MONASH University

Feeling in control: Designing the Melbourne bus user experience

Sarah Roberts. Industrial Design (Hons)

A thesis submitted for the degree of Doctor of Philosophy at
Monash University in the faculty of Art, Design and Architecture, 2019


VOLGREN
PT
ACCREDITED BUS SERVICE
VIC BOOO MR


PT
Route To
624 Kew
Hail Bus Here

For all the Robert[s] in my life

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Declaration

This thesis is an original work of my research and contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Sarah Roberts, October 2019

Abstract

Buses within the Melbourne, Australia, suburban environment are often negatively perceived. These perceptions are caused by a number of factors, with both vehicles and services broadly criticised as being less reliable, infrequent and less innovative compared to other transport modes. This project explores this topic area through a design enquiry lens and aims to discover how the problem of negative bus user experience in Melbourne suburban environments can be better understood and improved through design research and intervention. Gaps within the public transport (PT) literature identified the lack of holistic consideration and discourse for passenger experience, specifically within the local context of Melbourne, as well as a lack of evidence for how user-centred design (UCD) methods are applied in this context. These gaps provided the opportunity to explore this space through a UCD lens, with design-inclusive research (DIR) methodologies applied. This focus enabled the ability to understand user experiences qualitatively, and transfer and synthesise the findings into more UCD outcomes, as well as testing and evaluating concepts within alternative scenarios.

Three design ethnography (DE) studies – customer feedback data analysis, observations and travel diaries – were undertaken, resulting in control-based issues being identified as one of the main barriers to bus usage. The term control in the context of this work refers to passengers not being correctly informed about or not having the ability to change their travel environment. Design practice has been used to improve the issues associated with control, through a combination of app and on-board passenger information display (PID) concepts. Designs have been evaluated through virtual reality (VR) usability testing, providing concept validation, feedback and additional behavioural knowledge.

The application of novel design processes and the responses to the topic of bus user experience improvement have led to the development of three major contributions to bus and design knowledge:

1. Combined UCD framework and evidence applied within a Melbourne bus context.
2. Detailed representation of Melbourne's suburban bus user experience.
3. Proposals for a bidirectional digital interface to enhance control experience for bus users within the Melbourne environment.

These contributions to knowledge have been built from existing literature and developed based on the study findings and synthesis. This research demonstrates how user experiences, perspectives and interactions can be understood and improved through design research and interventions.

Acknowledgments

Firstly I would like to acknowledge and thank my supervisors Dr Robbie Napper, Associate Professor Selby Coxon and Dr Ilya Fridman for all their tireless support, guidance and feedback throughout both my undergraduate and PhD candidature. It's safe to say that I would not be the designer, researcher or public transport enthusiast I am today without each of their influence. Thank you all!

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I acknowledge Transdev, my industry supervisors, for providing financial support, industry data and knowledge surrounding the project topic. As well as allowing me the freedom to pursue my own interests.

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I acknowledge professional accredited editor Mary-Jo O'Rourke AE who provided copyediting and proofreading services according to the university-endorsed national Institute of Professional Editors (IPEd) 'Guidelines for editing research theses' (IPEd 2019). Thank you for all your help.

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List of publications

Fridman, I, Napper, R, & **Roberts, S** 2018, 'Data co-synthesis in developing public product service systems', *CoDesign*, vol. 14, pp.1–17.

Roberts, S, Napper, R & Coxon, S 2017, 'Issues and design factors concerning outer Melbourne bus vehicle design: A literature review', *paper presented at the 37th Australasian Transport Research Forum*, 27–29 November, Auckland, New Zealand.

Roberts, S, Napper, R & Coxon, S 2018, 'A new way to design buses: A methodological framework for the front end of design', *paper presented at the 38th Australasian Transport Research Forum*, 20 October–1 November, Darwin, Australia.

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Terminology and abbreviations

CFD	Customer Feedback Data
CSR	Customer Satisfaction Report
DoT	Department of Transport
HCI	human–computer interaction
ICT	information and communication technologies
ITS	intelligent transportation system
MaaS	Mobility as a Service
PID	passenger information display
PT	public transport
PTUA	The Public Transport Users Association
PTV	Public Transport Victoria
RTI	real-time information
VR	virtual reality
Transdev	a Melbourne bus operator

User: The term ‘user’ is applied in this research to refer to current and potential bus passengers. ‘Customer’ and ‘passenger’ replace the term when specific industry terminology is required, for example the customer satisfaction report.

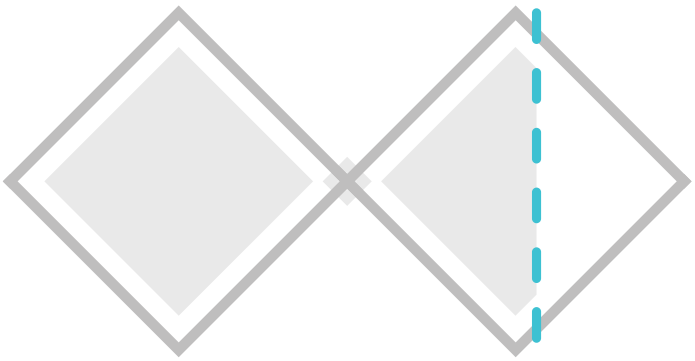


Figure 0.1: Double diamond diagram adapted from Design Council (2007)

The double diamond diagram, shown in Figure 0.1, is positioned at the beginning of each chapter to sign post the readers location within the design process. The diagram includes a blue line to indicate the readers current location, as well as a grey section to indicate the stages previously undertaken. For further information concerning the diagram and how it fits within this project’s context please see Section 3.4 Research Methodology. The following Figures 0.2 and 0.3 show the bus component and bus journey terminology that will be referenced throughout this document.

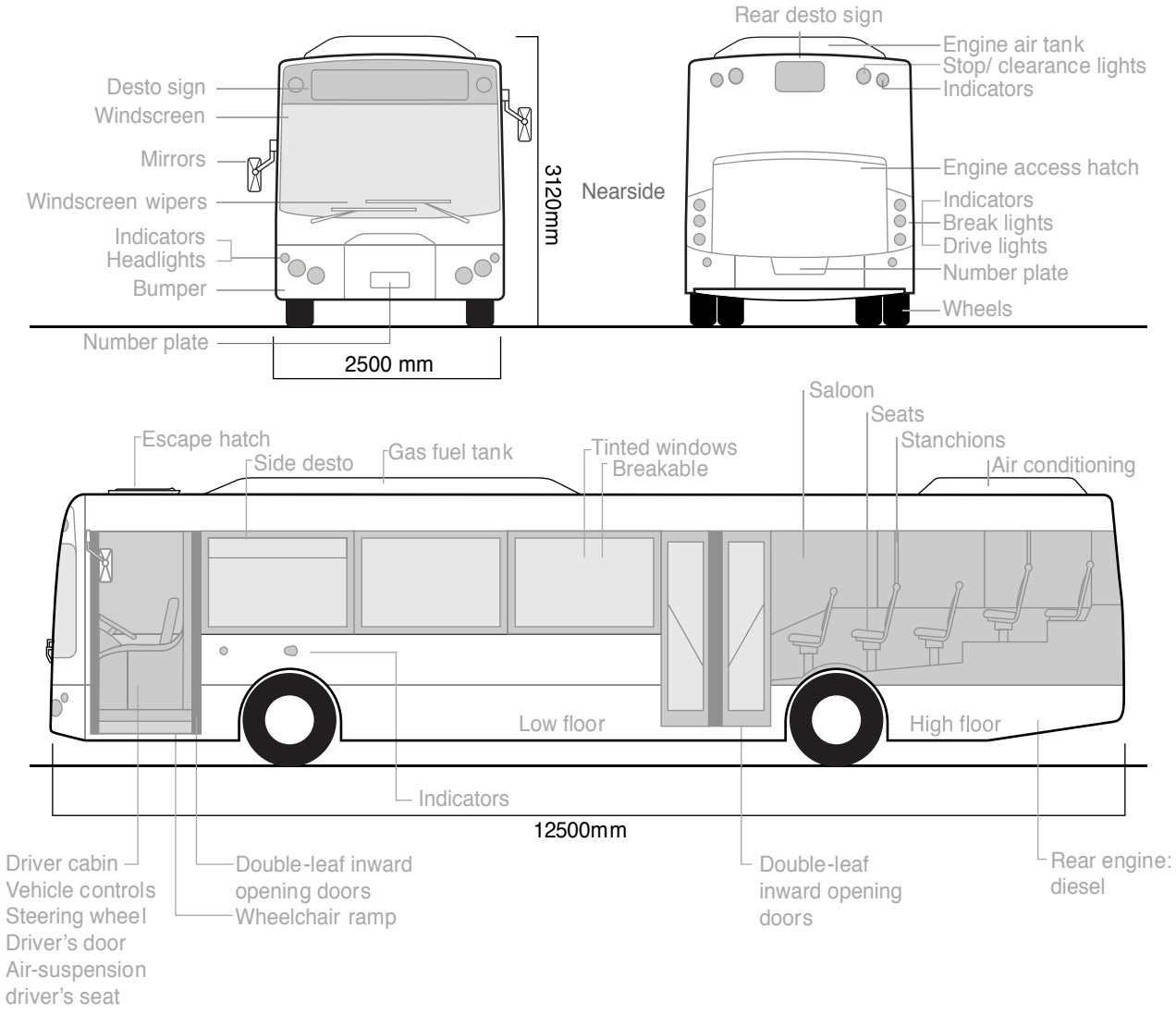


Figure 0.2: Bus vehicle terminology

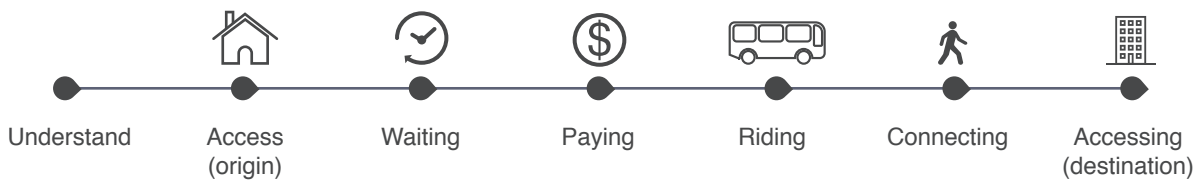
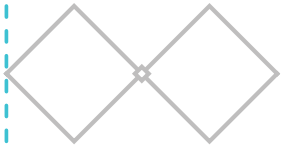


Figure 0.3: General bus user journey, adapted from (Walker 2012)

Chapter 1
Introduction



The foundation of public transport operation, as described by Walker (2012 p.13) consists of the delivery of "regular scheduled vehicle trips, open to all paying passengers, with the capacity to carry multiple passengers whose trips may have different origins, destinations and purposes". These services must be developed so multiple users' trip requirements are met simultaneously (ibid.). Answering these requirements is considered a complex task, requiring multiple stakeholders, assets and systems to achieve. Additionally, the buses, as with all public transport, serve a broad demographic, resulting in a diverse user group with differing travel needs and expectations that add to the complexity of bus delivery. Positive service quality is required in order to deliver successful journey experiences that encourage returning users and attract new ones, with operators working to deliver both accessible and satisfactory services which operate at an acceptable quality (Disney 1998).

Unfortunately, bus networks within Melbourne are currently not meeting expectations, with users reporting negative journey experiences and poor perceptions of the service (CFD 2017; PTUA 2019). These perceptions are caused by a number of factors, with both vehicles and services broadly criticised as being less reliable, comfortable, understood, innovative and modern, as well as being infrequent, slower and less aesthetically pleasing compared to other public transport (PT) modes (Beirão & Cabral 2007; Harrison et al. 1998; PTUA 2019; Tozzi, Guida, & Knote 2014; UITP 2006). The low-density environment of suburban Melbourne exacerbates these negative perceptions and experiences due to the low frequencies and coverage of services, resulting in accessibility issues (Frost & Dingle 1995; Mees 2010). The Public Transport Users Association (PTUA 2019) continues this opinion stating that image and poor patronage is not caused by people disliking the mode, but by poor service delivery.

This project has aimed to discover how the problem of negative bus user experience in Melbourne suburban environments can be better understood and improved through design research and intervention. This was a studio-based PhD and has been undertaken as part of the Sustainable and Effective Public Transport – Graduate Research Industry Partnership (SEPT-GRIP). This project was sponsored by the global mobility operator Transdev, with specific affiliation with the Melbourne bus operator branch.

1.1 Bus operating context

The Melbourne bus operational landscape and present-day associated problems are a product of historical urban and transport development, discussed extensively by Mees (2010). The low-density sprawl present in today's environment can be traced back to rapid rail extensions during the 1880s and 1920s, as well as higher wages and eight-hour working days, post second world war suburban boom, car adoption and other forces which will be discussed later in this section. During the 1920s period, servicemen who returned from the war established ad hoc cab-style transport services, which were considered unreliable due to unpredictable operating times. Service evolution resulted in the formation of bus companies, transferral from cabs to bus vehicles and the establishment of regular feeder routes – buses that connect to other services – and timetables. Even with these changes, the bus industry was still considered unreliable due to inconsistent arrival times and inconvenient transfers. These historical transport environments have influenced the structure of Melbourne's modern bus network, with routes, timetables, operators and resulting competition built on a past legacy. As car ownership increased during the post-war period, PT travel constraints lessened, with cross-suburban trips and suburban extension possible. PT could no longer compete with the car, with the low-density environment being identified by the Metropolitan Transport Association as a major barrier to successful PT improvement. This historical context helps to explain how Melbourne's current low-density transport environment, bus operational landscape and negative user perceptions are a historical by-product, heavily influenced by the past (Mees 2010).

A low-density environment is described as having 4–30 people per hectare (ppl/ha) (Spencer, Gill & Schmahmann 2015). Melbourne falls within this category, with a population density average of 22 ppl/ha and 55% of the population living between the low-density margin (ibid.). Figure 1.1 visualises the Melbourne suburban density. Low-density cities have become synonymous with poor PT coverage, with 30 ppl/ha considered the lowest density that supports mass transit (Mees 2010; Spencer, Gill & Schmahmann 2015). Mees (2010) goes on to oppose this idea, suggesting that properly planned service coverage, as seen in Zurich, can improve low-density environments, with different models of transport required to provide solutions to density areas.

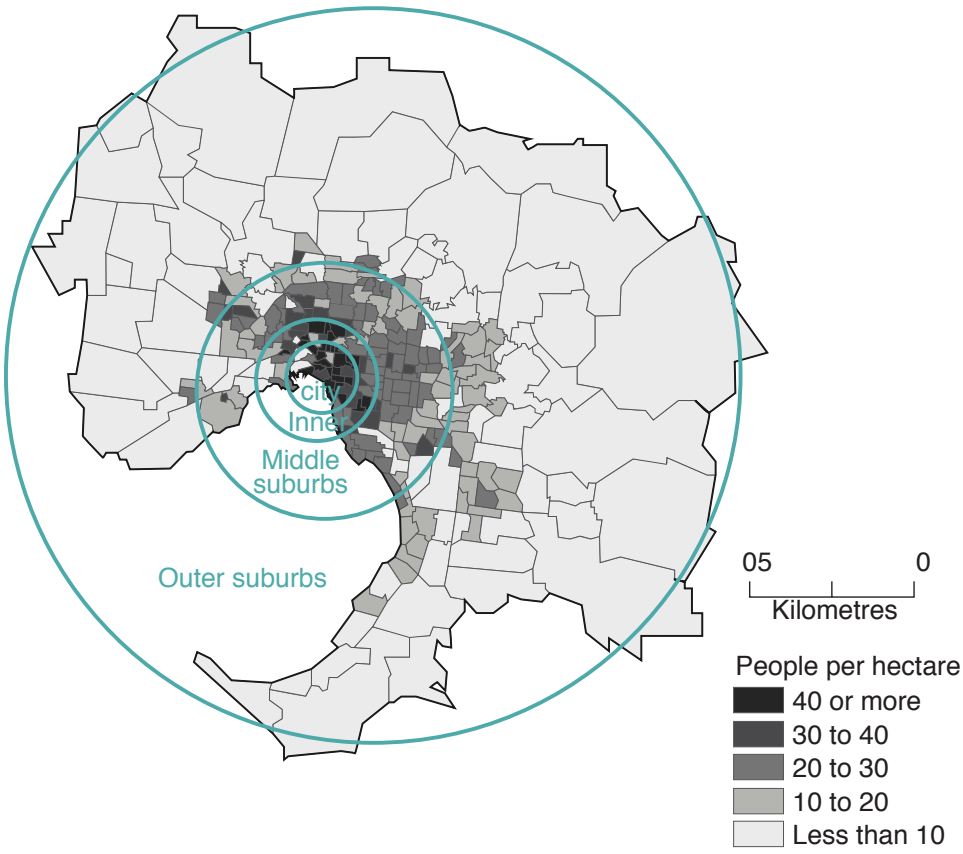


Figure 1.1: Melbourne's low-density sprawl, adapted from Australian Bureau of Statistics (2013), VISTA data (Transport for Victoria 2013) and Charting transport (2011).

This project was not focused on improving frequency and service coverage at a transport planning level; however, it did consider how the suburban landscape influences user travel experiences and perceptions.

The contemporary bus industry has evolved from its historical predecessor through technological improvements, as well as societal and industry growth. These changes have caused the bus-operating process to become more complex, with multiple stakeholders, assets, systems and services required to provide accessible, on-time service provisions.

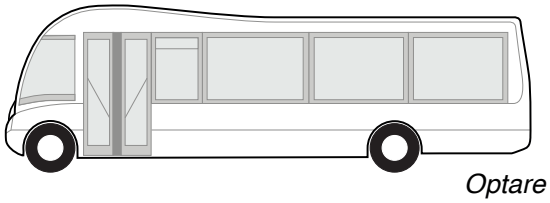
Melbourne's contemporary bus network is fully privatised, with bus services managed by 13 operators running 346 routes (PTV 2016). The bus fleet largely consists of low-floor route buses travelling on feeder routes, connecting suburbs to rail lines, and the SmartBus and DART – Doncaster Area Rapid Transit – services which act as light Bus Rapid Transit (VicRoads 2018). Within suburban environments, buses are regarded as the dominant and most suitable PT mode as they are not restricted by tracks, have flexible area coverage (Cervero 1993; Hutchinson 2000; UITP 2006), and require lower investment to implement and operate compared to other PT modes (Hensher 2000). However, due to Melbourne's low-density, sprawling environment, the bus network exhibits spatial and temporal issues in the form of low frequencies and service coverage. Attempting to mitigate this problem from a transport planning perspective has resulted in the implementation of orbital SmartBus services (Loader & Stanley 2009) to provide cross coverage and 400m bus stop distances to promote inclusion. Even though all interventions have been positive for developing an improved PT system, negative perceptions and inconveniences of use still remain among users and will be discussed further.

1.2 Bus vehicles

Within the bus industry, vehicle style and size classifications are primarily dictated by the functions the operators require the vehicle to perform. For example, high-demand routes are more suitable for articulated designs, as they allow for larger user occupancy without the need for higher frequencies (Vuchic 2007). The same reasoning is applied to the needs of low-density areas, which can be met with midi-sized buses. Figure 1.2 presents the common vehicle sizes found within the Melbourne environment.

Midi bus

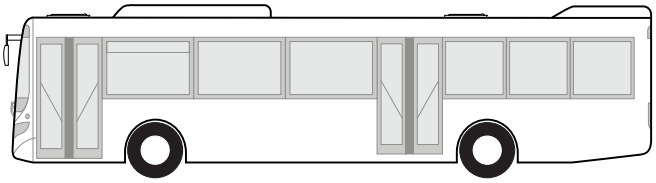
Length 8-10m
Seat # 16-30
Capacity 50



Optare solo

Standard bus

Length 10-12m
Seat # 35-55
Capacity 85



Volgren Optimus

Articulated bus

Length 16-18m
Seat # 40-75
Capacity 130

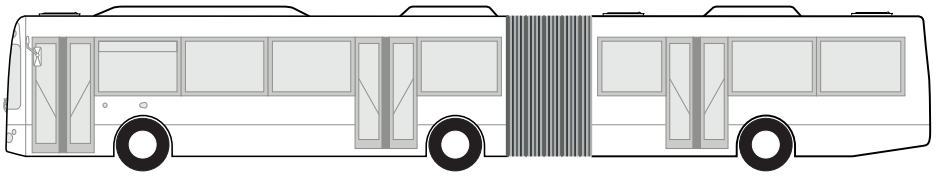


Figure 1.2: Bus types, adapted from Vuchic (2007)

Despite the diversity and availability of bus sizes, the standard 12.5m low-entry route bus currently dominates the Melbourne market, making up 88.5% of the overall fleet (PTV 2016). Brought into service in 1976, this wheelchair-friendly design promotes universal accessibility within an urban cityscape (King 1998; McKnight 1995), encouraging PT travel for people with children and baggage, the mobility impaired and the elderly (Suen & Mitchell 2000). These buses generally consist of a lowered front section that includes two doors and a raised back section. The low-entry bus is not to be confused with low-floor buses, which are more popular within European cities. The low-floor bus design consists of a fully lowered saloon, commonly with three doors distributed across the length of the vehicle. This layout is suitable in areas that have higher density and patronage levels, as they allow the distribution of passengers throughout the saloon, as well as enabling faster boarding and alighting times. Interior floor plans for both bus designs can be visually compared in Figure 1.3. The reason for the dominance of the low-entry bus within the Australian market relates to its suitability for both high- and low-density environments. The universal accessibility requirements within the saloon complement the extra seating capacity in the staired section. To purchase suitable vehicles, operators must undertake a procurement process as detailed in the next section.

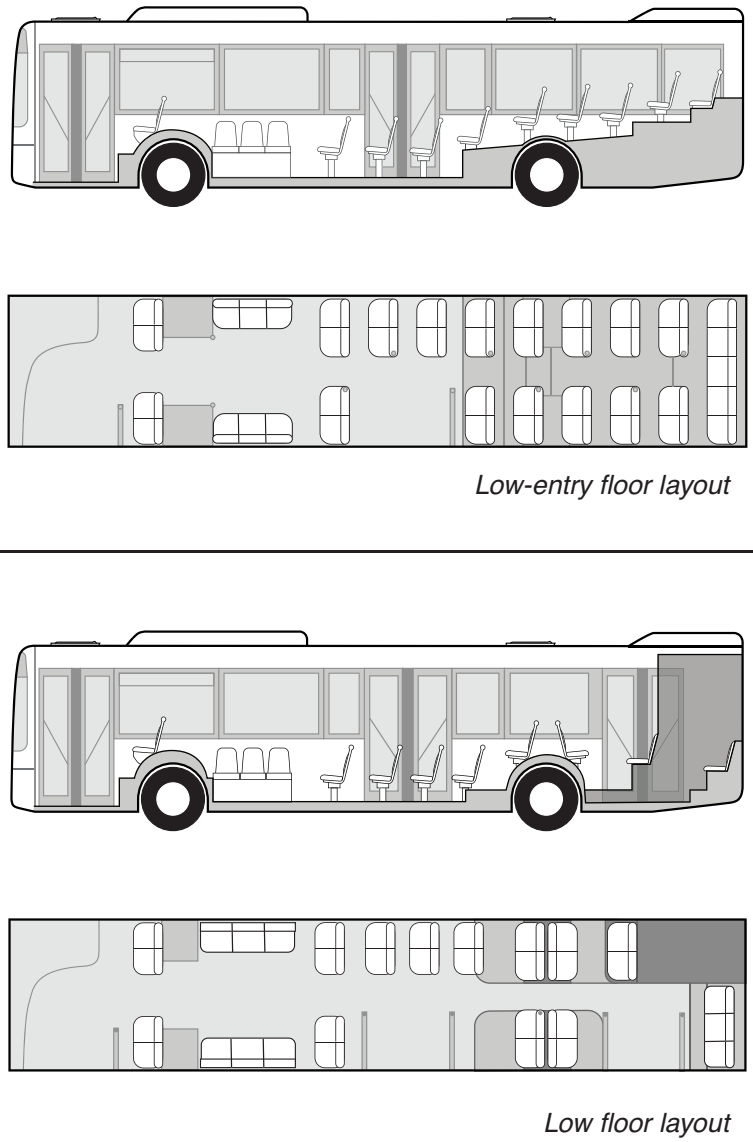


Figure 1.3: Low floor and fully low floor comparison

1.3 Vehicle procurement context

To perform their duties effectively, operators are tasked with vehicle procurement, requiring vehicles that can provide for and comply with the criteria seen in Figure 1.4. The manufacturers, being the sellers in this situation, work hard to fulfil the specified operator's requirements, which can be difficult to achieve based on the nature of bus design and the design process. During the procurement process, if user requirements are unspecified by the operators or communicated ineffectively, they may be neglected. This is due to manufacturers having no direct link to users. They are unaware of precise user requirements and travel behaviours within a bus vehicle, which means they are a step removed from the people who will be experiencing their products, which forces them to rely on the operators to understand users' needs. This communication can often fall short of the detail required to describe experiences, which results in the manufacturers making educated guesses that may produce adverse bus design outcomes (Napper 2007). Similarly, Hutchinson (2009), Rochefort (1981) and Schmitt (2015) argue that operator and user perceptions of the service can often be different, playing a role in negative user experience to the detriment of the system.

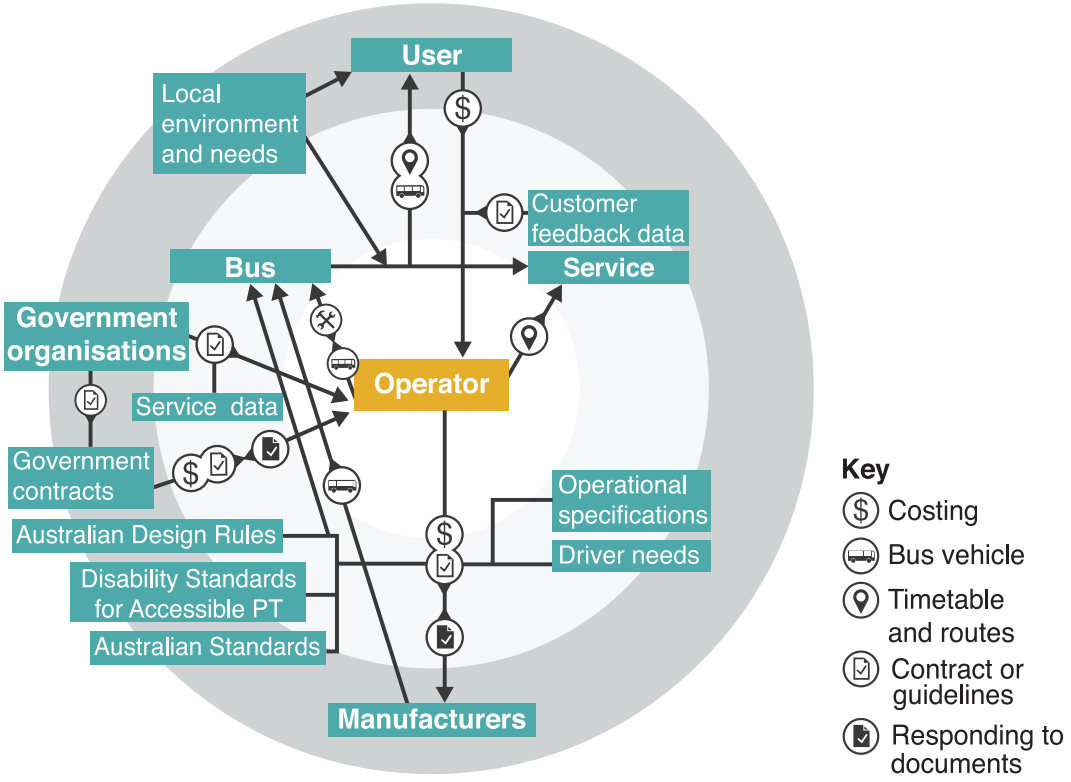


Figure 1.4: Melbourne bus stakeholder ecosystem map

Melbourne's mobility environment is changing and moving towards a stronger focus on usability and service designs, as seen in the Department of Transport's (DoT) user-focused department. Operators need a way to understand and incorporate user thoughts within their vehicle specifications and service designs. The next section discusses the current system for understanding and improving user satisfaction within the bus operational context.

