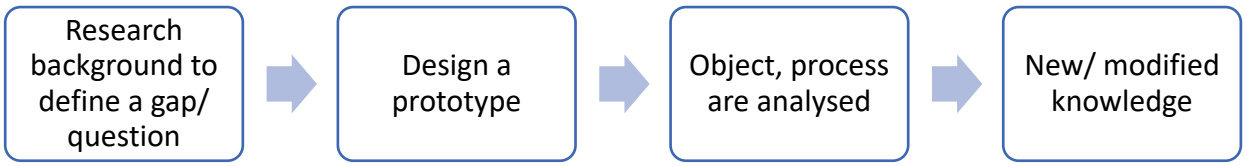


Figure 22: Basic research through design process

3.7 Research Design Levels

Research through design is adopted as the primary means of knowledge production (W. Gaver, 2012), and indeed is considered as an epistemic stance in its own right (Friberg, 2010). Reconciling different formulations of research through design with a range of practice is a challenge here. Reflective practice is central to insight generation, however precisely what constitutes suitably rigorous reflective practice is hard to define. Similarly, articulating how produced artefacts relate to reflection, and how both relate to 'new knowledge' is difficult to reconcile with a scientised perspective of design.

As defined above, research is a range of strategic and designed investigations used to expand existing knowledge and establish new facts (Kumar, 2019). According to (Pheng & Hou, 2019) the research methodology gives the research direction, presenting the logical process to accomplish research aims and objectives. Therefore, research methodology includes several layers that should be considered sequentially. Saunders, Lewis, Thornhill, and Bristow (2015) present an illustrated model called the research onion; this model depicts the layers of the research methodology as follows: research Philosophy, research approach, methodological choice, strategy, time horizon, and data collection and analysis. The research onion model continues evolving to include new methods. Moreover, research onion levels and classifications could be verified by all researchers, and it offers a comprehensive way of explaining a research method. Therefore, the research onion model is used to explain the methodological layers of this research, as shown in Figure 23. Following the aim and objectives of this study, the methodology of this research includes reviewing the existing literature, defining the gap in the subject area, formulating research design, experiment design, data collection, data analysis, final finding, and development.

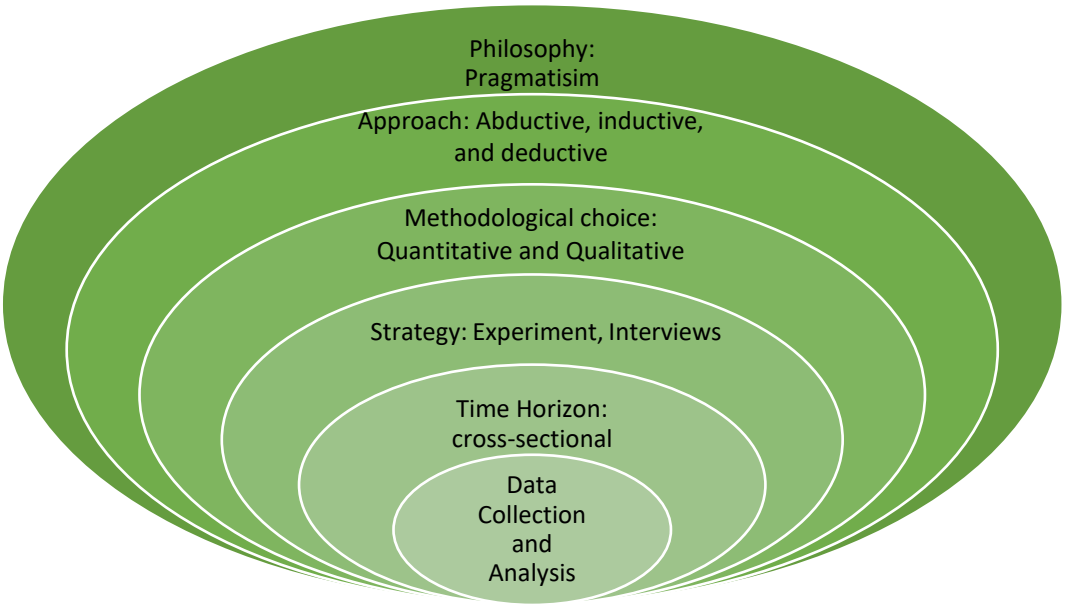


Figure 23: The research onion model, adopted from (Saunders et al., 2015)

3.7.1 Research Philosophy

The term research philosophy defines a system of assumptions and beliefs used to improve knowledge in a particular field, and perspective of the researcher pertaining to the nature of the knowledge and its relation to the outside world (Lee, 2017). Saunders et al. (2015) highlight that there are different types of assumptions, as follows:

- Epistemological assumptions describe existing knowledge and resources,
- Ontological assumptions represent the nature of realities and questions about "what exists",
- Axiological assumptions are related to values and moral consideration in the research.

These assumptions appear in all research, which reflects how the research problem is understood and treated by Saunders et al. (2015). Furthermore, (Mkansi & Acheampong, 2012) distinguish between five main types of research philosophy: postpositivist, constructivist, transformative and pragmatic. A brief explanation regarding each philosophy is listed in Figure 24 This research utilises a pragmatism philosophy because its foundational concept is of proposing inquiries through the practice of design and reflecting on this practice in researching social needs.

Postpositivism	Constructivism
• Determination • Reductionism • Empirical observation and measurement • Theory verification	• Understanding • Multiple participant meanings • Social and historical construction • Theory generation
Transformative	**Pragmatism**
• Political • Power and justice oriented • Collaborative • Change-oriented	• Consequences of actions • Problem-centered • Pluralistic • Real-world practice oriented

Figure 24: Types of research philosophy (Creswell & Creswell, 2017).

Pragmatism, according to (Suckiel, 1982) derives out of actions, situations, and consequences. Pragmatism focuses on methods; researchers focus on the research problem and use all available approaches to understand the problem (ibid). (Morgan, 2007; Tashakkori & Teddlie, 2010) clarify the pragmatism view for mixed-method studies: focusing the researcher's attention on the research problem in social science research, then utilising pluralistic approaches to obtain knowledge about the problem. Therefore, pragmatism provides a philosophical justification for research as follows (Creswell & Creswell, 2017):

- Pragmatism is not assigned to a certain system of philosophy and reality; it can be applied to both quantitative and qualitative methods or even mixed methods.
- It allows researchers to select the methods, techniques, or procedures that meet their needs and purposes.
- Truth in pragmatism is what works at the time, not duplicity between reality independent of the mind or within the mind; and that because practitioners employ both quantitative and qualitative data to fulfil the best understanding of a research query.
- Thus, for the mixed method researcher, pragmatism allows multiple methods, different assumptions, as well as different sorts of data collection and analysis.

3.7.2 Research Approach

Faste and Faste (2012) explain that traditional research tends to concentrate on two main strategies to accomplish its purpose: inductive reasoning, which involves discovering 'what is so' from practical observation; and deductive reasoning, deriving 'what must be so' from previous knowledge. However, designing for the future requires a third kind of logic called

abductive reasoning; alternatively, the means of envisioning 'what might be so' (Kolko, 2010). In the majority of technological research and investigation, abduction is manifested as hypotheses that are examined through experiments. Abductive activities that correlate with design research should be conducted in experience. As previously mentioned, design research is a sub-branch of practice-based research, located mostly in the bottom right sector at Figure 1, which addresses it as an empirical and applied approach regarding knowledge development. Indeed, this research has been subjected to multiple articulations, and interpretations depend on the purpose of the research and drawn contrasts between the variety of design research practice in the different working cultures of academia and industry and different working contexts. Therefore, to accomplish research objectives deductive, inductive, and abductive research approach should be adopted.

3.7.3 Methodological Choice

To conduct research, any researcher has to select their strategies within these three areas: qualitative, quantitative, and mixed methods approach. These approaches present a specific direction for conducting the research; some researchers call these directions strategies of inquiry (Denzin & Lincoln, 2011). Newman, Benz, and Ridenour (1998) explain that qualitative and quantitative approaches should not be labelled as distinct, or rigid strategies; rather, they illustrate different results on a continuum. Some studies tend to be more quantitative than qualitative, or vice versa, or representing mixed methods which have elements of both qualitative and quantitative strategies.

Furthermore, the difference between both qualitative and quantitative research is quite apparent, where qualitative research is framed in terms of using words, and the use of open-ended questions; and quantitative is labelled in terms of numbers, and the use of closed questions. A complete way to understand the scales of differences between both strategies is in the primary philosophical assumptions that researchers bring to the study. Therefore, this decides the type of tools the researcher will employ to build, reflect, collect, and analyse their data.

Qualitative research is an approach for exploring and interpreting the meaning that groups or individuals bring to a certain social problem. The process of the qualitative approach involves forming questions and schemes, data usually collected in the participant's setting, and the

analysis of these data based on themes produced by the researcher, in order to help to make reasonable interpretations of the data. According to Creswell and Creswell (2017) qualitative research identifies the procedures through grounded theory, where there is a viable way to conduct the research: narrative research, phenomenological research, ethnography, grounded theory, and case studies. Thus, the research tools have to reflect individuals or group views, and that would be collected through interview data, document data, observation data, and audio-visual data. Creswell and Creswell (2017) add that those who conduct this form of research "support a way of looking at research that honours an inductive style, a focus on individual meaning, and the importance of rendering the complexity of a situation."

Quantitative research is an approach for verifying objective theories by questioning the relationship between variables. These variables are measured through a certain instrument to collect numbers, then use statistical procedures to analyse the resulting data. Unlike qualitative research, which has a flexible structure, quantitative research has a set of a fixed structures. Both qualitative and quantitative researchers have hypotheses based on testing theories deductively, in order to avoid bias, and manage alternative interpretations, which allow generalisation and replication of the findings. Quantitative research can be conducted using instrument-based questions such as survey research and experimental research. The types of collected data are results of performance data, observational data, or attitude data. Therefore, it is manifested in statistical interpretations.

Mixed methods research is an approach to an inquiry utilising a combination of quantitative and qualitative data, combining the two forms, and using a different structure that may include philosophical assumptions and technical frameworks. The core premise of this form of research is that the integrating of both qualitative and quantitative approaches presents a more comprehensive understanding of a research problem than each approach alone would give. This form of research could be used to check the validity of other databases, as each approach could lead to a different type of exploration or questions about the other form. In the same vein, it could lead to improved instruments or databases.

The mixed-method approach is driven by knowledge production, in other words, deductive reasoning drives this approach. It has three primary models, as follows (Creswell & Creswell, 2017):

- Convergent parallel mixed methods are a type of mixed methods in which the researcher merges qualitative and quantitative information to provide a comprehensive interpretation of the research problem. The researcher usually collects both data in the same period, and then blends the outcomes in the analysis of the overall results.
- Explanatory sequential mixed methods: the researcher using this type of scheme conducts quantitative research, and analyses the resulting data, and then builds up a theory that could be explained in detail using qualitative research. This type of procedure is considered explanatory because the preliminary quantitative results are illustrated further with the sequential qualitative data. In the end, the fundamental quantitative stage is supported by the qualitative phase.
- Exploratory sequential mixed methods are the reverse of the explanatory sequential design. The first phase of this research begins with conducting qualitative research, in order to explore the views of the participant and the requirements of a particular proposal, social problems or hypothesis, then the resulting data is analysed. The data generated is used to build an experiment or instrument with which to validate the researcher's hypothesis or propose new or modified knowledge.

This research adopts exploratory sequential mixed methods for collecting diverse sorts of data, which provide a comprehensive understanding of the research problem. Further explanation of how this research collected data will be highlighted in the following section research strategy.

3.7.4 Research Strategy

This research has utilised a mixed research approach to investigate and justify the usage of Design Fiction in enhancing the adoption of Autonomous Vehicles. Multiple research analysis has been conducted to understand the different layers such as, research philosophy, research approach, methodological choice. The selected research strategies design includes four primaries that reflect research through the design view of conducting research. Therefore, the core of this strategy is to design an experiment to validate the research hypothesis. This process starts with background research involving defining the state of the design and formulating a research question (catalyst). The designed artefact generates data which could

be both quantitative and qualitative; thus, leading to a new or modified practice to generate new knowledge or method. Figure 25 shows how the research aim can lead to generate new knowledge.

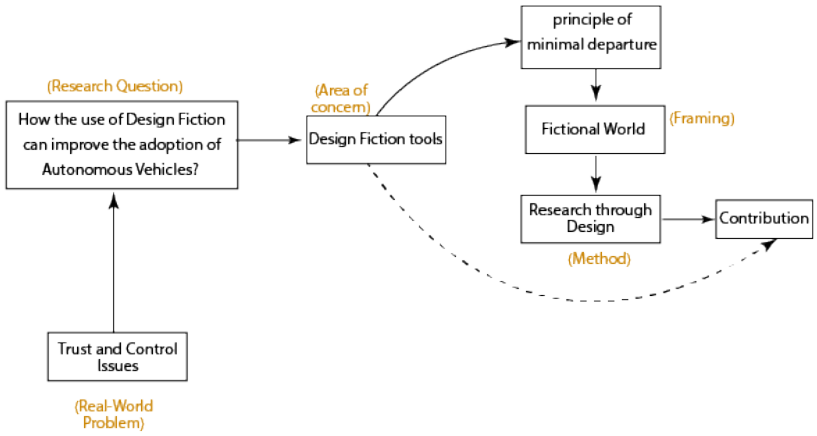


Figure 25: Contribution to knowledge diagram

Figure 26 explains in detail the research design, and where each step is demonstrated to verify the research objectives. The experimental design will be described in a separate chapter, which will include the user requirements classifications and different design stages. Following are details of the interviews, data collection and analysis scheme.

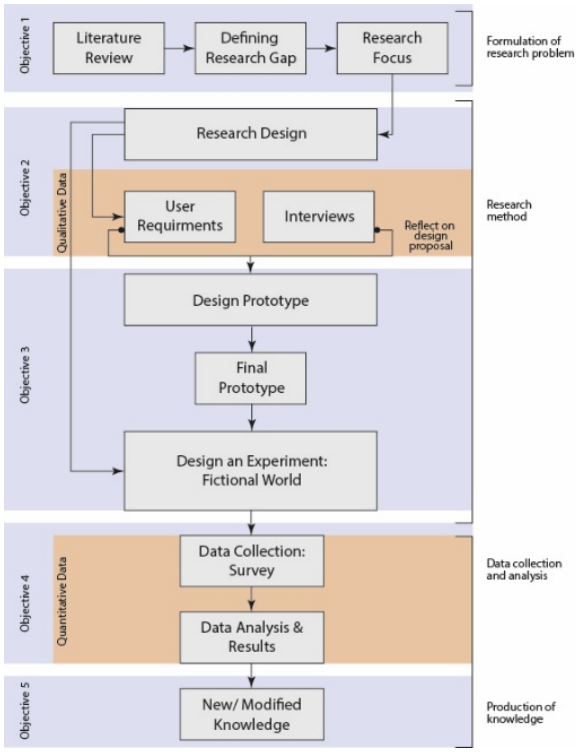


Figure 26: Representation of research methodological design.

1.1.1.1. Expert Interviews

The research administered two interviews with both automobile and interior designers. The purpose of interviewing an automobile designer was to gain more knowledge about the car components and their respective constraints, as well as to understand how we will progress to self-driving features. It was also essential to investigate safety implications and to understand what kind of components could be used. The interview lasted for 15 minutes and consisted of seven questions (see Appendix C for questions and interview transcript). The interview was begun with a brief presentation about the research, providing the interviewee with some existing examples. The first two questions where about the stakeholder's insights. To follow, a verbal and graphical insight into what the researcher wanted to achieve was shared. The second interview was in person with an interior designer, aimed at gaining an understanding of the distribution of the interior space. The interview was held for 30 minutes, with five questions being asked (see Appendix C). The interview started with a brief presentation, where the researcher began asking questions and referred to the concept generation map that was shared with the designer.

In addition, it was necessary, based on the automobile designer recommendations, to have a full understanding of the space and function needed on this stage of the design.

3.7.5 Data Collection and Analysis

This research employs Design Fiction techniques to enhance the adoption of Autonomous Vehicles, and to investigate when, how and why to trust the technology. However, this technology determines that the genuinely transformative benefits are only realised once the public adopts self-driving vehicles. This progress is contingent on the intuitive user who shapes the demands of the market, the policies that governments could take, and future investments in infrastructure. Hence, Design Fiction would provide a near-future world in which to explore the possibilities and consequences of today's emerging technology.

Though it is essential to mention that in this chapter we only describe the tools we have utilised to evaluate the research proposal. A further explanation of other mediums will be described in the Experimental Design Chapter, Development of Autonomous Vehicle Simulation section.

1.1.1.2. Data Collection Techniques

Qualitative Survey:

To evaluate this project, this research administered a qualitative survey to 40 participants in the UK, aged between 20-65, drivers and non-drivers (since the latter were believed to offer reflections unbiased by driving skill), and lasted between 10 -15 minutes. The researcher conducted the validation of this project through face to face discussion, during January 2020 and February 2020. The survey has three-sections (each section questions are listed on Appendix D), which will be detailed as follows:

- Section one aimed to collect demographic information such as age, ownership of a driving license, education, and travel preferences and behaviours. Further questions were about the participants' relationship with technology and cars.
- Section two, participants were shown a three-minute video[3] that explains how autonomous vehicle technology works, and what distinguishes this technology from existing cars. Following this, participants were asked a list of Likert scale questions regarding what they found most appealing about the technology; if they felt that AV technology is safe, and if they would like to own a self-driving car or be willing to share one.
- Section three gave the participants a chance to explore the new design through a video presentation (4 minutes for the research prototype[4], and 1 minute for scenario[5]) and a collection of images. Furthermore, the video showed possible scenarios of the car in operation, and how the car would respond and interact with the passenger (no longer a driver). This presentation was followed with technological acceptance model (TAM) Likert scale questions such as would self-driving cars be easy to use.

Experiment: Wizard of Oz

Further, in order to evaluate the user interface design IAR, this research conducted a Wizard of Oz experiment to allow participants to interact with the IAR system. This experiment was implemented using eight participants, in the UK, aged between (25-39),

[3] https://www.youtube.com/watch?v=ifRnVwNyz9k&t=65s
[4] https://www.youtube.com/watch?v=-2ieekt5CWY
[5] https://www.youtube.com/watch?v=tuLfGQaAWtA

drivers and non-drivers. Participants were recruited in person by the researcher. The experiment lasted for 20 minutes, starting with a presentation about AV's technology. After that, IAR was introduced and explained to the participants. The experiment was held inside a real car (Audi A7) and has two wizards; the primary wizard being the facilitator, and the secondary wizard was the driver. The secondary wizard's role was to fulfil the tasks assigned to him from the primary wizard. The participants were given a tablet to act as it controls the car. However, the primary wizard observed the participants' screen through remote screen software (TeamViewer) which was planted earlier on the participants' screen. The IAR was connected to the internet and some buttons were linked to the tablet features such as the Bluetooth, the location, and the weather. The need to observe the participants screen was to enhance the connectivity of the system. For example, one of the participants wanted to play songs on the car speaker; therefore, they needed a Bluetooth connection, as the facilitator could see their screen, they helped to fulfil this requirement. This experiment did not aim to deceive the potential user, but it allows researchers to test future prototypes. Figure 27 shows an illustration of how the experiment was conducted, and Figure 28 shows participant interaction with the tangible user interface (IAR).

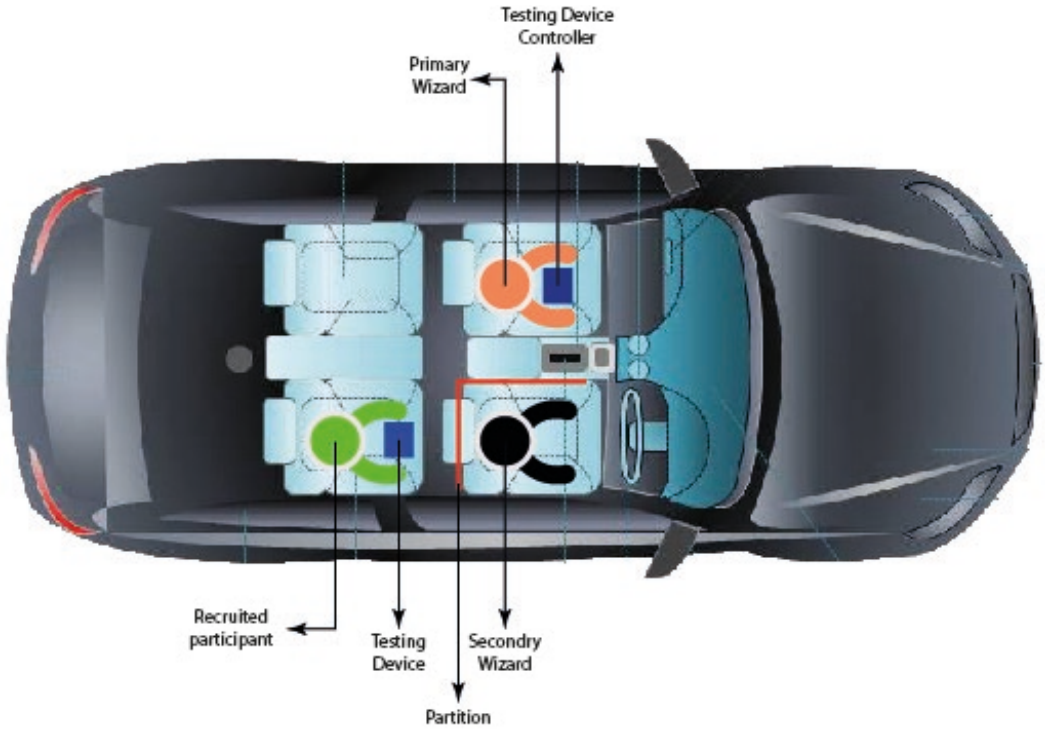


Figure 27: Wizard of Oz experiment Structure

Figure 28: Wizard-of-Oz In-car partition and participant interacting with the IAR prototype.

1.1.1.3. Data Analysis

This research utilised IBM SPSS Statistics software to analyse the quantitative data in order to reflect on the research methods and hypothesis. This research has utilised two different information system to validate the data: The Technology Acceptance Model (TAM), and System Usability Scale (SUS). The following will explain in detail each system.

1.1.1.3.1. TAM

The Technology Acceptance Model (TAM), was founded by Davis (1989) it is known as an information systems theory that demonstrates how users get to accept and adopt new technology. TAM considered as one of the most effective and widely adopted information systems for theoretical frameworks (Li, 2010). The usage of TAM has evolved to determine the relationship between perceived usefulness (PU), and perceived ease of use (PEOU), besides, to anticipate future employment of many emerging technologies (Horton, Buck, Waterson, & Clegg, 2001). TAM application can be found in numerous settings, such as social networking, online learning, and smartphones. For instance, a study was conducted to investigate attitudes towards the adoption of mobile commerce, contributed empirical evidence that the TAM model can be utilised to provide an adequate explanation of user adoption intentions. Similarly, Jansson, Marell, and Nordlund (2010) reviewed the factors regarding consumers' adoption associated with alternate fuel eco-friendly car technology by employing the TAM model. Further, TAM has evolved to include more standards that support each research investigation.

This research is utilising the following standards: Intention to Use (IU); Trust (T); Attitude Towards using the system (ATT); Perceived Usefulness (PU); Perceived Ease of Use (PEU); and Clarity (C).

1.1.1.3.2. SUS

The system usability scale is a Likert scale frame, contains Ten complimentary statements with Five responses (, providing a global aspect of subjective assessments of usability, originally created by John Brooke in 1986 (Sauro, 2011). The scale inquires to keep the statements on the same arrangements, and all of the items must be answered. The odd statements represent a positive attitude, where even-numbered items embody negative feedback. To calculation of the scale results will be highlighted in the Discussion Chapter. The items are as follows:

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

1.1.1.4. Validity and reliability

Validity and reliability are two significant aspects to ensuring the quality of a research instrument and analysis techniques. The word validity and reliability are widely used terms interpreted differently in both the qualitative and quantitative context of research. Validity means a systematic process of inspecting the quality of research data instruments and the analysis process (Yin, 2017). There are four widely used procedures for measuring the quality of the research instrument: construct validity (linking data collection questions with the hypothesis), external validity (generalisability of findings based of replication logic), internal

validity (explanatory aspects of the findings with comparison of data), and reliability, which involves the process of scrutinising the data and the reliable materials used for the data analysis (Yin, 2017). According to Mentzer and Flint (1997), a rigorous research should contain a valid process for checking the instrument used for data collection, accordingly this study has achieved the validity of the data collection instrument through the pilot study. This project data collection method can be used repeatedly for further exploration of empirical study.