1.4 Service quality context

Bus service quality reflects how users perceive the overall experience of a journey, with low service quality resulting in negative experiences (Tyrinopoulos & Antonious 2008). Service quality is considered a broad subject matter, dealing with all interaction points throughout the whole journey, including accessibility, frequency, ease of use, safety, cleanliness and comfort, to name a few (Fellesson & Friman 2012). Delivering high service quality is prioritised by operators to meet their users' needs and expectations. Meeting expectations will often result in future mode usage and satisfaction; however, unmet user expectations lead to service dissatisfaction and can act as a deterrent for future usage. It is therefore critical for operators to meet user expectations to retain and increase their ridership levels (Disney 1998; Eboli & Mazzulla 2009; Tyrinopoulos & Antonious 2008).

User satisfaction surveys and assessments are currently used to measure service quality. This provides operators with the necessary tools to determine what service characteristics are prioritised by users, allowing the operator to choose which service attributes to focus their resources upon (Weinstein 2000). The customer satisfaction monitor (CSM) (Wallis 2017) is an example of such a report within the Melbourne context. The 2017 CSM showed that service satisfaction was averaging 75.9%. Although the CSM showed positive user opinions concerning Melbourne bus usage, general negative associations were still commonplace through qualitative user feedback among the public. This highlights the discrepancy between quantitative surveys and qualitative perceptions formed on user experience during their journey.

To properly address this problem and understand what has been happening within the suburban environment, this project has reviewed the literature concerning service quality, user satisfaction and experience. These topics will be discussed at length in the next chapter, providing further in-depth context to the research problem.

1.5 Future context

The environment that buses operate within is in a state of transition, with user expectations and travel behaviours beginning to positively shift with technological innovations and societal changes. See Figure 1.5 for a timeline of the technological innovations influencing the development of the bus network.

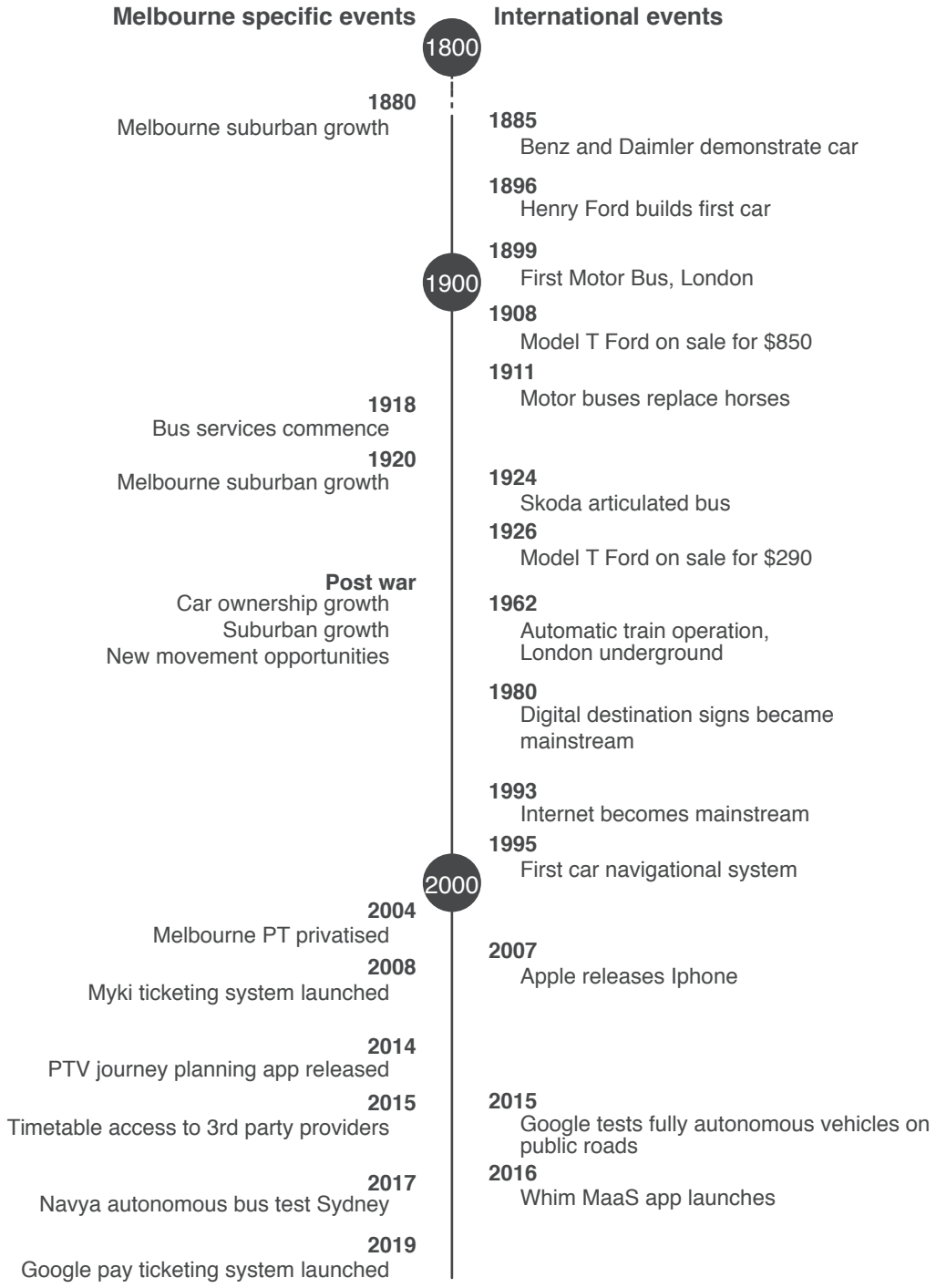


Figure 1.5: Timeline of the technology that has influenced the development of the bus context

To stay relevant and to continue to fit the task of mass transportation conveyance within this transitioning environment, buses need to evolve. These changes consist of three main themes, firstly, social changes consisting of an ageing population and technologically savvy millennial generation with differing travel perceptions (State Government of Victoria 2014). Secondly, technology and socially connected ideas such as Mobility as a Service (MaaS) and intelligent transportation systems (ITS) are becoming more popular and potentially changing the framing of transport operation (Camacho, Foth, & Rakotonirainy 2012; Datson 2016). Lastly, vehicle improvements such as autonomy and electric buses are becoming more relevant (Fridman 2015; Vermeulen et al. 2016). Cultural and technological changes such as these can give operators the opportunity to rethink the way their services are delivered, leading to the development of more user-centred designs. As new companies and mobility approaches enter the transport market, Garrett et al. (2016) suggests that "emotive engagement designed into the business model is paramount" for company survival as it allows user opinion and emotions to be understood and incorporated within the services delivered. The project described in this exegesis did not focus on the development of a business model for user centred design within the bus industry, however it did provide example of design methods that can be transferred across to deliver user centred design outputs, resulting in a novel UCD framework.

A speculative representation of the bus's future is represented in Figure 1.6. This diagram, based on industry trends and literature, highlights innovation points that can lead to improved usability and modernisation of the current bus system.

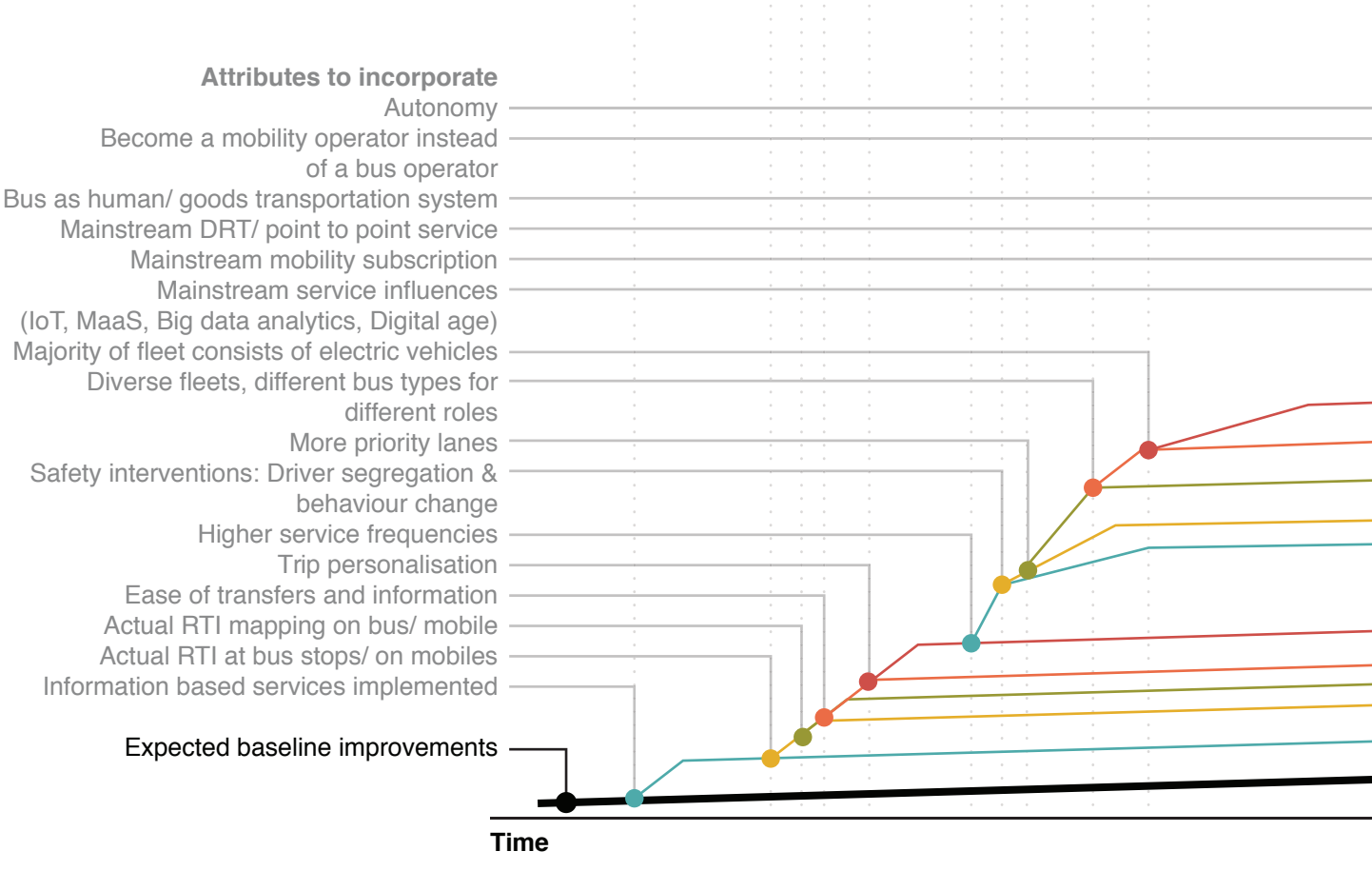
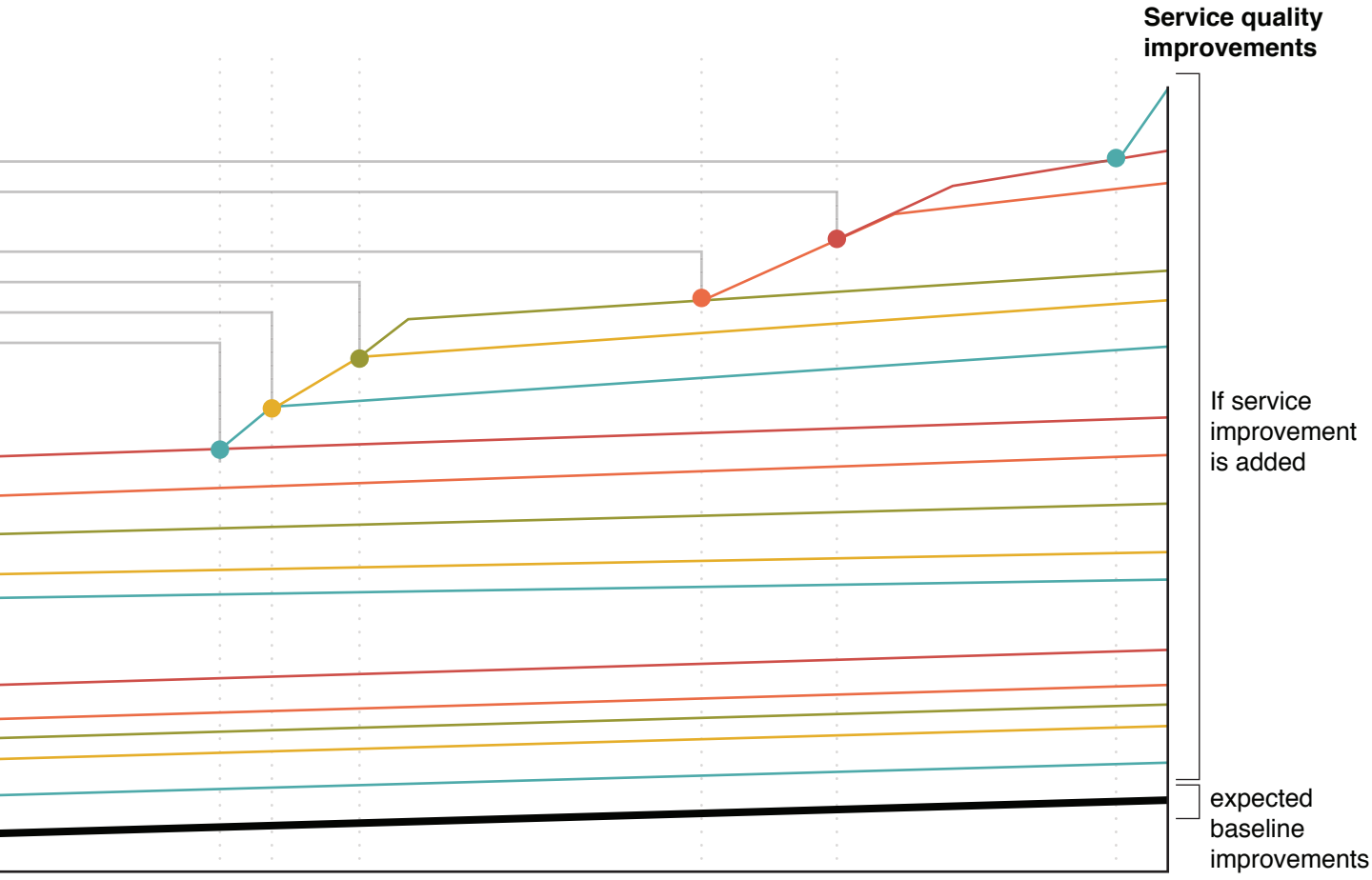


Figure 1.6: Melbourne bus future speculation


Service quality improvements
If service improvement is added
expected baseline improvements

1.5.1 Emerging bus landscape

Other projects looking at reimagining the future of the bus include: the European Bus System of the Future One and Two (EBSF 1 and EBSF 2) from the International Association of Public Transport (UITP 2006, 2018), the Mercedes Future Bus (Mercedes Benz 2016a), GATCHA (Muji, 2019a), Next (Future Transportation Inc 2012a) and the Super Bus (Ockels 2008). Each project will be briefly summarised below and their benefits and limitations discussed.

The future bus concept, presented in Figure 1.7, is a semi-autonomous city bus design based on the current Citaro 12m solo vehicle. The design focuses on testing autonomous capabilities, with a redesign of the interior and exterior presented as an opportunity to explore alternative layouts. The vehicle layout includes a novel, asymmetric, organically styled interior environment inspired by city architecture and natural settings. Additional technological capabilities are added with wireless phone charging and lighting (Mercedes Benz 2016a). This concept is a good example of how design can be applied to reimagine the bus's image; however, limitations could result in compromised capacity and space functionality.

Next and Moji, seen in Figures 1.8 and 1.9, are examples of how the bus can be reimagined to combine alternative functionality and purpose to mobility. Both concepts consist of small shuttle-like services that can be modularly adapted to incorporate on board stores, package delivery, restaurants and alternative mobility options (Future Transportation Inc 2012a; Muji, 2019a). Both concepts are considered blue sky with autonomy and system restructure required for real world integration.

Lastly, the EBSF One and Two projects, seen in Figure 1.10, were both developed by the International Association of Public Transport (UITP) with the goal of using innovation and technology to create the next generation of European buses. To do this UITP has connected with numerous stakeholders including, operators, manufacturers, and cities throughout Europe to identify problem points with bus services, with the project listing how they can be potentially improved or rethought. Some concepts discussed - such as tip-up seats seen in Gothenburg by Volvo (Jack 2012; UITP n.d.) - were retrofitted onto existing vehicle designs to provide an opportunity for real-world testing, although this involved a limited sample size. The first project, which ran from 2008-2013, provides concepts and product design specifications developed to improve service quality and functionality for users and stakeholders. These concept redesigns focus on improving issues within the following areas: on board, transit, communication, safety, road, driver's cabin, environment, revenue and maintenance factors. The project provides a platform to retrofit and test multiple concepts within real word cities, providing valuable feedback and insight (UITP 2006). The second project, 2016 - present, is a more compact and updated version of the previous project. EBSF Two (EBSF Two (UITP 2018) details a single bus design that incorporates improved usability and sense of place. To develop these findings, the EBSF project explores these points of interaction from a passenger, operator, manufacturing and city perspective, combining all stakeholder opinions. Both projects are considered a collection of recommendations, listing vehicle elements that could be changed to improve buses within European environments. Both projects are ideal for imagining potential future opportunities, with the usability issues placed at the centre of the redesign process. The project however does not explore Australian environments and culture, providing the opportunity to explore EBSF themes - recognition, accessibility, ease of use, information, comfort, safety and integration - within the Australian context.

It is encouraging to see that the above depictions of the future are focused on user requirements, for example, the EBSF Two (ibid.) concept focuses on combating main usability problems such as accessibility, information provision and comfort. To do this, EBSF Two incorporates an open layout configuration encouraging user movement, as well as more accessible signage within the interior and exterior.

Figure 1.7: the Mercedes Future Bus (Mercedes Benz 2016b)

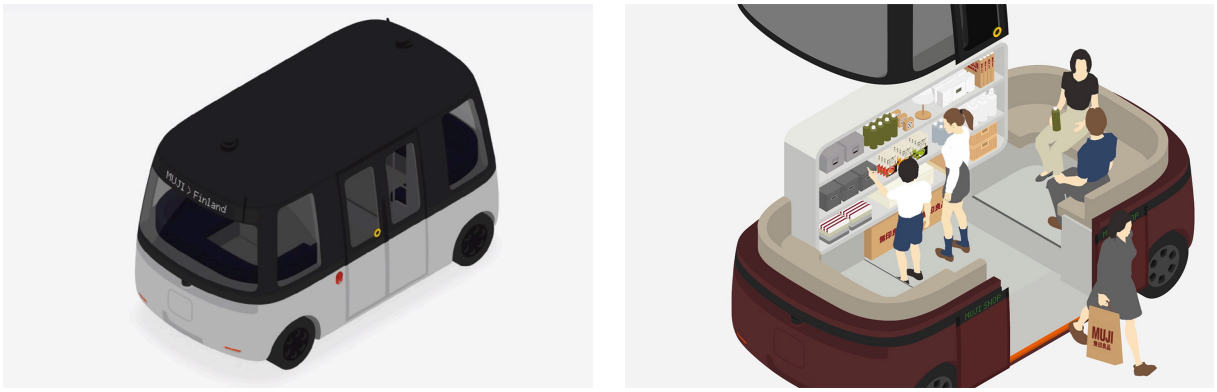


Figure 1.8: GATCHA (Muji, 2019b)

Figure 1.9: Next (Future Transportation Inc 2012b)

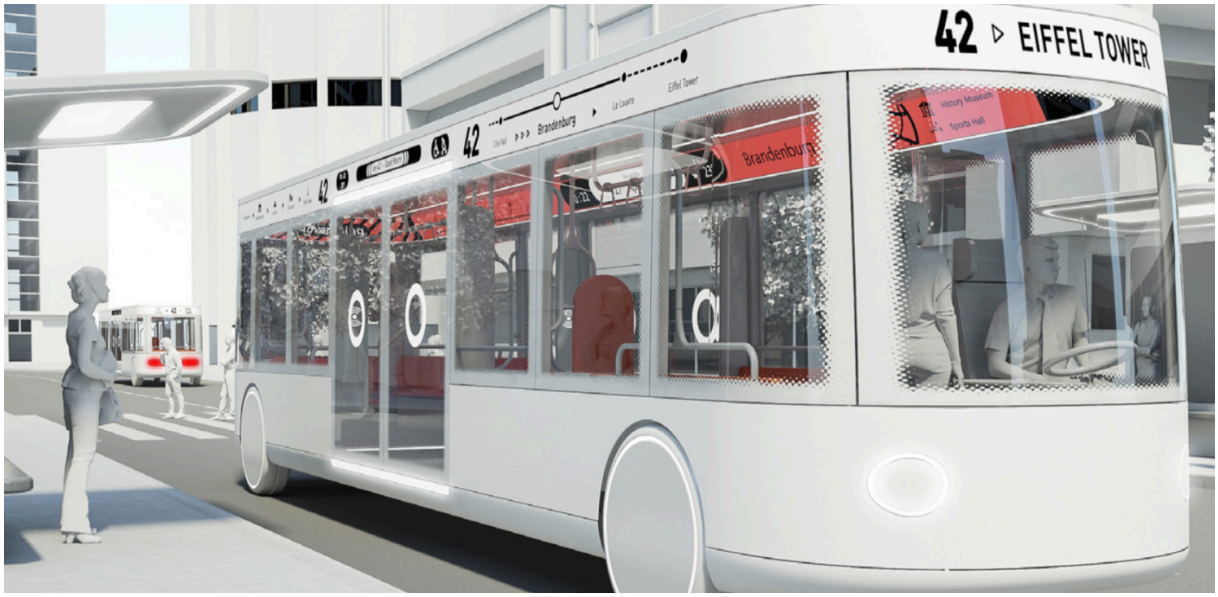


Figure 1.10: EBSF 2 (UITP 2018)

All of the projects mentioned above explore alternative vehicle designs. They represent good examples of what future buses could look like if focused on user requirements. These designs are also typically based within environments that have high user numbers and can afford investment in such developments. The project presented here differentiates itself from these studies by focusing on suburban environments where users must contend with low-frequency timetables, a lack of service coverage and limited signage.

1.6 Project framing and aim

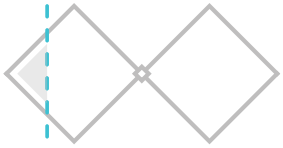
As contextualised within this Introduction, many bus services often fail to meet user expectations, with poor perception and journey experience being common within the Melbourne suburban environment. This chapter has introduced the operational landscape, the procurement process, service quality themes and incorporated problems, to contextualise the complex environment that the problem of poor user experience fits within. Additionally, future concepts in this space have been introduced to provide context as to what the industry will potentially move towards.

This project aims to discover how bus user experience in suburban Melbourne can be better understood and improved through design research and intervention. By achieving this aim, this project prepares operators and designers within the PT field for developing more user-focused bus services and vehicles. To achieve this, travel behaviours, motivations and key usability problems are established, analysed and improved through a user-centred design process. The UCD process and how it is currently being used within the transport field is described within the literature review. The UCD framework and how it is implemented within this project, as well as the determined value of such a focus and evidence of use is presented throughout but summarised within the Methodology and Discussion sections.

The next chapter presents a literature review to explore the problems related to bus user experience in more depth by examining the demographic breakdown of bus users and analysing problems related to poor service quality.

(Peng 2016)

Chapter 2
Literature and artefact review



The research aims of this project are, firstly, to determine the user experience and associated problems with catching buses and, secondly, to develop products and services that respond to these findings. The research outcomes will provide concepts that improve the user experience and encourage further discussion. This chapter reviews the literature and artefacts concerning the research topic. Themes related to bus user experience will be explored, reviewing user opinion, experiences, motivations and key concerns surrounding the whole bus system. To deliver this information, the literature will be reviewed, broadly discussing the Melbourne bus user demographic, service quality and user perception. The need for further research and gaps within knowledge will be identified and the project framed.

2.1 Melbourne bus user demographic breakdown

The demographic breakdown for bus users is considered broad, consisting of diverse user groups with differing travel requirements and expectations. Providing services that can meet all users' needs adds to the complexity of bus delivery. Following a human-centred design process "starts with the people you're designing for and ends with new solutions that are tailor made to suit their needs" (IDEO 2019). The initial stages of this process require designers to understand the needs and behaviours of the target audience, developing an empathic relationship that can be transferred into suitable design development.

According to Melbourne data from the Victorian Integrated Survey of Travel and Activity (VISTA), bus patronage accounts for 1% of total journeys travelled across Melbourne on an average weekday (Transport for Victoria 2018). Although this proportion is small, bus vehicles are essential within this region to allow a basic level of access to society. Furthermore, through service improvements patronage levels could be increased, helping to improve transport access for these environments (Loader & Stanley 2009). Despite this low proportion of total journeys travelled, bus users by their very definition are a diverse group, consisting of all social backgrounds with differing travel requirements and abilities (Litman 2018; Foth & Schroeter 2010). The PT demographic has been broken down into groups consisting of: schoolchildren, commuters, the elderly, people with low household incomes, people with no car access, special event attendees, and tourists (Hensher 1998). This demographic breakdown is confirmed by the VISTA data, which further identifies education, buying and work-related travel as the prominent trip activities for bus use in suburban Melbourne. Trip activity was also found to be influenced by age and gender, with women more likely to use bus services for shopping purposes, and the elderly for social or shopping activities (Transport for Victoria 2013); see Figure 2.1 for a breakdown of mobility used in Melbourne by mode and region.

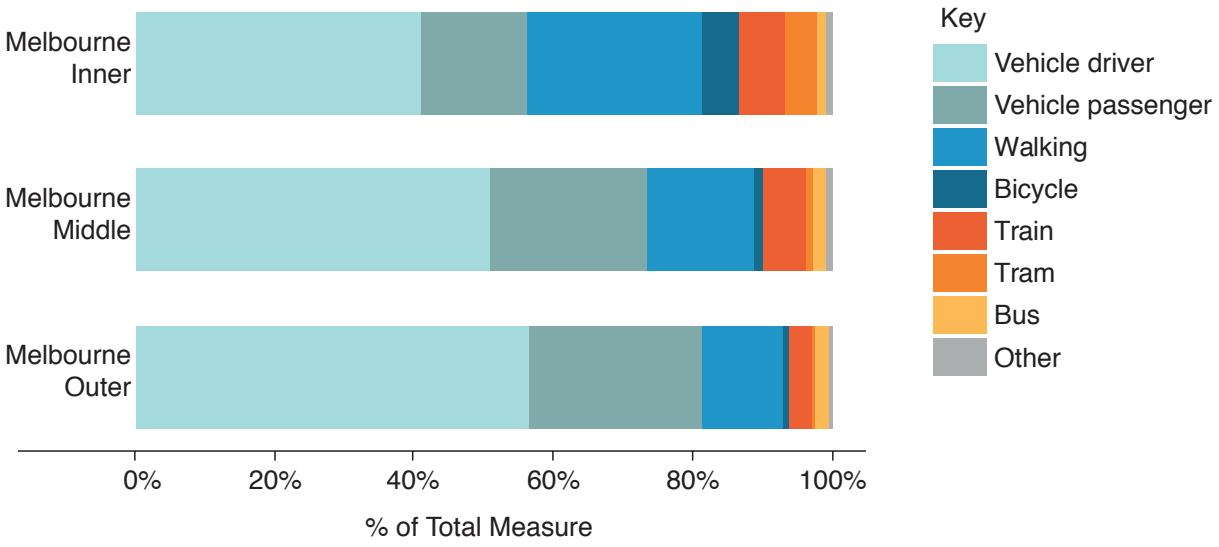


Figure 2.1: Number of trips by mode & region during 2014-16, based on VISTA data (Transport for Victoria 2018)

Designing a transport system that is suitable for each group becomes a challenge when trying to fulfil these "different needs and expectations" (Stickdorn et al. 2011, p. 30). Complexity is added when one group's needs contrast with other requirements, with the designer or engineer having to balance outputs to prevent worsened travel experiences (Ruud & Nordbakke 2005). For example, providing fully low floor interiors and faster boarding and alighting times to the detriment of seating. This type

of thinking is prominent within user-centred design fields, where the designer must accept that there are often multiple user groups with differing needs to be designed for (Stickdorn et al. 2011) and therefore a balance must be reached. This section outlines the needs of four common user groups found within suburban environments, consisting of millennials, captive riders, the mobility impaired and the elderly.