The following chapter will explain the experimental design process which was used to reflect on Design Fiction methods and techniques of preparing and presenting futuristic products.

3.7.6 Time Horizon

The time horizon is also an essential factor when administering any research project (Saunders et al., 2015). This elaborates the quality of planning and following protocols during the conduct of the research. Yin (2017) emphasises that the researcher should consider time availability and resources available when defining the research problem and its limits, the type of the employed analysis tools and data collection method.

Time horizon is the fifth layer of the research onion underlying the present research, as shown in Figure 13 (Saunders et al., 2015). The time horizon of research is assorted onto two types: cross-sectional and longitudinal. The cross-sectional research reviews a specific phenomenon at a snapshot of a particular period, whereas, the longitudinal study manifests a series of snapshot over a long period (ibid). Further, the time limitations of the research inquire the study to adopt a cross-sectional time horizon.

4 Chapter Four: Experimental Design

4.1 Introduction

Design Fiction affords us a technique to visualise the future. Design signifies the creative act of providing a solution whereas fiction aims to open up a discursive debate regarding these envisions and their possibilities in everyday activities.

Design Fiction is a future-oriented approach tends to distinguish and develop the perceived range of possible solutions by extending the design spaces and involve the public audience for future making scheme. This research employs Design Fiction to investigate the adoption of Autonomous Vehicles (AV's). AV's technology has the potential to improve safety and enhance quality of life. However, the populace appears reluctant to adopt the technology due to safety and control issues. The present research believes that the AV's concept needs a new technique of communication to overcome the challenge of earning the trust of its future customers, as they determine the demand in the technology market as well as future investments in infrastructure.

The present research proposed a new car design, derived from the user requirements, placed inside a fictional world in order to enhance the adoption of AV technology. Therefore, this proposal reflects on what it means that Design Fiction has an immediate challenge of closing the gap between a vision and its material expression by using 'what if' scenarios that situate the user in a shared conceptual space. Design Fiction is not about producing utopian visions that promote developing technologies but instead affords a means to explore the societal and technological distinctions of possible futures so that we can better understand our present.

This chapter will describe the design stages of car prototype, User interface (UI) prototype and a fictional world in which both previous artefacts were placed and tested the approach.

4.2 Required Elements

Since the potential design has to meet the customer requirements (needs) and fit with the industrial perspective (demands); (Ulrich & Eppinger, 2016) suggest the following to start with: (1) prepare a list of standards, (2) market analysis, (3) set ideal and marginally acceptable target values in order to reflect on the results. Preparing the design standard list requires translating the customer needs into what the design has to deliver. For instance,

when the customers expect a space where they can interact and chat with each other, this could be interpreted as "enable face-to-face meetings between the front and rear passenger. Furthermore, each need has been given a degree of importance label that has been used on deciding what is necessary to show into the design and what not to. However, with the market analysis data, it was impossible to study the efficiency of their designs since these companies only released conceptual cars design, as well as they only focus on the technical aspect of the car. Indeed, in the market there are a few companies, like Tesla, have released partially automated cars but it is difficult to set the target values based on them as the automated system is not really in use due to trust, regulation and other issues. Due to this, the market analysis was taken as a design reference only. Also, it is essential to clarify that there are some fundamental rules when designing a futuristic car: safety, ergonomics and environment (Anderson & Sallee, 2016); these criteria are most likely going to be strict in the future as they are today.

Investigating safety requirements been discussed further with the automobile designer, in order to find some relevant or restrict conditions that could be applied. Despite some constraints in the existing regulations and practical aspects of existing cars, the proposed design has taken a different dimension for the interior design. Due to the fact that regulations, legal requirements, and technologies change with the time, and by the time this product is poised to use there will be different legal requirements. Moreover, many components in the car had been combined, replaced, or no longer need for them, which give us more space and to think about advanced alternatives.

As mentioned before, technological development is accelerating the progress of AV's, which will substantially change the way we interact and use our cars. As the driver status would shift to become a passive passenger; consequently, there will be plenty of time during the journey, the user could utilise for personal activities. Hislop and Axtell (2015) compare travelling in a driverless car where the user has some extra advantages such as privacy can be similar to riding a train or a taxi, but with some constraints regarding space. A car is a closed fixed space that accommodates privacy, a decent level of quietness that legible for some office tasks, and enough space for the individual passenger (ibid). Subsequently, the future driverless car presents a new opportunity for the spatial layout, and interior design, it would allow more space as some components will not be needed any further such as steering equipment, and

brakes. The in-car structure can be better tailored to suit personal preferences, besides implementing features that support the activities that the user performs in the car such as meetings, playing games and working (Kun, Boll, & Schmidt, 2016).

Since the working style and habits currently are becoming more independent and flexible in terms of time and location, especially with the current pandemic the world is facing with Covid-19, employing the car as a working space appears to be of particular interest. Working during a business trip or to a holiday destination can increase productivity and provide somewhat an undisturbed space customised to our needs. Many studies have investigated how cars can be transfigured into functional and modern working space such (Benz, 2018; Pollmann, Stefani, Bengsch, Peissner, & Vukelić, 2019). While designs like the Mercedes-Benz F 015 Luxury in Motion appear to be relevant, car manufactures are still more concerned with the technical developments of autonomous technology than on time utilisation in driverless cars. Therefore, investigating the importance of the concrete design and the user experience (UX) would help to overcome and determine some issues. For example uncertainty, trust, level of autonomy understanding, loss of control concerns, and even acceptance (Meschtscherjakov et al., 2017). However, studies like (T. Becker et al., 2018; Ive, Sirkin, Miller, Li, & Ju, 2015; Pettersson et al., 2016) attempt to capture participants visions of AV's and particular activities they might practice while riding, but not proposing any guidelines on how the interior structure of the car can facilitate these activities. Hence, in order to develop a sufficient autonomous car, that meets the user of the future requirements, it is crucial to consider the activities the user could practice and how to modulate design options. Therefore, this research conducted a systemic review to outlines the user needs and preferences for the physical components Table 5), then utilised selected features in the futuristic driverless car concept this research is proposing. However, it is important to highlight that this investigation was regarding the design and activities and not for the technical aspect of autonomous technology.

For many years, the automated driving substitution has changed the user interface research. The automobile system for an extended time was limited to a sophisticated mechanical device, then by the middle of 1980s the mere idea of buying a car with a screen installed in the centre console, made motorists feel like they were producing a mile from the future. According to (Glon, 2019), in 1990, Mazda Eunos Cosmo presented the first series-produced

car with a touchscreen for navigation function, followed by Rivals Toyota and Mitsubishi. Subsequently, touchscreen technology has become widely used and adopted by almost all manufacturers; and its functions not restricted for navigation but exceeded to become a space for control, entertainment, and many other services. However, with advances in embedded systems, the automobile communication system has been transformed, the mechanical systems needed to meet the technological evolution by changing the way it presents the data and to match the different users' need to interact and operate the car most comprehensively and intelligently. Therefore, this research has conducted a systematic review to gain knowledge about what an autonomous car in-car interface should look alike (see Table 6).

Table 5, Systematic review to formulate car physical components

Paper and Study type	Strategy and aims	Results and possible requirements
Design of interior for a self driving car: Propose a conceptual design from a Body & Trim perspective that can be implemented in future self-driving cars (Filo & Lubega, 2015) • Explanatory sequential mixed methods	• Interviews: to obtain some knowledge from an autonomous drive perspective about each B&T component and their respective constraints. • Survey: to find the fundamental needs and preferences of the user.	• Provides the most suitable design that meets the user needs, convenient with the limited volume space in the car. • Meets the safety requirements. • In-car design that enables face to face meetings, wide view for every passenger, and provide table for interaction activities (see Appendix E for further details)
How to Work in the Car of the Future? (Pollmann et al., 2019) • Experimental research	• Three in-car interior configurations based on lighting, visual stimulation, sound. • Examine the impact of different car interior configurations from different perspectives.	• An interior structure with enough room, bright light, high blue components, and less visual and auditory stimuli would increase concentration and lower cognitive workload. As well as enhances

	• To experience traveling and working in a autonomous car.	participant performance and efficiency. • Contrary features of the above point would result in lower performance, reduced concentration, and higher cognitive of the workload, in fact, these features are quite similar to typical car configuration.
Setting the Stage for Autonomous Cars: A Pilot Study of Future Autonomous Driving Experiences (Pettersson & Karlsson, 2015) • Case study	• "Setting the Stage": this method requires placing the participant in a prototype, simulating the interior design of the car with the possibility of rearranging its sitting structure • Aims to investigate user expectations of autonomous cars.	• Presents detailed insight into how the user envisage the driverless car and reflect on how autonomous technology would change the kind of activity the user might practice while the car is driving itself. • Provides primary user perceptions, to be combined with additional processes at next stages of development.
Seating Positions and Activities in Highly Automated Cars. A Qualitative Study of Future Automated Driving Scenarios (Jorlöv et al., 2017) • Case study	• 'Setting the Stage' through social scenario called 'living room" position. • Aims to gain knowledge about user preferences and attitudes towards seating positions and activities inside an autonomous car	• This study affords information for future seating positions, which may necessitate new passive restraint systems to address future collision safety. • Safety responses for long and shorts rides

Table 6, Systematic review to formulate car interaction components

Paper and Study type	Strategy and aims	Results and possible requirements
An Open Road Evaluation of a Self-Driving Vehicle Human–Machine Interface Designed for Visually Impaired Users (Brinkley, Posadas, Sherman, Daily, & Gilbert, 2019) • A quasi-naturalistic study	• Wizard of Oz approach • To test a self-driving vehicle human–machine interface • A prototype system called ATLAS (Accessible Technology Leveraged for Autonomous Vehicles System) aims to imitate interaction with a genuine self-driving vehicle, with visually impaired individuals with the purpose of satisfying the experiential needs of blind and low vision users	• Participants showed increased trust and likely usability in driverless car technology. • Reduced fear of operational failures, which leads to a desire to purchase an autonomous car. • Interaction with a simulated self-driving vehicle could be sufficient to ameliorate feelings of distrust regarding the technology and those existing technologies.
Investigating User Needs for Non-Driving-Related Activities During Automated Driving (Pfleging, Rang, & Broy, 2016) • Survey research	• Web-based survey: to get a comprehensive overview of the users' expectations of highly automated cars. • Aims to investigate which other activities drivers want to practice while driving a highly or fully automated car, beyond the available driving assistance functions.	• Besides common activities such as socialising with other passengers, or listening to music, eating or drinking; drivers would like to have the ability to use their phones in a highly automated car and browse the internet and send messages. • This indicates the potential for mobile and ubiquitous multimedia applications inside the car.
The Importance of Interruption Management for Usefulness and Acceptance of Automated	• Cognitive models of task interruptions. • How to take into account, the changed	• This research argues that a main benefit of automated vehicles will be the prospect of

Driving (Naujoks, Wiedemann, & Schömig, 2017) • Survey research	role of the driver to become a passenger while designing human-machine interfaces (HMI) for an automated car. • Explains how engaging with non-driving related tasks (NDRTs) are likely to play an essential role in the acceptance and usefulness of the automated driving process, how HMI could interpret these design.	participating in NDRTs without interruptions. • Cognitive models of task interruptions have different advantages, such as: supporting the driver in taking decision even if he/ she is engaged with an NDRT, limit the collision between active HMI elements and NDRT.
Towards guidelines and verification methods for automated vehicle HMIs (Naujoks, Wiedemann, Schömig, Hergeth, & Keinath, 2019) • Empirical research	• Assembles an initial set of guidelines for the design of driverless car HMIs based on international standards and guidelines requirements.	• Provide adequate steps regarding applicable HMI standards, guidelines and best practices such as the operation principles, legibility, understandability, the indication of system mode, display installation and information presentation, colour coding, and warning messages.

4.3 Concept Generation

The nature of this research is about developing a user-centred design car that would encourage the adoption of AV technology. This section will detail the selection of physical design components. A *function-means tree* has been utilised to generate different design concepts in order to meet the purpose of the project.

4.3.1 Function Means Tree

A function-means tree is a graphical representation of what the design aims to cover and how to combine different design requirements into one unit. The primary stage was regarding the

kind of activities the passenger may practice inside the car, bearing in mind, that the selection of the activity is highly dependent on the estimated time of the journey. These activities are as follows: relaxation, entertainment and working. Each activity has it is own sub-branch (second series) that represent the required elements to attain its goal (see Figure 29). Each sub-branch has been divided into another subgroup (third series) that represents the criteria to achieve the second series demands. However, the third series elements reflect the user requirements review this research has identified previously (see Required Elements section). For example, the visual aspect that is classified under the relaxation activity represents the user need to be able to control transparency on windows, wide view for every passenger or interaction screens. Indeed, these branches are not secluded from each other; in fact, some of them have a common need that could be accomplished concurrently. For instance, to fulfil the entertainment mode, position and functionality play a fundamental role to fulfil the physical or interaction activities, which have direct support from the flexibility function under the relaxation branch. Therefore, the function-means tree works as a foundation for generating the concept phase in which covers the entire solution of the space and the components. This solution requires solving the lowest sub-functions in order to obtain the needs and ideas hierarchy; then these ideas will be combined to form the design concept.

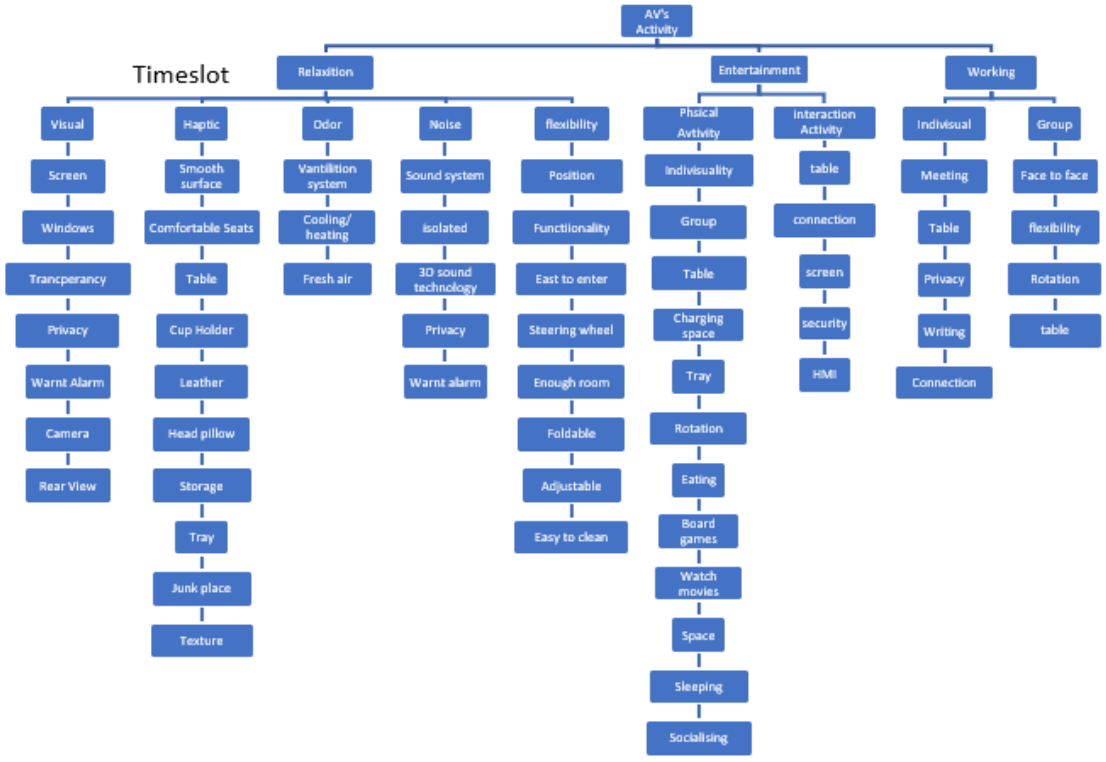


Figure 29: AV's concept function-means tree

Thus, through the function-means tree, three concepts have been generated: Bright Concept, Relax Concept and Social Concept. Each concept represents customer needs, industrial demands and considering safety limitations (see Figure 30).

Bright Concept

A technology-oriented concept. This concept provides four adjustable seat structures (2-1-0-1). The middle section has been removed to free up more space. The front seats are rotatable 180 degrees with the main emphasis being able to enable face-to-face meetings. A smart table is located between the rear seats, can be replaced in the middle of the car to enable different activities.

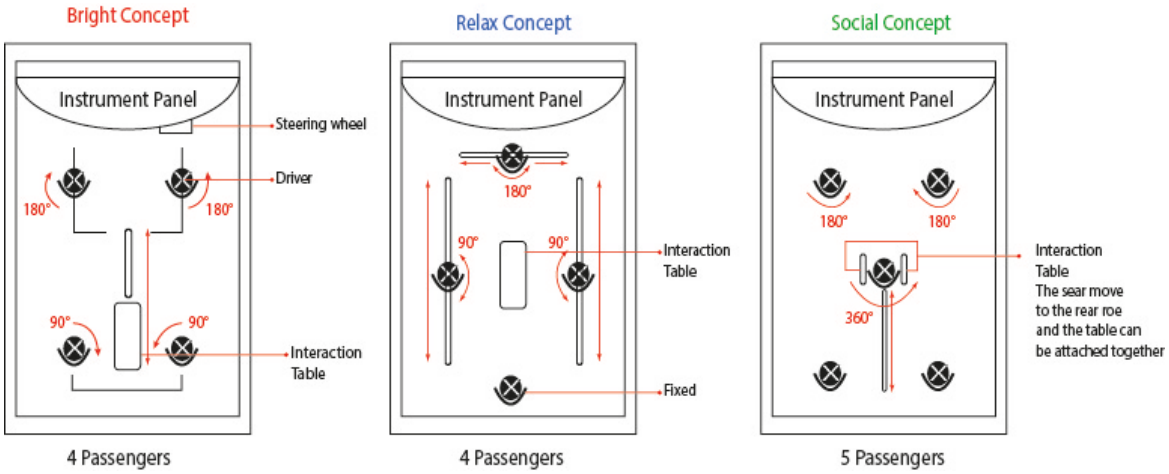


Figure 30: Generated concepts outline

Relax Concept

This concept provides four adjustable seat structure (1-1-0-1-1). The smart table has been located in the middle of the car to enable different activities. The middle section can be removed to free up more space to allow wheelchair access. This structure also provides more leg room and more privacy for each passenger.

Social Concept

This concept presents a five adjustable seat structure (1-1-1-1-1). The fifth seat is located in the middle of the car, with the possibility to relocate between the rear seats; the side of this seats are not adjustable, but they can be folded in the middle to get a smart table. On the contrary of the two previous concepts (Bright and Relax) this concept does not have a steering wheel, which means a full engagement with other activities apart from operating the car for

passengers, it implies an immersive social atmosphere. For further details regarding each concept see Appendix F.

4.4 Concept Evaluation

To ensure the proposed design will meet the research requirements from a Design Fiction aspect and the user requirements from target audience aspect it is essential to address, visualise, raise questions, and explore specific issues at the beginning of the design process. Therefore, concept evaluation is a crucial stage in the design process as it helps to evaluate the overall utility of design alternatives against the design objectives. Further, early concept evaluation saves time and effort of the overall prototype quality and development. The importance of design concept evaluation is evident because poor selection would mislead the research target and would be hard to be compensated at later stages of the investigation process. Thus, this research has employed *a Pugh* matrix to help determines which components or potential structure that more dependable than others. This matrix was employed after capturing and label the customer needs, or what (Aguwa, Monplaisir, & Turgut, 2012) calls the voice of the customer (VOC).

4.4.1 Pugh Matrix for Concept Selection

The Pugh Matrix is a decision-making tool that analyses and compares many design ideas leading to choosing the best design adheres a set of criteria. It also authorises a degree of qualitative optimisation of alternative concepts through the generation of hybrid ideas. The Pugh Matrix relies upon a series of pairwise correlations between design ideas in opposition to several criteria or requirements(Ulrich & Eppinger, 2016). All the customer's demands were ordered with their respective importance on the left side of the schedule. The significant numbers, in this case, are the same from the user requirements list. Each concept was horizontally arranged at the top with its weight (w) which is a measure of how the concept will meet the customers need. The order being from 1 (worst) up to 5 (best), these scales are linear. The points (t) are a result of the multiplication between the importance number (Imp) and the weight (w). The importance of each need was multiplied with the selected weight to get the total point. The total marks for every concept were summed up (see Table 7), and the Bright concept has been confirmed to be the selected concept to meet the customer needs

and the research goals, with slight changes that enable more efficiency of the selected structure.

Table 7: Pugh matrix

		Concepts					
		Bright		Relax		Social	
Requirements	Importance	W	T	W	T	W	T
Enough room for each passenger	5	5	25	5	25	4	24
Enable comfortable position	5	5	25	5	25	3	15
Enable face-to-face interaction	5	5	25	4	20	3	15
Enable wide view (panoramic)	5	5	25	5	25	5	25
Privacy	5	5	25	5	25	5	25
Control options	5	5	25	4	20	2	10
Steering wheel	3	4	12	4	12	0	0
Provide table for social activities	5	5	25	5	25	5	25
Technological engagement	5	5	25	5	25	5	25
Smart interaction	5	5	25	5	25	5	25
Easy to clean	3	5	15	5	15	5	15
Allow individual screen	3	5	15	5	15	5	15
Allow wheelchair on board	3	0	0	3	9	5	15
Easy access	5	5	25	3	15	4	20
	Sum		292		281		254

4.4.2 Bright Concept

As mentioned before, this concept offers four adjustable seat structure (2-1-0-1). The middle section has been removed to free up more space. A bucket seat that is designed to seat one person and can be adjusted individually. Each seat has heating, and ventilating mechanism built inside the seat to create a warm and cold area for the legs, thighs and back. A foldable smart table is attached to each seat that could turn to screen. The front seats are rotatable 180 degrees, particularly to enable face-to-face meetings. A smart table is located between the rear seats, can be replaced in the middle of the car to enable different activities. The instrument panel has been made thinner to increase space in the front part of the car. A futuristic touch screen has been placed in the instrument panel, enabling the front passenger to monitor the car, and also using it for entertainment. The front windshield displays different functions like speed, direction, maps, and the weather. Further Coulton et al. (2018) made a suggestion to increase believability towards a product, by keeping some typical characteristics from the original product, to convey a sense that the product is around the corner; therefore,

the bright concept kept the steering wheel component to enhance the believability of the prototype and dispatch the insight that the passenger will be able to operate the car at any time they wish to, wish may enhance the trust and safety around the technology. The proposed car doors open with gesture commands to ease the burden of using physical power. Figure 31 shows an initial sketch of Bright concept.

Figure 31: Graphical interpretation of Bright concept

The selected concept has been generated as a 3D model using 3ds Max software. The generated prototype is a detailed prototype, not a plain CAD model, as this model will be used inside the fictional world in order to investigate how a user-centred design concept could open up a discursive space, and influence the acceptance of autonomous cars technology (see Figure 32, Figure 33, Figure 34, and Figure 35).

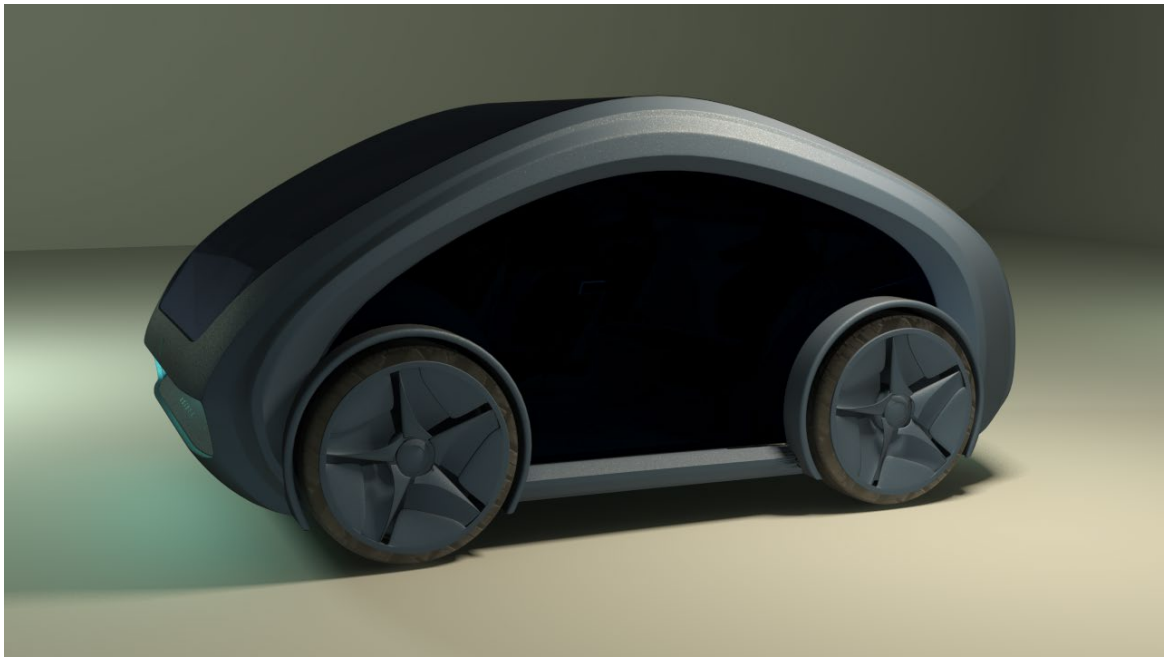


Figure 32: Bright concept external design

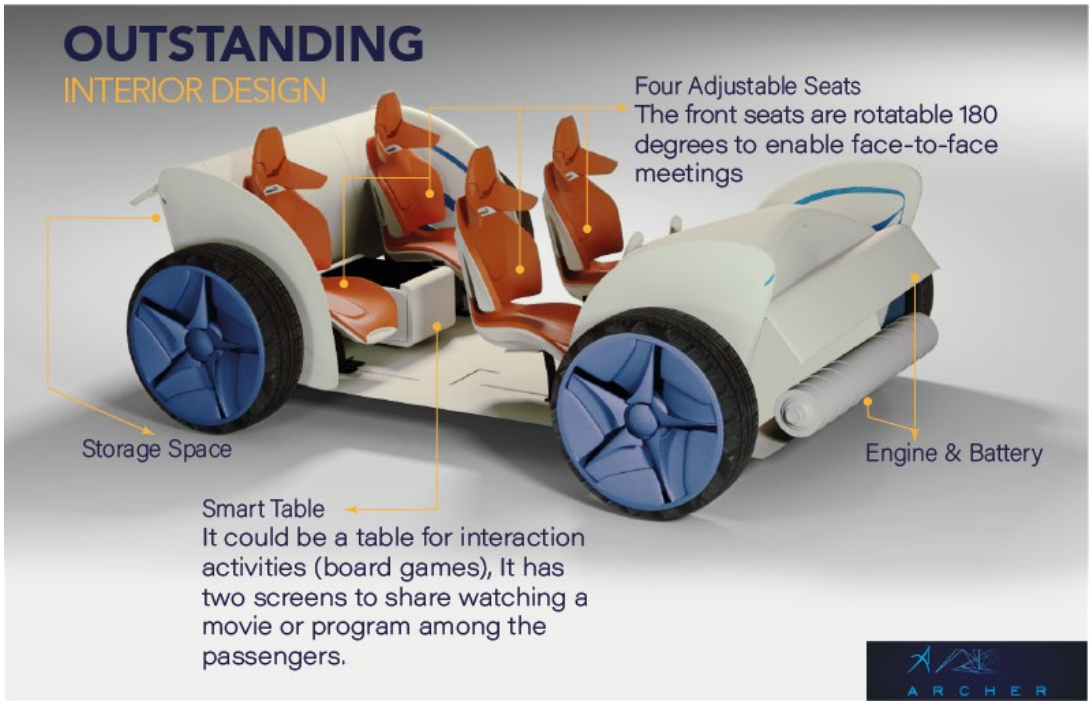


Figure 33: Bright concept internal design

Figure 34: Bright concept seat design

Figure 35: Bright concept instrument panel and steering wheel design

4.5 In-Car Interface Design

This chapter demonstrates that excellent communication between vehicle and passenger determines when to trust and not to trust the automated systems. In order to increase the trust and acceptance of automated vehicles it is crucial to balance the drivers need for efficient situational awareness where he/she can be informed about the vehicle status, actions, and intention with the desire to engage with other different activities. Thus, acceptance is associated with the perceived usefulness of new technology (V Venkatesh, Davis, & College, 2000). By example, SAE (the Society of Automotive Engineering) explains the driver assistance system aims to support the driver in the primary task of the driving process on L1 (see the figure from literature review chapter) whereas, the automated vehicle aims to decrease levels of driver involvements and increasing levels of vehicle ability (SAE, 2017). Developed incrementally, L3 represents the conditional automation, the driver is no longer obligated to monitor the driving task continuously. Driving time can, therefore, be employed for non-driving essential tasks, such as entertainment. Naujoks, Purucker, and Neukum (2016) state that driver engagement with non-driving related tasks increases gradually as the level of vehicle automation increased. However, car manufactures continue to develop what is known as in-vehicle infotainment (IVI), which relates to a vehicle system that combines information and entertainment transmission, whether to driver or passenger. The advanced driver assistance systems (ADAS) have developed towards more complicated assistance

functions, with a broader scope and a sharply increasing number of potential users with different abilities and needs. Therefore, to deal with the growing of use conditions and patterns and due to the intervention of different technologies such as mobile phones, (Hasenjäger & Wersing, 2017) promote the need to personalise ADAS systems to ensure optimal user experience (UX) and supplied system function, based on the driver/ passenger preferences or driving style and skills.

Explicit personalisation demands users to assert their preferences and to explicitly set up the system by choosing a particular setting that serves them best (Hasenjäger & Wersing, 2017). Such a system allows the user to obtain a direct control, but rather it restricts the user choice to the system options. Though, this option can be considered valid in the current driving status, but not for the futuristic automated car, with upcoming vehicle to vehicle (V2V), vehicle to the environment (V2E), or vehicle to pedestrian (V2P) communication technologies. Thus, this growth inquires a new means for HMI that meet the safety and trust concerns for the passenger who is no more a driver and keep the passenger occupied with different activities.

4.5.1 Human-Machine Interface

The need for adopting a novel UI's system is due to two factors: First it is about the current visual interaction that would not be valid for future users as it does not meet and communicate the alerts efficiently from the car to the passenger. secondly, with the potential of having different passengers on board with different needs and capabilities; for instance, they may have vision and hearing impairments. Hence, the UIs should employ multimodal outputs to guarantee sufficient communication with the passenger. Good communication between vehicle and passenger accommodates when to trust or not to trust automated systems. In this context, it is essential for the automated system to convey the sense of intentions awareness, able to take control at any time or even to give instructions about how to drive within the passenger's comfort zone. Achieving such a result is possible through a comprehensive HMI's presence for effective communication with the end-user. The UI needs to tell what its utility, how to use those features, and why these functions are fundamental in the design.

As mentioned before, a key component of immersive UX is explicit. For drivers, a fraction of a second can be the variation between getting into an accident or driving away safely. Studies show that it takes up to eight seconds for a driver to regain situational awareness, more than three to four seconds for reaction time, during this time the possibility of a collision is significantly increased (Wright et al., 2016). While recent cars technologies propped with safety features like backup cameras blinking and sensors, there are different types of driver distractions that impede the ability to spot hazards and react in time. Evidence explains that the disturbance caused by mobile phones, for example, can impair driving performance in many ways. Hence, what does suitable in-car technology have to look alike? Everyday smart technology level? Today, over 80% of the global population has a smartphone in their pocket, which has created an expectation amongst consumers that all screens must function at a high level even those in cars (Moreno-Munoz, Bellido-Outeirino, Siano, & Gomez-Nieto, 2016).

Indeed, the passenger has to be aware in case of any urgent situation that requires personal interaction. The need for multimodal in-car interaction is increasing to mitigate such challenges. Hence, this project aims to define a comprehensive HMI should provide. UI design in the automotive industry is interdisciplinary across many areas ranging from navigation, information services, primary driving control, assisted functions, to entertainment and games. Moreover, the urge to develop in-car interaction is to ensure their accessibility and usability for all kind of users; a prospect to increase independent mobility for people with disabilities and the elder generation.

As mentioned before, the user could perform more secondary tasks such as phone, email, looking up information, watching TV. Which is the core of our project, presents a distinct HMI's that could meet the customers' requirements while they are practising any activities in the ride. The essential question to ask how to design systems that make driving safer while providing for the users' needs? What can make the car genuinely effective at changing the behaviour (adopt the technology) of their users? A fundamental element of UX for in-car technology is clarity. The UI design features can have a measurable impact on how legible the in-car experience is. Various factors like illumination, colours, and typeface do contribute to understanding what makes a legible driving experience for drivers and passengers. (Naujoks et al., 2017) proposes a guideline that could lead to sufficient UI. For instance, "Display

installation and information presentation", to the driver the visual channel is yet the domain to deliver the needed information (ibid). This standard intends to facilitate the design of mode indicators and transitions by verifying that they can be easily perceived and distinguished from other tasks interpreted by the user of the AV. Another standard that Naujoks et al. (2017) are proposing are "visual interfaces used to communicate system states should be located at a suitable position and distance." This norm describes the status when the driver is not required to pay attention to the road while riding automated car (L3, L4, and L5), the in-car display can be mounted in different locations and not restricted to the typical locations; as long as the display would grab the passenger attention when it is needed and would be easy to access (ibid). The importance of this criteria stems from the fact that the human visual system is insensitive to every visual provocation in the periphery, such as colours. Colours are difficult to detect when presented in the periphery (S. J. Young, 2003), as many factors would play a fundamental role in the detection such as illumination and tint. Further, observed blink frequency of stimuli, which is usually used to conveying urgency, also decreases when stimuli are shown in the periphery (Jacob & Karn, 2003).

An example of the future in-car infotainment when the system is notifying the passenger about the car intention to change the planned route because of traffic or any other obstacles, the system has to show the navigation path in advance so that the passenger can take adequate actions if they disagree. Such a solution could be demonstrated through the advanced heads-up display (HUD), which can be adjusted for parallax effect based on the passengers' head position and movement, which display these directions or instructions on the windshield 3D-mapped to the road ahead instead of a static route.

Undoubtedly, efficient in-car infotainment hubs have to connect a variety of details with passengers, in order for them to be useful, they must be distinct at a glance. This research has investigated multiple effects of HMI's design on glance and response time across several variables, to obtain the right form of visual representation that reflects the user inquiries. These variables are divided into external and internal. Where the external factors are about the colours, illumination, polarity, contrast, and size; the internal factors are more about weight, stroke, modulation, case, serifs, and width. These factors contribute directly to the system clarity. Moreover, the display surface has specific characteristics that influenced by

these variables. By example, the polarity as an external factor has two conditions: positive polarity (white shades colour text on dark shades background) and negative polarity (dark shades text on white shades background). Testing colour polarity settings are different for HUD and infotainment screen. Hence, it is a way to examine the legibility of a dark screen with light text versus a bright screen with dark text. Similarly, illumination and other factors have a particular property contribute to the UX while riding. Indeed, this could help to understand the technology acceptance tendency. This research has referred to Naujoks et al. (2019), and Monotype (n.d.) as applicable HMI standards, guidelines, and best practices resources, such as the font type, colour, transitions, illumination and many other variables.

4.5.2 Interface Structure

As explained earlier, it is common for drivers to interact with a variety of activities and operate a vehicle at the same time. In order to design a comprehensive interface, this research classified these engagements as follows:

- The usage of personal devices such as mobile phones.
- Interaction with built-in infotainment systems.
- Interaction with advanced driver-assistance systems (ADAS).

In response to the above classification regarding the engagements with NDRTs, alongside with the previous investigation for the user needs and concerns that described; this study classified the essential functions that need passenger attention under three themes based on the function type and the need to respond: compulsory, complementary, and infotainments (see Table 8).

Table 8, Essential functions that requires passenger attention

Compulsory	Complementary	Infotainments
Charge the car	Shifting gears	Watch a movie
Seat belt	Light conditions	Receiving calls
Distance assist check	Air conditions	Games
Speed info.	Alternative routes	Social networks
Destinations	Seat adjustments	
Emergencies stop	Sky view	
Unlock/lock the vehicle	Window transparency	
	following vehicle assist	

HMI systems could be interpreted in two different contexts: why and how. Accordingly, why is more about taking an immediate reaction and how to show what to do (Koo et al., 2015). Thus, the design proposal must consider the representational and the interaction factors to fulfil its aim. By observing the existing UI, considering its distribution map, and symbol characteristic, pairing on the mind the prototype should not overwhelm or mislead the user with too many unwanted data. Though, as mentioned before the current user interface form would not be sufficient to meet and communicate for future users' requirements, due to the fact the passenger is no longer referred to as the driver. The significant use of personal devices has created a particular structure for sufficient interactional education through the use of mobile phones (iOS or Android). Krasniqi and Hajrizi (2016) illustrate that nowadays is the era of integral components in cars. For example, devices like mobile phones are used for communicating information wirelessly to a telematics service provider. Further, it is predicted that next-generation passengers would like to have their cars perform like smartphones on wheels (ibid).

The previous factors correspond with the progressive vision of AVs in which the passenger is liberated and can engage in other activities since they are not required to participate in active driving. This research proposes a new UI design called Intelligent Adaptive Ride (IAR). The IAR adopts standard mobile user interface structures, where symbols are used more extensively, and the control is automatically hidden until accessed. Considering the display device that will be used inside the car, the transition display will correlate with the essential tasks that need the passenger to be attentive and responsive as and when required. Figure 36 shows the process of designing an efficient interface for the futuristic automated car that utilises mobile interface structure.

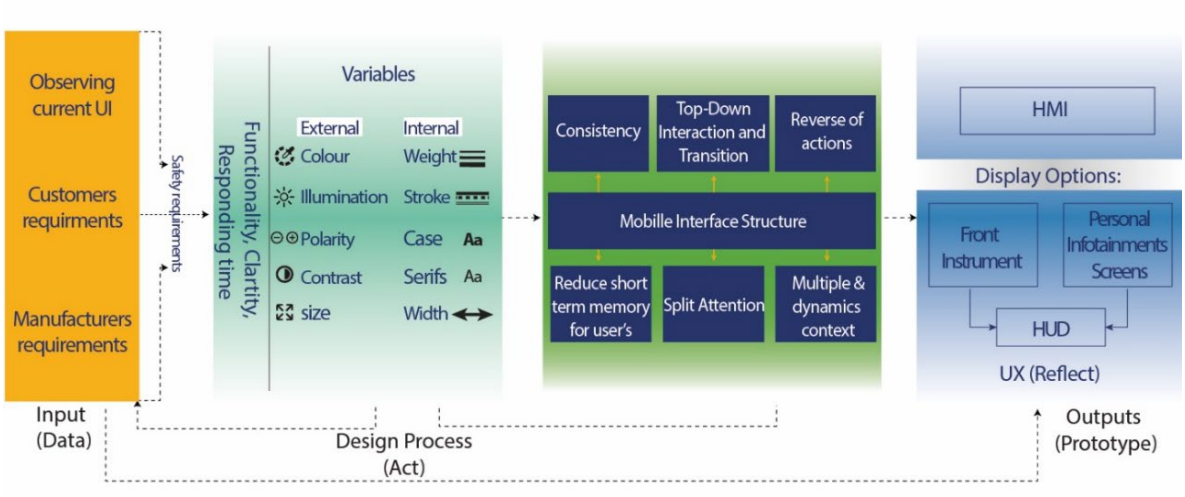


Figure 36, UI design Structure

A graphical representation of the IAR interface has been generated as an interactive model using adobe illustrator and adobe flash to activate the function of the prototype for further validation. A further explanation will be outlined in the discussion chapter. Figure 31 presents a description of the interface elements. The selected font in for the IAR is Frutiger. According to Monotype (n.d.), a series of studies conducted by the organisation found that 3.1% of their participants showed lower error rate when presented with Frutiger font. In dim lighting, participants responded 8.7% faster with Frutiger compared to other fonts (ibid). Furthermore, this is because font with open spacing and highly distinct shapes help ensure drivers get the message no matter the condition. Therefore, a typeface with specific characteristics can optimise the features of an auto HMI and reduce glance time for drivers.

Colours have substantial impacts on our recognition influence, not only the user mood, emotions and attention but also our task performance (Bagchi & Cheema, 2013; De Bock, Pandelaere, & Van Kenhove, 2013). Consequently, the intentional use of colours for the UI design is of utmost importance. Similarly, with motion interactions, humans' eyes use saccade and fixation when observing the world, with information gathered during stabilised fixation and saccades to shift gaze directions as rapidly as possible (Liversedge, Gilchrist, & Everling, 2011). Motion setup influences natural human eye movement and motor abilities whilst addressing many attractions that need a reaction. Furthermore, the colour coding for the IAR has been selected based on (Naujoks et al., 2019) guidelines, which it is an adequate way to maintain that drivers notice any changes as well as the consequences linked with them. For instance, using red colour will grasp the driver's attention to notice the high urgency of the

situation, while a green colour naturally reflects that a system is working correctly. However, there is a possibility of misinterpretation colour codes; therefore, it is essential to utilise these colours in accordance with their common stereotypes. Thus, valid, and unambiguous colour-coding should be of primary concern for the design of compatible HMIs for automated vehicles. Figure 37, Figure 38, and Figure 39 show different screens of IAR.

Figure 37, IAR interface elements

Figure 38, IAR main screen.

Figure 39, IAR car setting screen.

4.6 Design Fiction World

As discussed in the literature review chapter Design Fiction is a fusion of design and fiction. Where design is a creative act to find solutions, fiction is a technique to open up a discursive narrative. Furthermore, many studies investigate how Design Fiction has become popular in many futuristic profitable projects, playing a conspicuous role in research studies as well as shaping of future of technology. The present research defines a distinct perspective, where Design Fiction is considered as an evoking medium to enhance technologies growth and to explore potential to address, visualise and explore particular issues already at the beginning of the design process. From human curiosity to emotive machines and augmentation towards artificial intelligence Design Fiction can be used as an instrument to explore the potential of adopting the AVs technology. This technique is not intended to deceive users but operates more as a creative act that sets them into a discursive space for a while then lets them go. This research focuses on the idea of 'suspend[ing] disbelief about change' from Bruce Sterlings definition of Design Fiction as it encourages to prepare and present potential ideas that could serve societies and contribute to shaping the future. Therefore, design experience has to avoid the ambiguity that pretends to be real to perform a full experience and the user has to 'suspend their disbelief willingly' to enjoy shifting their imagination into a new and unfamiliar space.

Previously, this research demonstrated the elements that stimulate Design Fiction proposals: the narrative, the diegetic prototype and the context can be integrated together to present a distinct narrative to envisage the future, or they are known as perceptual bridges (See Figure 40). Regarding AVs technology, these three elements are as follows:

- The narrative is the technology adoption strategies.
- The diegetic prototype is the car design and accompanying items that provoking the scene.
- The context, where the scenarios will take a place to enhance reality and open up a discursive space to think about the technology.

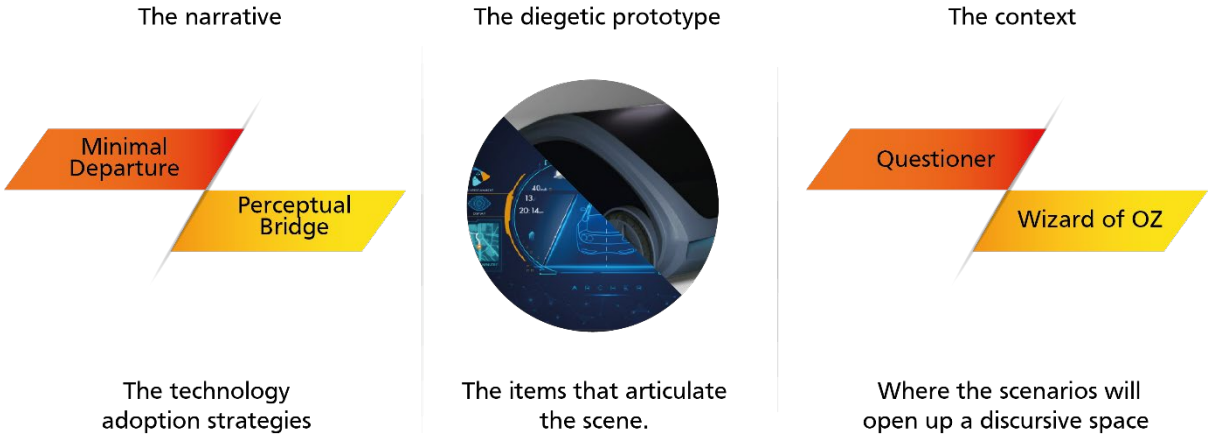


Figure 40, the implementation of Design Fiction elements in the research study

The Design Fiction as a world-building approach was invented by (Coulton et al., 2018), and inspired by an interview with the science fiction author Bruce Sterling, where he described Design Fiction as "It's not a kind of fiction. It is a kind of design. It tells worlds rather than stories". Therefore, the core of the world-building approach is to design things that convey the impression of a future world in which this world has diegetic prototypes and details that compile and create together a reciprocal prototyping loop. For the purpose of this research, a fictional world can invoke the debate and draws attention to small details that enhance the acceptance and believability of automated cars. Its functional features can be considered as a tactic to visualise incoming technologies in the future by employing a narrative structure to place these technologies within a probable scenario. Thus, in order to attain the research purpose, the world-building approach has to be designed around a question or a need. Therefore, the present research employed Design Fiction techniques to resolve the question

of what if automated cars become the main form of transportation. What kind of future vision could it reflect?

Indeed, driverless cars articulate a technological leap forward, proposing solutions to current transportation problems in order to change how people address mobility. Furthermore, too many car manufacturers propose guiding principles for their futuristic vision of AVs, but still, their proposal seems too far away in the future. Therefore, this research is presenting a user-centred design car concept to raise the debate around autonomous technology acceptance. By building a fictional world around the AV's concept, this research will be able to outline and provide a near-future world that explores the possibilities and consequences of today's emerging technology. In order to build this world, this research has utilised branding, marketing, and promotional material to create a world that could enhance the adoption of AV's.

4.6.1 Elements of World building

The first stage of this experiment was to decide on a name. Looking through different company proposals, some companies kept it simple by using numbers, such as BMW the higher the designation, the bigger, more expensive the model; A 1 series is small, A 7 series is huge. After discussing many ideas, the researcher selected the name, Archer. However, selecting the name was not a simple process as it should reflect the concept vision and it has to be easy to remember, but most importantly, relatable. Archer refers to the target that the research aims to achieve. Besides, the new brand has its logo and slogan 'designed for life'; few logos were suggested to be used for the brand (see Figure 41). Figure 42 shows the selected logo design.

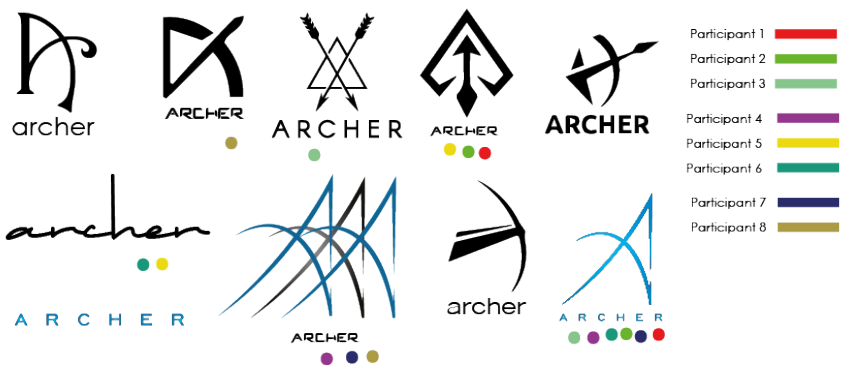


Figure 41, Logo suggestions for Archer

Figure 42, Archer logo and slogan design.

The logo design selection was done through dot voting practice (see Figure 41), the list of logos was shared with a group of colleagues and was explained to them, each participant voted for their top two by using dots, then dots were counted, were arranged in popularity. Logo colour (Blue) was selected based on the profile this experiment attempted to reflect. According to Singla and Aggarwal (2016), the blue colour in logos creates a sense of security while showing professionalism; reflects progression, especially in the modern world with easy accessibility of technology. It demonstrates the company intention in innovating and providing solutions to the needs of the audience.