There are two types of captive rider, PT-dependant and private transport dependant, the second being the focus here. This group consists of people who often live within outer Melbourne and due to "lack of effective PT services" (Currie & Senbergs 2007, p. 1) are often forced into car ownership, with lower income earners being the most affected, having to spend the majority of their income on vehicle ownership and travel (Loader & Stanley 2009; Social Exclusion Unit 2003), often leading to social disadvantage, affecting access to job prospects, health care and other necessary services (Dodson, Gleeson & Sipe 2004; Hurni 2005). Loader and Stanley (2009) suggest that the use of SmartBuses on updated routes helps to improve mobility access. This group's primary need is having the option of different transport modes so they are able to participate within society.

Millennials (or gen Y), born between 1982 and 2005 (Howe & Strauss 2007), are currently one of the largest generations represented in Melbourne, the most technologically capable and the largest users of PT, with decreasing car ridership levels being experienced internationally among the group (Delbosc & Currie 2013; Noble 2005). The reasons for this are still debated throughout the literature and could be due to household income, the millennials' changing view of the car, more strict licence requirement tasks or more multimodal mind-sets (Delbosc & Currie 2012). It is important to note that this phenomenon could change once this generation hits significant life events such as starting a family or moving to suburban environments, causing transport behavioural changes (Schmitt 2015). It is suggested that millennials are willing to use buses; however, according to Broome et al. (2010a), they have travel concerns including comfort, access, punctuality and travel uncertainty, safety, ticketing costs, travel time and readily available information. Some of these factors, such as wayfinding and information-based issues, could be mitigated through the use of technology, with this being the generation most capable of and willing to adopt such services (Blumenberg et al. 2012).

Mobility-impaired transport users are the most diverse group, including all forms of disabilities from mental to physical, each with unique difficulties, some of which can go unnoticed while travelling (Haveman et al. 2013). This group makes up 20–25% of PT users (Suen & Mitchell 2000) while often falling within the captive user group, relying more heavily on PT, assistance and physical interventions to allow for accessibility, usability and ease of trip chaining (Haveman et al. 2013; Suen & Mitchell 2000). "The design of the vehicle" is considered one of the most important factors and improving universal design features could improve the service for other users (Suen & Mitchell 2000, p. 1), while removing the impediments to the disabled. For example, electric ramps that allow wheelchair users to access the bus with no human aid provides the user with freedom, helping to reduce their impediment. Disability Standards for Accessible Public Transport and the Australian Design Rules are used to create a more universally accessible PT system (Federal Register of Legislation 2002, 2006). This system includes standards on wheelchair access, in the form of turning-circle ability, ramps and their locations, floor textures and levels, coloured stanchions for the visually impaired and appropriate priority-seating information. Although this is positive, negative attitudes from patrons and the refusal of entry onto buses by some drivers negate the whole system, causing negative connotations of the service (Haveman et al. 2013). Paratransit services are an alternative option for the mobility impaired providing door to door assistance and wheelchair accessibility. They are often more expensive, but provide flexible options and easier mobility (Suen & Mitchell 2000), particularly when compared to other PT modes.

Elderly users (60+ years) can have close correlations with the mobility impaired, as increased age can reduce ease of mobility (Metz 2003; Vuchic 2007). The current elderly population is more mobile than previous generations, with more driver licences held (Haustein 2012), as the car's flexibility and ease of use allows them to remain active (Currie & Delbosc 2010). Loss of licence can result in loss of mobility for this group, as bus usage can be too physically taxing (Haustein 2012; Hjorthol 2013) or unsafe because the elderly are susceptible to injuries from falls (VAED 2012–2015). The inability to travel leads to transport disadvantage, often causing negative health and social participation issues (Currie et al. 2010). Buses are one of the most important aspects of transport for the elderly (Broome et al. 2010b) as they provide basic access to society, combating transport disadvantage among this group. Areas to be considered when designing for the elderly include priority seating, appropriate timetabling, information, small walking distances, friendly and helpful drivers, the ability to be seated before the bus moves (Metz 2003), universal access, small access gaps, fewer stairs (King 1998) and well-placed handrails for mobility assistance (Broome et al. 2010b).

Although these groups do not represent all transport user demographics, they represent common user groups, which are frequently addressed within the literature. Designing transport systems for universal accessibility helps to provide added levels of accessibility and ease of use for captive, mobility impaired and elderly users, which improves overall service. Comparing the findings from the literature, millennials' and captive users' main concerns centre around service coverage and information provision, requiring service knowledge and accessibility. The elderly and mobility-impaired users are found to be more likely subjected to the environment and service attributes that prevent physical access for mobility-restricted users. The following section discusses familiar and non-familiar users, which helps to broadly cover other PT user groups.

2.1.1 Familiar and unfamiliar users

To simplify the demographic focus, DoT Melbourne use two central baseline user groups that need to be understood and considered when they design for different user-based elements: PT familiar and unfamiliar users. Other studies that use similar user identifiers include: Chamorro-Koc (2014) consisting of regular and irregular users; as well as the Customer Satisfaction Monitor (CSM) (Wallis 2017), which use regular and occasional user groups.

Familiar PT users consist of patrons who have undergone a particular trip previously and can recognise the location, route and signage that are involved in its undertaking. Familiar users do not need assistance navigating the system except when a disruption occurs, which requires familiar users to be updated so they can make decisions and continue their travel plans.

Unfamiliar users are people who, due to infrequent travel or the undertaking of a new journey, are unable to recognise a location, route or mode. They are identified as the group with the highest negative perception (Beirão & Cabral 2007) and require higher levels of information to correctly engage with a service (Schmitt 2015). Unfamiliar users are considered the main market for travel information services (Lyons 2006). Reassurances of correct location and time are also important for unfamiliar users, Beul-Leusmann, Jakobs and Ziefle (2013) finding that even if pre-planning is undertaken, the information present at the stop is a reassurance of correct travel plans.

It is important to note that the line between familiar and unfamiliar travel is blurred, with users able to experience both realities within a single trip. An example of this is when someone is travelling to a new location: the first portion of the trip may be familiar to them, whereas due to a transfer or direction change the second half becomes unfamiliar.

There is a tendency within PT literature to assume that non-users do not provide useful insights as they have no service experience and are, therefore, influenced by external opinions (HiTrans 2005).

However, an understanding of irregular and non-users is important to consider to determine "reasons for non-use", alternative perceptions provide information on how to retain or attract patronage (Beirão & Cabral 2007 p. 481), as well as providing insight from potential future bus users (Krizek & El-Geneidy 2007; Le-Klaehn, Gerike, Hall 2014). This inclusion provides the opportunity to "understand the hidden, unmet needs" and to improve the service based on potential user requirements (Norman 2010 p. 38). Additionally, multiple viewpoints can show failures within the bus services if the right questions are asked, highlighting particular stigmas and perceptions of the system, while regular users highlight existing issues. When combined, both user groups deliver well-rounded, critical and insightful information, which is important when conducting future studies. This review suggests that the inclusion of non-user opinions in future studies could help provide alternative insights. The next section will discover user centric industry standard documents, such as the CSM to provide a snapshot of the current satisfaction levels of the Melbourne bus user experience; however, it should be remembered that this report does not discuss non-bus users.

2.2 Melbourne bus user–specific bus-operation reports

Although there are multiple reports surrounding bus operation, this review discusses two main documents that have had great impact on the industry understanding of bus users within a Melbourne context. These documents are the Melbourne bus operation and CSM (Wallis 2017) and the bus customer journey map (PTV n.d.).

The CSM is produced annually, detailing the success and failures of the Melbourne PT industry, acting as a concise guide for operators to improve their service outputs. A review of the 2017 report can be found in Appendix A. The CSM report is a good example of usability requirement data undertaken through quantitative research means. The report captures the operational environment for the year, providing a robust evidence base for operational focus, improvement and continuation points. The report does not provide reasoning or experiential evidence for these scorings, or information that can lead to innovation and improved services. Findings suggest most bus utilities to be positively received, with the main failures noted as a lack of information regarding service disruptions and safety concerns while using the network after dark. The report suggests areas of operational improvement, with personal security receiving a "maintain and grow" status. Information provision is listed as a low priority for improvement. This is surprising, as some information categories received low usability scores from users; however, information is still not regarded as a focus area for improvement.

The customer journey map developed by PTV (n.d.) consists of a user-centred journey flow diagram for each Melbourne PT mode. The diagrams visually highlight points of user pain, satisfaction, inconsistency and universal accessibility throughout the whole journey and how they interface with journey attributes. Although the document offers a high-level overview of the service and encourages user-centred design, it does have limitations. It is limited when providing deep qualitative information behind each interaction and when identifying smaller, more specific interaction points. Designers require in-depth qualitative insights to help improve services; therefore, more information is required to understand this journey experience on a deeper level.

2.3 User experience and satisfaction

Literature discussing user experience and satisfaction is abundant, primarily developed from travel behaviour surveys and journey experience interviews. Literature combining user experience with design knowledge is less common. The work of Napper (2010) and Napper et al. (2009) is an example of such exploration, providing a comprehensive review of present literature and soft factors involved in positive vehicle design. This section will review the literature concerning user demographics, service attributes, overall user perceptions and issues, and socio-technological changes and their implementation to gain understanding of holistic user experience and what areas should be targeted for redesign.

2.3.1 Service quality measures

Introduced in Chapter 1, service quality is directly linked to the satisfaction of the mobility user, influencing their perception of the overall service performance and future journey expectations (Tyrinopoulos & Antonious 2008). It is crucial for operators to deliver satisfactory services in order to maintain and grow their patronage levels. Within the current system, operators use service-improvement strategies and customer satisfaction surveys to determine areas for improvement (van Hagen & Bron 2014; Weinstein 2000). Van Hagen and Sauren (2014) question if this is the best approach for the task, suggesting alternative ways to map service satisfaction, which will be discussed further below.

Within an academic context, true user satisfaction is considered difficult to define, as it is subject to individual travel experiences and user perceptions (Clayton, Jain, Parkhurst 2016; Paramita 2018). Parasuraman (1991) links human satisfaction with the delivery of basic human requirements, suggesting that users are satisfied when their basic requirements and expectations are met. If service satisfaction is not met, users become less tolerant and more disgusted (Barabino et al. 2012; Hirmukhe 2012; Randheer 2011; Souca 2011), resulting in negative perceptions.

Netherland Rail, mentioned by van Hagen and Sauren (2014) use the pyramid of customer needs, as well as satisfaction and dissatisfaction theory, to assess and map the importance of particular service attributes. The customer needs pyramid is a reflection of service quality and is divided into five key areas; see Figure 2.2. Firstly, the foundations of the pyramid consist of reliability, security, speed and ease of use, which together provide the base level and requirements of the bus-operating landscape. These points are classified as dissatisfiers: if any of them do not meet user requirements or expectations, service quality will drop, resulting in poor user satisfaction. Removing dissatisfaction points from these attributes does not improve user opinion, instead returning user expectations and experiences back to neutral, as they provide the base level of service (Kano 1984; Napper et al. 2009; van Hagen & Sauren 2014). Secondly, the top sections of the pyramid, comfort and experience, are classified as satisfiers, with their presence and improvement encouraging user satisfaction and true user happiness (van Hagen & Sauren 2014). Although not explicitly mentioned by van Hagen and Sauren, improved user experiences have the potential to provide ease of transit, positive perceptions and potential service uptake. However, increased service satisfaction within user experience can only be possible if all stages of the pyramid have been previously met (ibid.).

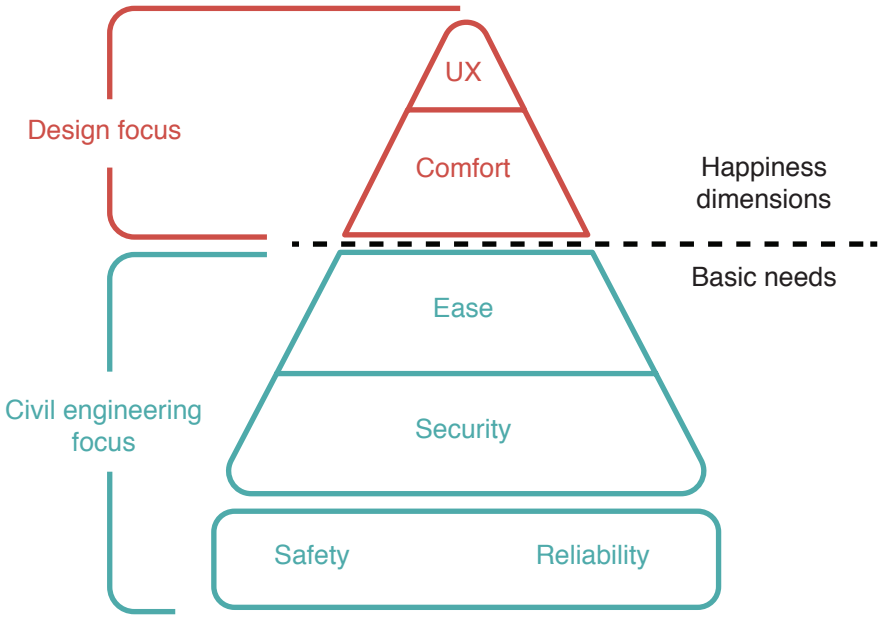


Figure 2.2: Customer satisfaction pyramid, adapted from van Hagen and Sauren (2014)

This pyramid is a visual representation of how the industry regards service quality. Currently, civil engineering research and service quality understanding and improvement measures such as the CMS focus on improving dissatisfier attributes. This is understandable, as they are considered the main requirement of bus delivery and are the foundations of an acceptable PT network (ibid.). Less attention was found to centre on understanding and improving the user experience section of the pyramid (ibid.), this being the main focus area for this project.

A limitation of the customer satisfaction pyramid is that not all service attributes are included, with many other attributes influencing service quality listed within the literature. Service quality attributes are often broadly categorised, referring to all vehicle and service aspects that interact with and affect user perception of transit (Weinstein 2000). PT literature has worked to categorise the service qualities into tangible themes, with the main themes listed below:

1. Safety and feeling secure
   (Fellesson & Friman 2012; Napper 2010)
2. System-related attributes: frequency, punctuality, reliability, accessibility and waiting time
   (Bates et al. 2001; Beirão & Cabral 2007; Broome et al. 2010a; Bunting 2004; Clayton, Jain, Parkhurst 2016; Fellesson & Friman 2012; HiTrans 2005; Napper 2010; Paramita 2018; Stradling et al. 2007)
3. Comfort, cleanliness and vehicle crowding
   (Beirão & Cabral 2007; Broome et al. 2010a; Corazza et al. 2016; Coxon, Burns, De Bono 2008; Fellesson & Friman 2012; Levis 1978; Napper 2010; Paramita 2018)
4. Staff attitudes
   (Fellesson & Friman 2012)
5. Service delivery
   (Fellesson & Friman 2012)
6. Positive utilities
   (Ory & Mokhtarian 2005; Salomon & Mokhtarian 1998)
7. Information and education
   (Paramita 2018; Beirão & Cabral 2007; Broome et al. 2010a; Bunting 2004; Coxon, Burns, De Bono 2008; Hensher 2007; HiTrans 2005; Hutchinson 2009; Scherer 2010; Thomas 2009)
8. Aesthetics
   (Napper 2010; Tozzi, Guida & Knote 2014)

The following section will start to connect and break down some of these service quality themes, discussing how they impact on bus user experiences and perceptions.

2.3.2 User perceptions

Buses within the Australian environment have been associated with a negative perception, with services being broadly criticised by the public (Bowen 2013; PTUA 2006, 2019). Negative perceptions within the bus context can be caused by a multitude of factors, including environmental and experienced-based (Clayton, Jain & Parkhurst 2016). For example, a user's service satisfaction may decrease if they are waiting at a dilapidated bus stop after dark, influencing the user's preconceptions of bus stops. These attributes, when negative, can lead to a poor image of the mode, which can only be countered by allowing alternative travel opinions to be formed through regular mode or environment use (HiTrans 2005; Scherer & Dziekan 2012).

Further negative service contributors can be found in the form of altered time perception, where users' sense of time is influenced by environmental characteristics. For example, if a user is waiting at a bus stop, they are expected to experience time 2x slower than reality. If the bus is unexpectedly

late, the perceived wait time is increased to 5x slower than real time (Booz Allen & Hamilton 2000). This interpretation of wait time causes vehicle arrivals to appear slower, causing users to feel more uncertain and anxious, subconsciously influencing the overall service perception negatively (Beirão & Cabral 2007). Countdown bus stop timers are an example of successful design interventions in this space as they diminish wait time perceptions. Mokhtarian et al. (2015) and Wardman, Hine and Stradling (2001) add to this theory, suggesting that time perception can also be influenced by users running late or if they are involved with an additional activity besides waiting. Additional or multitasking activities refer to other tasks a user might engage in while travelling on a bus, for example listening to music or reading a book. Ory and Mokhtarian (2005) describe these activities as positive travel utilities, as their presence adds further benefit to the bus trip besides the act of mobility. Positive utilities, when present, can work to improve wait time perception and improve experience perceptions, as they provide added value to the service, as opposed to wasted time. The improvement of wait time perceptions can help ease user perception and make for a more enjoyable and less anxious travel experience. Russell et al. (2011) conducted systematic observations of New Zealand bus and train travellers to determine the activities passengers undertake during transit. The most common activities included: looking ahead or out the window (65.3%), reading (12.5%), headphones (17%), talking (13.8%), and texting (9.2%), with some passengers shown to perform multiple activities during one trip. Some activities such as reading or phone usage were found to be demographically driven. Interestingly the most common activity, looking ahead or out the window, can be considered wasted travel time, providing no additional service satisfaction. Although, in reality, this time may not be wasted at all as users could be using it to relax by avoiding engagement with extra activities. Ory and Mokhtarian (2005) refer to this as the therapeutic value of travel.

2.3.3 User safety

PT within Melbourne is considered generally safe, with antisocial behaviour and threatening environments being uncommon (Currie, Delbosc & Mahmoud 2010). Despite this, the perception that the PT environment is personally threatening is becoming an increased opinion, acting as a main barrier and deterrent towards PT usage (Booz Allen Hamilton 2008; Currie, Delbosc & Mahmoud 2010; Kalms, et al. 2017). From reviewing industry documents, antisocial behaviour is documented and responded to by transport organisations, however due to confidentiality, data was not allowed to be included. Organisations are working to reduce the impact through the incorporation of CTV cameras, employing PSO officers (at train stations) and including safety zones and emergency buttons to alert authorities (Victoria Police 2020). Less research was found to focus on the psychological barriers associated with personal safety on PT networks and how the perceived threat of potential dangerous environments can affect transport usage. Perceived threats will therefore be the focus for this section, as it is becoming more prevalent and an important topic to mitigate.

Negative perceptions and the feeling that one might be attacked whilst out in the network can be a powerful influencer over travel behaviour, and can be as effective as actual negative experiences. Safety concerns while out in the network are influenced by user intrusion, antisocial behaviour (Moore 2011; Stradling et al. 2007), unpleasant environments, time of day (Flood 2006), trip isolation and direct driver violence (Lincoln & Gregory 2015). Experience with and the perception of anti-social behaviour can result in users changing their travel behaviours to avoid threatening situations (Kalms, et al. 2017; Thomas 2009; Wallis 2017). This can have a significant effect on girls and women, encouraging them to drive a car rather than catching PT (Kalms & Douglas 2019). Further examples of travel behaviour change have been described by Bissell (2018) which include alighting at an earlier stop and trying to be inconspicuous while travelling.

Antisocial behaviour can contribute to intimidation (Stradling et al. 2007), irritation, fear and anxiety concerning personal security when on the network. These responses can further result in reluctance to use PT by adults and children, and limiting of overall patronage levels (Moore 2011; Newton 2004;

Taylor & Ampt 2003). Thomas (2009) attributes these problems to a lack of perceived control over the system and the uncertainty these environments produce. The perception of threatening environments contributes to negative bus experience. Operators need to incorporate consideration of these feelings and concerns within their service and vehicle designs to create more inclusive service provisions.

2.3.4 User comfort

Often difficult to measure due to its intangible, subjective nature, (Oborne 1978; Vink ed. 2004) and perceived through its absence (Branton, 1972), comfort relates to a whole raft of sensory factors that affect the overall journey experience. These include lighting, temperature (Beirão & Cabral 2007; Coxon, Burns & De Bono 2008), noises, smells, seating, seat orientation, seat proximity to areas of access, seating access for groups and individuals, suitable sightlines, seats with backs (Coxon, Burns & De Bono 2008), passenger load, standing and in-vehicle time (Shen et al. 2016) and vibrations (Oborne 1978; Vink ed. 2004). Oborne (1978) suggests that these factors all influence the end users' opinion and perception of the comfort levels of the system, affecting people on an individual level, with familiarity with a service being a point of opinion difference (Beirão & Cabral 2007). Beirão and Cabral (ibid.) go further, believing that experience, informedness and personal reaction to the vehicle are also key influences on comfort level perception. This reaction is called the visceral effect, helping to identify the emotional responses to certain elements on a general basis (Norman 2004). Previously, Coxon, Napper and Allen (2007) related visceral effects to the PT field, connecting them as means of examining emotional components of designs. Figure 2.3 presents a review of the current bus environment in relation to positive and negative comfort associations compared against Norman's list of visceral factors. The figure suggests that the low-entry route bus design includes multiple negative visceral elements, encouraging unconscious negative perceptions. These negative visceral elements can be removed through design intervention.

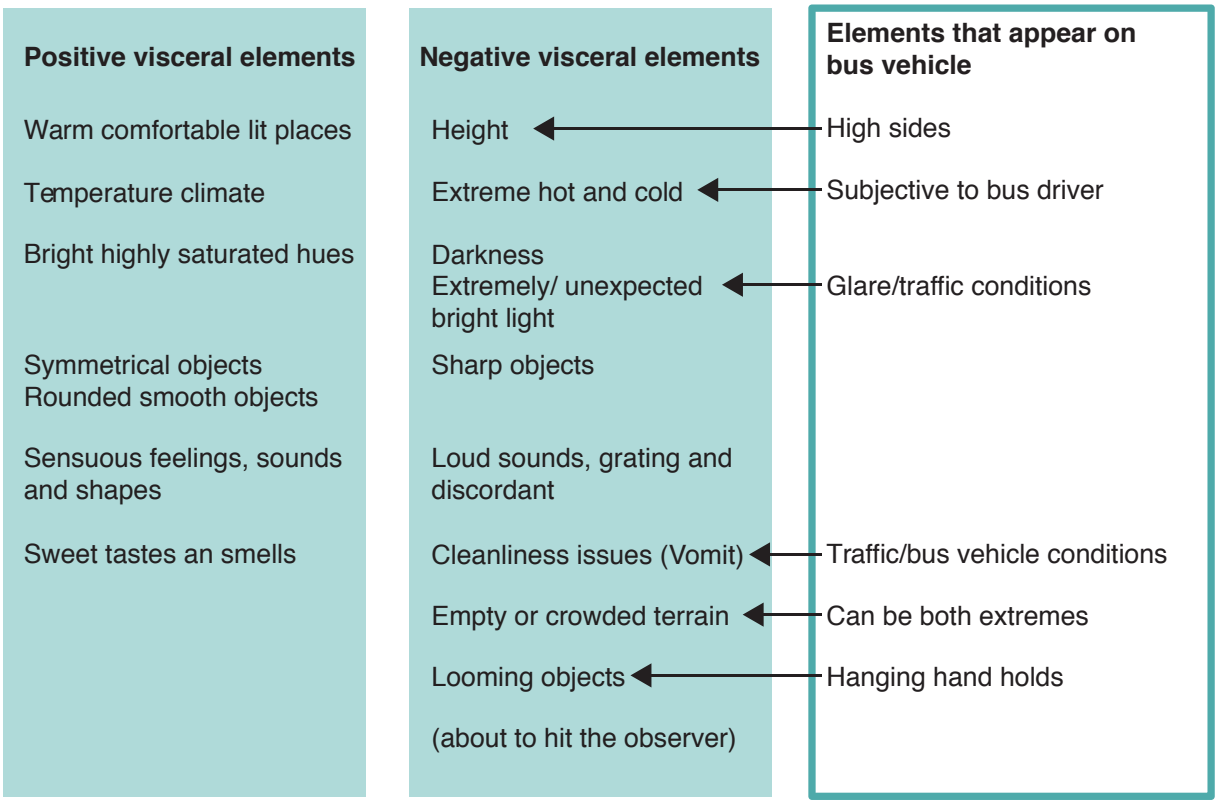


Figure 2.3: Visceral effects within bus vehicle design (Roberts, Napper & Coxon 2017, adapted from Norman 2004)

2.3.5 Bus experience compared with other mobility modes

This review has been discussing negative quality attributes and how they affect user perceptions of the bus as a whole. When comparing these attributes and journey experiences with other mobility modes, Ben-Akiva and Morikawa (2002) suggest that the bus is judged more negatively even when the same level-of-service exists. This opinion does appear accurate, with the majority of literature reviewed indicating more negative user experiences and perspectives regarding bus transit than other mobility modes (Beirão & Cabral 2007; Harrison et al. 1998; Scherer & Dziekan 2012; Tozzi, Guida & Knote 2014; UITP 2006), with fewer studies showing positive or neutral bus perception compared to other modes (Ben-Akiva & Morikawa 2002; Scherer 2010; Wallis 2017). A reason for this unfavourable perception comparison could be linked with level-of-service inconsistencies across modes. Although the fare is standardised, the level-of-service differentiates in relation to travel time, frequency, transfer amounts and image benefits (Ben-Akiva & Morikawa 2002; Mackett & Edwards 1998), with the train and tram being seen as superior. Additionally, tram and train services carry higher user capacities and require infrastructure, resulting in higher purchasing budgets. Within the Australian market, buses cost A$500,000 compared to trams at A$5 million and trains costing A$15 million (Victorian Auditor-General office 2011). Not all money goes towards an increased level-of-service; however, it is assumed that with increased vehicle costs higher levels of fit and finish are achieved, resulting in more aesthetically pleasing environments. Users are unaware of vehicle costings, but increased levels-of-service are directly linked to user satisfaction.

Further comparisons between the car and the bus have been discussed thoroughly within the literature, with the car regarded as more preferable for convenience and comfort (Beirão & Cabral 2007). Interestingly, car travel is often attributed with providing more control of travel experiences (Beirão & Cabral 2007; Stradling et al. 2007), identified as an “underlying desire” in mobility use (Beirão & Cabral 2007 p. 480; Gardner & Abraham 2007). Guiver (2007) adds to this argument, identifying that travel time, multiple location points and consistent and controllable interior space are contributing factors to the added control experienced. This is compared to bus travel experiences, which are regarded as having little or no control association (Mokhtarian et al. 2015; Stradling et al. 2007), particularly when concerning weather, vandalised environments, traffic factors and safety from antisocial behaviour (Guiver 2007; Hine & Scott 2000). Guiver (2007) further discusses this topic, noting that within their study participants described bus experiences where they felt they had limited control. The points of limited control referred to uncertain arrival times, discourteous drivers and the behaviour of other users. Positive associations with buses, such as not having to drive, were not associated with increasing user control over their travel experience. Alternative modes need to therefore increase users’ perceived control levels via improved accessibility, information and interactions if they expect to be more usable (Gardner & Abraham 2007).

2.3.6 User control

The term ‘control’ within this work refers to mobility users having the ability to understand and influence their travel experience. The phenomena of control can be divided into three main areas, all which relate to stress within adverse environments (Ory & Mokhtarian 2005; Zeithaml, Berry & Parasuraman 1988). Firstly, behaviour control refers to “the ability to make responses that influence threatening situations” (Averill 1973 cited in Zeithaml, Berry & Parasuraman 1988 p. 42); within PT this might refer to removing oneself from an antisocial behaviour to gain greater control over safety. Secondly, cognitive control aids in the reduction of uncertainty (Averill 1973), with information provided and processed helping to reduce stress (Zeithaml, Berry & Parasuraman 1988). Lastly, decisional control refers to having the ability to make a choice among alternative actions (Averill 1973), for example being able to choose the mode of transport. It should be noted that the concept of control is subjective and individual; due to this, adding control to an adverse environment may not alleviate stress (ibid.), with the individual response and abilities being the determinant. Within the mobility field, the presence of control has been identified as a positive travel utility, providing

additional value, user appeal and motivation beyond the fundamental need to travel (Ory & Mokhtarian 2005; Salomon & Mokhtarian 1998).

As discussed in the last section, control is predominantly featured as a benefit of car travel (Ory and Mokhtarian 2005). PT environments, alternatively, are considered environments of limited user control, where users are unable to influence services and are subject to operators' whims, environmental conditions, operational changes and transfers (van Hagen & Bron 2014). The provision of control helps to explain the car's preference over PT even when reasonable alternative transport options are available (Ory & Mokhtarian 2005). Within the PT environment, control is commonly attributed to information provision, with a lack of service understanding contributing to increased levels of lack of control and service uncertainty (Boyd & Wyosnick 2016; Fridman, Napper & Roberts 2018; Gardner & Abraham 2007; van Hagen & Bron 2014). Van Hagen (ibid. p. 259) leads the control discussion, identifying that train travel removes the ability for users to control their environment, with users becoming "dependent on a railway company for (punctually) delivering them to their destination". This lack of control causes users to "feel restless and unpleasant, preventing them from enjoying the train journey" particularly during points of waiting (ibid. p. 259).

Van Hagen and van der Made (2017 p. 5) build upon the original customer satisfaction pyramid (shown above) and identify control as a core user need presented within the base level of the pyramid; see Figure 2.4. The pair describe how problems with control can be addressed through design thinking processes and by designing services around three main themes:

1. "Always and everywhere convenient and accessible"
2. "The trip is always predictable"
3. "Appropriate help is always within reach to be successful"

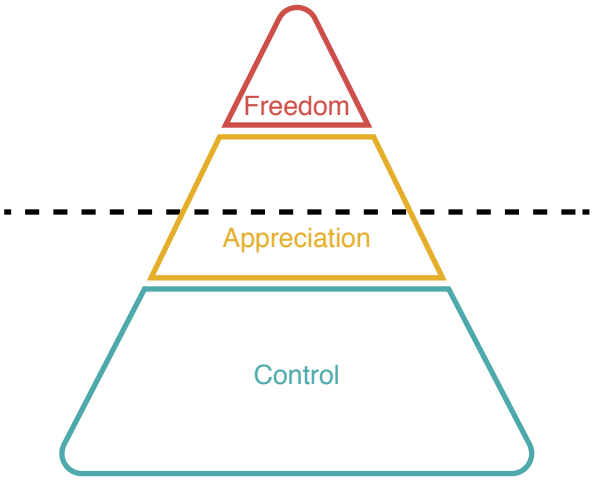


Figure 2.4: Customer satisfaction pyramid and control (van Hagen & van der Made 2017)

The benefits of using the car and the freedoms it allows have become synonymous with control. Interestingly, the literature rarely discusses how control may be implemented within the PT context, with limited research discussing how adding control to PT services could provide improved user experiences. Research that does discuss this mind-set consists of high-level framework information and does not pragmatically show how control can be designed into the network. This review has shown that perceptions of control are important to PT users; however, there is no literature discussing how it might be improved or how it may be designed into the Melbourne bus user experience.

2.3.7 Information

Digital technologies and information channels are providing an opportunity to overcome the perceived lack of control users experience with PT, leading to increased satisfaction levels (Handte et al. 2016). Transportation is a complex and interactive system, requiring users to engage with various information channels, environments and vehicles to achieve the end goal of mobility. As this environment grows more complex with better mode and transfer integrations, information technologies need to meet the changing service demands. This includes meeting users' evolving needs and expectations, as well as incorporating new services and additional modes. Such communication could influence how, what and when information is provided to the user, as well as providing ease of service use (Kolski 2011). Additionally, the information presented needs to remain relevant for its users, who want "quick and convenient access to information of relevance to their personal needs" (Lyons et al. 2018 p. 76).

Bus services can be difficult to navigate due to complex and confusing environments, travel uncertainties, location recognition and information interfaces (Woyciechowicz & Shliselberg, 2005). Wayfinding and system navigation are pertinent to the transport field as they provide location navigational tools through transport planning graphics and information designs. Wayfinding is an established field within its own right (Gibson 2009; Hunter, Anderson & Belza 2016; Montello & Sas 2006; Woyciechowicz & Shliselberg 2005); this section discusses wayfinding as it pertains to usability issues, helping to determine areas of navigational and system failure, as well as points where design intervention is necessary.

The process of wayfinding is identified to consist of four stages: "orientation, route decision, route monitoring and destination recognition" (Mollerup 2005; cited in Coxon, Napper & Richardson 2018, p. 138), with pre-trip and on-board stages of the journey process being the most informationally important (Camacho, Foth & Rakotonirainy 2012; Zito et al. 2011). All these stages require both sensory and physical artefacts in order to be completed successfully (Coxon, Napper & Richardson 2018). Correct information presentation throughout these stages consists of signage that includes legibility and continuity principles (King & de Jong 2016), visual access and familiarity. These factors are all-important to delivering successful wayfinding outputs for transit purposes (Montello & Sas 2006). Information communication breakdown or gaps within this service can lead to user frustration, confusion, system navigational failures, problems with timetable translation and uncertainty regarding vehicle arrival times (Caulfield & O'Mahony 2007; Beul-Leusmann, Jakobs & Ziefle 2013), with non-PT users being more susceptible to uncertain environments (Caulfield & O'Mahony 2007).

Within the Melbourne context, studies conducted by Schmitt (2015) confirm the above wayfinding problems, identifying that bus services, when compared to other modes of PT, are less preferred due to buses' lack of signage and non-descriptive suburban environments present within the network. These problems cause higher levels of uncertainty related to service navigation, as well as difficulties for first-time users who are unfamiliar with the information structures of the system. As seen within the literature, further wayfinding issues that negatively influence bus journeys include: visibility difficulties caused by fogged windows or night time conditions; the bus's ability to deviate from a route when avoiding obstacles or the lack of clarity for which streets a bus may turn down during operation; and the user needing to request the bus to stop at the appropriate location. These are worsened by unfamiliar routes and unknown environments, causing the user to feel a lack of control (Dziekan & Dicke-Ogenia 2010; Schmitt 2015). These issues associated with information provision are prone to occur within suburban environments, where low-density, minimal bus infrastructure and twisting suburban environments creates difficult-to-navigate environments.

The lack of information provision within bus networks is discussed as a barrier to bus usage. Similarly, the CSM report shows that users are unsatisfied with the information they receive concerning service disruptions. Despite these points, the CSM lists information as a low priority for operational focus,

this being a point of difference between the discussed literature and operation priorities. Through reviewing what is currently discussed in this field, it is clear there is a lack of understanding regarding what information users want within outer suburban environments and how this information can be successfully delivered to them.

2.4 Information and technology

2.4.1 Wayfinding and information tools

Information wayfinding tools within the PT environment are applied to help users navigate the space and become aware of travel opportunities through transit routes, with traditional tools consisting of 'low-tech' printed maps and timetables (Hunter, Anderson & Belza 2016). Information and communication (ICT), such as digital displays and apps, are one means of delivering information channels to service users. An area of ICT application in PT that has grown significantly over the past decade has been the delivery of information via personal mobile devices such as smartphones.

With the advent of the recent digital technological age, our society and lives are becoming more digitally intertwined, with 80% of Australians owning a smartphone (Deloitte 2015). Technological and innovation interventions have the ability to "increase the efficiency and quality of a service" (Ongkittikul & Geerlings 2006, p. 285). The establishment of ICTs within the PT industry and the measures taken to follow existing technology trends through the utilisation of social media, website applications and smartphone apps (Cottrill et al. 2017) have led to the modernisation and improvement of the transport industry. This has been achieved by bridging a gap between customers and transport operations (Beul-Leusmann, Jakobs & Ziefle 2013; Camacho, Foth & Rakotonirainy 2012). Local transport authorities are responsible for providing system information to the system users. This information transfer is mainly found in the form of pre-travel journey information consisting of ICT and ICT devices. These are currently presented in the forms of both public information: paper timetables, passenger information displays (PIDs) and destination signs (Caulfield & O'Mahony 2007; Woyciechowicz & Shliselberg 2005), and private information: smartphones, hotlines, websites and social media sites (ibid.). ICT development within the PT field has been connected with delivering positive travel utilities, whose implementations can be used to add certainty and control to the user experience through real-time information (RTI), trip personalisation and smartphone usage.

Accuracy of timetable, real-time information feedback, and individual customisation can help to improve user dissatisfaction, service complexities and uncertainties (Chamorro-Koc 2014). Additionally, RTI, when accurately portrayed, provides transparency to the network, helping to improve wait times, reliability perceptions, reduce uncertainty, change waiting behaviour and improve ridership (Beul-Leusmann, Jakobs & Ziefle 2013; Camacho, Foth & Rakotonirainy 2012; Cats & Loutos 2016; Caulfield & O'Mahony 2007; Cheung & Sengupta 2016; Dziekan & Kottenhoff 2007; Foth & Schroeter 2010; Gooze, Watkins, & Borning 2013; Monzon, Hernandez & Cascajo 2013; Watkins et al. 2011). Unfortunately, many of the aforementioned tools, such as passenger information displays, currently do not use true real-time travel information and are not personalised to specific trip chaining (Chow et al. 2016). True real-time information can be described as users having access to countdown timers or maps that show the vehicle's true location within the network based on GPS co-ordinates, as opposed to the timetable or previous bus stop arrivals, which can be inaccurate due to traffic or disruptions. The inclusion of true real-time information into apps and signage, for example TripView lite, is becoming more available with technology implementations, however its service integration is reliant on the operators providing vehicle location data. The majority of literature discussing RTI is often theoretical, as opposed to new practical applications for the technology. Thinking beyond bus stop countdown systems, RTI application has the potential to change how users interact with outer suburban bus systems, providing greater system understanding and ease of service usage, beyond bus stop countdown systems. Ride sharing companies such as Uber are a good example

of RTI use to inform mobility. Users cannot control the driver or make them arrive any faster, though they are able to track their service as it makes its way to them, providing them with a feeling of certainty through RTI.

Information platforms like apps also allow for a two-way exchange of information. Personalisation is an example of the type of information that a user can put into the system. Personalisation of trips beyond trip type and time provide the opportunity to create more unique and tailored journey experiences. Personal information relevant to a journey can include walking, origin and destination, visually impaired and mobility aid users, travel difficulties, travelling with bicycle, sorting routes, travel time and travel mode (Cheung & Sengupta 2016; Földes & Csiszár 2015; Jittrapirom et al. 2017). Being able to tailor the journey to any of these points provides users with the opportunity to control their experience and their travel requirements on a more personal level. Personalised information also provides transport agencies with greater information about its users, helping to tailor their services.

Smartphones and the connection of additional hardware and software - such as interactive signage - are identified as a game changer within environments that require individual navigation. These technologies have inbuilt personalised wayfinding capabilities that can be accessed whilst out in the network (Maus, Lindeman & Satariano 2016) and, if incorporated with operator information, provide access to up-to-date service navigational tools. Furthermore, smartphone technologies could be used to improve mobility access for mobility impaired users, with BlindNavi being an example of a wayfinding app for vision-impaired users (Camacho, Foth & Rakotonirainy 2012; Chen et al. 2015).

2.4.2 Socio-technological additions: a new idea for conceiving mobility

Along with the advancement of the ICTs and their establishment within the PT field, socio-technological concepts for alternative mobility options have been discussed in the literature and developed within the industry, rethinking the way mobility should be delivered. Some of these concepts are: the Internet of Things (IoT) (Davidsson et al. 2016; Jittrapirom et al. 2017; Hunter, Anderson & Belza 2016), Mobility as a Service (MaaS) (Datson 2016; Jittrapirom et al. 2017; Utriainen & Pöllänen 2018), Big Data applications (Hunter, Anderson & Belza 2016) and advanced traveller information systems (ATIS) (Camacho, Foth & Rakotonirainy 2012). All these socio-technological concepts are nuanced in changing mobility operation through user focus and technological implementations, developing more engaging human–computer interaction (HCI), connected services and information provisions, with improved user experience being the main goal of these applications. These ideologies could potentially lead to growth and application of new information channels, with service design interventions providing communication. However, practical outputs developed from the ideologies are required to validate, improve and deliver pragmatic context to the theories being presented. Iterative design approaches and development of these ideas into real-world pragmatic designs are often less represented within the literature, with design research discovery being less common compared to theoretical development.

From the above list of ICT devices, PIDs and smartphone apps will be discussed in more detail as they allow new ways of delivering information channels to bus users. MaaS will be discussed further in relation to journey planning apps, as they are an emergent topic with the ability to enhance daily mobility use (Melis et al. 2018).

2.4.3 MaaS and apps

MaaS is an emergent transport-based technology that has implications for social phenomena. MaaS is currently being heavily discussed within the literature and industry. MaaS restructures the framework of transport delivery to focus foremost on “mobility systems around user preferences” (Datson 2016,

p.10). MaaS operators combine mode choice to provide multimodal, trip-chaining options through a singular interface, mobility packages accessed by a smartphone app (Datson 2016; Hietanen 2014; Jittrapirom et al. 2017; Kamargianni et al. 2016). This means that transport users can access multiple mobility modes and transfer options through a single app and payment system, helping to provide information and control to mobility users. Current MaaS utilities provide more connected mode choices, including bus, train, tram, taxis, shared and on-demand transport. Often featured in apps, MaaS offers users ease, flexibility and control over mobility use, including cashless payment, journey information, RTI and navigation aids. Many of these features are currently implemented within regular journey planning apps (Datson 2016; Hensher 2017; Melis et al. 2018). MaaS therefore encourages mode integration, moving from isolated mode choices to integrated service opportunities. This allows PT apps to encompass all forms of mobility, providing a greater variety of mobility choice and information.

Since the popularisation of MaaS and its potential to improve the usability of transit environments, transport apps are starting to tailor their features towards MaaS needs, instead of being purely PT based. Citymapper, Moovit, Transit, UbiGo, Whim, Tuup, SHIFT, Optymod, Smile, Moovel and Arevo are examples of such integrations, each consisting of various levels of MaaS integration (Goodall et al. 2017; Jittrapirom et al. 2017; Kamargianni et al. 2016; Utriainen & Pöllänen 2018). Through reviewing the literature and 12 MaaS apps, Jittrapirom et al. (2017) summarised the core characteristics of MaaS. The correct implementation of these features is required to produce successful, user-based MaaS. The characteristics include: integration of transport modes; tariff options; one platform that includes multiple service providers; integrated technologies; user demand orientation; user registration requirement; user personalisation options; and service customisation, allowing users customise their trips. Karlsson, Sochor and Strömberg (2016) add to this list, including improved convenience, access and flexibility, and simplicity. Jittrapirom et al. (2017) goes on to show the features within each app currently used to aid MaaS integration, including journey planning, personalisation and customisation. Journey planning uses features such as RTI, congestion prediction and monitoring, mode booking, payment, service alerts, departure alarms and stop notification. Personalisation features store personal information such as regular and preferred routes, location, modes and optimised trip planners, to provide personalised trips. Customisation allows a trip to be tailored to suit the user's needs, including features such as minimised walking distance, disabled modes, links with calendar/personal contacts, maps including accessibility needs, budgets/top-ups, filtering trips by cost, time and CO2 footprint, and linking with social media accounts.

Similarly, Cheung and Sengupta's (2016) report is a comprehensive guide to journey planning apps that did not feature MaaS. The report analyses 20 of the top journey planning apps, rating their features, usability and popularity. In this study, mobility-necessary features are apparent, including multimodal, navigation, RTI, crowdsourcing service data, personalisation, maps/points of interest, geocoding, time of travel, customisation and route comparisons (cost, fuel, time etc). Although MaaS development was not a focus for this review, it shows great similarity with Jittrapirom et al.'s (2017) characteristics list, suggesting that these are important features for modern and successful journey planning apps.

Apps allow operators to provide more personalised and RTI to their service users. Conversely, during this information exchange operators require RTI from the users such as their location or user feedback. This bidirectional data exchange allows both groups to contribute to serving the users travel needs (Schmitz, Bartsch & Meyer 2016; Stelzer et al. 2016). Current relationships between apps, services and products within the context of PT are generally one-sided, with transport apps working hard to communicate services and navigational requirements to users. The app and vehicle, however, are mostly unconnected, with some apps showing the number of users on board but unable to prompt service change or interaction with the vehicle. City mapper is an example of an app interface being

incorporated within the signage of bus interiors, but again the user cannot influence the bus digitally. By incorporating bidirectional communication systems into the bus network, users become able to provide alternative information loops to the service operators, allowing the service to better meet user requirements. Filippi, Fusco & Nanni (2013) have categorised the potential development of bidirectional integrations into five categories seen below, providing insight into future information and mobility opportunities.

1. "Static information on supply: historical 1-way information on line routes and scheduled timetable;"
2. "Dynamic information on supply: updated 1-way information on bus positions and arrival times at bus stops;"
3. "Dynamic information on supply and demand: updated 2-way information on bus positions and arrival times at bus stops, as well as number of on-board users and empty seats;"
4. "Dynamic cooperative information: updated multilateral real-time information exchange from mobility agency to users and vice versa as well as among users; this allows users to share first-hand information on system performances, thus shortening the time lag between data measurement and information supply;"
5. "Dynamic adaptive system: integration of multilateral communication and transit operations; these allow dynamic adjustment of transport many-to-many supply to time-dependent users' needs (demand adaptive transit, timed transfer systems, complex bus priority strategies, advanced self-organizing personal transit systems)."

Filippi, Fusco & Nanni (2013) discuss bidirectional integrations as high-level possibilities, however they do not show how they can be integrated into the design of the vehicle and service to add positive information feedback loops. This theoretical focus is common within the literature, providing a knowledge gap for design investigation.

If integrated correctly based on user needs, MaaS has the potential to provide new travel opportunities and help to minimise the difficulty of mobility usage for its users. MaaS could be particularly effective in suburban environments where, due to the sprawl, PT is limited and alternative modes could ease the burden on the mobility industry. There is an opportunity to better understand the different ways MaaS can be integrated into the mobility system to improve people's ability to travel, as well as potentially improving the appeal of use.

2.5 Passenger information displays (PIDs)

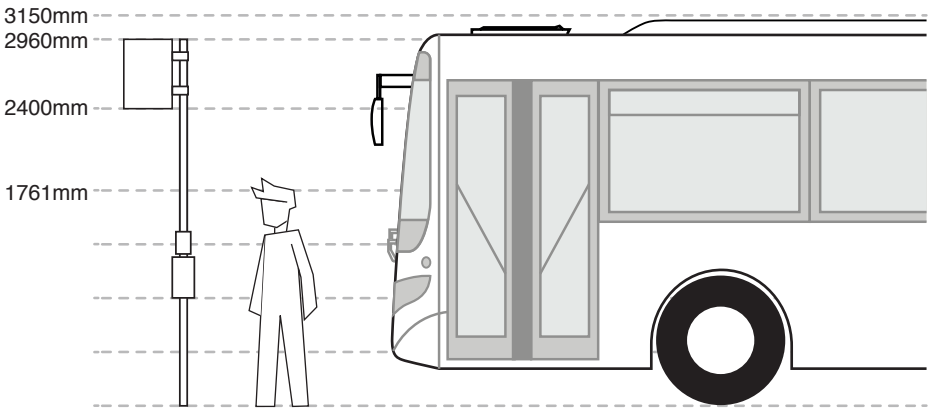
Passenger information displays are beginning to become more commonplace within PT environments, due to advances in display panels and ICTs (Matsumoto et al. 2014). These displays provide users with current and upcoming stop recognition; however, according to Camacho, Foth and Rakotonirainy (2012, p. 3), "this is not often the case with buses where it is up to the users to recognise their surroundings in an attempt to correctly identify where to alight the vehicle". Since 2012, these services have improved within the bus industry, with PIDs offering on-board and at-stop information access, allowing users to visually and audibly obtain context-sensitive information (Kühn, Lemme & Schlegel 2013) during the "route-monitoring and destination-recognition" stages of the journey (Mollerup 2005; cited in Coxon, Napper & Richardson 2018, p. 138). The addition of real-time passenger information provides further access to "dynamic, timely, and accurate information on alternative transportation services, such as vehicle arrival times, availability updates, and service change notifications" (Ge et al. 2017, p. 41). RTI has been noted to improve user satisfaction by reducing unreliability and uncertainty associated with waiting times (Cats & Loutos 2016). Barriers to use for such additional information include accessibility, with users being unaware, unable to understand or unable to obtain the service, making their benefits null (Lyons et al. 2018). Furthermore, with transit navigational abilities present within the smartphone, there are arguments to be made concerning the installation of PIDs and if they

are worth including within the bus network. Douglas (2018, p. 1), however, argues for their value, stating that there will always be "a need to confirm where you are and where your bus might be especially, for those without cell-phone information either by choice, poor reception or just a flat battery".

The majority of literature concerning PIDs consists of real-time passenger information development and user benefits (Brakewood & Watkins 2018; Cats & Loutos 2016; Ge et al. 2017), as well as technological capabilities and applications (Beul-Leusmann, Jakobs & Ziefle 2013). The literature is focused less on information quality and user requirements (ibid.), interface design of the displays and how existing displays within the field compare. Therefore, in order to locate areas for design improvement, according to Hörold, Mayas and Krömker (2015, p. 2809) information "systems have to be [analysed] to identify challengers, expectations and needs".

2.5.1 Designing information displays

In the context of this research, PIDs may be explored to address issues of lack of information within bus vehicles. Information displays can be developed in static, dynamic, interactive and interaction individual forms (Hörold, Mayas & Krömker 2015), with dynamic displays including real-time and updatable information being used within the current Melbourne environment. Regarding appropriate PIDs, Hörold, Mayas and Krömker (ibid.) identify four key design integrations listed below. Although these attributes centre on the design of bus stop timetable displays, the information can be considered relevant for similar on-board information. Firstly, the signage needs to be visible from a distance, including purpose clarity and a hierarchy of the information identified. Secondly, signs should include suitable content, with correct informational needs. Thirdly signs should include suitable font sizing and positioning, current size standards are listed in Figure 2.5. Lastly, signs' functions and interactions should be efficient to help users navigate content, reducing usage time and providing accessible information to different groups.



Viewing distance vs minimum type size

Viewing distance	Type size
2m	6mm
4m	12mm
6m	20mm
8m	25mm
12m	40mm
15m	50mm
25m	80mm
35m	100mm
40m	130mm
50m	150mm

From (Australian Standards1992) cited in Translink (2016)

Signage placement

1. If possible, signs are to be placed in accordance with AS1428.2 (Australian Standards1992) Clause 17.4, Location of signs.

2. If the design of the conveyance prevents strict compliance, signs must be placed above the head height of passengers, whether they are sitting or standing.

3. If used, destination signs must be placed above the windscreen. (Federal Register of Legislation 2002)

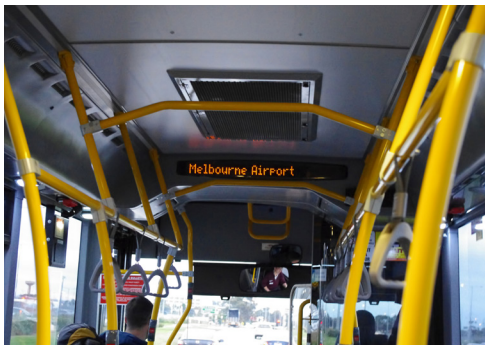
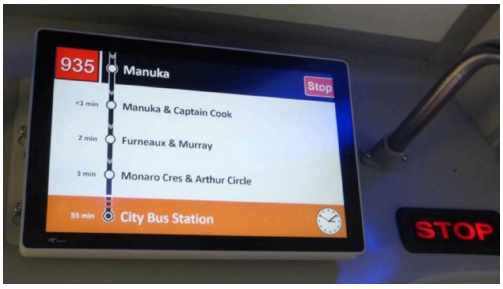
Figure 2.5: PT signage readability standards adapted from Translink (2016)

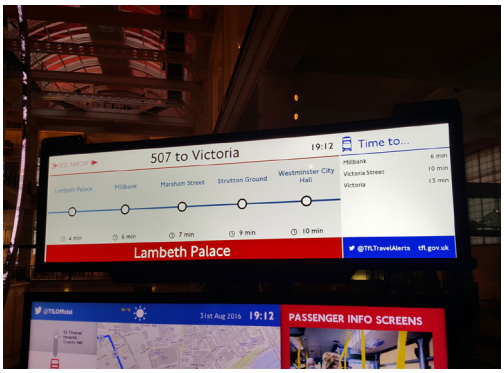
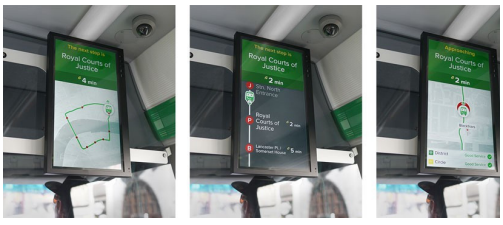
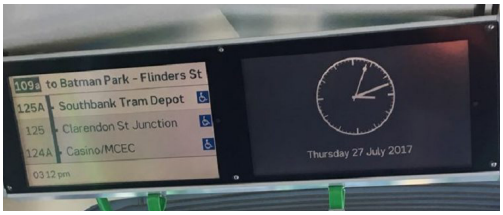
Further attention to information hierarchy is required, aiming to deliver suitable and correct information at the right time, preventing users from being overwhelmed by large amounts of irrelevant information (Lyons 2006):

1. Very important – information that is essential in determining the choice of mode, route or destination or whether or not to make a trip
2. Useful – information that does not affect the travel choices but enables the traveller to make a more convenient, comfortable trip with possibly greater confidence and assurance; and
3. Irrelevant – information that offers no value to the traveller in either planning or executing a trip and is likely to be viewed as irrelevant or off putting.

Based on this information, Table 2.1 presents review of the different types of PIDs based on the levels of information they provide to their users. This artefact review is not primary research; however, it does use real-world examples of PIDs combined with literature knowledge to identify different types of PIDs used.