Further, a website[6] has been created to convey the sense that this an existing company, it includes images of the prototype, descriptions, interface design (Intelligent Adaptive Ride (IAR)) and a live chat box for any potential inquiries by the website visitors (see Figure 43). Also, for the experiment day, a hard copy catalogue was available to allow the participants to correlate to the design (see Figure 44). Bruce sterling (2012) accommodates on his interview that "the most effective Design Fictions -techniques- to date have been videos"; hence, to validate the design proposal this research manifested a descriptive video to explain further about Archer world.

As previously stated, these branding and marketing elements (Coulton et al., 2018) define as “entry points into the Design Fiction world". These elements work as an invitation to explore possibilities through the small details; they provoke and raises questions regarding the

[6] https://omaymaalqatawneh.wixsite.com/archer

technology. This fictional world is not intended to deceive users but operates more as a creative act that sets them into a discursive space for a while then lets them go. It is a kind of world aim to prepare the audience to accept what the researcher calls the new normal.

Figure 43, Archer website

Figure 44, Archer catalogue

4.7 Development of AV simulation

To ensure that this research provides a convincing user experience (UX) that would enhance the adoption of AV's, this research has developed a different type of mediums, in order to verify the right instrument to the research proposal. These instrument as follows:

- Computer animation: Video and Images
- CARLA Simulator: is an open-source *simulator* for autonomous driving research.

The latter method aimed to provide an immersive experience, by focusing on two design activities: representational design and interaction design. According to Benyon, representational design deals with the style, aesthetics and the overall look and feel of the system (Benyon, 2014). The interaction design determines how functions will be allocated to the user and the machine and how the interaction between user and machine will take place. Representational and interaction design are selected because they have a significant impact on how users will perceive the system, how easy and enjoyable it will be to use and therefore, on the overall UX (Benyon, 2014). CARLA simulator was supposed to be tested through a simulation chair in which would enhance the experience of interacting with the automation system. However, due to Covid-19 distancing issue, the game engine and Carla simulation required social gathering; both instruments will be further investigated in future research. Therefore, a linear computer animation method was selected (the selected tool, explained in detail in previous sections). Figure 45 show a screenshot from CARLA simulator.

Figure 45, CARLA Simulator

5 Chapter Five: Results and Discussion

5.1 Introduction

Design Fiction is operated in the present research because it helps define solutions for far-reaching visions and questions concerning the consequences of technological development besides prototyping. Understanding how to operationalise Design Fiction is a big challenge since it describes a postmodern technique that opens a discourse about potential futures.

Design Fiction uses fictional scenarios or props to explore and discuss human progress and the emergence of creativity to recognise 'the plausible and the preferable' that drives human curiosity. Moreover, the fictional world helps to investigate and solve unanswered questions about the future, setting its artefacts halfway between illusion and reality to provoke a debate. Design Fiction tools bring innovative strategies to envisage scientific research. More particularly, Design Fiction draws attention to the social aspects and implications of techno-scientific solutions, utilising the techniques of fiction to examine the future of objects, define what their impact might be and present a range of possible alternative futures. This research has utilised research through design approach to investigate and justify the usage of Design Fiction in enhancing the adoption of Autonomous Vehicles, in which the core of this strategy is to design an experiment to validate the research hypothesis. This process starts with background research involving defining the state of the design and formulating research questions. This chapter will illustrate data collection techniques and analysis. Furthermore, a detailed discussion as a reflection of the research results.

5.2 Data Collection Techniques

To understand how the use of Design Fiction could enhance the acceptance of AV's concept this research conducted a survey to 40 participants in the UK, aged between 20-65, drivers and non-drivers (to offer reflections unbiased by driving skill). Participants were recruited by email and social media announcements distributed by the researcher. The survey lasted between 10 -15 minutes. The researcher guided the validation of this project through face to face discussion over a ten-day period between January 2020 and February 2020. The survey was divided into three sections; the first section aimed to collect demographic data, the tendency to adopt new technology and travel habits. The second section provided

information about AV's concept, as the researcher presumed some participants might not have enough information about AVs to offer a fully formed opinion or to present the right information about the technology. This was followed up by Likert scale questions regarding what they found most appealing about the AV technology. The third section presented the Archer design proposal via video and images that are accompanied by a short potential futuristic scenario for the use of automated cars. This was then followed by Likert scale questions to investigate the participants' responses to the technology through Archer concept lens. Moreover, to evaluate the user interface IAR, this research conducted Wizard of Oz experiment to allow participants to interact with the IAR system. After the experiment, the participants were given a System Usability Scale (SUS) to reflect on their experience.

5.3 Results and Analysis: Survey

This research utilised IBM SPSS Statistics software to analyse the survey data as well as referred to the technology acceptance model (TAM) criteria to evaluate the results. Demographic breakdowns for the respondents are provided in Appendix G: 23 participants were female and 17 were male. In total, 40% of participants were aged between 40 and 60, while those between 25-39 made up 37.5% of those participating in the study (see Table 9). Thirty-five percent of participants had a master's degree and 27.5% of participants had at least some high school education (see Table 10). Those who are currently employed full time is 50% which exceeded the combined number of respondents who were employed part time (12%) and students (12%) (see Table 11). The 40 participants were racially diverse: 60% identified as white, 12.5% as Asian and Black/African, 2.5% as Hispanic and European and 5% preferred not to say (see Appendix G). Income varied as well, with 45% of participants making between £20k - £50k, 15% making between £10k - £19.999, and 10% more than £50k and less than £10k; however, 17% preferred not to say (see Table 12). In our sample, 57.5% of respondents are married, 30% are single, 10% are divorced and 2.5% are widowed (see Appendix G).

Table 9: Summary of study participants by age group.

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-24	3	7.5	7.5	7.5

	25-39	15	37.5	37.5	45.0
	40-60	16	40.0	40.0	85.0
	60+	6	15.0	15.0	100.0
	Total	40	100.0	100.0	

Table 10: Breakdown of study participants by level of education.

Education: What is the highest degree or level of school you have completed? If currently enrolled, the highest degree received.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Bachelor's degree	10	25.0	25.0	25.0
	Doctorate degree	1	2.5	2.5	27.5
	Master's degree	14	35.0	35.0	62.5
	Professional degree	4	10.0	10.0	72.5
	Some High School	11	27.5	27.5	100.0
	Total	40	100.0	100.0	

Table 11: Breakdown of study participants by employment status.

Employment Status: Are you currently…?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		1	2.5	2.5	2.5
	Employed Full-Time	16	40.0	40.0	42.5
	Employed Part-Time	9	22.5	22.5	65.0
	Prefer not to say	5	12.5	12.5	77.5
	Retired	2	5.0	5.0	82.5
	Seeking opportunities	2	5.0	5.0	87.5
	Student	5	12.5	12.5	100.0
	Total	40	100.0	100.0	

Table 12: Breakdown of study participants by incomes.

What is your total household income?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	£10,000 to £19,999	6	15.0	15.0	15.0
	£100,000 - £200,000	1	2.5	2.5	17.5
	£20,000 - £50,000	18	45.0	45.0	62.5
	£50,000 - £100,000	4	10.0	10.0	72.5
	Less than £10,000	4	10.0	10.0	82.5
	Prefer not to say	7	17.5	17.5	100.0

Total	40	100.0	100.0	

Regarding the participants current mobility status and habits, 75% of participants have a driving license, while 25% do not (see Figure 46). With regards to owning a car, 47.5% of participants own a car, while 52.5% do not (see Figure 46). As a response to the question how many hours participants spend travelling (different purposes) every day, 60% spend less than one hour, 35% spend between 2-3 hours and 5% spend 4-6 hours (see Table 13). Thirty-seven and a half per cent of participants commute to work by their cars, 22.5% by walking, 15% public transport (bus and trains), 2.5% cycling or by taxi and 20% others (see Table 13). When travelling for leisure, 57.5% of participants travel by car, 20% via public transport, 10% by taxi, 5% walking or cycling, and 2.5% others (see Table 13). Participants responded to cars as basic transport: 57.5% yes, 35% no and 7.5% maybe (see Figure 47).

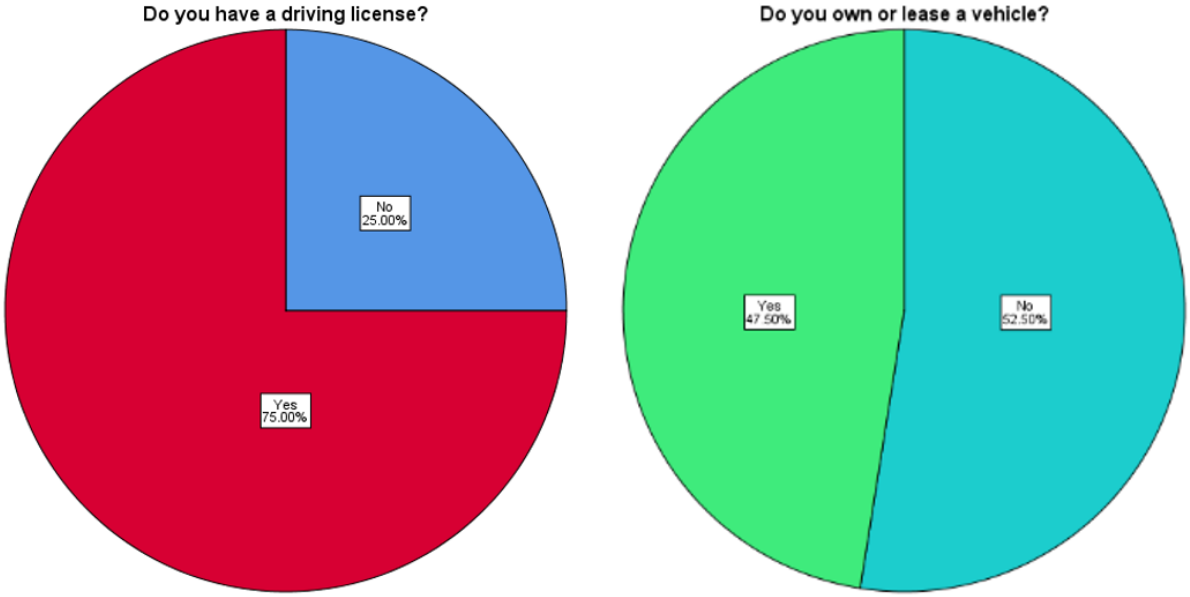


Figure 46: Participants responses for holding a driving license and owning a car.

Table 13: Breakdown of study participants traveling habits for work and leisure

How do you usually travel for Work (w) and Leisure (L)?

		Frequency		Percent		Valid Percent	
		W	L	W	L	W	L
	By bus	4	4	10.0	10.0	10.0	10.0
	By train	2	4	5.0	10.0	5.0	10.0
	Cycling	1	2	2.5	5.0	2.5	5.0
	Taxi	1	4	2.5	10.0	2.5	10.0

	Walk	9	2	22.5	5.0	22.5	5.0
	Other	1	1	20	2.5	2.5	2.5
	Your own car	15	23	37.5	57.5	37.5	57.5
	Total	40	40	100.0	100.0	100.0	100.0

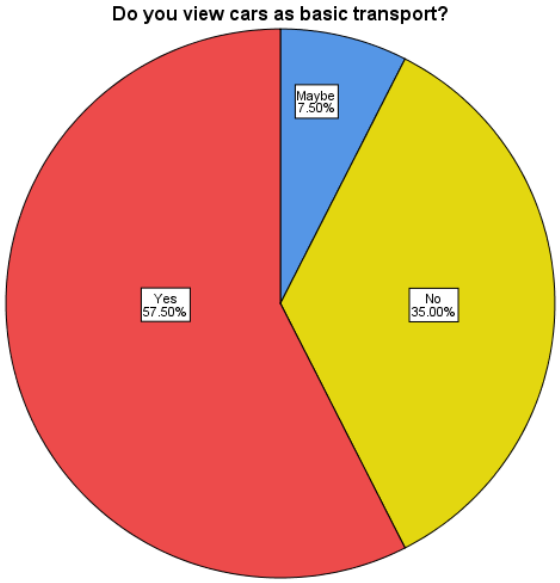


Figure 47: Cars as primary modes of transportation

The results of the survey show that 60% of participants are more likely to have an interest in new technologies and 42% believe that technology makes tasks more manageable (Table 14). However, 76.5% of male surveyed are more likely to be concerned as an early adopter or eager to try new technologies, comparing to 26.1% for female participants (Table 15). In response to the perceived behavioural control (PBC), 67.5% of participants would prefer to be the driver rather than the passenger, and 87% enjoy driving cars (Table 16).

Table 14: Summary of participants responses towards technology

		Count	Table N %
Do you have little or no interest in new technologies?	Maybe	8	20.0%
	No	24	60.0%
	Yes	8	20.0%
I like to use technology to make tasks easier	Agree	17	42.5%
	Disagree	1	2.5%
	Neutral	10	25.0%
	Strongly agree	12	30.0%

Table 15: Participant's tendency to adopt technologies on early stages

Do you consider yourself an early adopter, eager to try new technologies?

Gender			Frequency	Percent	Valid Percent	Cumulative Percent
Female	Valid	Maybe	5	21.7	21.7	21.7
		No	12	52.2	52.2	73.9
		Yes	6	26.1	26.1	100.0
		Total	23	100.0	100.0	
Male	Valid	Maybe	3	17.6	17.6	17.6
		No	1	5.9	5.9	23.5
		Yes	13	76.5	76.5	100.0
		Total	17	100.0	100.0	

Table 16: tendency towards giving away steering wheel

		Count	Table N %
I would enjoy driving a car	Maybe	2	5.0%
	No	3	7.5%
	Yes	35	87.5%
I would prefer to be the driver rather than the passenger	Maybe	8	20.0%
	No	5	12.5%
	Yes	27	67.5%

Turning to the automated car's concept and the intention to use (IU) AV's, this criteria was adopted from (Nees, 2016). The participants were asked about how much they have heard about self-driving cars. The responses are as follows: 52.5% some, 15% a lot and in total 32.5% have not heard about or do not have knowledge about the technology (Table 17). On the second section of the survey the participants were shown a video that explains how the AV technology works and aims to ensure participants had similar information. After the video participants were asked a series of questions aim to gather their perceptions of AV's technology. Participants were asked if they would like to use an automated car, 47.1% of male participants s were more enthusiastic about using the technology comparing to female participants, with only 17.4% (Table 18). The previous result seems to correlate with the following result: in total 86.5% of female participants believe they need to learn more about the AV technology before using it, while 58.9 of male participants believe so (Table 18). However, participants value the potential of the technology with 27.5 % willing to pay more

for a self-driving car compared to what they would pay for a traditional car, but 30% are not willing to do so (Table 19).

Table 17: Participants knowledge about automated cars

How much have you heard about self-driving cars?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A lot	6	15.0	15.0	15.0
	None at all	3	7.5	7.5	22.5
	Not much	10	25.0	25.0	47.5
	Some	21	52.5	52.5	100.0
	Total	40	100.0	100.0	

Table 18: breakdown of participants intention to use an automated car

	Gender		Frequency	Percent	Valid Percent	Cumulative Percent
I needed to learn a lot of things before I could get going with this technology concept	Female	Strongly Agree	9	39.1	39.1	100.0
		Agree	11	47.8	47.8	47.8
		Neutral	2	8.7	8.7	60.9
		Disagree	1	4.3	4.3	52.2
		Total	23	100.0	100.0	
	Male	Strongly Agree	2	11.8	11.8	94.1
		Agree	8	47.1	47.1	47.1
		Neutral	4	23.5	23.5	82.4
		Disagree	2	11.8	11.8	58.8
		Strongly Disagree	1	5.9	5.9	100.0
		Total	17	100.0	100.0	
I think that I would like to use Self-Driving Car	Female	Strongly Agree	4	17.4	17.4	87.0
		Agree	4	17.4	17.4	17.4
		Neutral	6	26.1	26.1	69.6
		Disagree	6	26.1	26.1	43.5
		Strongly Disagree	3	13.0	13.0	100.0
		Total	23	100.0	100.0	
	Male	Strongly Agree	8	47.1	47.1	100.0
		Agree	5	29.4	29.4	29.4
		Neutral	2	11.8	11.8	52.9
		Disagree	2	11.8	11.8	41.2
		Total	17	100.0	100.0	

Table 19: breakdown of participants intention to pay more for an automated car

I would be willing to pay more for a self-driving car compared to what I would pay for a traditional car

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	1	2.5	2.5	85.0
	Agree	10	25.0	25.0	25.0
	Neutral	17	42.5	42.5	82.5
	Disagree	6	15.0	15.0	40.0
	Strongly Disagree	6	15.0	15.0	100.0
	Total	40	100.0	100.0	

Another significant aspect the survey tends to reflect on is the trust (T), or what (Nees, 2016) describes as the perceived reliability of automation. Trust in automation is controlled by expectations and attitudes that emerge before a person adopts a system (Hoff & Bashir, 2015). Ten percent of participants strongly agree that automated cars are safe, 27.5% agree, 42.5% were neutral, 15% disagree, and 5% strongly disagree Figure 48). Thirty-seven and a half per cent of respondents would trust a self-driving car to get me to my destination (Appendix G); female participants were more dependent on this matter with 43.5% agree, while 23.5% for male participants (Table 20). In responding to the question if the computer should be driving the cars, 43.5% of female respondents agree, and 41.2% agree of male participants (Table 20). Moreover, 56.5% of female participants agree that there is a need to watch self-driving cars closely to be sure the computers do not make mistakes, and 29.4% of male respondents (Table 21). Furthermore, when asking about how essential for the user to be able to take back control from a self-driving car computer, 50% of participants strongly agree, 22.5% agree, and 17.5 neutral (Appendix G).

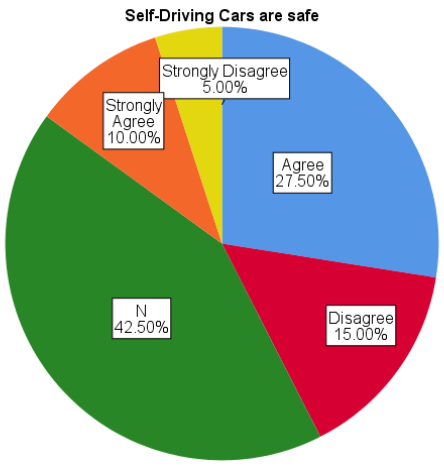


Figure 48: Summary of participants responses regarding the safety of AV's

Table 20: participants view of AVs to drive them to certain destinations

I would trust a self-driving car to get me to my destination

Gender			Frequency	Percent	Valid Percent	Cumulative Percent
Female	Valid	Agree	10	43.5	43.5	43.5
		Neutral	6	26.1	26.1	87.0
		Disagree	4	17.4	17.4	60.9
		Strongly Disagree	3	13.0	13.0	100.0
		Total	23	100.0	100.0	
Male	Valid	Strongly Agree	4	23.5	23.5	94.1
		Agree	5	29.4	29.4	29.4
		Neutral	6	35.3	35.3	70.6
		Disagree	1	5.9	5.9	35.3
		Strongly Disagree	1	5.9	5.9	100.0
		Total	17	100.0	100.0	

Table 21: Summary of participants responses about trusting AV's system

	Gender		Frequency	Percent	Valid Percent	Cumulative Percent
I do not think computers should be driving cars	Female	Strongly Agree	6	26.1	26.1	95.7
		Agree	1	4.3	4.3	4.3
		Neutral	5	21.7	21.7	69.6
		Disagree	10	43.5	43.5	47.8
		Strongly Disagree	1	4.3	4.3	100.0
		Total	23	100.0	100.0	
	Male	Agree	2	11.8	11.8	11.8
		Neutral	5	29.4	29.4	82.4
		Disagree	7	41.2	41.2	52.9
		Strongly Disagree	3	17.6	17.6	100.0
		Total	17	100.0	100.0	
People will need to watch self-driving cars closely to be sure the computers do not make mistakes	Female	Strongly Agree	13	56.5	56.5	100.0
		Agree	3	13.0	13.0	13.0
		Neutral	6	26.1	26.1	43.5
		Disagree	1	4.3	4.3	17.4
		Total	23	100.0	100.0	
	Male	Strongly Agree	2	11.8	11.8	100.0
		Agree	5	29.4	29.4	29.4
		Neutral	7	41.2	41.2	88.2
		Disagree	3	17.6	17.6	47.1
		Total	17	100.0	100.0	

Moreover, the attitude Towards using the system (ATT) adapted from (Viswanath Venkatesh & Davis, 2000) indicates to the degree to which a user has a favourable or unfavourable evaluation or appraisal of the behaviour in question. This survey questioned whether the benefits of a self-driving car would outweigh the amount it would cost. 30% of participants were neutral, 25% disagree and 20% agree (Appendix G). Only 20% of participants agree that the cost of an automated car would be the most important thing they would consider before purchasing one, 27.5% neutral and 20% strongly disagree with this statement (Appendix G). On the other hand, when asked the participants if self-driving cars become widely adopted, they would not buy a car and would use a share pool car, 37.5% disagreed and 37.5%were neutral with only 12.5 agree with the car share pool as a mode of transportation (Appendix G). Also, 40% of participants were neutral about the idea if they own an automated car, they could employ it as a share pool car, 25% disagree, and 20% agree (Appendix G). Twenty-two and a half percent of all participants they would like to own an automated car (Appendix G), 40% of participants who are aged between 25-39 said they would like to own an automated car as well as 25% of participants who are between 40-60 (Table 22).

Table 22: Participant's tendency to own an automated car

Would like to own a self-driving car

Age			Frequency	Percent	Valid Percent	Cumulative Percent
18-24	Valid	Agree	2	66.7	66.7	66.7
		Disagree	1	33.3	33.3	100.0
		Total	3	100.0	100.0	
25-39	Valid	Agree	3	20.0	20.0	20.0
		Disagree	3	20.0	20.0	40.0
		Neutral	2	13.3	13.3	53.3
		Strongly Agree	6	40.0	40.0	93.3
		Strongly Disagree	1	6.7	6.7	100.0
		Total	15	100.0	100.0	
40-60	Valid	Agree	3	18.8	18.8	18.8
		Disagree	3	18.8	18.8	37.5
		Neutral	2	12.5	12.5	50.0
		Strongly Agree	4	25.0	25.0	75.0
		Strongly Disagree	4	25.0	25.0	100.0
		Total	16	100.0	100.0	
60+	Valid	Agree	1	16.7	16.7	16.7

	Disagree	2	33.3	33.3	50.0
	Neutral	2	33.3	33.3	83.3
	Strongly Disagree	1	16.7	16.7	100.0
	Total	6	100.0	100.0	

In terms of Perceived Usefulness of Driverless Car Technology (PU - DCT), adopted from (Viswanath Venkatesh & Davis, 2000), in which the consumers realise the benefits of using DCT, and how it enhances their mobility, which eventually may influence their intentions to use a driverless car. Thirty-five percent of participants agree to operate self-driving cars in the same lanes as normal traffic, 27.5% are neutral and 20% strongly agree. Furthermore, Participants responded whether they would support a public bond measure to build new infrastructures, such as special lanes, or traffic signals for self-driving cars. The results are as follow: 27.5% agree, 27.5% neutral, 25% strongly agree, 12.5% and 7.5 disagree and strongly disagree sequentially. The result of the inquiry regarding if AV's will reduce traffic problems: 30% agree, 25% strongly agree, 17.5% neutral and disagree, and 10% strongly disagree.

On the other hand, the third section of the survey aims to investigate the response towards the Archer concept. As mentioned earlier, a descriptive video and images were shown to participants followed with a series of Liker scale questions. The first criteria to analyse these questions is the Intention to use automation (IU). A slight increase was recorded when the participants were asked if they would like to own a self-driving car, 30% strongly agree, 22.5% agree, 20% neutral, 15% disagree, and 12.5% strongly disagree (Table 23).

Table 23: A comparison of participants responses to own an automated car.

		Criteria	Count	Table N %
Section Two	Strongly Agree	ATT	10	25.0%
I would like to own a self-driving car	Agree		9	22.5%
	Neutral		6	15.0%
	Disagree		9	22.5%
	Strongly Disagree		6	15.0%
	Total		40	100%
Section Three	Strongly agree	IU	12	30.0%
I would like to own a self-driving car	Agree		9	22.5%
	Neutral		8	20.0%
	Disagree		6	15.0%
	Strongly Disagree		5	12.5%
	Total		40	100%

The response rate was 35% for participants who agree if they own an automated car, they still want to drive their own most of the time, 27.5% were neutral, 20% disagree and 15% strongly agree. More than 55% of participants agree that it is crucial to be able to turn off the automation system and operate the car, which is slightly raised from the responses on section two (Table 24). The last questions relate to the intention of use were about if the participants have the intention to purchase an automated car once the technology is fully developed and if they would like to own a car has the same features as Archer, results shown in Table 25.