Table 2.1: PID technology review

Description	**Location example**	**Image**
Style 1: Consisting of an LED screen and audio. Information present: Next stop and line of operation. This display includes the baseline of information a user needs to successfully undertake a journey. Within the Melbourne environment, the operating requirements suggest that destination and route number displays are only required by the transport regulations, providing less incentive to install sizable and in-depth systems, current systems opting for the base level of information. This highlights the lack of current investment in information provision, with Lyons (2006) indicating that investment in information won't be made unless usability benefits are seen.	Melbourne	 (Oz Bargain Blog 2012)
Style 2: Consisting of an LCD screen and audio. Information present: Basic route information, next, following and final stop identifiers. Final stop helps to identify route direction. Arrival times and route number.	Canberra Limerick Dallas	 (Pinterest 2019)

Description	Location example	Image
Style 2 (continued): This level of information provides service reassurance to unfamiliar users (Lyons 2006; Beul-Leusmann; Jakobs & Ziefle 2013), providing users with information to determine that they are within the correct service and when to prepare to alight. Aesthetic design consideration: The majority of these signs are cluttered and difficult to decipher, with unnecessary information, colour and hierarchy treatment.		 (ACTBUS 2018)
Style 3: Consisting of an LCD screen and audio. Information present: All previously mentioned information. Destination and transfer points. Nearby rail lines and bus stop timetables for transfers. Stop amenity information. Similar displays can be found on other transport modes (such as Melbourne tram network) which have higher focus on information communication. Although this example is the most informed, there is, however, information missing including: clear route location indications, previous stop indicators and next location information.	London	 (ianVisits 2018)
Other displays: Citymapper Further information pushing the boundaries for service provision includes the Citymapper dynamic map display. Built into Citymapper's MaaS smart app system, this allows users to follow their bus throughout the service in real time, simulating the current Google Maps navigation behaviour.	London	 (Sawers 2018)
Other displays: Train and tram Train and tram designs including full list of previous and upcoming stops, providing route location and use of pre-emptive departure planning.	Melbourne	 (Rail Express 2018)

2.6 User-centred design

The user-centred design (UCD) process places the potential service users at the middle of the design process (Ledbury 2018). This process encourages designers to move past their ideas and assumptions in order to determine what people want and need, and how they interact in their daily lives. This process helps to drive innovation by making "new products and services better meet the needs of users" (Sanders & Stappers 2012, p.19; see also Brown 2008; Grott 2019; Ledbury 2018; Siricharoen 2010). UCD is applied throughout the entire design process, helping to generate user-based knowledge, respond to this knowledge through designs, and iterate and evaluate the designs with user input (Mao et al. 2005). UCD is considered "the key to product usefulness and usability [and] an effective approach to overcoming the limitations of traditional system-centred design" (Mao et al. 2005, p. 105). This is because the framework encourages designs to fit and solve human problems, as opposed to changing human behaviour to accommodate designs (Grott 2019).

Within PT operation, the users are considered the centre of the system, with services designed to fit their changing needs. UCD, along with design-thinking principles, are therefore growing within this industry, with system improvement through design processes becoming more transparent. By adopting user-centred approaches the PT industry can deliver services that are "mutually beneficial for both passengers and operators", helping to shape communities and develop effective transport solutions (Mitchell, Claris & Edge 2016, p. 33; Culén, van Der Velden & Herstad 2014). The following are examples of PT projects that use UCD and user experience methods. "UX for a better public transport" (Marcos 2018), explored Madrid bus satisfaction for regular bus users, with a focus on disability and mobility problems, responding with a digital design solution. "Illuminating the Journey: improving public transit rider experience" (Boyd, Wyosnick 2016), explored user experience of PT within Seattle, focused on delivering UCD technology and services to improve the experience and user adoption. Lastly the objective of "The Melbourne public transport traveller: UX case study" (Houston 2018), was to develop additional features to the current PTV app, through UCD processes user insights were able to be determined and incorporated.

Each of these projects follow a design process and ethos similar to that of IDEO (2015). Firstly, initial field research was conducted in the form of observations or interviews to understand core user values, journey interactions, problems and overall user experiences. Secondly, the initial data collected were reviewed, synthesised and organised into themes, prompting the development of personas and journey maps. These are described by IDEO as the inspiration stage, where empathy and user insights are revealed. The insights help focus the project, allowing user needs to be addressed (IDEO 2015). Thirdly, the ideation stage provides tangible responses to the initial data gathered, resulting in improved user experiences. During this stage, designs developed are placed back in the hands of the users, providing opportunity for assessment. This stage allows user opinion and feedback to be incorporated within the design process, and the designs to be refined based on feedback. Lastly, the implementation stage consists of product finalisation and development for manufacturing and release (IDEO 2015). This last stage was not presented within the above examples.

At each of these stages, the user is considered the central informer, providing feedback and design direction. For example, during the Marcos' (2018) project, initial problem framing and understanding was developed concerning bus user experiences in Madrid. These problems and insights formed personas and journey mapping visualisations, providing the team with user-centred knowledge to design from. This knowledge resulted in the production of interactive bus stops, providing users with the ability to hail and be informed of upcoming services. Each of these projects are examples of the insights and creative problem-solving capabilities that design methods can bring to the PT field. The project presented in this exegesis will follow a very similar UCD framework, exploring how this process benefits low-density, suburban environments, with a focus on both vehicle and service integrations.

2.7 Knowledge gaps and research focus

The purpose of this literature review has been to explore the problems related to bus user experience in more depth by examining the demographics of bus users and analysing problems related to poor service quality. Through reviewing the literature three knowledge gaps have been identified: first, a lack of detailed, Melbourne suburban specific research; second, limited concept development for bidirectional app and vehicle integrations; third, limited design specific methodologies used to conduct research. Research questions have been developed to address these knowledge gaps. These will now be discussed.

Literature discussing negative quality attributes and how they affect user perceptions and journey experiences provided thorough insight into bus user experience. There was limited literature addressing these experiences through qualitative methods within suburban Melbourne specific environments. CSM data and PTV journey maps provided context-specific insight; however, a more detailed and holistic representation of the user experience and problem points is required to better understand and design for this specific environment.

While reviewing the information channels, MaaS literature was often explored within high-density environments, and appeared limited when discussing the integration of MaaS systems and user requirements within low-density and limited mode choice environments. Similarly, MaaS and bus vehicle bidirectional interactions, also based on user requirements, was found to be limited. Developing these ideas into concepts and synthesising the present knowledge and user requirements could develop visually new ways of understanding and delivering bus services.

Knowledge found during the literature review was predominantly based on transport planning, ethnography and behaviour, using traditional engineering and social science techniques to conduct research and discuss user behaviours and mobility issues. There appears to be interest building for the incorporation of design methods in PT development, with the UCD projects previously mentioned, and user-focused departments of transport organisations being examples of initial integration. However, examples within this space are still limited, particularly in relation to Melbourne bus operation, vehicle and system designs. This can result in limited synthesis of knowledge around user experience and design. This last research gap therefore provides two opportunities for practical and theoretical research contributions through design enquiry.

The literature review has provided extensive information regarding bus user experiences globally; however, limited knowledge was available concerning the specific Melbourne context. Further data-gathering research must be undertaken to provide deeper levels of understanding, with research questions developed to help produce relevant responses.

Through reviewing the literature, the research context and project scope have been identified. The aim of the project is to discover how the problem of negative bus user experience in Melbourne suburban environments can be better understood and improved through design enquiry. The following section presents the developed research questions that will be answered during the PhD to help focus the project and deliver an answer to the original research aim.

Primary research question:

> *How can bus user experience in suburban environments be improved through design enquiry?*

Subsidiary questions have been developed to help break the main research question down into more tangible outputs:

> *Sub 1: What is the current bus experience like for Melbourne suburban bus users and what are their main concerns?*
>
> *Sub 2: How can ethnographic methods be applied in design practice to develop user-centred bus services?*
>
> *Sub 3: How can design practice be used to respond to the research findings and improve the bus user experience?*

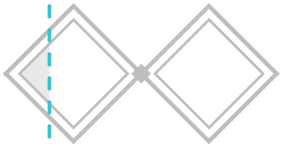
The research focus and project scope have been identified in response to a review of the literature. The aim of the project is to discover how the problem of negative bus user experience in Melbourne suburban environments can be better understood and improved through design research and intervention.

2.8 Summary

This chapter explored the literature concerning the bus user experience. The outcome of the review helped to develop the project scope and highlight gaps within knowledge that, if filled, may help to understand and improve the bus user experience. The main identified gaps included: the limited number of design methods used to understand bus user experiences, the lack of specific, context-based research, and the lack of design investigation of bidirectional information channels. Now that the literature has been reviewed and the project scope identified, the methodology behind this research will be discussed to greater extent in the following chapter.


Clayton Campus
Monash University Intercampus Shuttle Bus
To Caulfield Campus

Chapter 3
Methodology



The previous chapter reviewed the literature regarding bus user experience. From reviewing the literature, knowledge gaps were revealed to include the lack of design methods to understand bus user experiences and the lack of specific, Melbourne context-based research. These knowledge gaps present the opportunity to explore suburban bus user experiences through design enquiry that can generate new knowledge. To help respond to these gaps and the project aims, main and subsidiary research questions were developed:

> *How can bus user experience in suburban environments be improved through design enquiry?*
> *Sub 1: What is the current bus experience like for Melbourne suburban bus users and what are their main concerns?*
> *Sub 2: How can ethnographic methods be applied in design practice to develop user-centred bus services?*
> *Sub 3: How can design practice be used to respond to the research findings and improve the bus user experience?*

This chapter provides methodological framing for this research project. The research project is first positioned within the broader field of PT research by explaining the project's theoretical stance. The methodological framework of design-inclusive research (DIR) with a UCD focus is then introduced as the dominant approach applied within this work. Specific research activities are then discussed in response to each subsidiary research question and the overall project aim.

3.1 Research position

As discussed during the literature review, PT user requirements can be mapped within a customer satisfaction pyramid (van Hagen & Sauren 2014), seen in Figure 3.1. The pyramid is used to further contextualise this project and provide a visual representation of where it fits within the complex considerations of PT research.

The PT field is currently dominated by a civil engineering focus, tasked with delivering safe and reliable transport services that are fast and easy to use. These attributes are considered the foundation of the pyramid, and of transport delivery, that when implemented meet the base levels of user satisfaction and service quality. These bottom levels were identified as the area where the majority of the literature sits and as the main focus for civil engineering input, as inability to maintain and grow would result in user dissatisfaction and system failures. In contrast, this project and design contribution to the PT field is placed within the top section of the pyramid, as it seeks to understand and improve user experience. This consideration of higher level needs focuses on improving overall user experience and satisfaction levels.

During the literature review, less attention was found to have been focused on the top sections of this pyramid and even less attention was found to have used creative design approaches to conduct research and produce solutions to service problems. This has provided the opportunity for this project to explore bus user experiences through design enquiry, placed at the top of the pyramid.

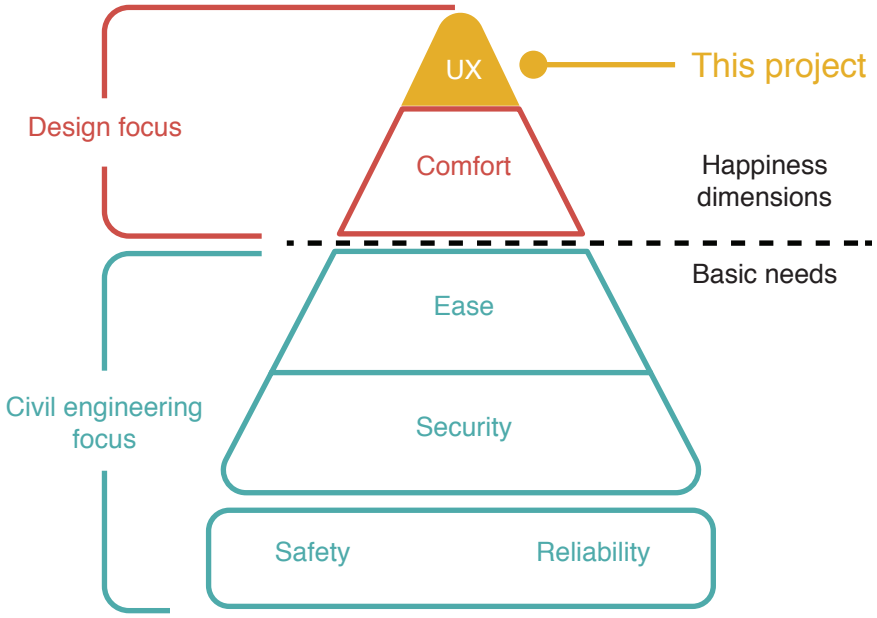


Figure 3.1: Customer satisfaction pyramid adapted from van Hagen & Sauren (2014)

3.2 Design enquiry

The design field can be considered a “distinctive domain of knowledge”, as well as a “specific form of learning and knowing” (Horváth 2008 p. 62). The second consideration can be classified as design enquiry, where production of intelligence for design, explanation and results are sought through knowledge synthesis, and analysis during the artefact development process (ibid.). Similarly, design enquiry provides a platform for the development of artefacts through “a combination of knowledge analysis and synthesis” (ibid. pp. 62-63). The goal of design research is the development, articulation and communication of design knowledge (Cross 2007). Unlike scientific methods, whose focus is on understanding problems through analysis, design enquiry produces solution-based outputs due to its

focus on problem-solving by synthesis (Cross 1982). This framing encourages design development and iterative processes to take place, leading to both problem understanding and creative solutions. As previously noted, the PT environment is complex, consisting of multiple interwoven problems, due to their complexity and difficulty in solving. The issue of poor user experience is also complex, due to the multi-stakeholder environment, large service usage, service coverage and the increased complexity of society and travel-related issues. Unfortunately, traditional problem-framing approaches are becoming less suitable for creating solutions to these complex problems, as they require holistic understanding of the topic in order to be suitably solved (Dorst 2015). Design approaches are suggested as an alternative response; these have proven suitable for handling complex problems as they offer creative ways of understanding and problem-solving (ibid.).

This research was undertaken as a studio-based research project which used design enquiry with a UCD focus - as discussed during to literature review - to understand and improve bus user experience. Design practice worked within this research as a tool to gain user centred knowledge and interpret findings into physical service and vehicle solutions that improve bus users' needs. Applying design enquiry to the transport field allowed the complex environment of existing problems, changing environments and user behaviours to be understood and synthesised holistically. This knowledge then informed concepts and helped to produce user-centred solutions and service innovations. To apply a UCD focus, specific design ethnographic methods of data collection and testing were applied, to allow user opinion to be the central focus at each stage of the design process. These methods, which will be described in detail during Section 3.5, show evidence of UCD implementation and how incorporating user opinion at the beginning of the design phase encourages alternative designs opportunities. This framework is described within Figure 3.3. The following section describes the theoretical perspective undertaken to help provide the user centred focus.

3.3 Theoretical perspective

Crotty's (1998) four elements were utilised as a way to understand the theory and knowledge behind this project. The chosen elements, shown in Table 3.1, were used to help ground the project within a philosophical framework, each was chosen to complement the others. Each proposed element was broken down and discussed in relation to its suitability for this project.

Table 3.1: Philosophical framework (adapted from Crotty 1998)

Epistemology	Constructivism
Research methodology	Design inclusive research
Data collection and generation methods	Qualitative data analysis Observations Travel diary/cultural probe Design practice Usability testing

Constructivism is viewed as the formation of truth and meaning through the interaction of a subject with the world. An object therefore has no meaning until it engages with the consciousness of a subject (ibid.) and individual interpretations lead to a variety of ways that objects may be understood. A constructivist view of the world places design as a "way of life and a socially embedded process of discovery" as opposed to purely material manifestations (Horváth 2008). This view of knowledge was considered suitable for the project as it encourages perspectives, relationships and experiences to be derived. This view is considered important as mobility usage is complex and often intangible, requiring travel behaviour, perspectives and experiential understanding to be determined before increased service satisfaction can be produced. The project then focused on changing these interactions

and experiences via an improved redesign of the vehicle and service. Understanding these realities allowed for a deeper knowledge to be gained of the current bus user and encouraged informed service changes to be implemented.

3.4 Research methodology

This project followed a design-inclusive research (DIR) methodology as described by Horváth (2007, 2008), which was used to provide scientific rigour to the creative design enquiry process (ibid.). This process was utilised for its ability to embed design within public transport research, which is already a rich field of knowledge. This allowed new opportunities to be explored and subject matter to be contextualised within the bus environment. Additionally, this creative process enabled the development of knowledge which was unique to this space. As seen in Figure 3.2, the DIR process consisted of three main phases. First, in a stage of divergent explorative research, existing knowledge was aggregated to identify themes in the field. Focus then converged on defining the knowledge gaps in current literature and design precedents. Following this stage, a hypothesis was developed based on the knowledge gaps that provided direction for the design activities. The creative design action stage allowed the research obtained to be synthesised into outputs through divergent and iterative design cycles. Lastly, confirmative research action allowed the design outputs to be tested against the results of the pre-existing body of knowledge developed during the initial research stages. This resulted in design and hypothesis validation. Horváth (2008 p. 68) presented DIR as an existent methodology within the industrial design field, providing four PhD case studies from Delft University of Technology as evidence of DIR project framing. These case studies show that DIR framework can be successfully utilised to provide knowledge and design outputs to a variety of different project contexts. The DIR framework can be mapped onto the UK Design Council's double diamond design framework for clarity (Design Council 2007), as seen in Figure 3.2. Divergent and convergent knowledge production occurred during the DIR methodology framework, which led to data generation and concept production.

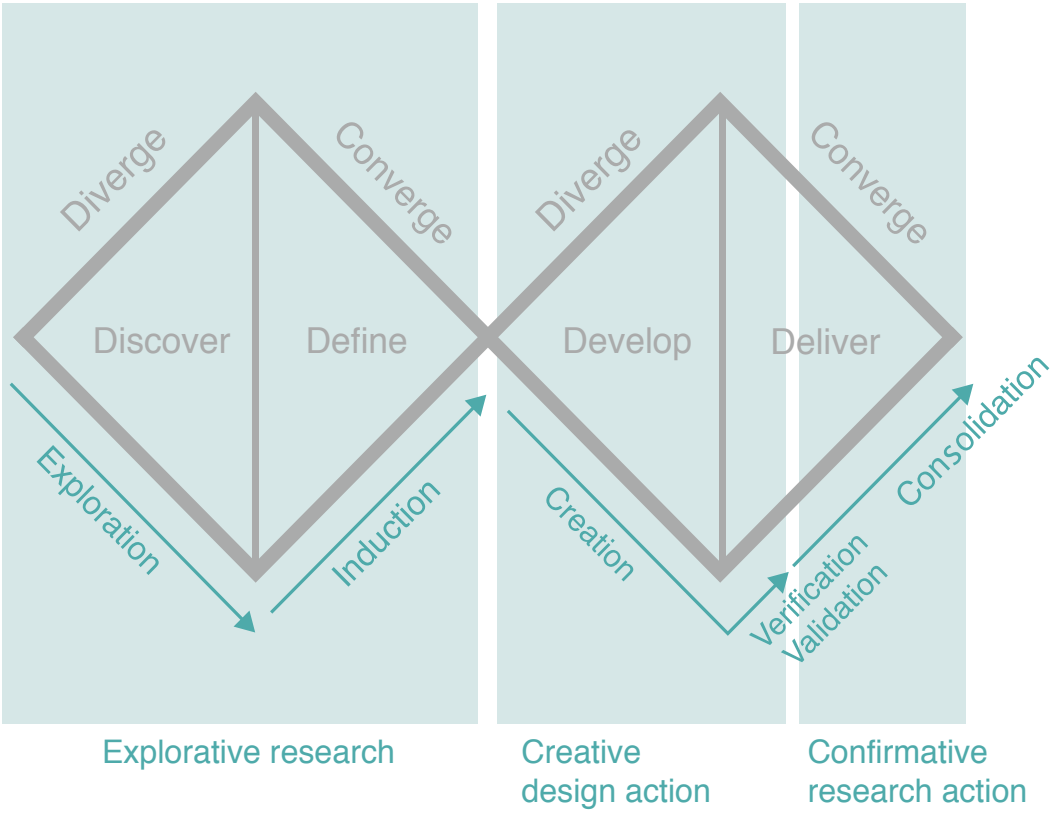


Figure 3.2: DIR methodology within the double diamond (Design Council 2007)

Design ethnography (DE) methods were implemented throughout this DIR methodology, allowing human ecology and user-centred understanding to be the central focus during the data-gathering stages and throughout the design process. Applying DE methods, such as observations and cultural probes, allowed the project to take a strictly user-centred approach and focus on the identification of user needs by understanding their actual behaviours and desires, as opposed to what they say they do and want (Norman 2013). This helped to uncover new dimensions of users and ways to satisfy needs that users did not know they had (Salvador, Bell & Anderson 1999; Ventura 2011; Wasson 2000).

3.4.1 Design ethnography

DE, or applied ethnography, first gained prominence within the late 1990s and is currently used within the front-end of design research as a means of understanding culture and to inform designs (Rodgers & Anusas 2008; Salvador, Bell & Anderson 1999). DE provides researchers with methods allowing them to study and understand cultural routines and everyday life experiences concerning the use of a particular product or system. The methods consist of field-based research, helping to create first-hand, empathic observations of the user and allowing the designer to "work from the perspective of users on new designs for relevant slices of [their] daily lives" (Stickdorn et al. 2011 p. 102), as well as allowing the design to "determine human needs that can be addressed through new products" known as actionable insights, providing a "context for innovation and creativity" (Lindley, Sharma & Potts 2014, p. 239; see also Norman 2013; Rodgers & Anusas 2008; Segelström & Holmlid 2012).

Although DE is a subcategory of the traditional social science field of ethnography, the goals and results of the two areas differ. In relation to this research, the main point of differentiation between DE and ethnography is that DE creates actionable insights for design interventions based on cultural understandings of people and their relationships to a product (Lindley, Sharma & Potts 2014). This knowledge can directly inform the design process (ibid.). DE is also typically a shorter process when compared to ethnography, due to being set within the commercial world (Salvador, Bell & Anderson 1999). This influences the way designers conduct their research, using time-sampled observations or sampling research techniques like the use of cultural probes, instead of spending long periods out in the field (Hanington & Martin 2012).

3.5 Data collection methods and progress

This project can be divided into three main stages: explorative, creative and confirmative, as illustrated in Figure 3.2. Firstly, the exploration stage was undertaken during the early stages of the project and focused on gaining a knowledge foundation for the project, achieved by analysing artefacts, literature and industry data currently available and relevant to the subject. This initial research allowed the knowledge gap to be discovered, leading to the formation of the research questions, as well as the design enquiry focus. Gaps within the literature created the need to undertake further studies focused on user experiences within Melbourne suburban environments. The studies used DE methods and were designed to build upon the literature findings to develop a more cohesive understanding of bus interaction and to improve this experience (Barab et al. 2004). The methods used consisted of customer feedback data analysis, observational fieldwork and travel diaries. Each method was designed to gather slightly different user-based information, which built a clearer picture of the user environment. The information gained was analysed separately and then triangulated and reviewed as a whole; this allowed "concepts, categories, patterns, exceptions and/or hypotheses to surface" (Nova ed. 2014, p. 55). By applying design ethnography methods during the exploration stage, strong empathic connections were generated between the researcher and the user, with key insights and perspectives developed. The CFD first provided a broad understanding of the system, by listing first hand user grievances and current service issues. Observations allowed primary research to be undertaken where user behaviours and interactions were experienced first-hand by the researcher. Lastly, the travel diaries allowed users to voice their opinion further concerning the specific themes identified within the previous studies. These UCD methods allowed user insights and experiences to directly inform the design solutions.

During this first stage, experience models (Jones 2006) were developed to visually synthesise the data. This resulted in identification of the main issues within the user experience, as well as allowing the design direction and design hypothesis to emerge. These data-gathering and analysis processes helped to create the foundations for the second and third research stages, the design process and evaluation stages. The design stage consisted of synthesising the primary research and developing it into design concepts that respond to the identified problems. These designs were then reviewed during the formative, usability-testing stage. Virtual reality (VR) was used to assess and validate the concepts, which encouraged further user-centred knowledge to be developed. By incorporating users during testing and concept review stages, their opinions and experiences provide feedback and additional design development. Placing usability testing processes at early stages of the design process and repeated throughout allows time for user feedback to be incorporated within the designs (Dumas & Redish 1999; Sandars & Lafferty 2010). This process was only able to be undertaken once during this project, however future work suggests more testing is required. Refinement was then undertaken to produce sophisticated concept outputs that responded to the usability-testing feedback. Each of these specific methods is described in more detail within the following corresponding chapters.

3.6 Project theoretical framework

Figure 3.3 is a summary of the project's theoretical framework, showing how each of the stages and methods were framed to answer the research questions and project aim. UCD methods were applied within the DIR, to create a combined UCD framework present throughout the project. The combined project framework is represented within Figure 3.3, displaying a more detailed and rotated version of the double diamond/ DIR diagram initially shown within Figure 3.2. Figure 3.3 includes the overall visualisation of the theoretical framework, whilst also showing ordered project stages during the design process. The diagram is supplemented by research questions and UCD components to indicate where in the project they will be addressed.

3.7 Summary

This chapter has discussed the research framework that was applied to help the research successfully respond to the project aim and research questions. A design-inclusive research methodology was presented as the framework foundation, allowing design enquiry to lead the research and design process within the context of PT. The project framework consisted of three main stages. The explorative research stage consisted of a literature review, three data-gathering studies and their analysis via triangulation. This stage was supplemented with DE methods to allow user-centred, qualitative and Melbourne-specific experience knowledge to be gathered. At the end of this stage, the main experiential problems were identified and prepared to be designed for. The creative design action stage then synthesised this data helping to provide informed design responses to the experience problems identified. Lastly came the confirmative research action stage, providing design testing and validation processes. The next chapter presents the user-centred data collection and design synthesis stages of this research. Specific methods are elaborated on within each section for greater detail.

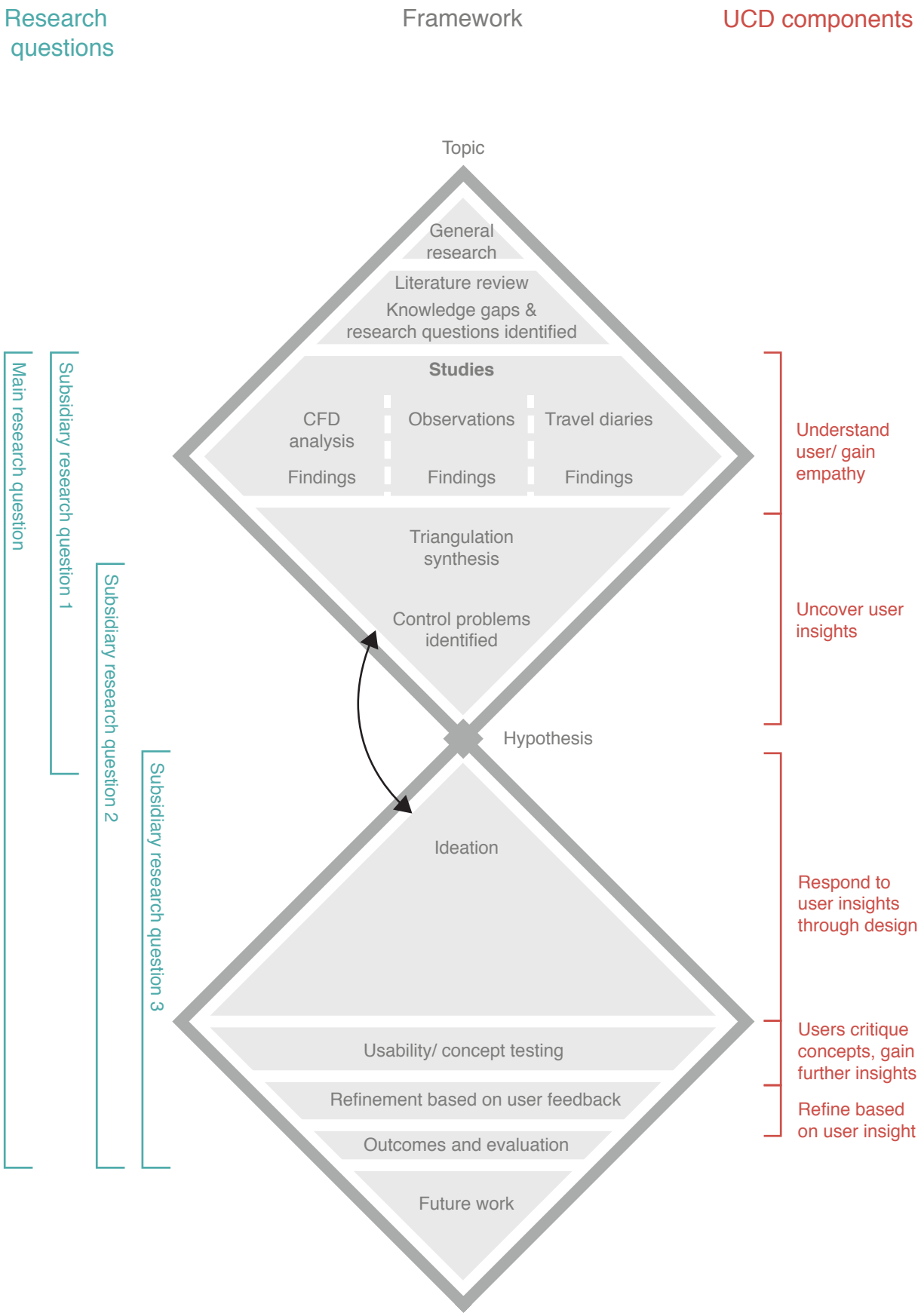
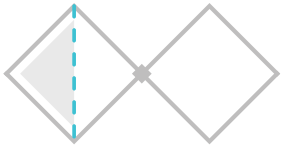


Figure 3.3: Project framework - read from top to bottom

Chapter 4
Qualitative data gathering and analysis



The previous chapters have built a picture of the current bus operational environment and identified the problems related to the poor service perception and experiences associated with bus usage. Although this knowledge was extensive, there was still a lack of information specific to the experience of Melbourne suburban bus users. Further research was required to answer the first subsidiary research question, which will be explored and answered within this chapter. This research provided the opportunity to explore the bus user relationship through design-based methodologies, an area that was identified to be limited during the literature review.

> *Sub 1: What is the current bus experience like for Melbourne suburban bus users and what are their main concerns?*

To answer this question, three different studies were conducted to build upon existing knowledge and provide multiple perspectives concerning the same research topic. The methods used within the studies consisted of qualitative customer feedback data analysis, observations and travel diaries. These methods assisted in the delivery of a user-centred approach. Each study focused on the collection of data surrounding the topic of Melbourne bus user experience, with each new method designed based upon the previous studies' knowledge. This targeted the questions and answers being sought. By using these three distinct data collection methods, different viewpoints and layers of information were developed, determining a detailed picture of bus travel. To strengthen these findings, triangulation was used during analysis of the overall study findings (Section 4.4) to compare the different datasets; discover the areas of convergence within the research; and validate the qualitative research outcomes (Visocky O'Grady & O'Grady 2009).

This chapter will discuss the studies and their results separately, providing a detailed account of each study's establishment, data collection structure, analysis process, results found, limitations and study value. Once all the studies have been reviewed individually, the findings section compares all the results, highlighting the key findings, themes that emerged and potential avenues for design implementation.

4.1 Study 1: Customer feedback data (CFD)

The first study collected and analysed CFD and was employed to better understand the concerns and failures users are experiencing with current Melbourne bus services. The main objective of this study was to analyse the CFD to understand the recurring issues affecting user's experiences within Melbourne, as well as determining what problems are the most pressing. This study, similar to the studies that follow, was focused on gathering qualitative data, providing detailed accounts of the environment and what is occurring within the system from user perspectives. Unlike the following studies, the CFD consisted of a broad dataset, including all communicated user issues. This provided an evidence base for the themes discovered during analysis, which formed the basis for the following two studies.

4.1.1 Customer feedback dataset

CFD is a qualitative database that transport operators have at their disposal, consisting of all customer feedback and communications to the operator and transport-governing agency. It provides users with a direct line of contact to the operators to express their concerns or to gain further insight about services. Similarly, it provides operators with feedback surrounding service failures and realities that are occurring within their system, with the public acting as the operator's eyes and ears out in the field. CFD subsequently acts as a reliable source upon which to base operational changes, and is a necessary and valuable database that the system inherently creates. It should be noted that CFD does include a number of limitations such as: a self-selection bias, where negative circumstances or other factors such as personality or time availability can encourage respondents to write or call the operator about an issue. This system often results in disgruntled feelings and responses. These feelings often move people to engage with the customer complaint process, resulting in the CFD being skewed towards particular viewpoints. The data were originally deidentified, preventing the researcher from determining demographic correlations. Despite this, the owner of the data did link higher respondent rate with older public transport users. Although not evidenced this might influence feedback provided.

The CFD obtained consisted of feedback given by bus users during the whole of 2016. Due to the broad topic range of the dataset, the area of scope was narrowed, firstly centred on vehicle-related feedback: cleanliness, air-conditioning, pushchair space, comfort (poor conditions), injury, comfort (other), wheelchair ramps and vandalism. Secondly, service issue responses were introduced and analysed, as they were found to be the most commonly discussed topics (making up 96.3% of the two data sets) and were important to explore if major user concerns were to be identified. The main categories featured in the service-related feedback were driver-related issues, user-related injuries, antisocial behaviour, missed buses, overcrowding, route changes, running early or late, cancellations, wrong routes and service changes. All categories mentioned were from the CFD grouping system used by the operator for the vehicle and service based comments. As the CFD was considered sensitive, direct quotes were not included within this section.

4.1.2 Data analysis

The initial scoping of the data took place within Excel, where the data was categorised in order of the most discussed topics. In-depth analysis was then performed to provide qualitative understanding and assessment of the data provided. Of this data, all 283 vehicle accounts were analysed. However, due to the large dataset for the service feedback, a smaller sample size of 200 accounts – including all categories – was randomised for analysis. This approach was taken because the high-level category breakdown of service problems had already been acquired, detailing what issues most commonly affect Melbourne bus users. The next research objective was to determine the in depth reasons behind these problems, discussing the user experience, the causes, and responses to the system failures. The dataset included rich qualitative data and a sample size was considered suitable to allow a more thorough analysis of specific experiential insights to take place. Additionally, a sample size of 200 sets was seen as sufficient as the themes started to be repeated. Both sets of data were imported into the

qualitative data analysis software Nvivo, where the analysis took place. The analysis stage consisted of reviewing and coding the raw data to produce more precise information regarding the original categories. For example, the category of vandalism was able to be broken down into subthemes including graffiti, user-specific feelings and photo evidence. This process identified behaviour commonalities and opinions regarding service problems, and how the users responded. The results from this data breakdown will be discussed in the next section.

4.1.3 Results

The data analysis was broken down and discussed within the two overarching themes of vehicle and service feedback. During the analysis of both groups, subthemes were found which will act as the main topics of discussion for this section.

Once analysed, it became apparent that some of the feedback featured an overlapping of results, with users giving feedback or making complaints about more than one aspect of their travel experience. This led to an accumulation of different frustrations and issues they had previously experienced. Table 4.1 is a more detailed breakdown of the main themes.

Table 4.1: CFD analysis breakdown for vehicle and service attributes

Category	**Number of responses**
Vehicle	
Antisocial behaviour	3
Fed up with vehicles	4
Maintenance	18
Cleanliness	58
Bodily fluids	8
Should not be in service	3
Took photos	1
Graffiti	41
Negative feelings	9
Shouldn’t be in service	4
Took photos	4
No universal access	17
Shouldn’t be in service	1
Took photos	1
Noise	13
Old bus	12
Pollution	37
Shouldn’t be in service	3
Safety	8
Shouldn’t be in service	1

Category	Number of responses
Smell	10
Temperature	61
Air-conditioner not working	17
Shouldn't be in service	3
Too cold	16
Too warm	28
External factors (weather)	11
Would like a response	21
Service	
Driver did not stop	16
Frustration with situation	18
Full and cramped buses	10
Lack of information or false information	34
The bus being late having repercussions	13
Minor stop timing points	4
Had to call operator	4
Wanted to know why the bus was late/did not arrive	16
Having to wait for multiple services	2

Both of the above tables respond to the studies' objective by providing an overview of the user problems associated with Melbourne buses. The following section will present the findings for the issues that caused the most dissatisfaction and barriers to service use.

Fleet age

The age of the bus fleet affects the condition of the vehicles, causing safety, noise and pollution concerns, as well as wear and tear. In several complaints, users expressed their annoyance at frequently having to catch older buses. These were considered unreliable, prone to failure and with lower levels of comfort, as well as not being watertight and leaking during wet weather periods.

This unpredictable nature of older buses, not knowing what you will receive from service to service, and the knowledge that more comfortable and acceptable buses exist may increase the dissatisfaction of the users. Some respondents described their immediate frustration at seeing an older bus arrive at their stop, with past experience directly influencing their current experience.

Vehicle access for mobility impaired

The common 12.5m low-floor bus within the Melbourne environment features an accessible design, including kneeling and manual ramp deployment, to provide access to mobility-impaired, mobility-aided and pram users (King 1998). These features aside, the CFD includes multiple accounts of this system failing, with mobility-impaired users being unable to board and forced to wait for another service to arrive. The comments discuss the causality of these scenarios, including bus drivers being unable to deploy the ramp due to: ramp being out of service; back problems and manual-handling concerns; unwillingness to deploy ramp for unknown reasons; running late; not seeing the user.

Another commonly identified problem was the usage of older buses that were not DSAPT-compliant. Older buses were said to cause longer waiting periods if they were used unexpectedly on routes with low frequency. The main concern of the usage of older buses centred around their random nature and the uncertainty and disruption of travel they brought to their users. Users were said to be left in outdoor conditions, forced to wait for the next bus, with no guarantee of boarding, creating uncertain environments that make overall user journey planning redundant.

Lack of information, false information and lack of communication

Information provision was more often described through negative journey experiences within the CFD. The two main themes found can be described as non-existent or incorrect information. When zero information was delivered, users described this situation as feeling uncertain, confused or frustrated about the journey experience. This sometimes resulted in users saying that they needed to ask for more information from other users, bus drivers, or by using alternative electronic means; for example, calling the operator, using transit apps or the internet.

The lack of information was associated with services being late or early, or buses missing stops entirely, prompting users to communicate with the operator to find out more details as to why the situation had occurred. Incorrect information being displayed, often caused by a lack of real-time service updates and out-of-date timetables, was described through negative experiences and comments. These incorrect information channels led to a lack of trust towards operators and the service information they provide. The lack of information within this environment was associated with passengers expressing a lack of trust and control over their travel plans and experiences. These negative associations could result in uncertain travel environments, as well as diminished accessibility.

Timing points

Another example of a lack of information and education within the bus system that was highlighted in the dataset is regarding missing services due to timing points. Missing services was a common theme found within the data; however, missing services due to early operating times were discussed with greater annoyance and confusion. The issue surrounding these complaints was not that the service was running early, but that the users had a lack of understanding of how bus systems operate at minor stop timing points. Based on this data, timing points do not appear to be common knowledge for Melbourne bus users, with operators needing to explain the concept repeatedly. Within the data this was a good example of how a lack of information and communication can worsen a bus journey experience, creating an unnecessary negative perception of the overall service.

Drivers not stopping

Similar to physical vehicle access, 16 accounts showed that drivers did not stop to pick users up. These were explained by a number of reasons, including: services being converted into express services without warning; buses already full on arrival; users not being seen; buses running late; and drivers unable to deploy ramps. Being left at a stop when you have done everything correctly was shown to lead to frustration, uncertainty about the situation and further trip repercussions; for example, being late to work.

Frustration and repercussions

Unlike interviews and survey-based studies, which often use participants' memory of a specific situation, the field-based style of the CFD is predominantly reaction based, associating the feedback with participants' emotional state. Users in heightened emotional states responding to situations deliver skewed responses as compared to a user being asked for a retroactive memory-based response, as often found within the literature. An example of this is that someone may file a complaint if the bus is not on time, but is less likely to talk about how they enjoy being able to zone out during their

bus trip (Stradling et al. 2007). Frustrated language is commonly presented within the CFD, with the feedback language being a good example of why buses are so negatively perceived. Interestingly, some respondents' feedback was only given after multiple negative experiences occurred, with a complaint being the final course of action resulting from service frustration.

4.1.4 Discussion and conclusion

This method analysed qualitative information to understand the main issues currently present within the Melbourne bus environment. This dataset was broad, providing all communicated issues with users, giving a robust evidence base to the data analysed.

The results of this study showed the main vehicle and service issues for users within the Melbourne bus environment. It was also apparent that user concerns over service-based attributes significantly outnumber that of their concerns for the vehicle itself. While analysing this data, it became apparent that the dataset was inherently based on three different attributes. Firstly, the data followed a similar pattern to the service quality and user satisfaction theory reviewed in Chapter 2. The reviewing users generally made complaints about a service when it fell below their expected base level of service, which often limited user insights. Secondly, feedback provided was often highly emotive, discussing service failures. This reduced the likelihood of positive responses and discussions around common service usage, leaving information gaps surrounding general user behaviour and experience. Service failures generally concerned the lack of information present within the system, with users wanting to know why a particular situation occurred, to gain more control and understanding about the service.

Other limitations of the data set included the exploration of only vehicle and service comments. The other categories such as lost property were deemed to be less insightful of the product and service failures; however, they may have provided alternative opinion to some themes discussed. As previously mentioned the data were deidentified and unable to be included. The method of analysing the data allowed a broad understanding of the main problem points to be assessed, with the qualitative details of each comment providing deeper scenario understanding. The main limitation and need for alternative primary research is the inability to determine regular journey experiences. Despite the often-negative opinions, the CFD was considered a rich and vast source of information that is very important to understanding the pressing issues within the Melbourne bus landscape. It was also a useful source of information for the operators to base service changes upon. Now that a clear understanding on the main user concerns of buses within Melbourne has been reached, further studies will be conducted to better understand proactive journey experiences through a broader, less reactive, fault-based focus, allowing journey requirements, travel plans and service usage to be seen and synthesised.

4.2 Study 2: Observations

The CFD was an appropriate way of understanding the pressing bus vehicle and service issues. As previously discussed, the CFD only captured snippets of a user's experience, often highlighting only the negative instances where they felt compelled to make a complaint. Full journey experiences are, therefore, important to understand if a more user-based service and vehicle design are the intended outcomes. The objective for the second study was for a single researcher to observe bus experiences, identifying the interactions they and the users had with the vehicle and service, as well as identifying any problems that occurred. This study helped to further inform the CFD results, focusing on what a regular journey looks like, as opposed to only failures and issues.

4.2.1 Observational method

Observations allowed the researcher to engage within the field and observe a particular culture, gaining empathy and understanding of the users and their environment. This method is useful when tracking "different contextual data such as work flows, sequences of actions, the physical environment, ergonomic and usability issues as well as interactions between persons and products" (Mattelmaki 2006 p.164). It allows research to be conducted directly on how people act in particular situations, instead of what participants say they do, giving a first-hand account of what actually happens (Denscombe 2010).

The observations were conducted by a single observer. The single-observer approach was based on the Hirsch and Thompson (2011) study, which used a single observer as a way to prevent multiple perspective biases from occurring and to ensure consistency within the fieldwork observations. This approach, however, can cause a single perspective bias to occur (Denscombe 2010). As a way to counter this, a systematic checklist was created and utilised. The findings from the observations were used to inform the creation of the third study, travel diaries, allowing the observational findings to be discussed and analysed.

The type of observation conducted was participatory based, focused on observing user experiences and the interactions that users have with the bus or service. Furthermore, this study allowed the researcher the opportunity to "go native" (ibid.) and observe their own bus experiences, which enabled a further level of empathy and understanding, as well as informing later research methods such as the travel diary study. To perform the observations successfully, it was important for the researcher to retain "certain detachment", allowing them to walk a fine line between observing their own experiences and those of the users (ibid.). As a means of doing this, the researcher used systematic field-notes, in the form of a checklist of particular themes to be observed. This allowed a more formal method of note-taking, including a systematic checklist, to prevent biases. The checklist included two main information channels, firstly generic service information: route, time of day, external and internal factors (e.g. weather, travelling alone/with someone), new or regular journey and if any abnormalities occurred. These points allowed a basic level of context to be identified concerning each trip. For example, wet weather may impact how passengers board the bus to prevent slips and trips, or the observer might require additional wayfinding information during abnormal journeys. Secondly, observational themes where the researcher would note down interactions and observed experiences people had when interacting with the bus system. These generally centred around user interactions and touchpoints: touching on, driver interactions, sitting compared to standing, catchment zones, what multitasking activity users performed and how these were affected by driving styles. These provided insight into users' behaviour, travelling routines, interactions and responses.

4.2.2 Pilot study

Initial observation fieldwork - now considered the pilot observations study - consisted of 40 documented trips, taking place throughout 2017, when the design researcher used the bus as their dominant mode of transport, allowing the researcher to gain first-hand empathic experiences. The findings from this study were considered rich; however, due to the lack of communication and access to users' thought processes, assumptions were made. These findings were therefore used to inform the next travel diary study to help validate and unpack the observation findings, with the emerged insights informing the design outcomes developed. It should be noted that ethical expectations changed during the course of the project which affected the ability to present the initial observational study. These unforeseen changes came to light at the end of the project prompting the researcher to re-conduct the observation study with the university's appropriate ethical clearance and change any resulting design or conclusions that were impacted. The subsequent observation study was to follow a similar structure to the initial, pilot, observations, however, taking place over a condensed period and observing multiple different suburban bus routes within Melbourne's south-eastern suburbs. The researcher went into the field open-minded; to prevent the previous study's findings from biasing the new observations.

4.2.3 Observational fieldwork data

This study received Monash University ethical clearance: 21910 as it was performing human research, the study explanatory statement can be found in Appendix B. The observational fieldwork took place during a two-week period in September 2019, where 40 journeys and upwards of 850 people were observed using the bus network. Journeys underwent systematic observational note-taking in which both generic service information and observational themes were noted. A template of the notes taken, as well as all notes made can be seen in Appendix C. Small sample sizes for this type of research are suitable, with Hutchinson (2009) suggesting that only 25–200 trips may be necessary before diminishing returns are seen. During this period both peak and non-peak periods were observed; however, due to traffic conditions and the narrow peak period window, fewer peak journeys were observed, 30% between the hours of 8.00-9.30am, 4-6.30pm. A single trip consisted of the researcher boarding and alighting a bus, with trip lengths ranging from 5 minutes such as travelling from Monash University Clayton to Huntingdale Railway Station on the 601 bus, to 40 minutes, such as travelling from Chadstone shopping centre to Box Hill Railway Station on the 903. The weather during observations included both sun, rain, warm and mild temperature. Although the researcher was considered a competent bus user, both familiar and unfamiliar routes and locations were traversed, with the goal of accessing emotional and navigational responses to alternative environments.

The following is a small sample of the observation process of one of the bus trips taken:

> *Trip number: 12, Date: 19/9/19, Weather: Sunny, Location: Clayton train station, Time: 2.06pm-2.21pm, Bus: 703 to Blackburn, Alighted Monash Clayton bus loop, Trip familiarity: Familiar, Weather conditions: Sunny 23°*
> *Notes: Six people were waiting at the bus stop, four of the people were on their phones and listing to music, one person had three bags of full groceries, the other passenger had a pram, with groceries attached to the handles. Whilst boarding lady with pram turned and asked the person behind them if the bus was going to the correct stop (did not ask the driver, although they were right in front of them). This lengthened the boarding process. No one complained. She received a confirmation from the person behind them and continued to board (researcher's notes).*

4.2.4 Results

This section will discuss the findings from the observations. The findings are divided up into the three main journey stages – before, during and after boarding – as the study focused on the interactions of the journey and the phenomena that occur when this process is attempted.

During this study, only user behaviours and engagement with the system were observed. Trip motivations, experiences, familiarity and pre-planning information were hidden. Some of these information points could be inferred based on service location, demographic, carry-on items or the bus's tardiness. However, for the sake of this research this information is discussed from the researcher's point of view, to illuminate one viewpoint, before the topic could be correctly addressed during the third study.

User behaviour before bus journey

At three separate locations, when the observer arrived at a bus stop with a destination in mind but no prior journey planning, they felt like they were left to the whims of the transport system. Waiting times during this moment were considered to be wasted, as the researcher could have continued their alternative activity, for example working or shopping, for a longer period and arrived at the stop at a more appropriate time. During this time, the researcher did not believe it would be worth re-engaging with the other activity as they then might miss the next bus service by accident.

> *Left work and arrived at the bus stop - I did not check the bus time prior and had to wait 13 minutes. I could have left my office slightly later, instead of waiting outside (researcher's notes).*

On the bus's arrival, participants were observed walking in front of the bus to read the destination sign to determine if it was the correct service. Some users were observed asking surrounding users or the bus driver for service information, to either reassure them that they were in the correct place or to gain information as to where to go. One passenger was seen showing the driver a Google map of their final destination, although the driver was unable to help, another passenger was able to offer confirmation of correct service.

> *Person boarded with a map of the location they wanted to go presented on their phone. They showed the driver, who didn't know. The lady who boarded before (sitting in the front left seat), looked at the phone and confirmed that yes this was the correct bus (researcher's notes).*

On one occasion an older user with a language barrier asked the driver and driving instructor for route information. Driving instructors are often present for training or navigational purposes when a driver is learning; they normally sit in the front left seat and help assist the driver, providing feedback and support. The driver and instructor responded, offering to notify them when they were approaching their stop so they knew when to depart. This interaction was then made easier by the user sitting in the front right seat near the driver and instructor so wayfinding information could easily be offered. This interaction is an example of how a user with limited system knowledge, language barriers and travel difficulties was provided with wayfinding ease via access to decipherable information. This observation also highlights the driver as an information point for some users, signifying that their job extends beyond bus driving.

> *A person sitting in the priority seated area stood and walked up to the bus driver, whilst the vehicle was in motion. She asked the driver how far away her stop was (limited language used). The driver consulted with the trainer, and the trainer informed her that there were a few stops to go and offered to tell her when they arrived. She then sat in the front right seat... The trainer indicated to the lady that her stop was approaching, she started to get ready and the driver pulled up at a minor stop and she alighted (researcher's notes).*

At bus loops, which consist of a large infrastructure containing multiple bus stops, users were often observed walking around the loop looking for the current bus stop location, studying bus stop signage in conjunction with looking at their phone, as well as running or walking briskly towards their service. Running towards a bus created two different situations. Firstly, users would run to the bus, preventing themselves from being late. This action sometimes resulted in the driver delaying departure, to allow the running user time to board. Secondly, users would misinterpret a bus's departure time and unnecessarily run for the service.

> *The door closed and had to be reopened to let another person on board (they were running toward the bus) (researcher's notes).*
>
> *After exiting 2 people were seen running for the mid Brighton bus. This ended up being unnecessary as the bus stayed there for several more minutes (researcher's notes).*

This situation was experienced by the researcher on one occasion, when the bus was early and idling at the bus stop pre-departure. Being uncertain as to how long the bus would remain and if it would leave the stop early, the researcher ran for the vehicle to prevent missing the service. This action of stress and exertion was made redundant when the vehicle did not depart for another 10 minutes. Once experienced, this action was observed to be undertaken by multiple other users. Figure 4.1 includes examples of the behaviour and interactions users have with the service before a bus journey.

Figure 4.1: Visual examples of user behaviour before bus journey, images were not taken during the study

User behaviour when boarding the bus

Although the sample size for mobility-impaired, elderly and pram-pushing users boarding was very small, the few examples that were observed show insight into their movements and how other users responded. Elderly users with mobility impairments appeared to take longer to board and alight from the bus. This was due to their movements being slower in general, as well as the need to hold onto handrails

to board and alight while being able to move their mobility aids or shopping trolleys on and off the bus. Once on-board, finding a seat seemed important, with elderly moving to find appropriate seating.

> *The bus arrived at a stop with a significant vertical gap. An older lady with a shopping cart wished to depart. She walked to the edge of the door, holding the hand grab and lifted her shopping cart off the bus (this took some effort as the ground was low). Once on the ground, she then proceeded to step down slowly, using the handrail and the shopping cart on the ground for support (researcher's notes).*

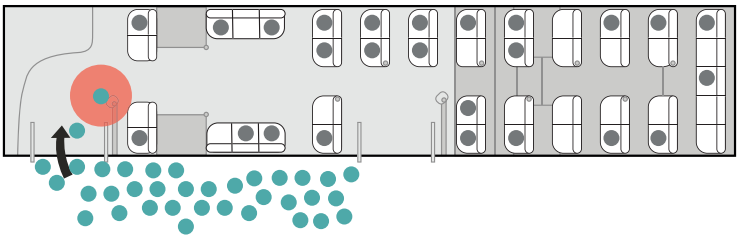
The main problem spaces for pram users appeared to be initially boarding the bus, due to vertical gap challenges, and finding a place for the pram to fit once on-board. The allocated spaces are ideal for placement as they are out of the way and provide caregiver seating for the parents. However, during the observed journey this was not an option as this allocated area was occupied by another pram user, resulting in the parent standing with the pram in the front walkway adjacent to the wheel hubs. What was interesting is the bus after this service was relatively empty and if the parent had known could have alleviated the boarding problems and flow issues to the cost of 10 minutes.

> *The pram user therefore had to stand near the wheel hub section. This acted as a catchment point for anyone boarding the bus, resulting in a passenger standing between the pram and the driver, instead of moving past and sitting on one of the many available seats (researcher's notes).*

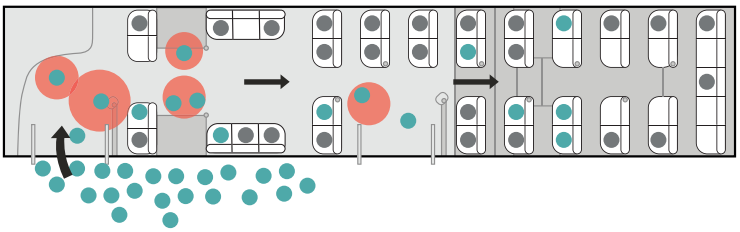
From these observations, it became apparent that the mobility-impaired elderly and pram users had similar goals of travel to the majority of bus users: to board the bus, find a place to sit or stand and then alight from the bus once at their destination. Unsurprisingly, their ability to achieve these tasks required different components, such as longer times, more space, correctly placed seating and handholds.

During the observations, particular note was taken of how users boarded and flowed throughout the bus, with the layout being crucial to the function and interaction of the bus interior. Layouts can promote better or worse passenger flow, affect service times, encourage design for greater accessibility, ease of movement, and create areas that influence user behaviour. The buses used during this study showed commonalities consisting of 12.5m length, two doors, a staired section and a priority downstairs area. However, seating layouts showed several seating configurations consisting of altered front and sideways facing seating, proving more or less standing space. Figure 4.2 is a visual representation of passenger flow on-board low-floor route buses during weeknight evening peak hour. The figure is a synthesis of the observational field work, collating the movement behaviours observed. The data synthesised can be seen in Appendix C. The figure is a representation of a vehicle experiencing high passenger capacity, which is not uncommon for peak periods within suburban environments. A high capacity bus was explored as it showed the issues surrounding passenger flow. The figure is a representation of how users interacted with the bus, initially moving towards non-occupied window seats in the lower saloon section and then gradually filling the area.