Table 24: Allow taking control from the automation system.

		Criteria	Count	Table N %
Section Two	Strongly Agree		20	50.0%
It is important for a human to be able to take back control from a self-driving car	Agree		9	22.5%
	Neutral	**T**	7	17.5%
	Disagree		4	10.0%
	Total		40	100%
Section Three	Strongly agree		22	55.0%
In a self-driving car, it will be important to me to have the option to turn off the computer and drive	Agree		8	20.0%
	Neutral	**IU**	9	22.5%
	Strongly Disagree		1	2.5%
	Total		40	100%

Table 25: Purchasing an automated car

		Criteria	Count	Table N %
I would purchase a self-driving car once the technology is fully developed	Strongly agree		8	20.0%
	Agree		11	27.5%
	Neutral	**IU**	11	27.5%
	Disagree		8	20.0%
	Strongly Disagree		2	5.0%
	Total		40	100%
I would purchase a self-driving car that has same features as Archer]	Strongly agree		5	12.5%
	Agree		12	30.0%
	Neutral	**IU**	14	35.0%
	Disagree		6	15.0%
	Strongly Disagree		3	7.5%
	Total		40	100%

As explained earlier, perceived usefulness (PU) criteria have an impact on enhancing the intended usage of AV's technology. Thirty-two and a half percent of participants believe that AVs would help them to become more productive as they are not responsible for the driving

process, 22.5% are neutral, 20% strongly agree, 17.5% disagree and 7.5% strongly disagree. However, when participants were asked about the potential benefits of driverless cars to enhance mobility, 42% of participants agree, 20% strongly agree, and 12.5 of participants selected disagree (Table 25). Also, if using a driverless car would reduce driver stress and improve driving performance, participants result showed that 27% strongly agree, 27% agree, 22.5 neutral, 12.5% disagree, and 10% strongly disagree (Table 26).

Table 26: Potential benefits of automated cars

		Criteria	Count	Table N %
I sense using a driverless car would reduce driver stress and improve driving performance	Strongly agree	PU	11	27.5%
	Agree		11	27.5%
	Neutral		9	22.5%
	Disagree		5	12.5%
	Strongly Disagree		4	10.0%
	Total		40	100%
I foresee that a driverless car would enhance the mobility of people regardless of their age, skill, and ability	Strongly agree	PU	8	20.0%
	Agree		17	42.5%
	Neutral		8	20.0%
	Disagree		3	7.5%
	Strongly Disagree		4	10.0%
	Total		40	100%

Another critical aspect this research has employed to analyse the survey data which is the Perceived ease of use of automation (PEU) by (Davis, Bagozzi, & Warshaw, 1989). This aspect is interpreted as the degree to which the user considers that using a particular system would free their physical and mental interactions and effort. This survey asked the participants about their perception of whether self-driving cars will be easy to use, 30% of participants agree, 25% neutral, 20 strongly agree, and 17.5% disagree with this statement (Appendix G). Thirty-five per cent of participants believe it will not take them long to figure out how to use a self-driving car, 32.5% were neutral, while 17.5% strongly disagree with the statement, and 12.5% disagree (Appendix G). Forty-five per cent of participants believe that the public will promptly learn how to use an automated car, 25%, 15% disagree and strongly disagree sequentially (Appendix G). Moreover, 30% of participants were neutral about the need to learn many things before using AV technology, 22.5% strongly agree and disagree

sequentially, and 20% agree. This statement records a difference comparing to the responses in section two (Table 27).

Table 27: The need to learn more about the AV technology.

		Criteria	Count	Table N %
Section Two	Strongly Agree	IU	11	27.5%
I needed to learn a lot of things before I could get going with this technology concept	Agree		19	47.5%
	Neutral		6	15.0%
	Disagree		3	7.5%
	Strongly Disagree		1	2.5%
	Total		40	100%
Section Three	Strongly agree	PEU	9	22.5%
I need to learn a lot of things before I could get going with this technology concept	Agree		8	20.0%
	Neutral		12	30.0%
	Disagree		9	22.5%
	Strongly Disagree		2	5.0%
	Total		40	100%

Compatibility (C), also known as Appropriateness of automation, is another pattern adopted from (Nees, 2016). This reflects the user acceptance of the system capability to operate safely and respond effectively to any urgent conditions. The participants' responses to the statement assumes technology is more accurate than humans, which leads to safer driving process as follows: 30% agree, 30% neutral, 17.5% disagree, 15% strongly agree and 7.5% strongly disagree. When the survey asked about if there are some driving scenarios that will be too difficult for a self-driving car technology to handle, 32.5% of participants strongly agree, 30% neutral, 22.5% agree, and only 12.5% disagree (Appendix G).

The last aspect to consider is the Attitude Towards using the system (ATT), which is meant to reflect on the proposed prototype Archer. The survey asked if participants think the various functions of Archer were well-integrated, as shown in Figure 49. 42.5% of participants agree, and 30% neutral. Seven and a half per cent of participants think that Archer concept has too much inconsistency, in contrast, 35% disagreed with this statement, and 30% were neutral (Appendix G). The results regarding the statement that Archer concept is very intelligent, future-oriented, and encourage participants to think about having or trying a driverless car as follows: 40% agree, 22.5% strongly agree, 15% neutral, 12.5% disagree and 10% strongly disagree (see Figure 50).

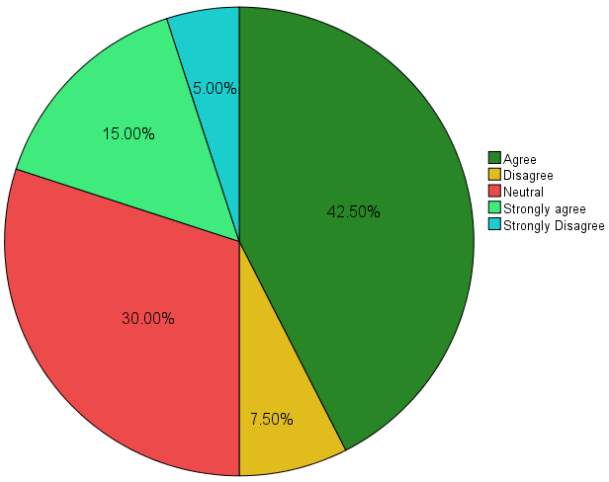


Figure 49: Participants responses regarding Archer concept Q11

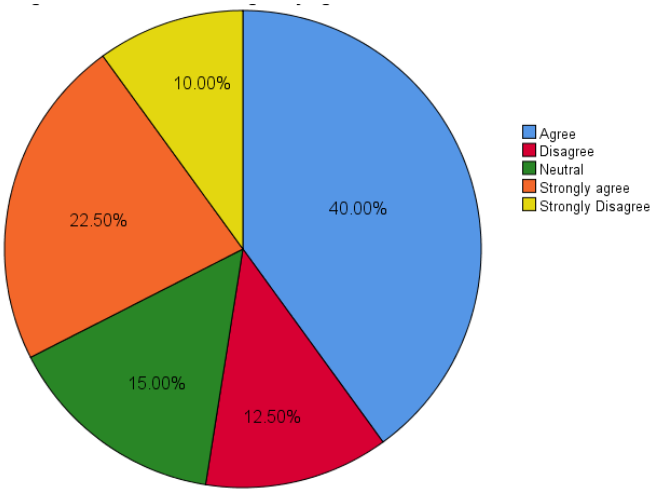


Figure 50: Participants responses regarding Archer concept Q14

5.4 Results and Analysis: Wizard of Oz

This section aims to analyse the data that resulted from the Wizard of Oz experiment. As described in the methodology chapter, this experiment intended to evaluate the use of IAR, followed with SUS Likert scale questions. Demographic breakdowns for the respondents are provided in Appendix H. This experiment was conducted with eight participants, 4 participants were female and 4 were male, aged between (25-39), drivers and non-drivers.

As mentioned before, the SUS survey includes ten compulsory statements and should remain on the same arrangements. The odd-numbered statements express positive attitudes, while the even ones - negative views. The SUS responses are presented in the form of a Linkert five-point scale, ranging from 1 to 5; where 5 represents strongly agree, 4 agree, 3 neutral, 2 disagree and 1 is strongly disagree. The following will explain how to calculate the SUS score:

- The odd-numbered statements subtract 1 from the score that the participant added.

- The even-numbered statements subtract their value from 5 from the score that the participant added.
- Count these new values together (individually for each participant), then multiply this by 2.5.
- Calculate the average for the new values.

However, the SUS score is translated through Letter grades: A = Above 80.3, Excellent; B = between 68 and 80.3, Good; C = 68, Ok; D = Between 51 and 67, Poor; and F = Below 51, Bad (Bangor, Kortum, & Miller, 2008). The IAR has recorded 81 in which mean good. Table 28 shows the participants score.

Table 28: SUS score calculation

Participant ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	SUS Row Score	SUS Final Score
1	3	1	3	3	3	1	3	2	4	1	28	70
2	5	2	5	1	5	2	4	1	4	1	36	90
3	3	2	4	1	4	1	4	1	5	2	33	82.5
4	4	2	3	1	3	1	2	2	2	1	27	67.5
5	3	1	5	1	5	1	3	1	5	5	32	80
6	4	1	3	3	3	3	3	1	4	2	27	67.5
7	5	1	3	1	4	1	4	1	1	3	30	75
8	5	1	4	2	5	1	3	1	2	3	31	77.5
Average												76.25

5.5 Discussion

The present research offers a study to investigate the acceptance of a self-driving vehicle concept through a user-centred design prototype and a human-machine interface concept. This attempts to employ Design Fiction techniques to present the potential future for the users of tomorrow.

This section will develop meaning for the results of the conducted literature study, experiment, and survey. The following five core questions were used as a guide through the validation of the discussions:

1. Does the individual's travel behaviour, relationship to cars and technology influence their opinion about AV's?
2. How does the public conceive the merging of AV's technology in the current market?
3. Would AV's technology become widely adopted and in what form?

4. What does the public find most and least appealing about autonomous vehicle technology?
5. How does a user-centred vehicle design and the uses of fictional scenarios enhance the adoption of AVs?

These questions aim to allocate the results into groups in order to ease the understanding of the research purpose and to link the participants' responses with the research aims and hypothesis.

Does the individual's travel behaviour relationship to cars and technology influence their opinion about AV's?

The results of the survey show that male participants are more likely to be concerned about their independence of mobility and less likely to share their car with other passengers. For instance, we hypothesised that participants who are less likely to use a shared pool, whether it is their own or a public one, they might be more concerned about their privacy. Though, to value the potential of technology to improve mobility, it is essential to define the ability to accept and explore new technologies. When asking the participants to describe their relationship to technology and cars; for example, do they view cars as a primary mode of transportation? Do they consider themselves as an early adopter to technologies or willing to try new technologies? These questions intended to detect if the travel behaviour and the relationship with technology and cars might influence respondents' prospect of driverless cars. Hence, we presumed that early adopters of new technologies could be more willing and enthusiastic to adopt AV's.

However, the income also shapes public attitudes towards technology and transportation in general. Since fully autonomous technology seems to cost much more compared to the semi-autonomous or partially autonomous cars, it is more likely that the cost would influence the decision of adopting AV. For example, when asking the participants, the cost of a self-driving car would be an essential thing they would consider before purchasing one; participants who earn between £20k-£50k were more concerned about the cost, but they were more likely desire to own a driverless car, and early technology adopters. Moreover, participants who usually commute to work by walking or by car were more likely to give up control and allow

an automated car to get them to their destination and agreed that AVs would allow them to be more productive. In that instance, we hypothesised that participants who think automated cars would make them more productive they are the more likely to give up control and allow autonomous technology to operate.

How does the public conceive the merging of AV's technology in the currently used network?

There is an opportunity to influence public opinion if we invite them to think about seeing automated cars operating on a regular basis on the same lanes as the other modes of transportation. The survey raised this matter to invite the respondents to envisage the existence of automated cars. Considerably, the respondents found this idea acceptable; also, they encourage building new traffic signals and some new infrastructure. Furthermore, as mentioned before, perceived usefulness of AV's is criteria where in which the consumers realise the benefits of using particular technology and eventually it may influence their intentions to use it. Such a concept was reflected in participants responses when asked if self-driving cars will reduce traffic problems, more than half of the respondents agreed.

Would AV's technology become widely adopted and in what form?

In the second section of the survey, the autonomous car concept was presented to explain why manufacturers need to develop automated cars; besides showing some potential benefits and facts of adopting the technology. Such a narrative is good to grasp the attention and the importance of technology; yet it is not enough to envisage the future use nor for the potential user to place themselves on such world. For example, when we asked the participants if they needed to learn many things before, they could get going with the automation technology concept, with the majority of those surveyed agreeing with the statement. In this research, we believe knowledge is not restricted to the technical aspect; it exceeds to cover the social aspects and our relationship with everyday objects. Indeed, as mentioned on the research aim "People do not shift unless they have a vision of what it is, they are shifting to" (Agassi, 1966). Therefore, as an attempt to envisage the use of automated car technology, this research proposed a new user-centred car design 'Archer' reflects a futuristic vision; besides, it provided a vision regarding the activity future user could practice while the car is driving itself. For instance, when asking the participants if they find the 'Archer'

concept very smart, future-oriented and encourage them to think about having or trying a driverless car, the majority agreed with the statement. Moreover, over half of those surveyed indicated that the various functions in Archer were well-integrated. We hypothesised in the research, placing the participant in a futuristic scenario where they are practising regular activities and how the new technology could fulfil secondary task which would enhance the acceptance of the technology. For example, the scenario video on the third section of the survey.

What does the public find most appealing and least appealing about autonomous vehicle technology?

As outlined in the systematic literature survey investigation, some essential features have priorities when presenting the automation technology such as control and safety (Anderson & Sallee, 2016). In the research we believe that trust and safety are not only crucial for material interaction only but also their long-term impact on the user as it is not common for humans to have no control on the steering wheel. Lack of control, costs, liability, privacy, and safety were considered on the survey from a futuristic aspect; for instance, the vast majority of the participants strongly agree that it is essential for a human to be able to take back control from a self-driving car. In the same context, more than half of the respondents believe there is a need to watch self-driving cars closely to be sure the computers do not make mistakes. These questions intend to place the participants on a decision-making platform, assumes that the automation technology will be implemented soon, and the public perspective is crucially needed.

How does a user-centred vehicle design, and the uses of fictional scenarios could enhance the adoption of AVs?

User-centred design practice is a process in which the user and their requirements are the core elements of the design process. Our findings demonstrate that the subsequent interaction with the prototype through participant selection record a dramatic increase in adopting the technology. The process has not intended to deceive the participants, but more of a creative act that sets them into a discursive space for a while then let them go. It started by investigating their relationship with technology and their travelling habits; then introduced

the automation concept in general but was an invitation to think of the technology. The following stage was to let them inside the world of autonomous vehicle by proposing a physical prototype and HMI, in order to envisage the use of the technology. The respondents were placed in a decision-making platform. For instance, when asked about operating the AV on the same lane of standard cars, or the ability to take control from the automation system. Such method did not attempt to impose the technology as a sudden shift but as gradual improvements in our mobility. The process has reflected on the previously mentioned concept, the design experience has to avoid the ambiguity that pretends to be real in order to perform a full experience and the user has to 'suspend their disbelief willingly' to enjoy shifting their imagination into a new and unfamiliar space.

To conclude this section, the previous questions identify the context of a fictional world to enhance reality and open up a discursive space to think about the technology. From Design Fiction lens, the diegetic prototypes are the car design and accompanying items that are provoking the scene. Thus, both previous elements were combined under a distinct narrative to envisage the future by utilising 'Perceptual Bridges' technique, where connecting the unusual speculation with personal experience in order to appear convincing which led to envisaging the future proposals. However, it is essential to mention this narrative with slight changes could be placed under 'Fictional Space as Design Space' techniques, where creating props to support producing fictional truths, and involving participants throughout a game-of-make-believe that is facilitated by props; this would work if the delivery method were different.

This Chapter has explained the results of the survey and the experiment that this research had conducted in order to verify its proposal. This enabled us to provide an explanation of how these results reflect Design Fiction techniques to open up a discursive space for discussion.

6 Chapter Six: Conclusion

6.1 Introduction

Design Fiction is considered a genre of self-reflection, an early step in the design process. In contrast, technology affects more aspects of our daily life, and it is more about an experience. The motivating shifts in recent decades are a substantial change to how things are seen, defined, categorised, or quantified. Although this change is considered the hardest to predict, it is essential to clarify that these technological improvements do not present a brand-new technology but developed versions of the existing one and are more integrated with the modern world. This thesis has investigated different aspects of utilising Design Fiction and provided a potential solution that could enhance the adoption and acceptance of driverless cars.

6.2 Synthesis and Objectives

This section will describe where the research has accomplished its aims and inquiries, by employing Design Fiction strategies to stimulate the acceptance of driverless cars, in which open up a discursive space that allows the potential user to review the technology, raise questions and reflect on their use of it.

Objective One: Identify what a Design Fiction approach is and how it can be considered a valuable tool to investigate future technologies to influence our understanding of design applications. To also describe how Design Fiction as a service design approach can address, visualise, and explore specific issues at the beginning of the design process.

This objective was acknowledged in chapter Two, demonstrating the notion of Design Fiction and its strategies and remarkable attempts to employ the approach. This thesis supports evidence from the previous literature that Design Fiction raises far-reaching questions concerning the consequences of technological development. This study has shown that Design Fiction tools bring innovative strategies to envisage scientific research; draw attention to the social aspects and implications of techno-scientific solutions; and utilise the techniques of fiction to examine potential technologies, define their impact, and present a range of possible alternative futures. Furthermore, Design Fiction as a service design approach places the public need and requirement in the centre of the design process to understand the

concept of future technologies and employ them in real-world scenarios. This employment encourages observing how these innovations might be used and how people might react to these new objects and present a range of possible alternative futures.

Objective Two: Investigate autonomous car technology and what challenges need to be overcome to proceed to the plateau of productivity. Then employ Design Fiction strategies to prepare and present the technology by centring upon the idea of 'suspend[ing] disbelief about change.'

A further study to understand autonomous technology has been conducted in Chapter two. Autonomous cars technology is an emerging technology that promises to bring a safe, adequate, and accessible transportation system to all kinds of users. Consequently, the autonomous technology concept requires a new communication class to overcome the challenge of obtaining the trust of future customers. Therefore, reflecting on what it means, Design Fiction has an immediate challenge of closing the gap between a vision and material expression. This research studied and investigated how Design Fiction tools and strategies can be utilised to enhance the adoption of autonomous vehicles. This objective was achieved in Chapter two.

Objective Three: Develop a fictional prototype for an autonomous vehicle that fulfils the research process and purpose. Then, generate a context around this prototype to support the narrative that reflects the future vision and the product functionality by Design Fiction.

In order to implement Design Fiction strategies, it was essential to stimulate its elements: the narrative, the diegetic prototype, and the context, which were combined to present a distinct narrative to envisage the future. A new conceptual car called Archer, and a human-machine interface model called Intelligent Adaptive Ride (IAR), were presented in this research. These prototypes were derived from the user requirements and placed inside a Design Fiction world. This proposal reflects on what it means that Design Fiction has an immediate challenge of closing the gap between a vision and its material expression by using 'what if' scenarios that situate the user in a shared conceptual space. Chapter Four has illustrated a detailed process of how this objective was accomplished.

Objective Four: Validate the efficiency of the proposed strategy to stimulate the adoption of autonomous vehicle technology by employing different data collection tools such as the survey and experiment.

This objective has been introduced through several methods: Survey and an Experiment (Wizard of Oz). The survey intended to present the AV technology as a general concept; introduced the fictional prototype Archer and the IAR; then the participants could reflect their vision through the questions. The Wizard of Oz experiment was assigned to allow the reflection of using the IAR. This objective was fulfilled in chapters Three, Four, and Five.

Objective Five: Evaluate how the use of Design Fiction within service design could help the acceptance of automation technology.

A discussion was conducted to fill the communication gap between the research aim and its method to conclude this thesis. Further, to define the validity of the research strategy and how it can be developed for future studies. This objective was outlined in Chapter Five.

6.3 Contribution of the research

This research intended on investigating the Design Fiction approach to enhance the adoption of future technologies. The point of departure was the research question: How the employment of Design Fiction can stimulate the adoption of Autonomous Vehicles? Design Fiction, as a future-oriented approach, investigates the future through a combination of prototyping and storytelling. It can bring products not yet in existence to a concrete platform for examining purposes. The trigger for this investigation is Bruce sterling definition of Design Fiction "to suspend disbelief about change." This study demonstrates that Design Fiction is a tangible continuation of the speculative design concept that enables designers to prototype physical objects, reflecting on how they visualise the future. It provides a space where practitioners could drive their minds to visualise an object, giving it a tangible form and then constructs a narrative by placing the prototype in a new world for the audience to interact and raise a debate. Furthermore, this research interprets that Design Fiction is not about predicting the future or creating utopian visions that develop emerging technologies. Instead, it affords a means for investigating the societal, technological differences of possible futures so that we can better understand the present.

The evidence from this study found that extensive research has utilised Design Fiction techniques and some other methods to present new technologies; some have employed storytelling and what-if scenarios to shift the potential user into a futuristic world. These attempts have a set plan, aiming to provoke the debate and reflect their acceptance based on the pre-prepared elements. This research has employed the principle of minimal departure, where the viewer of a fictional world would locate their knowledge, experiences, even ideals into the actual world. This technique proposed autonomous technology gradually to the audience. Starting by visualising the current transportation system, then exploring the participant relation with this system, subsequent presenting the autonomous mode and how everyday travel could look in the future, concerning their travel habits, vehicle shape, and even the in-car interaction system.

The employment of the Research through Design (RtD) approach to establish 'how Design Fiction tools and strategies could enhance the adoption of AV's' was because the design Fiction approach does not provide a clear image of the kind of knowledge it could produce. Therefore, building meaningful experiments based on discourse alone is not sufficient. RtD is a combination of process and research ends; the results of this combination are always an artefact that serves the purpose and plays a significant role in defining new knowledge. By employing RtD, this research included traditional research tools and documentation to build the study understanding. Consequently, this thesis managed to reflect on their proposed artefact and improve it similarly to that of diagnostic design research methods.

Indeed, the experiment became an invitation to think of the automation technology in which the participants were not involved as a roleplay; they are instead a real play. Although different possibilities of expression enhanced the engagement of the participants, the narrative was utilised as a technique to anticipate opportunities and challenges. Following with questions, this intended to place the participants on a decision-making platform assumes that the automation technology will be implemented soon, and the public perspective is crucially needed. Perceived usefulness of AV's is criteria where the consumers realise the benefits of using a particular technology, and eventually, it may influence their intentions to use it.

Based on the above strategy, the outcome knowledge takes a theory with practical general applicability and predictive ability. Consequently, it is derived that the Design Fiction platform

allows the integration with other approaches to validate the proposed prototype, such as SUS and TAM, in the early stages of the design process without the concern of misleading the experimental concept. Hence, this approach has the advantages of encouraging the acceptance of automation technology and developing the proposed prototypes for futuristic use. However, to accomplish such results, it is essential to set the user requirements as the core of the design and implement a prototype that users could relate to and has futuristic properties to serve the research purpose.

6.4 Limitations and Future Works

Design Fiction as a futuristic approach tends towards influencing interaction design based on the exploration of innovations in interactive technologies. However, it is vital to underline that the Design Fiction approach has barriers that designers might not be able to overcome. By example, Design Fiction is trying to reveal that users of these objects are the users of today, not tomorrow, so their conventions and assumptions are those of the present. Moreover, how these technologies unfold is still unknown, as it may take an entirely different shape than what is presently familiar to the public. More information or future events may change people's attitudes.

Although Design Fiction is still developing as a method of enquiry, it has a limitation that could mislead the future-oriented researcher concerning the type of the future they wish to examine. While 'possible' includes all potentials when recognising particular issues; plausible and probable futures debatably have conventional plans to offer when attempting to raise awareness, as they are frequently relevant to the current experience of the time. Though, preferable future could be characterised as what we wish to happen and thus could be implemented within any future. Such discourse might confuse the designer about the phase this product/ service needs to gain some attention; for example, the trough of disillusionment where the product is no longer recognised, or the slope of enlightenment in which the product might fail to accomplish expectations.

Another limitation this research found was regarding the AV investigation to explore the user vision. The majority of the studies this research found were attempting to outline some technical aspects, which their results were oriented towards the manufacturer development,

not to enhance or enlighten the user acceptance. This research believes that more studies regarding our driving habits will likely lead to define new tools to stimulate the acceptance of driverless cars.

As well as it is worthwhile to mention that this research had placed the proposed design into a game environment (simulator) to perceives the benefits of utilising an interaction medium, but the researcher could not validate the use of this medium, as it required a social gathering and one to one engagement. However, this experimental was hard to conduct due to Covid-19 pandemic. The experiment was supposed to take place in March and April 2020; therefore, the validation of the research was limited to the computer animation method - mentioned in chapter four-. However, as further development of this research in the future, this medium will be evaluated in future publications.

Future stages of the project are to examine the proposal with more specific users, such as senior drivers, potential users who have health conditions. This could lead to a new leap of targeted technology. Further, collaboration with manufacturers could help to develop the design model, which will be more user-oriented than before. Certainly, determine the right medium to present the technology for the potential user, has impact trust and safety. AR/VR technologies have grown into automotive marketing in recent years. AR/VR technologies are highly engaging, where the users can investigate and configure the potential vehicle and interface, they could use. Thus, using such techniques would reduce the errors and the accidents risk for all parties. Moreover, utilising interaction technologies would open up a different discursive space for Design Fiction strategies. This chapter concludes a thesis titled ‘Design Fiction as an Approach to Stimulate the Adoption of Autonomous Vehicle.’

References

Agassi, J. (1966). Thomas Kuhn," The Structure of Scientific Revolutions".

Aguwa, C. C., Monplaisir, L., & Turgut, O. (2012). Voice of the customer: Customer satisfaction ratio based analysis. *Expert Systems with Applications, 39*(11), 10112-10119.

AKKA-technologies.com. (2013). Link&Go Using technology to rethink car usage. Retrieved from https://www.akka-technologies.com/en/innovation/projects/link-go

Anderson, S. T., & Sallee, J. M. (2016). Designing policies to make cars greener. *Annual Review of Resource Economics, 8*, 157-180.

Arana, L. M. L. (2019). Architecture Between the Panels: Comics, Cartoons and Graphic Narrative in the (New) Neo Avant-Garde. *Architectural Design, 89*(4), 108-113.

Archer, B. (1995). The nature of research. *Co-Design Journal, 2*(11), 6-13.

Auger, J. (2012). *Why robot?: speculative design, the domestication of technology and the considered future.* Royal College of Art,

Auger, J. (2013). Speculative design: Crafting the speculation. *Digital Creativity, 24*(1), 11-35. doi:10.1080/14626268.2013.767276

Auger, J., & Loizeau, J. (2009). Afterlife. Retrieved from http://www.auger-loizeau.com/projects/afterlife

Bagchi, R., & Cheema, A. (2013). The effect of red background color on willingness-to-pay: The moderating role of selling mechanism. *Journal of Consumer Research, 39*(5), 947-960.

Bagloee, S. A., Tavana, M., Asadi, M., & Oliver, T. (2016). Autonomous vehicles: challenges, opportunities, and future implications for transportation policies. *Journal of modern transportation, 24*(4), 284-303.

Bang, A. L., Krogh, P., Ludvigsen, M., & Markussen, T. (2012). The role of hypothesis in constructive design research. In *Proceedings of the Art of Research Iv*.

Bangor, A., Kortum, P. T., & Miller, J. T. (2008). An empirical evaluation of the system usability scale. *Intl. Journal of Human–Computer Interaction, 24*(6), 574-594.

Bardzell, S., Bardzell, J., Forlizzi, J., Zimmerman, J., & Antanitis, J. (2012). *Critical design and critical theory: the challenge of designing for provocation.* Paper presented at the Proceedings of the Designing Interactive Systems Conference.

Becker, F., & Axhausen, K. W. (2017). Literature review on surveys investigating the acceptance of automated vehicles. *Transportation, 44*(6), 1293-1306.

Becker, T., Herrmann, F., Duwe, D., Stegmüller, S., Röckle, F., & Unger, N. (2018). Enabling the value of time. Implications for the interior design of autonomous vehicles. In: Fraunhofer IAO.

Benyon, D. (2014). Designing interactive systems: A comprehensive guide to HCI, UX and interaction design.

Benz, M. (2018). The Mercedes-Benz F 015 Luxury in Motion. In.

Bland, J., & Westlake, s. (2013). *Don't Stop Thinking About Tomorrow: A modest defence of futurology*. Retrieved from https://media.nesta.org.uk/documents/dont_stop_thinking_about_tomorrow.pdf

Bleecker, J. (2009). Design Fiction: A short essay on design, science, fact and fiction. *Near Future Laboratory, 29*.

Blythe, M. (2004). Pastiche scenarios. *Interactions, 11*(5), 51-53.

Blythe, M. (2014). *Research through design fiction: narrative in real and imaginary abstracts.* Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.
Blythe, M., & Wright, P. (2006). *Pastiche scenarios: Fiction as a resource for user centered design. Interacting with.* Paper presented at the Computers.
Bosch, T. (2012). Sci-Fi Writer Bruce Sterling Explains the Intriguing New Concept of Design Fiction. Retrieved from https://slate.com/technology/2012/03/bruce-sterling-on-design-fictions.html
Bowen, S. (2010). *Critical theory and participatory design.* Paper presented at the Proceedings of CHI.
Brinkley, J., Posadas, B., Sherman, I., Daily, S. B., & Gilbert, J. E. (2019). An Open Road Evaluation of a Self-Driving Vehicle Human–Machine Interface Designed for Visually Impaired Users. *International Journal of Human–Computer Interaction, 35*(11), 1018-1032.
Broadbent, J. (2003). Generations in design methodology. *The Design Journal, 6*(1), 2-13.
Brooks, L. J. A., & Pollock, I. (2018). Minority Reports from 2054: Building Collective and Critical Forecasting Imaginaries via Afrofuturetypes and Game Jamming. *TOPIA: Canadian Journal of Cultural Studies*, 110-135.
Buttrick, L., Linehan, C., Kirman, B., & O'Hara, D. (2014). Fifty shades of CHI: the perverse and humiliating human-computer relationship. In *CHI'14 Extended Abstracts on Human Factors in Computing Systems* (pp. 825-834).
Candy, L. (2011). Research and creative practice. *Interacting: Art, research and the creative practitioner*, 33-59.
CeArley, D., Burke, B., Searle, S., & Walker, M. J. (2016). Top 10 strategic technology trends for 2018. *The Top, 10*.
Chamberlain, P., Bonsiepe, G., Cross, N., Keller, I., Frens, J., Buchanan, R., . . . Jonas, W. (2012). *Design research now: essays and selected projects*: Walter de Gruyter.
Coles, A. (2016). *Design fiction* (Vol. 2). Berlin: Sternberg Press.
Coulton, P., Burnett, D., & Gradinar, A. I. (2016). Games as speculative design: allowing players to consider alternate presents and plausible futures.
Coulton, P., Lindley, J., & Cooper, R. (2018). The little book of design fiction for the Internet of things.
Coulton, P., Lindley, J. G., Sturdee, M., & Stead, M. (2017). Design fiction as world building.
Creech, C., Jayaraman, S. K., Robert, L., Tilbury, D., Yang, X. J., Pradhan, A., & Tsui, K. (2017). Trust and Control in Autonomous Vehicle Interactions.
Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*: Sage publications.
Cross, N. (2001). Designerly ways of knowing: Design discipline versus design science. *Design issues, 17*(3), 49-55.
Cross, N. (2007). Designerly ways of knowing. Board of international research in design. *Basel: Birkhiuser, 41*.
Crowley, K., & Head, B. W. (2017). The enduring challenge of 'wicked problems': revisiting Rittel and Webber. *Policy Sciences, 50*(4), 539-547.
Dalton, N. S., Moreau, R., & Adams, R. K. (2016). *Resistance is Fertile: Design Fictions in Dystopian Worlds.* Paper presented at the Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems.

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly, 13*(3), 318-340.
Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: a comparison of two theoretical models. *Management science, 35*(8), 982-1003.
De Bernardi, P., & Gilli, M. (2019). Museum Digital Innovation: The Role of Digital Communication Strategies in Torino Museums. In *Handbook of Research on Examining Cultural Policies Through Digital Communication* (pp. 161-181): IGI Global.
De Bock, T., Pandelaere, M., & Van Kenhove, P. (2013). When colors backfire: The impact of color cues on moral judgment. *Journal of Consumer Psychology, 23*(3), 341-348.
Dedehayir, O., & Steinert, M. (2016). The hype cycle model: A review and future directions. *Technological Forecasting and Social Change, 108*, 28-41.
Denyer, D., Tranfield, D., & Van Aken, J. E. (2008). Developing design propositions through research synthesis. *Organization studies, 29*(3), 393-413.
Denzin, N. K., & Lincoln, Y. S. (2011). *The Sage handbook of qualitative research*: sage.
Dey, D., & Terken, J. (2017). *Pedestrian interaction with vehicles: roles of explicit and implicit communication.* Paper presented at the Proceedings of the 9th International Conference on Automotive User Interfaces and Interactive Vehicular Applications.
Dindler, C. (2010). Fictional space in participatory design of engaging interactive environments. *Aarhus University*.
Dindler, C., & Iversen, O. S. (2007). Fictional inquiry—design collaboration in a shared narrative space. *CoDesign, 3*(4), 213-234.
Doos, L., Packer, C., Ward, D., Simpson, S., & Stevens, A. (2016). Past speculations of the future: a review of the methods used for forecasting emerging health technologies. *BMJ open, 6*(3), e010479.
Dow, S., Fortuna, J., Schwartz, D., Altringer, B., Schwartz, D., & Klemmer, S. (2011). *Prototyping dynamics: sharing multiple designs improves exploration, group rapport, and results.* Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.
Drucker, P. F. (2011). *Landmarks of tomorrow: A report on the new*: Transaction Publishers.
Dunne, A. (2007). Critical Design FAQ. Dunne & Raby. In.
Dunne, A. (2008). *Hertzian tales: Electronic products, aesthetic experience, and critical design.* Royal College of Art,
Dunne, A., & Raby, F. (2011). Critical Design FAQ. Retrieved from http://dunneandraby.co.uk/content/bydandr/13/0
Dunne, A., & Raby, F. (2013). *Speculative everything: design, fiction, and social dreaming*. Cambridge, Massachusetts: The MIT Press.
Ekman, F., Johansson, M., & Sochor, J. (2017). Creating appropriate trust in automated vehicle systems: A framework for HMI design. *IEEE Transactions on Human-Machine Systems, 48*(1), 95-101.
Emilson, A. (2015). *Design in the space between stories: design for social innovation and sustainability–from responding to societal challenges to preparing for societal collapse*: Faculty of Culture and Society, Malmö University.
Evans, M. (2011). Empathizing with the future: creating next-next generation products and services. *The Design Journal, 14*(2), 231-251.

Fallman, D. (2007). Why research-oriented design isn't design-oriented research: On the tensions between design and research in an implicit design discipline. *Knowledge, Technology & Policy, 20*(3), 193-200.
Fantl, J., & McGrath, M. (2002). Evidence, pragmatics, and justification. *The Philosophical Review, 111*(1), 67-94.
Faste, T., & Faste, H. (2012). *Demystifying "design research": Design is not research, research is design.* Paper presented at the IDSA Education Symposium.
Filo, P., & Lubega, I. (2015). Design of interior for a self-driving car: propose a conceptual design from a body & trim perspective that can be implemented in future self-driving cars. *Master's dissertation. Department of Product and Production Development, Chalmers University. Gothenburg, Sweden*.
Forlizzi, J., DiSalvo, C., Bardzell, J., Koskinen, I., & Wensveen, S. (2011). Quality control: a panel on the critique and criticism of design research. In *CHI'11 Extended Abstracts on Human Factors in Computing Systems* (pp. 823-826).
Frayling, C. (1993). Research in art and design.
Friberg, C. (2010). Moving into the Field of the Unknown. A Reflection on the Difference between Theory and Practice. In *At the Intersection Between Art and Research. Practice-based Research in the Performing Arts* (pp. 19-37): NSU Press.
Future, T. M. o. t. The Museum of the Future: Machinic Life. Retrieved from http://www.museumofthefuture.ae/
Gaver, W. (2012). *What should we expect from research through design?* Paper presented at the Proceedings of the SIGCHI conference on human factors in computing systems.
Gaver, W. W., Beaver, J., & Benford, S. (2003). *Ambiguity as a resource for design.* Paper presented at the Proceedings of the SIGCHI conference on Human factors in computing systems.
Gibbs-Smith, C. H. (2013). *The history of flying* (Vol. 9): Cambridge University Press.
Glon, R. (2019). Buick launched the first in-car touchscreen when the NES was still cutting edge. Retrieved from https://www.digitaltrends.com/cars/first-car-with-touchscreen-infotainment/
Gonzatto, R. F., van Amstel, F. M., Merkle, L. E., & Hartmann, T. (2013). The ideology of the future in design fictions. *Digital Creativity, 24*(1), 36-45.
Google. (2020). Waymo Our Journey. Retrieved from https://waymo.com/journey/
Grand, S., & Jonas, W. (2012). *Mapping design research*: Birkhäuser Basel.
Grand, S., & Wiedmer, M. (2010). *Design fiction: a method toolbox for design research in a complex world.* Paper presented at the proceedings of the DRS 2010 conference: Design and Complexity.
Hales, D. (2013). Design fictions an introduction and provisional taxonomy. *Digital Creativity, 24*(1), 1-10.
Hasenjäger, M., & Wersing, H. (2017). *Personalization in advanced driver assistance systems and autonomous vehicles: A review.* Paper presented at the 2017 ieee 20th international conference on intelligent transportation systems (itsc).
Hekkert, P., van Dijk, M., & Lloyd, P. (2011). Vision in product design: Handbook for innovators. In: BIS publishers.
Herbst, J. (2005). *The history of transportation*: Lerner Publications.
Herriott, R. (2019). *What Kind of Research is Research Through Design?* Paper presented at the International Association of Societies of Design Research Conference.

Heutger, M., Kückelhaus, M., Zeiler, K., Niezgoda, D., & Chung, G. (2014). Self-driving vehicles in logistics. In: DHL Trend Research, Bonn, Germany.
Hislop, D., & Axtell, C. (2015). The work-related affordances of business travel: a disaggregated analysis of journey stage and mode of transport. *Work, employment and society, 29*(6), 950-968.
Hoff, K. A., & Bashir, M. (2015). Trust in automation: Integrating empirical evidence on factors that influence trust. *Human factors, 57*(3), 407-434.
Holmström, J., Ketokivi, M., & Hameri, A. P. (2009). Bridging practice and theory: A design science approach. *Decision Sciences, 40*(1), 65-87.
Homden, R. (2019). The evolution of in-car voice control Retrieved from https://www.simpleusability.com/inspiration/2019/02/the-evolution-of-in-car-voice-control/
Horton, R. P., Buck, T., Waterson, P. E., & Clegg, C. W. (2001). Explaining intranet use with the technology acceptance model. *Journal of information technology, 16*(4), 237-249.
Howard, D., & Dai, D. (2014). *Public perceptions of self-driving cars: The case of Berkeley, California.* Paper presented at the Transportation Research Board 93rd Annual Meeting.
Hu, S. J. (2013). Evolving paradigms of manufacturing: from mass production to mass customization and personalization. *Procedia CIRP, 7*, 3-8.
Ive, H. P., Sirkin, D., Miller, D., Li, J., & Ju, W. (2015). *" Don't make me turn this seat around!" driver and passenger activities and positions in autonomous cars.* Paper presented at the Adjunct Proceedings of the 7th International Conference on Automotive User Interfaces and Interactive Vehicular Applications.
Jackson, L., & Cracknell, R. (2018). *Road accident casualties in Britain and the world*: House of Commons Library.
Jacob, R. J., & Karn, K. S. (2003). Eye tracking in human-computer interaction and usability research: Ready to deliver the promises. In *The mind's eye* (pp. 573-605): Elsevier.
Jansson, J., Marell, A., & Nordlund, A. (2010). Green consumer behavior: determinants of curtailment and eco-innovation adoption. *Journal of consumer marketing, 27*(4), 358-370.
Johnston, S. F. (2020). *Techno-fixers: Origins and implications of technological faith*: McGill-Queen's Press-MQUP.
Jorlöv, S., Bohman, K., & Larsson, A. (2017). *Seating positions and activities in highly automated cars–a qualitative study of future automated driving scenarios.* Paper presented at the International Research Conference on the Biomechanics of Impact.
Keinonen, T. K., & Takala, R. (2010). *Product concept design: a review of the conceptual design of products in industry*: Springer Science & Business Media.
Kirby, D. (2010). The future is now: Diegetic prototypes and the role of popular films in generating real-world technological development. *Social Studies of Science, 40*(1), 41-70.
Kirman, B., Linehan, C., Lawson, S., & O'Hara, D. (2013). CHI and the future robot enslavement of humankind: a retrospective. In *CHI'13 Extended Abstracts on Human Factors in Computing Systems* (pp. 2199-2208).
Klein, N. (2014) *Dystopian Fiction's Popularity Is a Warning Sign for the Future/Interviewer: D. B. Kirtley*. the Geek's Guide to the Galaxy, wired.com.

Knutz, E., Lenskjold, T. U., & Markussen, T. (2016). Fiction as a resource in participatory design. *50th Anniversary Design+ Research+ Society ConferenceDesign Research Society*, 1830-1844.
Knutz, E., & Markussen, T. (2014). The Role of Fiction in Experiments within Design, Art & Architecture-Towards a New Typology of Design Fiction. *Artifact: Journal of Design Practice, 3*(2), 8.1-8.13.
Kolko, J. (2010). Abductive thinking and sensemaking: The drivers of design synthesis. *Design issues, 26*(1), 15-28.
Koo, J., Kwac, J., Ju, W., Steinert, M., Leifer, L., & Nass, C. (2015). Why did my car just do that? Explaining semi-autonomous driving actions to improve driver understanding, trust, and performance. *International Journal on Interactive Design and Manufacturing (IJIDeM), 9*(4), 269-275.
Koskinen, I., Zimmerman, J., Binder, T., Redstrom, J., & Wensveen, S. (2011). *Design research through practice: From the lab, field, and showroom*: Elsevier.
Koskinen, I., Zimmerman, J., Binder, T., Redstrom, J., & Wensveen, S. (2013). Design research through practice: From the lab, field, and showroom. *IEEE Transactions on Professional Communication, 56*(3), 262-263.
Krasniqi, X., & Hajrizi, E. (2016). Use of IoT technology to drive the automotive industry from connected to full autonomous vehicles. *IFAC-PapersOnLine, 49*(29), 269-274.
Krippendorff, K. (2007). Design research, an oxymoron?
Kroes, P. (2002). Design methodology and the nature of technical artefacts. *Design studies, 23*(3), 287-302.
Kršić, D. (2014). Design has always been a signifying practice. *interview," Design borderline", Golub Marko (ed), Dan D festival newspaper, Croatian designers society, Zagreb,(20-26)*.
Kuehl, R. O., & Kuehl, R. (2000). Design of experiments: statistical principles of research design and analysis.
Kumar, R. (2019). *Research methodology: A step-by-step guide for beginners*: Sage Publications Limited.
Kun, A. L., Boll, S., & Schmidt, A. (2016). Shifting gears: User interfaces in the age of autonomous driving. *IEEE Pervasive Computing, 15*(1), 32-38.
Laboratory, N. F. (2015). Helios: Pilot Quick Start Guide. Retrieved from https://nearfuturelaboratory.myshopify.com/products/helios-pilot-quick-start-guide
Laurel, B. (2003). *Design research: methods and perspectives*: MIT press.
Law, J., & Urry, J. (2004). Enacting the social. *Economy and society, 33*(3), 390-410.
Lee, A. S. (2017). Philosophy and method: making interpretive research interpretive. In *The Routledge Companion to Management Information Systems* (pp. 30-46): Routledge.
Lepage, J.-D. G. (2017). *Military Trains and Railways: An Illustrated History*: McFarland.
Lewis, D. (1973). Counterfactuals and comparative possibility. In *Ifs* (pp. 57-85): Springer.
Li, L. (2010). A critical review of technology acceptance literature. *Referred Research Paper, 4*.
Lindley, J. (2015). *Researching design fiction with design fiction.* Paper presented at the Proceedings of the 2015 ACM SIGCHI Conference on Creativity and Cognition.
Lindley, J., & Coulton, P. (2014). *Modelling design fiction: what's the story?* Paper presented at the StoryStorm Workshop at ACM conference on Designing Interactive Systems in 2014.

Lindley, J., & Coulton, P. (2015). *Game of drones.* Paper presented at the Proceedings of the 2015 annual symposium on computer-human interaction in play.
Lindley, J., & Potts, R. (2014). *A machine learning: an example of HCI prototyping with design fiction.* Paper presented at the Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational.
Liversedge, S., Gilchrist, I., & Everling, S. (2011). *The Oxford handbook of eye movements*: Oxford University Press.
Lunenfeld, P. (2003). The design cluster. *Design research: Methods and perspectives*, 10-15.
Lutin, J. M., Kornhauser, A. L., & MASCE, E. L.-L. (2013). The revolutionary development of self-driving vehicles and implications for the transportation engineering profession. *Institute of Transportation Engineers. ITE Journal, 83*(7), 28.
Mäkelä, M. (2007). Knowing through making: The role of the artefact in practice-led research. *Knowledge, Technology & Policy, 20*(3), 157-163.
Makri, S., & Blandford, A. (2012). Coming across information serendipitously–Part 1: A process model. *Journal of Documentation, 68*(5), 684-705.
Markoff, J. (2010). Google cars drive themseleves, in traffic. *The New York Times, 9*.
Markussen, T., & Knutz, E. (2013). *The poetics of design fiction.* Paper presented at the Proceedings of the 6th International Conference on Designing Pleasurable Products and Interfaces.
Mazé, R. (2009). *Critical of what.* Paper presented at the Iaspis forum on design and critical practice: The reader.
Mazé, R. (2014). *Our Common Future? Political questions for designing social innovation.* Paper presented at the Proceedings of the Design Research Society Conference.
McKenney, S., & Reeves, T. C. (2018). *Conducting educational design research*: Routledge.
Mejia Sarmiento, J., Pasman, G., Stappers, P., Lloyd, P., & Bohemia, E. (2016). Vision Concepts within the landscape of design research.
Mejia Sarmiento, J., & Simonse, W. (2015). *Design of vision concepts to explore the future: Nature, context and design techniques.* Paper presented at the The 5th CIM Community Meeting, Enschede, The Netherlands, 1-2 September 2015.
Mentzer, J. T., & Flint, D. J. (1997). Validity in logistics research. *Journal of business logistics, 18*(1), 199.
Mercedes-benz. (2020). Inspired by the future: VISION AVTR. Retrieved from https://www.mercedes-benz.com/en/vehicles/passenger-cars/mercedes-benz-concept-cars/vision-avtr/
Mercedes-benz.com. (2018). Vision URBANETIC – The mobility of the future. Retrieved from https://www.mercedes-benz.com/en/mercedes-benz/vehicles/transporter/vision-urbanetic-the-mobility-of-the-future/
Meschtscherjakov, A., Tscheligi, M., Fröhlich, P., McCall, R., Riener, A., & Palanque, P. (2017). *Mobile interaction with and in autonomous vehicles.* Paper presented at the Proceedings of the 19th International Conference on Human-Computer Interaction with Mobile Devices and Services.
Mkansi, M., & Acheampong, E. A. (2012). Research philosophy debates and classifications: students' dilemma. *Electronic journal of business research methods, 10*(2), 132-140.
Mollon, M., & Gentes, A. (2014). *The Rhetoric of Design for Debate: triggering conversation with an" uncanny enough" artefact*.
Mom, G. (2012). *The electric vehicle: Technology and expectations in the automobile age*: JHU Press.