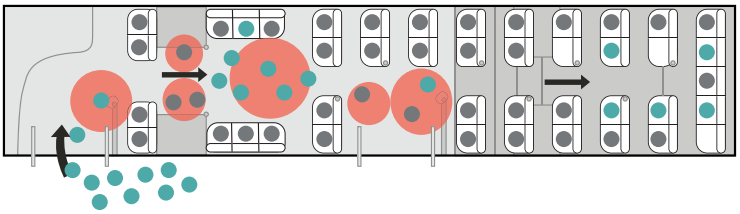
1. Initial seats filling up. The bottle neck is created around the ticketing system



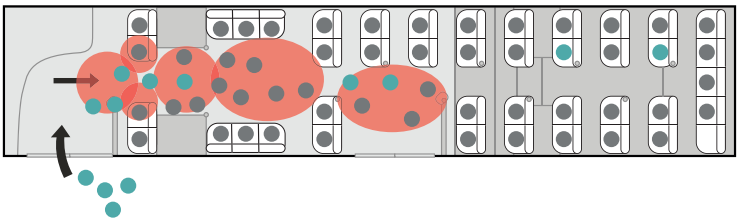
2. The initial seats have been taken and passengers are taking the optimal standing positions



3. It is now hard to move past the standing passengers, it is assumed that no seats are left free



4. The passengers have not been told to move down, four passengers are left behind even though room was available



Key

- Moving/ newly boarded passengers.
- Stationary passengers.
- Catchment zones that form as the bus fills. Sizing indicates areas that are affected.
- Myki machine.
- General movement.

Figure 4.2: Passenger flow diagram within low-entry bus

The problem with the low-entry layout appeared to be that users were required to board the bus at the front door, needing to pass through a standing catchment point (the front wheels) to enter the saloon. Passengers touching on with their Myki caused passengers to board at a consistent pace - unless the Myki did not work. During one journey, the front Myki system was out of service, causing passengers to move through the bus and use the second machine. After using the machine passengers who wanted to sit towards the front of the bus caused passenger flow disruptions.

> *On board the bus, the front myki machine was broken. The driver encouraged people to move down and touch on the second reader. This caused a bottle neck for passengers who wanted to sit near the front (researcher's notes).*

Asking the driver questions or topping up the myki - as seen within the second diagram - can cause boarding to slow or halt. Once users started to stand within the front wheel hub section, it became

difficult for passengers to move beyond or to identify free seating further down the vehicle. This passenger behaviour caused catchment zones or bottlenecks to occur.

> *4 passengers are standing around the front wheel hubs. This is creating a catchment zone, where people are struggling to move past it to find a seat. They are seen manoeuvring through the crowd to the back of the bus (researcher's notes).*

The red sections within the diagram highlight the most common places catchment zones were observed to form, affecting passengers' ability to move further down the bus. Additionally, the increased number of standing users made movement to the back of the bus more difficult, with the stairs acting as a movement barrier.

Lighting and heat were also observed to affect the travel experience and behaviour of some passengers. For example, a lady was observed taking off her coat and shifting seats due to the sun's presence on one side of the bus. Other passengers within the priority seating were seen blocking the sun's glare with their hands. Lastly, two passengers were seen boarding and then immediately alighting an abnormally heated bus, commenting on how they weren't prepared to be uncomfortably hot during their trip.

> *Someone moved from the left side to the right side of the bus (the same seat). The sun might have been the cause as it was streaming through the left side windows. She then took her coat off once she had moved (researcher's notes).*

This behaviour is expected to be more prominent during summer periods. Rain was also seen to influence travel behaviour. On one occasion passengers were seen asking other passengers to close windows to prevent from getting wet, as well as other passengers standing so they could better see their upcoming stop location through the rain splattered windows.

> *2 passengers.. realised they were getting wet because the access hatch was open above them. They later asked politely if I could close the window above them/ me as it could also let water in (researcher's notes).*

User behaviour during journey

Behaviours that were observed to take place on the bus mainly consisted of users looking out the windows and zoning out, on their phones or listening to music. Other behaviours observed included talking to other users, active wayfinding, sleeping and other multitasking activities such as working on a laptop or reading a book. The main disruptions to these activities were having to alight or move to allow for other users to alight. Multi-tasking activities appeared to be demographically driven with younger adults observed to be more likely to use mobile phones or listen to music. This matches the findings of Russell's et al. (2011) study, mentioned during the literature review.

Standing did not appear to change user interactions with their phones, resulting in many users either holding onto a grab handle with one hand or not at all. This was concerning during heavy braking or turns, as such users appeared to be paying less attention. Standing users tended to cluster around stanchions, as opposed to holding onto hanging handgrips, as these offer very little support during heavy braking and bus turns. Some users were seen holding onto multiple hanging handgrips for extra support. However, as the journey progressed and the users became more comfortable with the motion, the holding-on behaviour decreased until a jolt or jerk prompted the users to redouble their grips.

User behaviour alighting from bus

Again, this study was not able to conduct research regarding why users were undertaking particular travel behaviours and what their thoughts were at particular stages of travel. The researcher's experiences on unfamiliar journeys used Google Maps, PTV's journey planning app, Citymapper and

landmarks to indicate where they were along the route and when an appropriate time to press the stop button would be, providing reassurance and ease of use. In some situations, with higher capacities, the bus stop button was difficult to reach, which resulted in the researcher hoping that someone else would press the button or that the bus would stop regardless.

When the bus was approaching a busy location such as the Chadstone bus loop, a flurry of activity around the myki reader - the smart card ticketing system in Melbourne - was observed, with users touching off before the bus stopped. This activity generally consisted of users who were in close proximity to the myki machine, including users leaning out of their seats. This process generated a faster alighting process, as myki readers generally take multiple seconds to register, which can result in a bottleneck at the door and feelings of awkwardness. The researcher also felt pressured when touching off with their myki that they were holding up the queue of users trying to depart, with the feeling made worse with the slow myki touch-off times. This process was also observed at train station myki barriers, where myki cards that were difficult to locate – within handbags or wallets – disrupted passenger flow.

User behaviour during anti-social behaviour

A potentially threatening situation occurred during observations:

> *Two passengers boarded the bus from a minor stop along the route. The young woman sat on an aisle seat next to the second door and the young man sat in the spare seat in the wheel hub section. The male was showing boisterous behaviour as he boarded the bus and moved down to the back section, swinging from handrails and hand grabs in the process. Once seated he tried to strike up conversations with surrounding passengers to no avail. Four minutes into the journey the male got back up and moved to stand in the second door area, opposite the young woman he had boarded with. He was trying to make conversation with her (leaning on the stanchions and moving closer to her), she was trying to ignore him looking at her phone. At this stage, the researcher thought of intervening but didn't know if they did know each other as they boarded at the same location, as well as not knowing what to actually do in this situation. At the next stop, multiple people alighted from the back door, during this process the man had to step away from the door and move to the priority section to let the people past. During this moment, the woman hopped off the bus with the other passengers and walked briskly behind them. At this point man also jumped off the bus walking beside her briskly trying to have a conversation, with exaggerated hand gestures. As the bus pulled passed the two, the woman tried to turn and walk in the opposite direction as the man but he kept jumping in front of her. By this stage the other passengers who had alighted with them had moved on. The researcher had stayed on the bus for the whole encounter and was troubled by not knowing what to do and if it was appropriate to interject during the situation. It looked like the woman was uncomfortable for the whole encounter but again it was difficult to determine. No other bus passengers appeared to respond to the incident (researcher's notes).*

This experience, although rare, reaffirmed how buses and public spaces can be threatening, uncertain and dependent on other people within the environment. Having a system that could reassure users that they are not alone during their travels or provide users with the ability to help others, may provide additional control and reassurance to transport users. Instead the interaction made the researcher feel less safe and confident with catching this particular service.

For a summary of the findings discussed please see Table 4.3. The table helps to triangulate the data, allowing findings from the three studies to be compared and validated.

4.2.5 Discussion and summary

In summary, the observational study was crucial to understanding how people are currently using the Melbourne bus network, with the study illustrating general bus journeys within the south-eastern suburbs, centred around the Chadstone and Monash University Clayton bus loops, seen in Figure 4.3. The main findings focused on user behaviour before and during the journey, including passenger flow, waiting and travelling behaviours, as well as vehicle and service interactions. These findings unpack

the current human ecology of the bus environment, with the common behavioural attributes pointing towards possible areas for redesign. Such areas include information channels to better inform users of bus movement; layout configurations to promote better human flow opportunities; and standing comfort tailored towards safety and mobile phone usage. All of these components would influence the effectiveness and ease of bus use. Similar to the customer feedback data findings, the lack of information present within the system made for uncontrolled user behaviours, with bus drivers or other users needing to step in to fill the information gaps and provide system navigation control to the users.

Figure 4.3: Clayton bus loop

Both the initial pilot observational study and subsequent observational study resulted in broadly similar conclusions, with both studies providing examples of similar user engagement with the bus vehicle, service, and infrastructure as well as any interaction issues. The anti-social behaviour incident was the only observation that was considered unique, only observed during the subsequent observational study.

The method of observations allowed context and behavioural understanding concerning regular bus user experiences. Although this study provided insights, it is necessary to be aware of study methods and finding limitations when determining the value of the results. The routes and time of observations were considered narrow. Observations were undertaken in the Melbourne south eastern suburbs, with Monash University Clayton and Chadstone being the centre locations. Due to close proximity to a University these routes attracted high proportions of students, with further afield routes, such as Bentleigh station seeing more diverse demographics. Remote outer suburban environments were not explored due to their limited accessibility. Although hot, cold and raining weather was able to be observed, a seasonal bias was present. A greater number of non-peak trips were also undertaken. Future studies at different times of the year, representing both peak and non-peak times, should be undertaken throughout alternative suburban environments to further validate results. The structure of the method undertaken prevented bus passengers' motivations from being determined, unless they verbally announced their intentions. The researcher tried not to make assumptions based on passenger behaviour. Some circumstances were experienced by the researcher, for example feeling confused or needing to use additional wayfinding methods to navigate a particular route. These personal insights when gained were compared against other research findings or other user behaviours to determine if they were insightful. On board passenger flow was difficult to track and take notes on. To provide some detail, passenger location within the vehicle was noted during each trip, sometimes

multiple times when major passenger changeover occurred. This form of note taking, however, did not identify the types of demographics drawn to particular locations, or if someone alighted and was immediately replaced with another passenger. A better system of cataloguing passenger flow needs to be incorporated within future observation studies. The observer tried to sit in a similar place during all their trips as it provided a good observation vantage point. Seats behind the observer were difficult to see; therefore, small behaviours undertaken by passengers at the back of the bus were not noted.

Despite the limitations, this study allowed the researcher to be placed within the field, gaining empathy and contextual user behaviour findings. Limitations of passive observational methods, as well as what changes and innovations should be incorporated to improve the service, were considered the greatest disadvantages. These gaps in knowledge prompted the development of the third and final study, focused on answering these ‘why’ questions based upon the current knowledge gained.

4.3 Study 3: Cultural probes

Within UCD processes, observations and cultural probes can be classified as complementary techniques. When combined, they reveal user experience that can be seen, as well as aspects that cannot (Mattelmäki 2006). A cultural probe is a design-led approach that uses guided evocative tasks to encourage participants to perform self-documentation tasks and to elicit thoughts and clues about their lives (Gaver et al. 2004; Hanington & Martin 2012; Mattelmäki 2006). This type of research, particularly travel diaries, is "ideal for collecting information from participants across time, sampling their thoughts, feelings, or behaviours at key moments" (Hanington & Martin 2012, p. 54). This method allows user-oriented and observational research to be conducted in the early stages of the design process, helping designers gain contextual understanding and empathy, which leads to new design solutions and ideas (Visser et al. 2005). The objective of this study was to further develop the knowledge from the previous two studies, and understand and gain deeper insights into the motivations and frustrations of Melbourne bus users.

4.3.1 Recruitment

This study received Monash University ethical clearance: 9513 as it was performing human research, the study explanatory statement can be found in Appendix D. Participants were recruited through a research database that was comprised of people who expressed interest in engaging in mobility-related research. A call for participation was submitted including an explanatory statement detailing the project. From this process, a small sample size of 20 diaries were distributed to willing participants, with 14 being returned. 64% of participants were women, with an average age of 35 years, ranging between 18–66 years. 50% of participants were also considered industry experts as they work or conduct research within the public transport field. This industry inclusion allowed different opinions to be explored. Diaries were distributed to both regular and irregular bus users within Melbourne, 42% of participants used the bus less than once a week, with the study categorising them within the irregular and non bus user category. 14 diaries are considered suitable for such a study, with Mattelmäki (2006) suggesting that 5–10 participants from the target group are all that is required before information returns start to diminish, due to the deep qualitative nature of the research tool.

4.3.2 Diary structure

Qualitative travel diary data gives designers deep insight as to how and why users perform "activities and the environmental factors that come into play" (Norman 2013, p. 224), generating information that is highly informative and targeted towards creative outputs. To achieve more in-depth qualitative results, the diaries covered a total span of seven days and included multiple activities focused on understanding people's current opinions and interactions with the bus. Participants had the option of receiving the diary in either digital or physical form. Due to the digital component and the encouragement for participants to fill out the diaries whilst in motion, the diary responses were primarily text based. Additionally, as participant backgrounds were varied, the diaries were designed to elicit expressive responses, but not to confuse or overwhelm participants. This might have limited some creative responses, but allowed all participant diaries to be useful. To incorporate these needs, a range of tasks, some expressive or simple, were utilised to encourage participants to think and discuss their opinions and observations to uncover useful, open and sometimes creative qualitative responses and experiences. The tasks within the travel diaries included two main sections, firstly a daily travel information section acting as the diary component of the probe, consisting of a set of questions to be filled out daily. This set of questions focused on keeping track of the types of trips the participants performed during their weekly travels and the different types of experiences, thoughts and annoyances that occurred. Secondly were reflective tasks which changed daily, prompting participants to discuss how they perceived the bus and its various attributes. Participants also rated experiences and issues, and compared various different types of modes and bus vehicles. This allowed factors discussed within the literature and during the observations to be further understood. Figure 4.4a and b presents imagery of the travel diaries, for full documentation please see Appendix E.

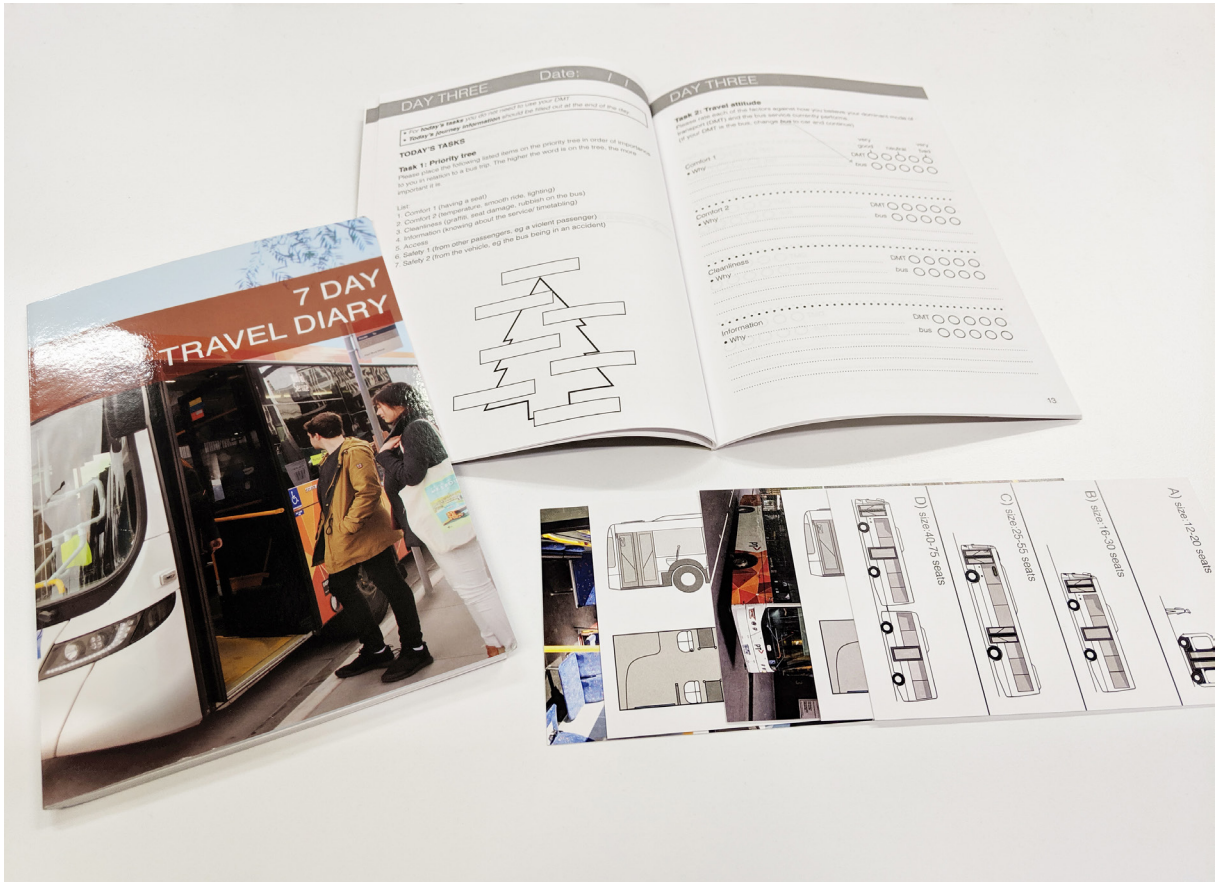


Figure 4.4a: Travel diary kit

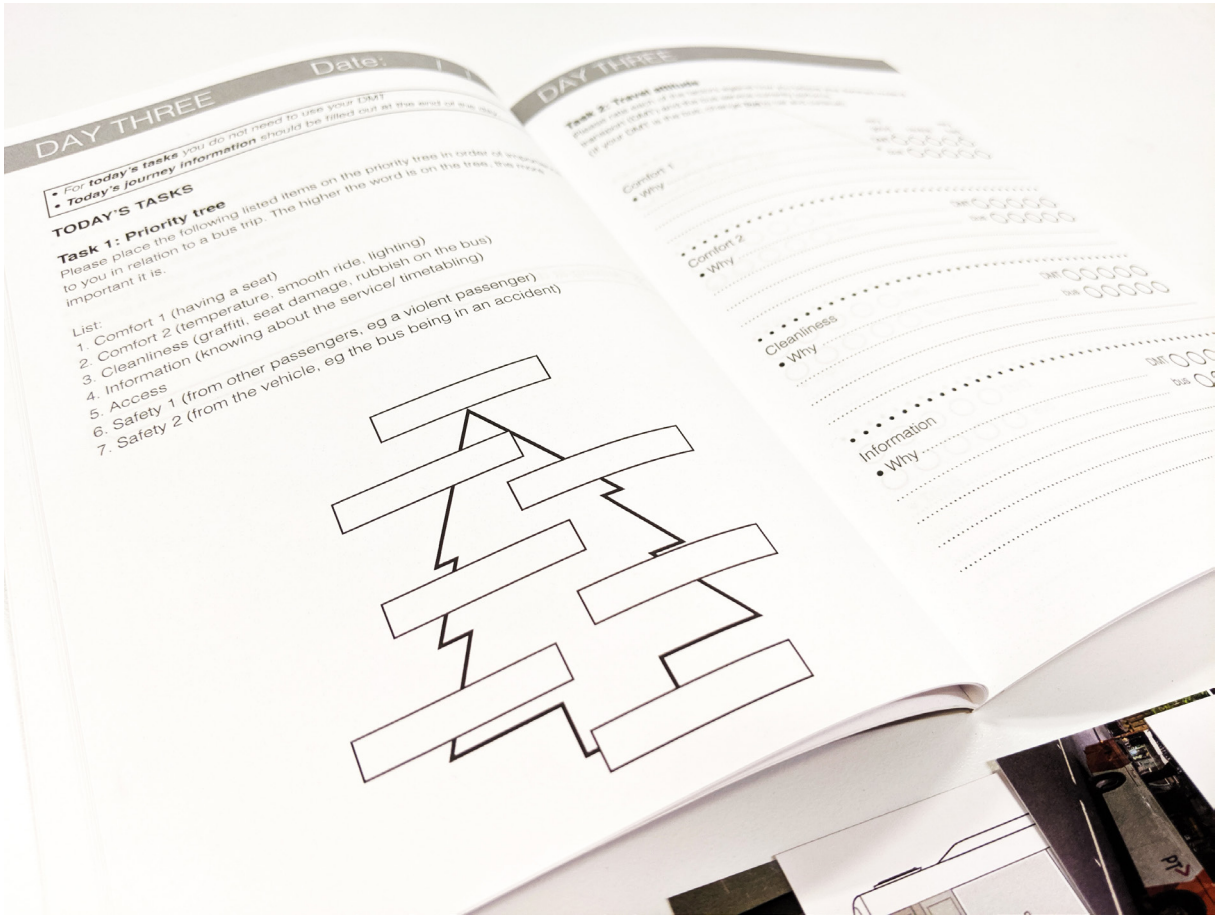


Figure 4.4b: Travel diary page example

4.3.3 Analysis

The same process of analysis as for the CFD study was undertaken, with the similar goal of synthesising and analysing the data collected into common themes and patterns. This helped to produce theories and new knowledge. Again, Nvivo was used as the data-processing software, with the inclusion of both text-based data and images of bus layouts collected from the study.

The findings from the travel diary study relate to service outputs regarding major interaction points of the bus journey experience. The main aim of these findings was to create a clear picture of this experience, highlighting the journey process in detail, as well as participants' observations, feelings and experiences when using this mode compared to others.

4.3.4 Results

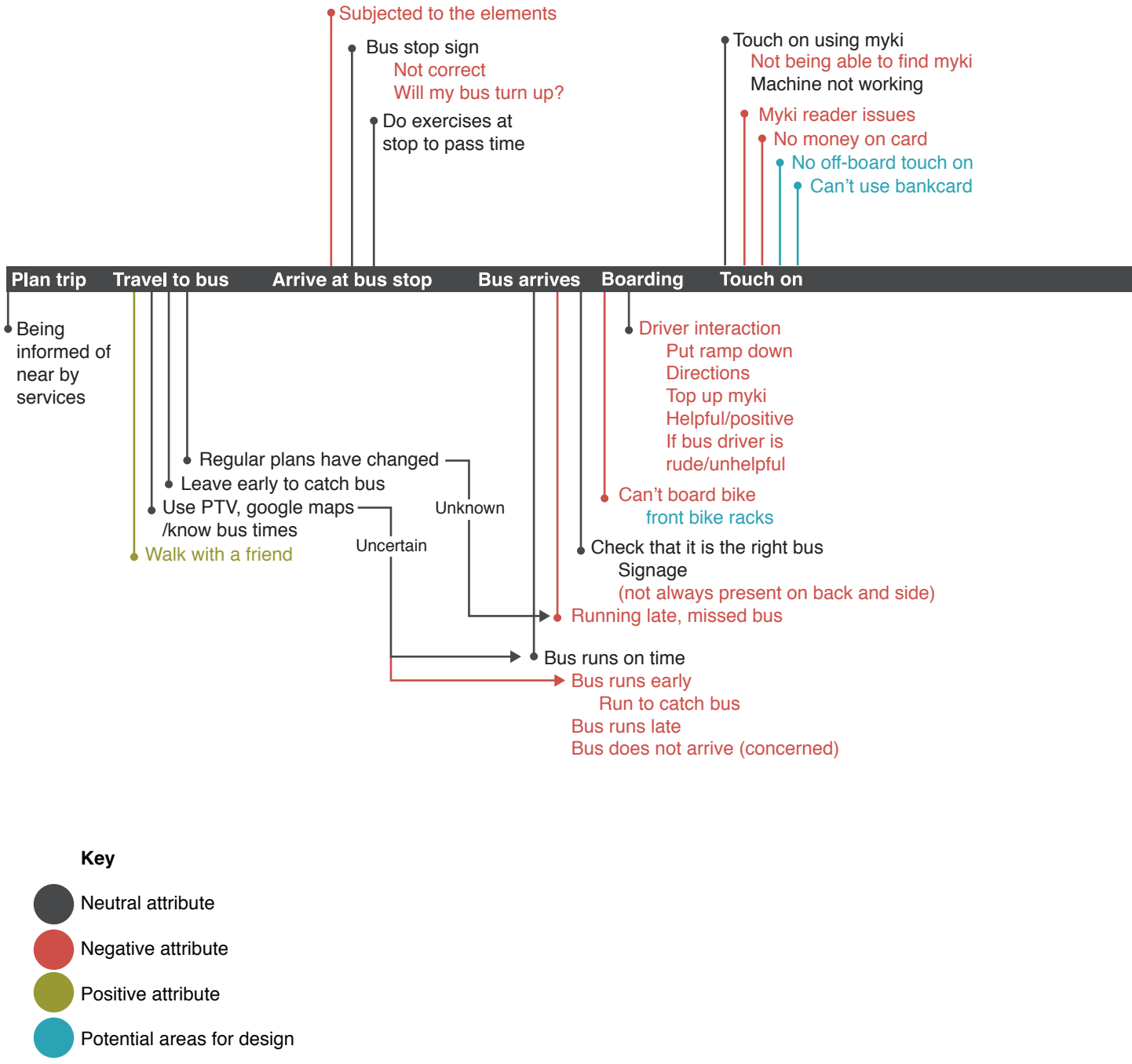
Positive and negative journey and vehicle interaction points

One aim of the travel diaries' design was to understand the likes and dislikes participants experienced when they were navigating the system. This aided in determining areas of system failure and how these failures interconnected with the system as a whole, which provided context to knowledge from the CFD. To do this, the attributes and touchpoints mentioned within the travel diaries were initially categorised into two groups, positive or negative, which allowed their suitability or problem associations to be distinguish. This was undertaken for all the activities, including those specifically designed to elicit this type of information. Table 4.2 shows the themes commonly mentioned within the diaries in relation to being positively or negatively described.

Table 4.2: Bus vehicle and service positive and negative associations

Negatively associated	Number of mentions by participants		Positively associated	Number of mentions by participants
Information	11		Driver	7
Frequency	9		Not having to drive	7
Jerky and bumpy ride	8		Seat	6
Driver	7		Multitasking	5
Seats (location and comfort)	7		Convenience	5
Other users (being annoying)	6		Information	4
Routes	6			
Temperature	6			
Bus stop	6			
Cleanliness	5			
Safety: Antisocial behaviour	2			
Safety: Falls/crashes	4			
Accessibility	4			
Connections	4			
Punctuality	4			
Reliability	4			

The majority of the issues listed in the negative category match those found in the CFD, confirming the negative service interaction points and providing insight as to the reasons behind these negative associations. For example, the bus driver can be seen positively as a source of information, as well as negatively as being rude, unhelpful and frustrating. These inconsistencies within the system add to the complexity of the topic, with one participant noting that the quality of their journey can alter between different services. Examples of this included the driver, service busyness, bus type and layout configurations, as well as personal experience and trip purpose. This indicates that all themes are interwoven, showing both positive and negative associations. When designing, these interactions need to be considered in a holistic manner.