Monotype. (n.d.). How to win the in-car technology race. Retrieved from https://hello.monotype.com/In-Car_Technology_Race.html
Moreno-Munoz, A., Bellido-Outeirino, F., Siano, P., & Gomez-Nieto, M. (2016). Mobile social media for smart grids customer engagement: Emerging trends and challenges. *Renewable and Sustainable Energy Reviews, 53*, 1611-1616.
Morgan, D. L. (2007). Paradigms lost and pragmatism regained: Methodological implications of combining qualitative and quantitative methods. *Journal of mixed methods research, 1*(1), 48-76.
Morisson, A. (2011). *Ruminations of a WiFi cow.* Paper presented at the Nordes 2011: Making it Matter! 4th Nordic Design Research Conference, Helsinki, Finland.
Morisson, A. (2014). *Design Prospects: Investigating Design Fiction via a Rogue Urban Drone.* Paper presented at the DRS 2014 Conference, Umeå, Sweden.
Mulgan, G. (2013). Tell me a story of the future. Retrieved from https://www.nesta.org.uk/blog/tell-me-a-story-of-the-future/
Muller, P. J. (2017). *New Sustainable Transportation Infrastructure System.* Paper presented at the International Conference on Sustainable Infrastructure 2017.
Naujoks, F., Purucker, C., & Neukum, A. (2016). Secondary task engagement and vehicle automation–Comparing the effects of different automation levels in an on-road experiment. *Transportation research part F: traffic psychology and behaviour, 38*, 67-82.
Naujoks, F., Wiedemann, K., & Schömig, N. (2017). *The importance of interruption management for usefulness and acceptance of automated driving.* Paper presented at the Proceedings of the 9th International Conference on Automotive User Interfaces and Interactive Vehicular Applications.
Naujoks, F., Wiedemann, K., Schömig, N., Hergeth, S., & Keinath, A. (2019). Towards guidelines and verification methods for automated vehicle HMIs. *Transportation research part F: traffic psychology and behaviour, 60*, 121-136.
Nees, M. A. (2016). *Acceptance of self-driving cars: An examination of idealized versus realistic portrayals with a self-driving car acceptance scale.* Paper presented at the Proceedings of the Human Factors and Ergonomics Society Annual Meeting.
Newman, I., Benz, C. R., & Ridenour, C. S. (1998). *Qualitative-quantitative research methodology: Exploring the interactive continuum*: SIU Press.
NHTS, N. H. T. S. A. (2011). USDOT Connected Vehicle Research Program: Vehicle-to-Vehicle Safety Application Research Plan. *DOT HS, 811*, 373.
Nikiforuk, A. (2013). The Big shift last time: from horse dung to car smog| The Tyee.
Nova, N., Miyake, K., Chiu, W., & Kwon, N. (2012). Curious rituals: Gestural interaction in the digital everyday. In.
Oakley, A. (2002). Social science and evidence-based everything: The case of education. *Educational review, 54*(3), 277-286.
Orwell, G. (1989). Animal farm: A fairy story. 1945. *London: Secker and Warburg*.
Panetta, K. (2017). Top Trends in the Gartner Hype Cycle for Emerging Technologies, 2017.
Pasman, G. (2016). *Design fiction as a service design approach.* Paper presented at the Service Design Geographies. Proceedings of the ServDes. 2016 Conference.
Perks, H., Cooper, R., & Jones, C. (2005). Characterizing the role of design in new product development: An empirically derived taxonomy. *Journal of product innovation management, 22*(2), 111-127.

Pettersson, I. (2017). Travelling from fascination to new meanings: Understanding user expectations through a case study of autonomous cars. *International Journal of Design, 11*(2).
Pettersson, I., & Karlsson, I. M. (2015). Setting the stage for autonomous cars: a pilot study of future autonomous driving experiences. *IET intelligent transport systems, 9*(7), 694-701.
Pettersson, I., Rydström, A., Strömberg, H., Hylving, L., Andersson, J., Klingegård, M., & Karlsson, M. (2016). *Living room on the move: autonomous vehicles and social experiences.* Paper presented at the Proceedings of the 9th Nordic Conference on Human-Computer Interaction.
Pfleging, B., Rang, M., & Broy, N. (2016). *Investigating user needs for non-driving-related activities during automated driving.* Paper presented at the Proceedings of the 15th international conference on mobile and ubiquitous multimedia.
Pheng, L. S., & Hou, L. S. (2019). Research Design and Methodology. In *Construction Quality and the Economy* (pp. 89-111): Springer.
Pollmann, K., Stefani, O., Bengsch, A., Peissner, M., & Vukelić, M. (2019). *How to Work in the Car of the Future? A Neuroergonomical Study Assessing Concentration, Performance and Workload Based on Subjective, Behavioral and Neurophysiological Insights.* Paper presented at the Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems.
Pomering, A., & Frostling-Henningsson, M. (2014). ANTHROPOMORPHIC BRAND PRESENTERS. *Brand Mascots: And Other Marketing Animals*, 141.
Poynor, R. (2003). *No more rules: graphic design and postmodernism*: Yale University Press.
Poynor, R. (2005). Art's little brother. *Icon Eye, 23*. Retrieved from https://www.iconeye.com/icon-023-may-2005/arts-little-brother-icon-023-may-2005
Raghavan, B., & Ma, J. (2011). *Networking in the long emergency.* Paper presented at the Proceedings of the 2nd ACM SIGCOMM workshop on Green networking.
Raven, P. G., & Elahi, S. (2015). The New Narrative: Applying narratology to the shaping of futures outputs. *Futures, 74*, 49-61.
Reeves, S. (2012). *Envisioning ubiquitous computing.* Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.
Reid, S. E., & de Brentani, U. (2012). Market vision and the front end of NPD for radical innovation: The impact of moderating effects. *Journal of product innovation management, 29*, 124-139.
Reilly, T. (1996). The St. Petersburg-Tampa airboat line: 90 days that changed the world of aviation. *Tampa Bay History, 18*(2), 4.
Ryan, M.-L. (1980). Fiction, non-factuals, and the principle of minimal departure. *Poetics, 9*(4), 403-422.
SAE. (2017). Automated driving. Retrieved from https://www.sae.org/misc/pdfs/automated_driving.pdf
Sanders, E. B.-N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. *Co-design, 4*(1), 5-18.
Saunders, M. N., Lewis, P., Thornhill, A., & Bristow, A. (2015). Understanding research philosophy and approaches to theory development.
Sauro, J. (2011). Measuring usability with the system usability scale (SUS). In.

Schoettle, B., & Sivak, M. (2014). A survey of public opinion about autonomous and self-driving vehicles in the US, the UK, and Australia.
Schön, D. A. (1987). Educating the reflective practitioner.
Selloni, D. (2019). *Educating the Next Generation of Social Innovators. Lessons Learnt from a Series.* Paper presented at the Project and Design Literacy As Cornerstones of Smart Education: Proceedings of the 4th International Conference on Smart Learning Ecosystems and Regional Development.
Simon, H. A. (1973). Does scientific discovery have a logic? *Philosophy of science, 40*(4), 471-480.
Simon, H. A. (2019). *The sciences of the artificial*: MIT press.
Singla, V., & Aggarwal, N. (2016). Examining the Effect of Emotions Associated with Colour of Logo on Brand Perceptions. *Amity Journal of Marketing, 1*(1), 20-31.
Šnajdar, T. (2020). History of Travelling: How people started to travel. Retrieved from https://culturetourist.com/cultural-tourism/history-of-travelling-how-people-started-to-travel/
Sterling, B. (2005). Shaping Things. Mediawork Pamphlet Series. In: MIT Press, Cambridge, MA.
Sterling, B. (2013a). Fantasy Prototypes and Real Disruption.
Sterling, B. (2013b). Patently untrue: fleshy defibrillators and synchronised baseball are changing the future. Retrieved from https://www.wired.co.uk/article/patently-untrue
Stokes, S. L. (1991). *Controlling the future: Managing technology-driven change*: QED Information Sciences.
Stolterman, E. (2008). The nature of design practice and implications for interaction design research. *International Journal of Design, 2*(1).
Suckiel, E. K. (1982). The pragmatic philosophy of William James.
SuperFlux (Writer). (2015). Uninvited Guest. In.
Tanenbaum, J. (2014). Design fictional interactions: why HCI should care about stories. *Interactions, 21*(5), 22-23.
Tanenbaum, J., Tanenbaum, K., & Wakkary, R. (2012). *Steampunk as design fiction.* Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.
Tashakkori, A., & Teddlie, C. (2010). Putting the human back in ‘‘human research methodology’’: The researcher in mixed methods research. In: Sage Publications Sage CA: Los Angeles, CA.
Taura, T., & Nagai, Y. (2011). Discussion on direction of design creativity research (Part 1)-New definition of design and creativity: Beyond the problem-solving paradigm. In *Design creativity 2010* (pp. 3-8): Springer.
Tharp, B. M., & Tharp, S. M. (2009). The 4 Fields of Industrial Design:(No, not furniture, trans, consumer electronics and toys).”. *Core77*.
Tomiyama, T. (2006). *A classification of design theories and methodologies.* Paper presented at the ASME 2006 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference.
Tonkinwise, C. (2014). Design Studies—What Is it Good For? *Design and Culture, 6*(1), 5-43.
Transport, D. f. (2018). *Reported road casualties in GreatBritain: quarterly provisional estimates year ending June 2018*. Retrieved from

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754685/quarterly-estimates-april-to-june-2018.pdf
Ulrich, K. T., & Eppinger, S. D. (2016). *Product design and development* (Sixth ed.). New York, NY: McGraw-Hill Education.
Väänänen, N., Pöllänen, S., Kaipainen, M., & Vartiainen, L. (2017). Sustainable craft in practice: From practice to theory. *Craft Research, 8*(2), 257-284.
Venkatesh, V., Davis, F., & College, S. (2000). Theoretical acceptance extension model: Field four studies of the technology longitudinal. *Management science, 46*(2), 186-204.
Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management science, 46*(2), 186-204.
Verberne, F. M., Ham, J., & Midden, C. J. (2012). Trust in smart systems: Sharing driving goals and giving information to increase trustworthiness and acceptability of smart systems in cars. *Human factors, 54*(5), 799-810.
Vermaas, P. E. (2014). Design theories, models and their testing: on the scientific status of design research. In *An anthology of theories and models of design* (pp. 47-66): Springer.
Volkswagen. (2018). The Volkswagen I.D. Family. The future of Volkswagen Electric Mobility.

. Retrieved from https://www.volkswagen.co.uk/about-us/concept-cars/volkswagen-id
Volvo. (2016). Drive Me, the world's most ambitious and advanced public autonomous driving experiment, starts today. Retrieved from https://www.media.volvocars.com/global/en-gb/media/pressreleases/196240/drive-me-the-worlds-most-ambitious-and-advanced-public-autonomous-driving-experiment-starts-today
Voros, J. (2017). Big History and Anticipation: Using Big History as a framework for global foresight. *Handbook of anticipation: Theoretical and applied aspects of the use of future in decision making*.
WHO, W. H. O. (2018). *The top 10 causes of death*.
Wiltse, H., & Stolterman, E. (2010). *Architectures of interaction: an architectural perspective on digital experience.* Paper presented at the Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries.
Wolmar, C. (2019). *A Short History of Trains*: Dorling Kindersley Ltd.
Wright, T. J., Samuel, S., Borowsky, A., Zilberstein, S., & Fisher, D. L. (2016). *Experienced drivers are quicker to achieve situation awareness than inexperienced drivers in situations of transfer of control within a Level 3 autonomous environment.* Paper presented at the Proceedings of the Human Factors and Ergonomics Society Annual Meeting.
Yagoda, B. (2000). *Will Rogers: a biography*: University of Oklahoma Press.
Yang, J., & Coughlin, J. (2014). In-vehicle technology for self-driving cars: Advantages and challenges for aging drivers. *International Journal of Automotive Technology, 15*(2), 333-340.
Yin, R. K. (2017). *Case study research and applications: Design and methods*: Sage publications.
Young, J. O. (2019). Literary Fiction and the Cultivation of Virtue. *Croatian Journal of Philosophy, 19*(56), 315-330.
Young, L. (2015) *Interview: Liam Young on Speculative Architecture and Engineering the Future*. nextnature.net.

Young, S. J. (2003). Design of an agricultural driving simulator for ergonomic evaluation of guidance displays.

Zimmerman, J., & Forlizzi, J. (2008). The role of design artifacts in design theory construction. *Artifact: Journal of Design Practice, 2*(1), 41-45.

Zimmerman, J., Stolterman, E., & Forlizzi, J. (2010). *An analysis and critique of Research through Design: towards a formalization of a research approach.* Paper presented at the proceedings of the 8th ACM conference on designing interactive systems.

Appendices

Appendix A

Market Analysis: Benchmarking

Mercedes Vision URBANETIC: The mobility of the future.

Mercedes-Benz introduces a revolutionary mobility design that goes way beyond existing ideas on Autonomous Vehicles. Vision URBANETIC is a fusion between people driving and goods transport. Accomplish the needs of cities, businesses from diverse divisions. Mercedes claims that this concept reduces inner-city infrastructures, contributes to an improved quality of urban life, and reduces traffic flows.

Mercedes Benz is developing within the autonomous driving market and has made an effort into making the interior comfortable for the passengers. It is a carriage looks similar to a pod with wheels, slightly out on the edges that measure 3.7 m in length, and it has a volume of 10 cubic metres. This car has enough room for 12 people sat in a 360-degree arrangement and is geared towards ride sharing. High-resolution screens display vehicle destination and other information. With a modernistic external design that reflect the futuristic city lines. While a powerful onboard computer plans route guidance according to the stops needed for deliveries or passenger collection, and this processing power also means route updates and revisions are made in an instant to avoid potential hold-ups. The vehicle can also communicate with its surrounding with the help of LED lights on the front and rear end (Mercedes-benz.com, 2018).

The AKKA “LINK & GO” Concept Vehicle

AKKA Technologies is a European Engineering and Technology Consultancy Group that proposes technical services to major industrial clients. The self-driving electric concept car

designed for urban environment called Link & Go. The AKKA mission is to reduce the environmental impact of urban transport. The car is small to its size and has hexagon shaped doors that opens sideways for easy access. it been designed to fit for four-seat modular interior that can be transformed into a lounge environment when the car in self-driving mode. The front seats are rotatable 180 degrees, and central touchscreen that controls driving modes, navigation. The rear seats are merged looking like a sofa. The steering wheel is adjustable inside the instrument panel to provide extra space. to enhance the shared environment between the four passengers a lounge screen can be controlled by gesture and touch recognition systems has been provided on the upper side panel to provide entertainment (AKKA-technologies.com, 2013).

The Volkswagen I.D. CROZZ

I.D. CROZZ is a highly automated electric car that will travel 400 to 600 kilometres on a single battery charge. With its iconic, modern design, this car is considered as revolutionary; it has the potential to make history as the Beetle was seven decades ago, which maintained as one of the world's most successful cars of all time. With its impressive electric range, it has been composed to be a compact all-rounder that will help to make electric vehicles the 'everyday' choice. The new I.D. is a prototype between an SUV and a four-door coupé that Volkswagen has further developed. The I.D. CROZZ offers a powerful, sharp form, with a wide bonnet, clearly contoured wing panel and a high gloss back roof surface. The I.D. CROZZ has a liberal amount of room and highly flexible seating concept and no B-pillars, the large pivoting and sliding doors can open wide, allowing the driver to transport even a cyclocross bike easily. The air conditioning system guarantees that the air in the interior is always pleasant to breathe, regardless of the environmental conditions. The car has also featured a new voice assistant

recognition that can open and close the doors with a simple spoken command (Volkswagen, 2018).

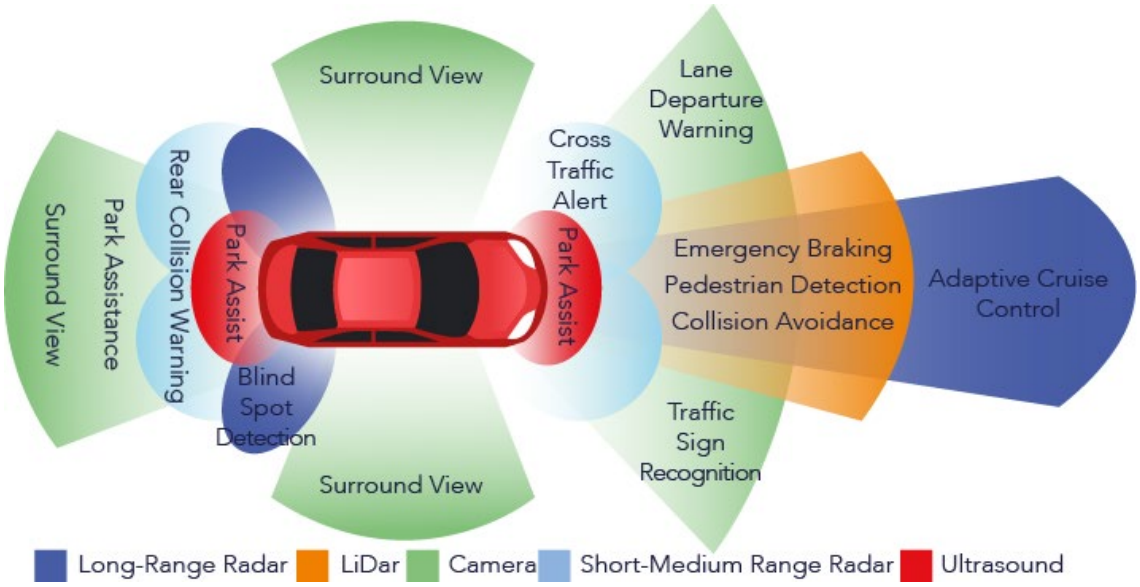
Appendix B

The Basic Functions to Achieve a Capable Autonomous Vehicle

Many autonomous features can be found in most recent vehicles such as an Anti-Lock Braking System (ABS) and Cruise Control (CC). These functions already have many advanced features that could take over the driving process. However, this technology maintains a specified distance between conventional and autonomous driving. The following points are going to justify what distinguishes the functionality of the autonomous vehicle from the conventional ones.

1- Navigation System (NAVI) is essentially a path planner that precisely forms and recalculates a digital map that covers information about projected routes such as road types, directions, and weather forecasting. The current system provides vehicles with comprehensive route planning using a Global Positioning System (GPS). In Autonomous Vehicles, the navigation Sys. is supported by integrating a vehicle-to-vehicle (V2V) connection. V2V describes the continuing transfer of data between vehicles via communication systems, and it can identify critical and dangerous conditions at an early stage and collect the necessary safety information within a fraction of a second (Heutger, Kückelhaus, Zeiler, Niezgoda, & Chung, 2014)

2- Situational Analysis monitors the environment while the vehicle is running to assure that the system is aware of all surrounded objects and their movements such as vehicles, pedestrians, traffic signs, using visual image verification techniques. Additional techniques supporting this include Radars and Ultrasonic Sensors. These components are responsible for tracking the location of all moving vehicles in a fixed area and detecting any obstacles in their way by creating electromagnetic waves and ultrasonic waves. Where visual image recognition operates on good weather, radar, and ultrasonic technology work efficiently in challenging weather conditions such as fog or heavy rain. Moreover, LIDAR (light detection and ranging) is an additional system using a remote sensing technology, employing laser pulses (optical detection) instead of electromagnetic waves, creating a rapid series of 360° contours. Figure 6 illustrates the coverage of different sensors. LIDAR is considered as one of the particular recognition technologies that make autonomous driving possible (Heutger et al., 2014)



3- Motion Planning recognises the vehicles movements, using sensors that require an exact course of motion within a defined period. It assures that the moving vehicle remains in its lane continuously and moves in the right direction to avoid clashes with the static or dynamic objects that are recognised by the Situational Analysis. The current position of the vehicle defines the direction, therefore decisions have to proceed within adapting speed and direction, which are based on a series of variables (Heutger et al., 2014)

4- Trajectory control is about the performance of pre-planned changes in speed and direction, while observing and maintaining driving stability. The autonomous system performs the actions in accelerating, braking and in adjustments of the steering wheel. Driving stability is scaled by comparing the actual with the expected changes that occur after a speed or direction intervention. However, if there is a high deviation between the expected and actual changes, the autonomous system adjusts to return to a stable driving mode (Heutger et al., 2014).

Appendix C

Automobile expert

Questions:

- How will we get to the self-driving future? Will it be the current approach of most carmakers, which involves adding the different feature at a time and offering another element over the previous function until eventually, we reach a fully autonomous?
- What are the safety requirements we need to consider accomplishing acceptable SDC design?
- What are our limitations in terms of redesign a car? What are the main features we need to keep?
- Are there any limitations regarding the positioning of the steering wheel? Can we apply a screen across the whole instrument panel for example?
- Are there any restrictions in terms of positioning of the seats?
- Is it possible from a safety perspective to implement rotating seats?
- Is there a possibility to extend the panoramic roof in the longitudinal direction? What are the consequences?

Interior expert question

Questions:

- How can we make the most of the interior space for the car?
- How can we reflect the senses like haptic?
- Are there any restrictions in terms of positioning of the seats?
- Is it possible from to implement rotating seats with multi-function for the suggested space?
- What kind of light you would recommend for a car with a panoramic roof?

Automobile expert interview transcript:

This interview started with a presentation regarding Autonomous Vehicles, and the recent vision concepts car by famous companies, like Mercedes Benz, and General Motors. This transcript will refer to the interviewee as AD (stands for Automobile Designer), and the interviewer as the researcher.

Researcher: Thanks for accepting my invitation to discuss with you the concept of driverless cars and get your opinion about some requirements. This interview will be recorded, and it is protected under the UK Data Protection Act 2018, am happy to take your question any time and would share the results of this research with you.

AD: no problem at all and am willing to share my knowledge with you to help you fulfill your research goal.

Researcher: Thank you so much. I would start with the presentation and following I will start my questions. Researcher: As you have seen in the presentation too many companies like Tesla has presented driverless car in a more utopian vision which is I think does seem unrealistic and far to accomplish because not everyone would be able to afford a smart car, as well I think to have such system other cars on the street must have a level of automation to allow a level of interaction with other cars. What do you think how will we get a self-driving car in the future? Is it going to be a gradually change?

AD: Yeah, self-driving cars have a fascinating concept. A breath taking one. And yes, as you said Tesla as one of the pioneers in the industry did present far vision to driverless cars, this comfortable and fantasy ride is not anytime nearby unless if the car driving alone in a specific track and has a well-developed machine learning system. The transformation towards the technology should have more time being experienced. We are developing this kind of automation because we need it, it will make too many people mobility easier, will reduce traffic, but before using driverless car issues like how the car interact with passengers, other cars, pedestrian all these issues must be solved. Some regulations must be changed to allow these cars on the streets. Once we sort these issues, the form we are going to present will be already developed to meet the user needs. Can you explain what do you mean by gradually change?

Researcher: I mean like would it be a car modification like adding different feature at a time and offering another element over the previous function until eventually, we reach a fully autonomous?

AD: you know we already have semi-autonomous cars, and it is always good to use the features some company adds to their car like ford with their parking assistance, or Mercedes replacing mirrors with cameras, Tesla, and sensors. So, these features already part of driverless cars and are in use on the current cars. They do help to decrease the driver involvement and increase the car control. Answering your question, yes, we are moving gradually to reach a full autonomous car.

Researcher: that sounds interesting! And I think the safety issue will lead the driverless existence, what are the safety requirements we need to consider accomplishing acceptable driverless car design?

AD: safety requirements have different aspects because we have different factors could change the whole concept I don't know if you heard before of trolly dilemma, it is about a classical clash where the decision you make can change the whole scenario, so there will be

always a difficulty regarding the decision the car could take! because we as a driver have a certain level of consideration the machine need much training to understand. I believe the most important thing is to ensure the user of the car that they can take control at any time they wish to. Yes, this means you should have a license to drive a driverless car.

Researcher: Yeah, I think that could be a limitation for the time being, so probably a deep training can change the concept. What are our limitations in terms of redesign a car? What are the main features we need to keep?

AD: Okay! That take us back to your question if the changes should be gradually presented. The future vision of a driverless car should reflect the car purpose. There is an interesting future car concept called IDEO[7], it is a four seated car, each seat has it is own head cover, with transparent doors and windows, you see such design show how independent and relaxed the ride can be, it is quite interesting design, but it has some concerns regarding the safety, out of experience I find the head cover could be an issue while entering and existing the car. The transparent door might cause a privacy issue. But on the other hand, the concept kept the steering wheel and that would overcome the fears towards controlling the car, the hight of the car is suitable maybe for elderly passenger as they might not need to bend to get in. and so on. I think some elements need to be there such as the seatbelt, the ability to get in and out in the easiest way, and most importantly enough room for each passenger and the driver.

Researcher: Brilliant! So, keeping on mind the purpose of using the car must be a main factor while designing an autonomous car. But like for the seats are there any restrictions in terms of positioning of the seats? Is it possible from a safety perspective to implement rotating seats?

AD: Yes, for the current regulations and driving habits both front seats must keep facing the front, and you know you still can adjust the back position and the leg room but facing the front view. But for future cars and if we assume all cars are going to be smart cars on the road, I do not see any limitation of rotating the seats, this encourages some social activities. But this must be done in a way will not be a problem with other passengers' comfort and safety. Actually, Mercedes URBANETIC driverless concept has a living room seating structure, which is quite interesting. It allows social activity and different things to be done as a group while riding.

Researcher: Yeah, I have seen that, and there is another company called Next Future Transportation are already taking steps to make transportation systems and seating position more towards future usage. It will be really amazing to try such car. Moving from the seats position the panoramic roof. Is there a possibility to extend the panoramic roof in the longitudinal direction? What are the consequences?

AD: Yes, few companies like Ford, Jaguar, Peugeot and many more already have panoramic sunroofs. it makes the car more expensive because the material that some manufacturer using, the potential of being creative with this type of roof, more style, it is nice addition. But as far it is not causing any dims or light issue inside the car, then it's futuristic and quite in style.

[7] https://automobility.ideo.com/preface/intro

Researcher: Fabulous! Just before we finish this interview just wanted to ask about the front seat position why it is not allowed for the front passenger to rotate their seat?

AD: because it might cause a distraction for the driver.

Researcher: Okay! That sounds clear. Thank you so much for your time and comments. It is much appreciated.

AD: Thank you and best of luck with your work.

Appendix D

Survey Questions

Section 1: Demographic Data

1. **Gender:** Male ☐ Female ☐
2. **Age:** ☐ 18-24 ☐ 25-40 ☐ 40-60 ☐ 60+
3. **Ethnicity** ☐ White ☐ Asian ☐ Hispanic or Latino ☐ Black or African ☐ Prefer Not to say
4. **Marital Status:** ☐ Single ☐ Married ☐ Widow ☐ Divorced ☐ Separated ☐ Prefer Not to say
5. **Do You live in the UK?** ☐ Yes ☐No
6. **What is your total household income?** ☐Less than £10,000 ☐£10,000 to £19,999 ☐£20,000 - £50,000 ☐£50,000 - £100,000 ☐£100,000 - £200,000 ☐More than £200,000 ☐Prefer not to say
7. **Employment Status: Are you currently…?** ☐Employed Full-Time ☐Employed Part-Time ☐Seeking opportunities ☐Student ☐Retired ☐Prefer not to say
8. **Education: What is the highest degree or level of school you have completed? If currently enrolled, the highest degree received. *** ☐No schooling completed ☐Some High School ☐Bachelor's degree ☐Master's degree ☐Professional degree ☐Doctorate degree
9. **Including yourself, how many people live in your household**? ☐1-2 ☐2-5 ☐6-8 ☐9+
10. **Do you have a driving license?** ☐ Yes ☐No
11. **Do you own or lease a vehicle?** ☐ Yes ☐No
12. **How many hours do you spend travelling every day? (Whether to work, University, Home, or any other destination) *** ☐Less than 1 hour ☐2-3 hours ☐4-6 hours ☐7 + hours
13. **How do you usually commute to work*** ☐Your own car ☐By bus ☐By train ☐Pool car (a car you share with other passengers) ☐Taxi ☐Cycling ☐Walk☐Other
14. **How do you usually travel for leisure?** ☐Your own car ☐By bus ☐By train ☐Pool car (a car you share with other passengers) ☐Taxi ☐Cycling ☐Walk☐Other
15. **do you consider yourself an early adopter, eager to try new technologies?** ☐ Yes☐No ☐Maybe
16. **do you have little or no interest in new technologies?** ☐ Yes ☐No ☐Maybe
17. **Do you view cars as basic transport?** ☐ Yes ☐No ☐Maybe
18. **I would enjoy driving a** car ☐ Yes ☐No ☐Maybe
19. **I would prefer to be the driver rather than the passenger** ☐ Yes ☐No ☐Maybe
20. **I like to use technology to make tasks easier** ☐Strongly agree ☐Agree ☐Neutral ☐Disagree ☐Strongly disagree
21. **How much have you heard about self-driving cars?** ☐A lot ☐Some ☐Not much ☐Non at all

Section 2:

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I think that I would like to use Self-Driving Car					
I needed to learn a lot of things before I could get going with this technology concept					
Self-Driving Cars are safe					
I would trust a self-driving car to get me to my destination					
People will need to watch self-driving cars closely to be sure the computers do not make mistakes					
I would be willing to pay more for a self-driving car compared to what I would pay for a traditional car					
The benefits of a self-driving car would outweigh the amount of money it would cost					
The cost of a self-driving car would be the most important thing I would consider before purchasing one					
I do not think computers should be driving cars]					
It is important for a human to be able to take back control from a self-driving car]					
Self-driving cars can operate in the same lanes as normal traffic					
I would support a public bond measure to build new infrastructure, such as special lanes, or traffic signals for self-driving cars					
Self-driving cars will reduce traffic problems					
If self-driving cars become widely adopted, I would not buy a car I would use a share pool car					
I would like to own a self-driving car					
If I own a self-driving car, I will make it a share pool					
In a self-driving car, it will be important for me to have the option to turn off the computer and drive					

Section 3:

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I would like to own a self-driving car					
A self-driving car would allow me to be more productive					
Self-driving cars will be easy to use					
Even if I had a self-driving car, I would still want to drive myself most of the time					
In a self-driving car, it will be important to me to have the option to turn off the computer and drive					
It would take me a long time to figure out how to use a self-driving car					
I believe technology is more accurate than humans, therefore driving process will be safer using self-driving cars.					
I sense using a driverless car would reduce driver stress and improve driving performance.					
I foresee that a driverless car would enhance the mobility of people regardless of their age, skill, and ability.					
I think it would be easy for me to become skilful at using a driverless vehicle.					
I found the various functions in Archer were well integrated					
I thought there was too much inconsistency in this concept					
I would imagine that most people would learn to use the car very quickly					
I found the proposed concept “Archer” very smart, future oriented, and encourage me to think about having or trying a driverless car					
I need to learn a lot of things before I could get going with this technological concept					
There are some driving scenarios that will be too difficult for a self-driving car technology to handle					
I would purchase a self-driving car once the technology is fully developed					
I would purchase a self-driving car that has same features as Archer					

Appendix E

Design of interior for a self-driving car: Propose a conceptual design from a Body & Trim perspective that can be implemented in future self-driving cars (Filo & Lubega, 2015). User needs conversion table.

Question /Prompt:	**Typical customer statement(s):**	**What the system should deliver:**
What is for you the most difficult thing when driving very far?	• I get uncomfortable in my back. • I have problems with being alert long distances. • I get very bored • I feel pain in my muscles	• **Provide space for comfortable seating position**
What would you like to do in the car if it would be self-driven?	• I would work with my laptop. • Have a meeting with co-workers. • I would definitely watch movies. • Have a cup of coffee • Eat my dinner on the way home from work • Interact and play games with others. • Definitely, sleep! • I would like to paint my nails and do my makeup. • I would pay my bills, text message friends, check my emails and make calls. • I would want to have my own space and as well be able to have wide view so I do not feel isolated. • Read my favourite book • I would love to have a place where I can store my jacket and bags and stuff.	• **Every passenger should be able to watch their own movies/programs.** • **Provide placement for food and drink for every passenger.** • **Enable every passenger to have comfortable sleeping position** • **Enable face-to face meetings between front and rear passengers.** • **Provide table interaction activities.** • **Enable wide view for every passenger.** • **Provide spacious interior** • **Things that is not used should be non-visible** • **Provide place for storage of goods in the interior.** • **Is easy to clean**

Do you believe that you can fully relax during the drive without worrying about the safety aspect? Why?	• In the initial stage, no! I would like some form of warning. Before e.g. sharp turns. • I won't be able to entrust technology with my life! I want to be able to take control in case of anything. A camera overview of the outside would be good. • No, can be exposed to cyber-attacks, however trust will come with time. • On motorways yes, but in urban traffic, No! Something else needs to catch my interest so I can relax.	• **Warn/alert the passenger ahead of time if any situation might occur.**
Would you consider to have a steering wheel or not even if is not needed?	• Yes, definitely. It could be cool if it was movable • Yes, like a joystick or something. • Yes, to control and take over in case of anything. • Initially, it is important but with time we might do without.	• **Car has a steering function, pedals and parking function.**
For privacy sake, would you prefer concealed windows or have like a "curtain" function where you can choose?	• When I have a meeting or when I am watching movies I would prefer concealed but not at all times, so a curtain function should be good. • I want to choose myself. This would be cool with some type of transparency change.	• **Enable to control transparency on windows**
	• Definitely a curtain function. It is good to have privacy of course but it is also good to be seen by people. Seeing people is a sign of life. This is very important when driving for a long time on highways.	

Appendix F

Concept generation details:

Bright Concept

Ideas	Benefit:
Instrument panel is thinner and has a panoramic shape	Free up more space in the front part of the car.
Heads up display (HUD)	Provide large view and display to different functions.
Windscreen on A pillars.	enable wider view for front passengers
Smart Light lines on the in car sides	Allow passenger more control on the dim
Screen on the instrument panel	support connectivity between passengers through their smart table
Smart screen on the middle table	Smart Table Between the rear seats. Can be place in the middle of the car for different such as games or watching a movie with its smart screens.
Slide doors open with hand gesture	Ease the burden of using physical power
Steering wheels	Futuristic design steering wheel. To enable you to operate the car if you wish to.
A bucket seat	Seat one person and can be adjusted individually, each seat has a heating and ventilating mechanism built inside the seat to create a warm and cool area for the legs, Thighs, and back.
Ability to change window transparency	Each passenger has the choice to change window transparency by their side individually.
The front seats are rotatable 180 degrees	allow face-to-face meetings. And more social atmosphere
Smart tray/table attached to each seat	enabling the passenger to monitor the car and also using it for entertainment.
Windscreen as a screen for virtual interaction.	permit the passengers to have a wider control.
3D sound technology	Allow privacy to each passenger
the middle section has been removed	to free up more space

Relax Concept

Ideas	Benefit
Self-emitting light style in Instrument panel, Door panel	provides relaxation in visible places.
Panorama roof with adjustable transparency	Enable natural light source in a convenient place
Windows with concealing option	enhance premium feeling.
Windows (touch)	Enable passenger to control the car. Entertainment
Windows glass with heat resisting glass.	Provide a cool environment in efficiency way
Seat with in-built pillow	Provide comfortable place and healthy headrest.
Seat structure 1-1-0-1-1	More room for all passengers
Front seat rotatable	Enable face to face meetings
Holographic screen in the middle	Provide visual for the passengers at a convenient place.
Foldable tables in door panel	Provide convenient component to place food, cups, or junk.
Footrest integrated in each seat	Enhance comfort for legs
Noise suppression	Provide a comfortable noise level inside the car

Social Concept

Ideas	Benefit
Seat structure 1-1-1-1-1	More room for each passenger. Allows wheelchair on board.
Cup holder.	Every passenger has their own food, drink, or junk space.
Charger in door panel.	Ease electric access.
Armrest with first class LED screen for every seat.	Every passenger has access to his or her own screen.
Middle seat handle can be used as interactive table.	Enhance the social atmosphere. Free the middle space
No steering wheel in the instrument panel	Replace it with table for front passenger.
Sound absorbing transparent wall	Provide a quiet interior

Appendix G

Survey data analysis

Ethnicity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		2	5.0	5.0	5.0
	Asian	5	12.5	12.5	17.5
	Black or African	5	12.5	12.5	30.0
	Dual Heritage English & Irish	1	2.5	2.5	32.5
	European	1	2.5	2.5	35.0
	Prefer not to say	2	5.0	5.0	40.0
	White	24	60.0	60.0	100.0
	Total	40	100.0	100.0	

Marital Status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Divorced	4	10.0	10.0	10.0
	Married or domestic partnership	23	57.5	57.5	67.5
	Separated	1	2.5	2.5	70.0
	Single	11	27.5	27.5	97.5
	Widowed	1	2.5	2.5	100.0
	Total	40	100.0	100.0	

Including yourself, how many people live in your household?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-2	20	50.0	50.0	50.0
	2-5	17	42.5	42.5	92.5
	6-8	2	5.0	5.0	97.5
	9+	1	2.5	2.5	100.0
	Total	40	100.0	100.0	

Section Two responses:

Please rank the following statements based on your preferences

		Criteria	Count	Table N %	Row N %
I think that I would like to use Self-Driving Car	Agree	IU	9	22.5%	100.0%
	Disagree		8	20.0%	100.0%
	Neutral		8	20.0%	100.0%
	Strongly Agree		12	30.0%	100.0%
	Strongly Disagree		3	7.5%	100.0%
I needed to learn a lot of things before I could get going with this technology concept	Agree	IU	19	47.5%	100.0%
	Disagree		3	7.5%	100.0%
	Neutral		6	15.0%	100.0%
	Strongly Agree		11	27.5%	100.0%
	Strongly Disagree		1	2.5%	100.0%
Self-Driving Cars are safe	Agree	T	11	27.5%	100.0%
	Disagree		6	15.0%	100.0%
	Neutral		17	42.5%	100.0%
	Strongly Agree		4	10.0%	100.0%

	Strongly Disagree		2	5.0%	100.0%
I would trust a self-driving car to get me to my destination	Agree	T	15	37.5%	100.0%
	Disagree		5	12.5%	100.0%
	Neutral		12	30.0%	100.0%
	Strongly Agree		4	10.0%	100.0%
	Strongly Disagree		4	10.0%	100.0%
People will need to watch self-driving cars closely to be sure the computers do not make mistakes	Agree	T	8	20.0%	100.0%
	Disagree		4	10.0%	100.0%
	Neutral		13	32.5%	100.0%
	Strongly Agree		15	37.5%	100.0%
I would be willing to pay more for a self-driving car compared to what I would pay for a traditional car	Agree	IU	10	25.0%	100.0%
	Disagree		6	15.0%	100.0%
	Neutral		17	42.5%	100.0%
	Strongly Agree		1	2.5%	100.0%
	Strongly Disagree		6	15.0%	100.0%
The benefits of a self-driving car would outweigh the amount of money it would cost	Agree	ATT	8	20.0%	100.0%
	Disagree		10	25.0%	100.0%
	Neutral		12	30.0%	100.0%
	Strongly Agree		3	7.5%	100.0%
	Strongly Disagree		7	17.5%	100.0%
The cost of a self-driving car would be the most important thing I would consider before purchasing one	Agree	ATT	7	17.5%	100.0%
	Disagree		10	25.0%	100.0%
	Neutral		11	27.5%	100.0%
	Strongly Agree		8	20.0%	100.0%
	Strongly Disagree		4	10.0%	100.0%
I do not think computers should be driving cars]	Agree	T	3	7.5%	100.0%
	Disagree		17	42.5%	100.0%

	Neutral		10	25.0%	100.0%
	Strongly Agree		6	15.0%	100.0%
	Strongly Disagree		4	10.0%	100.0%
It is important for a human to be able to take back control from a self-driving car]	Agree	T	9	22.5%	100.0%
	Disagree		4	10.0%	100.0%
	Neutral		7	17.5%	100.0%
	Strongly Agree		20	50.0%	100.0%
Self-driving cars can operate in the same lanes as normal traffic	Agree	PU	14	35.0%	100.0%
	Disagree		3	7.5%	100.0%
	Neutral		14	35.0%	100.0%
	Strongly Agree		8	20.0%	100.0%
	Strongly Disagree		1	2.5%	100.0%
I would support a public bond measure to build new infrastructure, such as special lanes, or traffic signals for self-driving cars	Agree	PU	11	27.5%	100.0%
	Disagree		5	12.5%	100.0%
	Neutral		11	27.5%	100.0%
	Strongly Agree		10	25.0%	100.0%
	Strongly Disagree		3	7.5%	100.0%
Self-driving cars will reduce traffic problems	Agree	PU	12	30.0%	100.0%
	Disagree		7	17.5%	100.0%
	Neutral		7	17.5%	100.0%
	Strongly Agree		10	25.0%	100.0%
	Strongly Disagree		4	10.0%	100.0%
If self-driving cars become widely adopted, I would not buy a car I would use a share pool car	Agree	ATT	4	10.0%	100.0%
	Disagree		15	37.5%	100.0%
	Neutral		15	37.5%	100.0%
	Strongly Agree		1	2.5%	100.0%
	Strongly Disagree		5	12.5%	100.0%

I would like to own a self-driving car	Agree	ATT	9	22.5%	100.0%
	Disagree		9	22.5%	100.0%
	Neutral		6	15.0%	100.0%
	Strongly Agree		10	25.0%	100.0%
	Strongly Disagree		6	15.0%	100.0%
If I own a self-driving car, I will make it a share pool	Agree	ATT	8	20.0%	100.0%
	Disagree		10	25.0%	100.0%
	Neutral		16	40.0%	100.0%
	Strongly Agree		3	7.5%	100.0%
	Strongly Disagree		3	7.5%	100.0%
In a self-driving car, it will be important for me to have the option to turn off the computer and drive	Agree	T	7	17.5%	100.0%
	Disagree		2	5.0%	100.0%
	Neutral		13	32.5%	100.0%
	Strongly Agree		17	42.5%	100.0%
	Strongly Disagree		1	2.5%	100.0%

Section Three responses:

Please rank the following statements based on your preferences

		Criteria	Table N %	Count	Row N %
I would like to own a self-driving car	Agree	IU	22.5%	9	100.0%
	Disagree		15.0%	6	100.0%
	Neutral		20.0%	8	100.0%
	Strongly agree		30.0%	12	100.0%
	Strongly Disagree		12.5%	5	100.0%
A self-driving car would allow me to be more productive		PU			
	Agree		32.5.%	13	100.0%
	Disagree		17.5%	7	100.0%

	Neutral		22.5%	9	100.0%
	Strongly agree		20.0%	8	100.0%
	Strongly Disagree		7.5%	3	100.0%
Self-driving cars will be easy to use	Agree		30.0%	12	100.0%
	Disagree		17.5%	7	100.0%
	Neutral	**PEU**	25.0%	10	100.0%
	Strongly agree		20.0%	8	100.0%
	Strongly Disagree		7.5%	3	100.0%
Even if I had a self-driving car, I would still want to drive myself most of the time	Agree		35.0%	14	100.0%
	Disagree		20.0%	8	100.0%
	Neutral	**IU**	27.5%	11	100.0%
	Strongly agree		15.0%	6	100.0%
	Strongly Disagree		2.5%	1	100.0%
In a self-driving car, it will be important to me to have the option to turn off the computer and drive	Agree		20.0%	8	100.0%
	Neutral		22.5%	9	100.0%
	Strongly agree	**IU**	55.0%	22	100.0%
	Strongly Disagree		2.5%	1	100.0%
It would take me a long time to figure out how to use a self-driving car	Agree		12.5%	5	100.0%
	Disagree		35.0%	14	100.0%
	Neutral	**PEU**	32.5%	13	100.0%
	Strongly agree		17.5%	7	100.0%
	Strongly Disagree		2.5%	1	100.0%
I believe technology is more accurate than humans, therefore driving process will be safer using self-driving cars.	Agree		30.0%	12	100.0%
	Disagree		17.5%	7	100.0%
	Neutral	**C**	30.0%	12	100.0%
	Strongly agree		15.0%	6	100.0%
	Strongly Disagree		7.5%	3	100.0%

I sense using a driverless car would reduce driver stress and improve driving performance.	Agree	PU	27.5%	11	100.0%
	Disagree		12.5%	5	100.0%
	Neutral		22.5%	9	100.0%
	Strongly agree		27.5%	11	100.0%
	Strongly Disagree		10.0%	4	100.0%
I foresee that a driverless car would enhance the mobility of people regardless of their age, skill, and ability.	Agree	PU	42.5%	17	100.0%
	Disagree		7.5%	3	100.0%
	Neutral		20.0%	8	100.0%
	Strongly agree		20.0%	8	100.0%
	Strongly Disagree		10.0%	4	100.0%
I think it would be easy for me to become skilful at using a driverless vehicle.	Agree	PEU	27.5%	11	100.0%
	Disagree		12.5%	5	100.0%
	Neutral		40.0%	16	100.0%
	Strongly agree		15.0%	6	100.0%
	Strongly Disagree		5.0%	2	100.0%
I found the various functions in Archer were well integrated	Agree	ATT	42.5%	17	100.0%
	Disagree		7.5%	3	100.0%
	Neutral		30.0%	12	100.0%
	Strongly agree		15.0%	6	100.0%
	Strongly Disagree		5.0%	2	100.0%
I thought there was too much inconsistency in this concept	Agree	ATT	22.5%	9	100.0%
	Disagree		35.0%	14	100.0%
	Neutral		30.0%	12	100.0%
	Strongly agree		7.5%	3	100.0%
	Strongly Disagree		5.0%	2	100.0%
	Agree	PEU	45.0%	18	100.0%
	Disagree		15.0%	6	100.0%

I would imagine that most people would learn to use the car very quickly	Neutral		25.0%	10	100.0%
	Strongly agree		15.0%	6	100.0%
I found the proposed concept “Archer” very smart, future oriented, and encourage me to think about having or trying a driverless car	Agree	ATT	40.0%	16	100.0%
	Disagree		12.5%	5	100.0%
	Neutral		15.0%	6	100.0%
	Strongly agree		22.5%	9	100.0%
	Strongly Disagree		10.0%	4	100.0%
I need to learn a lot of things before I could get going with this technological concept	Agree	PEU	20.0%	8	100.0%
	Disagree		22.5%	9	100.0%
	Neutral		30.0%	12	100.0%
	Strongly agree		22.5%	9	100.0%
	Strongly Disagree		5.0%	2	100.0%
There are some driving scenarios that will be too difficult for a self-driving car technology to handle	Agree	C	22.5%	9	100.0%
	Disagree		12.5%	5	100.0%
	Neutral		30.0%	12	100.0%
	Strongly agree		32.5%	13	100.0%
	Strongly Disagree		2.5%	1	100.0%
I would purchase a self-driving car once the technology is fully developed	Agree	IU	27.5%	11	100.0%
	Disagree		20.0%	8	100.0%
	Neutral		27.5%	11	100.0%
	Strongly agree		20.0%	8	100.0%
	Strongly disagree		5.0%	2	100.0%
I would purchase a self-driving car that has same features as Archer	Agree	IU	30.0%	12	100.0%
	Disagree		15.0%	6	100.0%
	Neutral		35.0%	14	100.0%
	Strongly agree		12.5%	5	100.0%
	Strongly Disagree		7.5%	3	100.0%

Appendix H

Wizard of Oz Data Analysis

Wizard of Oz Participants Demographic Summary

	1	2	3	4	5	6	7	8
Case Number	33	34	35	36	37	38	39	40
ID	1	2	3	4	5	6	7	8
Age	0	0	0	0	0	0	0	0
Gender	Male	Female	Female	Female	Female	Male	Male	Male
Ethnicity	Asian	Asian	Asian	White	White	Black or African	White	Asian
Marital Status	Single	Single	Married	Single	Divorced	Married	Married	Single
income	£20,000 - £50,000	Prefer not to say	£20,000 - £50,000	£20,000 - £50,000	Less than £10,000	Less than £10,000	£20,000 - £50,000	£20,000 - £50,000
Employment Status	Employed Full-Time	Prefer not to say	Prefer not to say	Employed Full-Time	Prefer not to say	Student	Employed Part-Time	Employed Full-Time
Education:	Bachelor's degree	Some High School	Some High School	Bachelor's degree	Some High School	Master's degree	Some High School	Bachelor's degree
Do you have a driving license?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Do you own or lease a vehicle?	Yes	No	Yes	Yes	No	No	Yes	No
Traveling Hours / day	Less than 1 hour	2-3 hours	Less than 1 hour	2-3 hours	Less than 1 hour	Less than 1 hour	Less than 1 hour	2-3 hours
How do you usually commute to work	By train	Your own car	Your own car	Your own car	Walk	By bus	Cycling	By train

How do you usually travel for leisure?	By Car	By Car	By Car	By Car	Taxi	By bus	By train	By train
Do you consider yourself an early adopter, eager to try new technologies?	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Do you have little or no interest in new technologies?	Yes	No	No	No	Yes	Maybe	No	No
Do you view cars as basic transport?	Yes	Yes	Yes	Yes	No	Yes	Yes	No
I would enjoy driving a car	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
I would prefer to be the driver rather than the passenger	Yes	Maybe	Yes	No	No	Yes	No	Yes
I like to use technology to make tasks easier	Agree	Agree	Agree	Neutral	Agree	Neutral	Strongly agree	Strongly agree
How much have you heard about self-driving cars?	Some	Some	A lot	Not much	Not at all	Not much	Some	A lot

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