Key

- Neutral attribute
- Negative attribute
- Positive attribute
- Potential areas for design

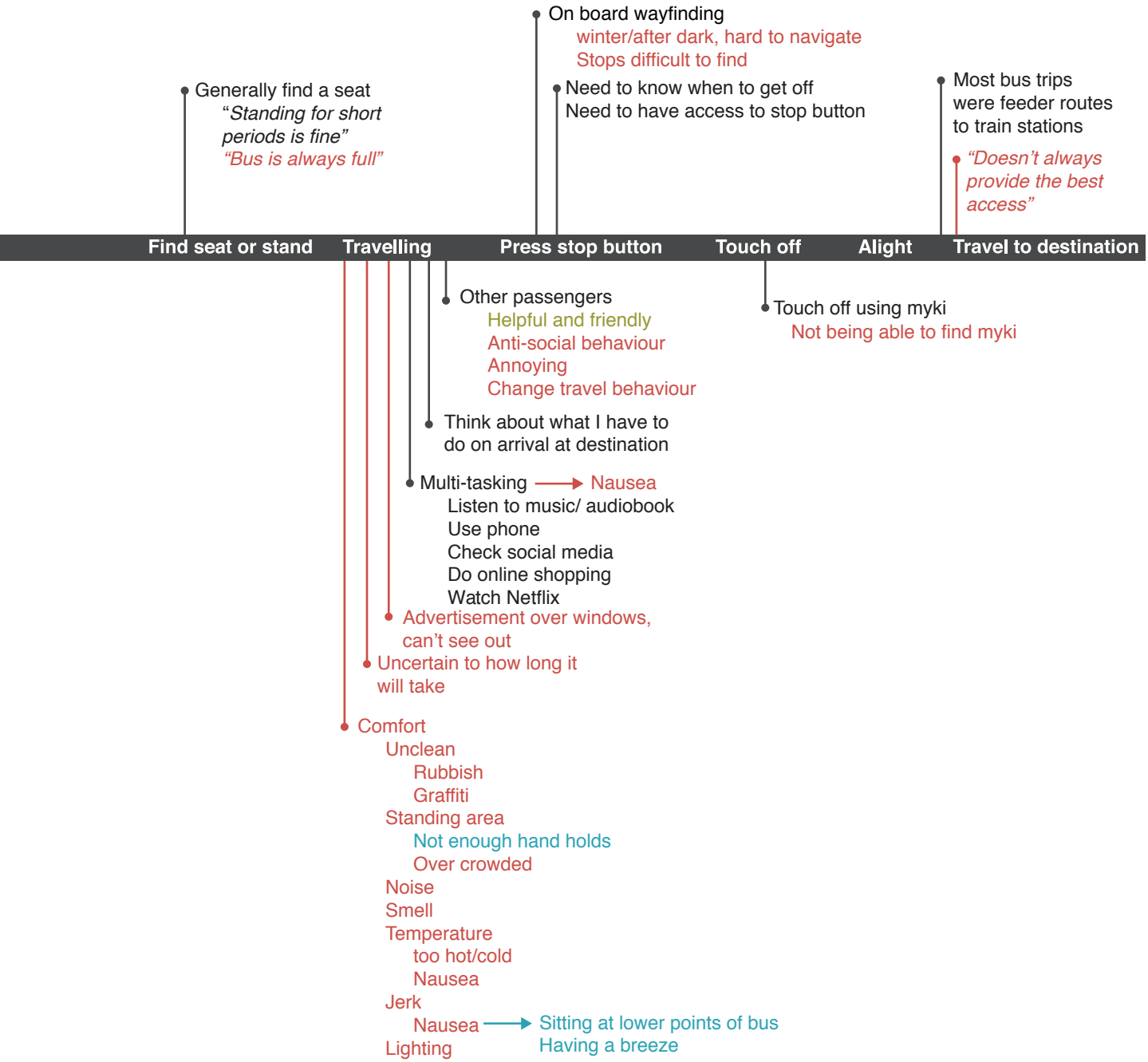


Figure 4.5: Themes discussed within the diaries and when they occur during the journey

Barriers to use

Barriers within this document and PT literature reviewed refer to obstacles that make catching the service more difficult and not as streamlined. These barriers can be psychological, in reference to perceived safety issues; or physical, for example buses not being physically present preventing people from using the bus mode. The barriers listed within this section are elements of the bus catching process that participants listed as a difficulty or deterrent from using the bus.

Accessibility, inconvenience and the unreliable nature of the bus network were identified within the study as being the most common barriers to bus use for both regular and non-regular user groups. These problems related directly to the low-frequency and low-coverage environments, in which catching a bus was impractical compared to other mobility modes, as they were found to be one of three things. Firstly, they were often inaccessible, with participants travelling further distances in order to access the service, as well as modes not being available during particular times. This information was interesting as a trend emerged from the study surrounding mode loyalty, where participants used the most convenient mode rather than a specific mode. This suggests that if service provision and bus use are easier, more users would be expected.

> *Quicker and most direct PT option. I just use the most convenient option. I'm not loyal! (Participant 2: Section: About you and the bus)*
>
> *Mainly, they just aren't around my house that much (Participant 4: Section: About you and the bus).*

Secondly, services were not well advertised, with participants being uninformed about local buses.

> *Buses to uni, city and nearest shopping centres are all within 10 min walk, but I found out ONLY through word of mouth (Participant 3: Section: 3, task: 2).*

Thirdly, buses did not interface or connect well with other modes and were not effectively integrated within the transport system.

> *The bus 'system' is perceived to be fragmented and difficult to use as it does not clearly interface with other modes (Participant 7: Section: About you and the bus).*

When the lack of accessibility was disregarded and buses could be accessed, the unreliability, punctuality and lack of information became issues. These problems were found during the study to cause uncertainty resulting in service speculation and distrust regarding bus arrivals, if the bus was running early or late, and if the user would arrive at their destination on time.

> *PTV offers a lot of information, the only downfall is you don't know if it's running on time or not (Participant 13: Section: 3, task: 2).*

It was observed that these types of uncertain environments, depending on journey purpose, could influence a change in user opinion and behaviour. Uncertainty could cause users to become anxious or to physically leave earlier to catch the bus, or to leave multiple services earlier to be on time. This behaviour change minimised the impact and lack of control people experienced when catching the bus, adding extra time to the trip. This extra time added to a trip can be costly within an environment with low bus frequencies, causing excess wasted wait time.

> *I am never sure exactly how long my bus journey will take. It makes relying on buses as a form of transport difficult for me, if I am ever going anywhere where I need to arrive at a particular time (Participant 6: Section: 3, task: 2).*
>
> *Travelled on bus to Chadstone S/C to meet for lunch and movie. Bus only runs half hourly so arrived 25 mins early to be on time (Participant 7: Section: today's trip information, trip: 3).*

Pre-trip

The barriers mentioned above mainly concerned attributes regarding the pre-trip stages of a journey, when the user had the most active engagement with the system. This appeared to be the point where users could be most uncertain and vulnerable to service disruptions. This section will list the travel diary participants' experiences at the pre-trip stage, clarifying the negative factors at play.

Figure 4.5 (seen above) is a representation of these findings, listing all the touchpoints participants discussed during the whole journey process. The diagram indicates both positive (green) and negative (red) interactions with the bus network, as well as highlighting any design interventions or possible solutions (blue) the participants noted down. As the figure shows, the participants focused on many negative aspects, with several attributes connecting or influencing each other. The pre-trip stage can be divided into four major categories, based on the travel diary findings. Firstly, trip planning, which occurred any time before the trip, including up to days in advance or just an hour beforehand. It was at this point that participants worked out what services were around them and what time they would need to catch that service. Participants generally used the PTV app or Google to do so, or relied on previous experiences. The main concerns at this point regarded whether the service would arrive on time.

> *I never know when you're going to turn up, or whether you'll be stuck in traffic (Participant 11: Section: 5, task: 1).*

Secondly, travel to the bus. Thirdly, stop arrival, at which point participants would start waiting for the bus, uncertain as to whether it would arrive on time.

> *There was no bus for 30 mins even though there should have been one every 12 mins. After a 36 min wait, the bus arrived. It was packed so I had to stand (Participant 15: Section: 6, task: 1).*

Wait time anxiety is common for time-based activities, with PT being no exception, including a baseline of uncertainty built into the system (Beirão & Cabral 2007). However, this uncertainty can be heightened if time pressure is applied, for example travelling to a job interview (Beirão & Cabral 2007; Mokhtarian et al. 2015). The bus stop signage information was mentioned as both a reassurance and a source of confusion if it provided incorrect times. One participant discussed countering the wait time by engaging in exercises, turning wasted wait time into active wait time. Finally, bus arrival, in which users needed to visually identify and hail the bus, or at larger stops identify the correct bus among other services.

> *At bus stop on Hoddle st, I do my physio exercises and stretched whilst waiting- productivity passes the time (Participant 18: Section: 2, task: 1).*

The underlying issues relating to the pre-trip section appear to mainly fall into the category of information provision, with participants listing a lack of information or incorrect information as a main source of trip confusion and annoyance within the pre-trip stages. In addition, due to distrust of the system, participants appeared to doubt the information presented to them and wondered if the bus would behave in accordance.

> *I find information about bus times unreliable or non- existent. This is mainly due to the stops where I board buses to be without real- time info, this is probably my biggest barrier to bus use (Participant 11: Section: 3, task: 1).*

Information

The communication of service information from the operators to the users was considered one of the most poorly rated attributes of the bus experience within the pre-trip stage. Information provisions scored in top position for negative association, as seen in Table 4.2, as well as scoring second highest for most prioritised bus need within the priority tree study. Information was discussed within the

context of pre-journey planning, bus stops, bus arrival and bus departure points, with each point being an information channel between the service and user. Unreliable or lack of information at these points resulted in service uncertainty, confusion and distrust.

The lack of RTI and the information present at bus stops was an area of negative association. Most suburban stops include timetables and route maps used to indicate bus arrivals. More advanced SmartBus stops include digital countdown timers, where the bus's position and timing information is updated once a SmartBus passes a corresponding stop, which provides bus stop displays with estimated vehicle arrival times. Unlike RTI which uses GPS positioning, the SmartBus system can be inaccurate as it is subject to traffic conditions between stops, resulting in incorrect information sometimes being displayed. Participants had concerns regarding signage when it was incorrect or differed from the printed or online timetable, saying that it caused confusion and uncertainty as to when the bus would arrive. This problem was then further heightened by the unreliable perceptions and punctuality issues associated with buses and whether they will arrive on time. This lack of informedness, coupled with the unpredictability of service arrivals, caused uncertainty, anxiety, use difficulty, concern and confirmation of previous poor experiences. These problems caused doubt as to whether the service was on time, had been missed, was running late or had been cancelled, affecting overall service trust. This uncertain environment matches information found within the CFD and was suggested as being solvable through information interventions.

> *Buses are ok. The most annoying thing is waiting at a pole and not knowing if you're early or late (Participant 4: Section: 3, task: 2).*
>
> *I am never sure exactly how long my bus journey will take. It makes relying on buses as a form of transport difficult for me, if I am ever going anywhere where I need to arrive at a particular time (Participant 6: Section: 3, task: 2).*
>
> *Why are you so unreliable? Last week, we both agreed to meet again, like always at 8.38 in our usual spot. I don't know why I believe anything you say any more- it's just never the truth with you (Participant 1: Section: 5, task: 1, participants were asked to write a love or break up letter to the bus to encourage creative responses and new insights to be developed).*

Destination signage on the outside of the bus was seen as lacking or incorrectly placed by some of the participants, referring to the inability to quickly identify and arrive at the bus, particularly at larger stops. Better signage locations have been included in new bus models, but this again relates to the inconsistent nature of the PT network and how this can cause confusion and standard inaccuracies. Although this problem had a pre-existing solution, it raised the question as to what other information might be appropriate to display on the outside of buses to improve system wayfinding capabilities.

> *They need numbers on the back, so you can decide whether or not to run for it. I have also heard this from multiple other bus users (Participant 13: Section: About you and the bus).*
>
> *Destination and route number often only on front of bus, making it difficult to confirm correct bus at multiple stops and stations (Participant 7: Section: 7, task: 2).*

Information on-board present in PIDs was also regarded as lacking, with participants discussing inconsistencies between services. Although these points were not discussed in detail as to what would improve them, it does provide an area for further exploration and improvement.

> *Display of stops does not work well in all buses (Participant 8: Section: About you and the bus).*
>
> *Drivers don't make announcements when running late to advise [passengers] who can call ahead for pick up etc (Participant 7: Section: 7, task: 2).*

Gaps and failures within information flows can cause negative user perceptions, including uncertainty, mistrust and annoyance. Findings suggest that if these communication gaps are filled, users would have greater network understanding and be more positive and trusting of buses in general, as opposed to being uncertain. Although information is mainly a problem during the planning and starting stages of a trip, it was found to influence the whole journey. Based on the travel diary findings for successful information implementation, the information presented to users needs to be: real-time and accurate; presented at the correct time and in the correct location; have tracking/mapping capabilities; commonly accessible; in unison across the different aged vehicles; and inform users about what is happening in the current bus network. Images of this environment are shown in Figure 4.6.

During the bus journey

The participants did not discuss in-vehicle interactions as negatively as they previously discussed pre-trip attributes. The reason for this is unknown but could have been caused by the journey stage having fewer interactions, uncertain and anxiety causing touchpoints to contend with. Once on board, users had the opportunity to zone out and make actual trip progression. Figure 4.5 shows the interaction points and participants' discussions within the themes of boarding the bus, alighting and finding their next location. This section will discuss some key aspects in more detail.

Figure 4.6: Imagery of the current information chains

Sitting versus standing

Bus crowding and seat availability were a divided topic among participants, with comments suggesting that buses are both too full, with more seats required, as well as being empty, with seats available.

> *At peak hour catching a bus (midline) into the city means I will not get a seat. Catching my bus to uni (start of line) means I sit next to people (Participant 3: Section: 3, task: 2).*

Beyond the issues of crowding, topics such as seat comfort, access and direction were discussed in a negative context. Seats were described as rigid, hard, narrow and difficult to access when other users were within close proximity. Forward-facing seats were preferred compared to longitudinal seating, which was the least favoured option as some participants found them difficult to stay seated on during braking.

> *Difficult to stay seated in some circumstances, particularly in emergency stop (Participant 7: Section: 7, task: 1).*

Although not explicitly listed, a correlation was seen between comments about sitting and those that discussed undertaking multitasking activities. Alternative multitasking activities are activities that can be undertaken while travelling on the bus. Participants listed activities such as reading, using their phones and listening to music or podcasts as being a positive of bus use, as they did not have to pay attention to driving or be engaged with the act of transportation. Salomon and Mokhtarian (1998) describe these as multi-tasking activities.

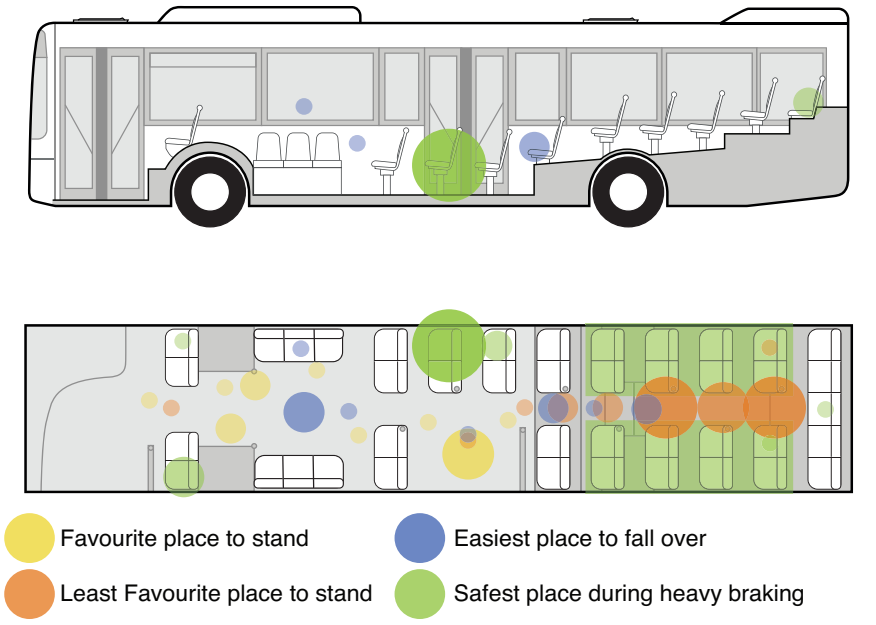


Figure 4.7: Most popular and least popular places to sit

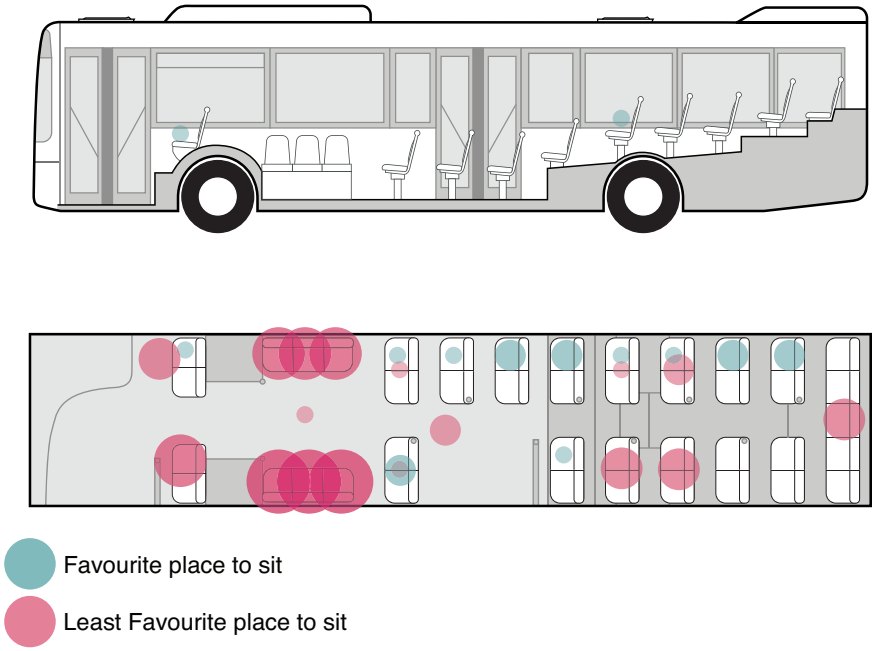


Figure 4.8: Most popular and least popular places to stand

Participants did not discuss standing on buses in much detail, only mentioning the need for appropriately placed handgrips and stanchions to hold onto in case of braking. Comments then discussed the main topic point: the uncomfortable and awkward nature of full services. In the travel diary, participants were asked to indicate where their favourite and least favourite standing and sitting positions were, as well as where they perceived the safest location to be during heavy braking and likely places to fall. As evident in Figure 4.7 and 4.8 the least favourite sitting positions were within the longitudinal seating, the front seating and the back-wheel hub section. Wheel hub sections were noted by one participant to cause accessibility and safety issues.

> *In some cases where seats are placed over the wheel arch the climb up into the seat is impossible for elderly and dangerous for children (Participant 12: Section: 3, task: 2).*

This opinion was also displayed during the observation study, where window wheel-hub seats were found to be less commonly occupied compared to surrounding seats. The observer also found it more difficult to alight from that position, especially when they had a bag, or someone was sitting next to them. The least favourite standing position consisted of the staired section. Both of these points were confirmed with the observational data, showing that the wheel hub seats were often the last to be used and that the staired section was a deterrent for suitable passenger flow. The most favoured places to stand were areas that include stanchions and that do not interfere with seated user space. Similarly, the majority of the favoured seat layouts included two-by-two rows of seats facing forward, with standing users preferring areas away from seated or aisle movement areas and where they can hold onto a pole, for example next to the second door.

Other humans

The problems generally listed concerning other users include general human annoyances and reactions to being in a confined space with strangers, making the environment awkward. Some concerns were: smells; touching other users' hands due to handhold placement; users speaking loudly; users taking up multiple seats with personal items; users sitting in the aisle seat, preventing the window seats from being used; having to sit or stand next to other users; users wanting to engage in a conversation; and not taking backpacks off.

In regards to antisocial behaviour, the majority of participants had never experienced antisocial behaviour while on the bus and had never felt unsafe. This aside, personal safety from violent users was considered the most important attribute when riding the bus. Participants who had experienced antisocial behaviour or threatening situations discussed changing their travel plans and purposely alighting at unintended stops that were more populated, to either remove themselves from the threatening environment or prevent unsavoury bus users from following them home. These experiences were not just inconvenient, but heightened negative safety perceptions when using PT services, something that is commonly discussed within the literature. As this topic was discussed within the diaries, commonalities of antisocial perception became apparent, indicating that a common underlying perception regarding this topic was still present, regardless of personal experience. These negative perceptions included: services during peak periods being less threatening, as more users were present; and the time of day or night influencing the likelihood of experiencing antisocial behaviour.

> *At the time of day I travel, I haven't really encountered any unruly passengers (Participant 11: Section: 3, task: 2).*
>
> *Would never catch a bus at night (Participant 3: Section: 3, task: 2).*
>
> *I have been in several threatening PTV situations and have left purposely at the wrong stop (most populated) so I wasn't followed home (Participant 5: Section: 3, task: 2).*
>
> *You can't escape any situation when the bus is moving. It's also an inconvenience if you have to get off before your intended stop (Participant 13: Section: 3, task: 2).*

Furthermore, as seen in Figure 4.9, the participants had a similar mind-set as to where antisocial behaviour was likely to take place within the bus environment, being asked to indicate on the diagram the areas where they believed the most violence and antisocial behaviour was taking place. As noted, the back section of the bus was seen as the most violent and antisocial area. Again, this information is based on participant perception, with no participants citing evidence of personal experience of antisocial behaviour within these areas. Although participants were not explicitly asked why they believed this, from a design focus it could relate to the back area being more isolated due to the low roof and lack of windows, and being hidden from the driver on the bus.

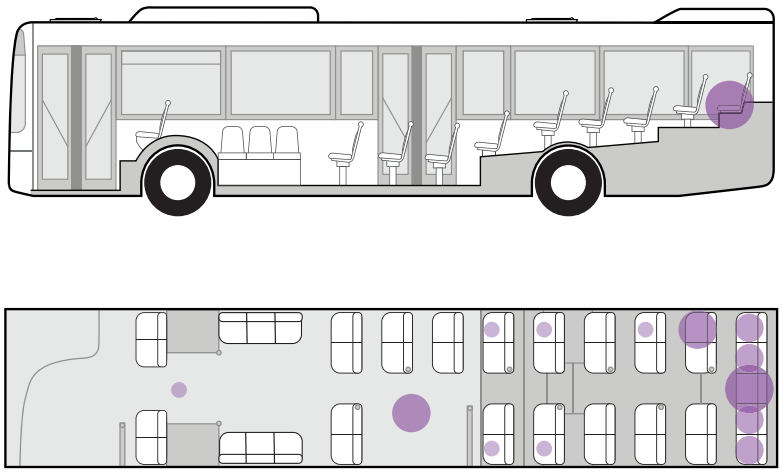


Figure 4.9: Where antisocial environments are perceived to occur on the bus

Navigational issues within the bus

Within the information provision section, participants stressed finding on-board information to be lacking, due to service inconsistency and PIDs not showing enough information. This lack of information was found by some participants to create further on-board navigational difficulties when trying to navigate the bus route. These issues firstly included not always knowing where the service was going. This was caused by the environment and winding routes often taken by suburban buses, as well as the lack of information within the bus signifying the current bus location and route direction. This gave no reassurance to unfamiliar users, unless they had access to online information.

> *Not always sure where I am going (Participant 14: Section: 7, task: 2).*
>
> *I hate the way you use backstreets (Participant 2: Section: 5, task: 1).*

Secondly was missing your stop. This could be caused by users not paying attention, time of day, seasonal and weather factors, and poor signposting affecting the ability to see the stop from within the bus.

> *Difficult in winter after dark to ascertain where you are (Participant 7: Section: 7, task: 2).*
>
> *I worry that I'm going to miss a bus stop. From on a bus I don't feel they are well signposted (Participant 2: Section: 3, task: 2).*
>
> *Stops are difficult to see (Participant 4: Section: 7, task: 2).*

Alighting, transfer and post trip

Alighting, transferring and post-trip activities were not discussed in great detail, with participants limiting their responses to "I walked to this location" or "I had to organise a lift as there was no other PT in this area". One interesting point made was that buses were perceived as difficult to use due to being less integrated with other modes, referring again to poor information and access provided. Other factors relating to this include: bus stops being placed in less optimal transfer locations, particularly at railway stations; no announcements being made if services are running late, influencing users' ability to adjust pickup times accordingly; needing to organise pickups as other transfer modes do not connect; and not being able to board with a bike.

Other notable comments

Other interesting results that emerged from this research discussed journey trip types, aesthetics and mode comparisons. The majority of journeys listed during the daily mobility use section of the diaries showed

participants taking multiple smaller trips. These trips consisted of participants moving about their local environment to go to the shops or post office, or pick up a friend before going to their desired location. While doing this, some participants used multiple modes, further highlighting the most convenient mode option. This mobility behaviour is interesting as it shows that travel modes need to be flexible and integrated (such as with MaaS) to fulfil the needs of the public. The lack of information, flexibility and reliability of buses found within these studies was seen as a preventive for system engagement.

Similar to what is discussed in the literature, when the bus was compared against other mobility modes it came across negatively, often listed as average within the categories of comfort, cleanliness, information, access, safety, appearance and experience. When other modes were discussed, the participants focused on the positives of having more control, as compared to the more restrictive bus experience. These aspects related to having control over: airflow; being able to take bulk items and keeping them in a car; jerk rate; flexibility and convenience of car journeys; higher frequency services; and more information. The car, however, required the trade-off of being alert and engaged with the act of driving; similarly, the train was considered busier and less likely for finding a seat. These points allowed the bus to be more conducive to an environment in which the user could zone out or undertake another task while seated. As this appeared to be the most favoured attribute of bus travel, it is important to promote and encourage.

4.3.5 Study summary

In summary, the travel diaries were designed to build upon the existing knowledge and answer the remaining unknowns, mainly focused on determining the reasons behind bus interactions and behaviours. The diaries have shown that participants often had complicated travel patterns, making multiple detours and using multiple modes. Some participants were motivated by the most convenient mode available to them. Unfortunately, as identified within the barriers to use section (Section 4.3.4), the bus was often perceived as unreliable, unpredictable, inconvenient and often inaccessible. These perceptions developed from a lack of knowledge about surrounding services or a lack of nearby services, as well as poor transfers, multiple negative experiences featuring buses being late or not arriving, antisocial behaviour, negative word of mouth, or confusing or false information presented. These themes all centred around users not feeling in control of their bus experience, as the bus was subject to an inconsistent environment caused by a lack of information. This problem is a commonality with the other two studies and, if solved through design means, could significantly improve the current user experience while preparing the bus for more future mode integrations.

The method applied appeared suitable and thought provoking with a range of opinions and experiences being discussed. The study findings were limited during the daily travel sections, where few responses discussed pre-and post-travel stages. Similarly, during this section, participants had the option of choosing their travel mode, which created a variety of mobility options to be explored as opposed to only buses. Having a more focused approach during this section might have resulted in more specific data, however the focus on bus usability within the other activities accounted for this.

Now that the three studies and their findings have been discussed individually, the following section will work to triangulate the gathered knowledge, combining discovered themes and insights into a broader picture of bus experience. This synthesis and data visualisation process will provide knowledge verification, as well as begin transferal of insights from written to design solutions.

4.4 Overall study findings

This chapter has sought to better understand the user experience of suburban bus users on a holistic level, focused on determining the greatest barriers and issues to usage and improving these problems through design practice. Each study was chosen for its ability to add new layers of knowledge to the same subject area, strengthening the findings and filling in the information gaps.

The different datasets and findings will now be combined and compared, creating a triangulated overview of the bus user experience. This process will firstly highlight areas of convergence within the three studies, while validating the qualitative outcomes (Visocky O'Grady & O'Grady 2009). Through identifying the theme similarities a design focus will be produced, with the datasets helping to develop a basis for the design responses. This section will begin to answer the second research question: How can ethnographic methods be applied in design practice to develop user-centred bus services?

4.4.1 Differences and similarities

The three studies gathered information on the same topic through different means, providing different experiences and knowledge from different perspectives. For example, the CFD only produced findings based on service complaints and issues, as opposed to regular service experiences and touchpoints as featured in the observation, travel diary and workshop studies. Even though differences exist, the majority of findings are similar. Individually the findings from the study would not have been sufficient to determine bus user experience, with their limitations providing narrow views. Triangulation allowed the study findings and assumptions to be confirmed or negated, as well as provide a broader picture of bus user experience. The triangulation process generated a means to determine commonalities and pressing issues, providing multiple view points on similar topics. Minor issues that are only found with one method can therefore be missed or classified as less important. Similarly, the triangulation is subject to similar coverage and mode limitations, being Melbourne and bus centric. Table 4.3 shows an overview of the main findings that each method produced. A breakdown of the qualitative data discussing the interaction points and experiences discovered can be found in the findings section of each study.

Table 4.3: Study findings breakdown

	CFD	**Observations**	**Travel diaries**
Objective	To analyse the CFD to understand the recurring issues affecting journey experiences within Melbourne, as well as to determine what problems are the most pressing.	To observe the bus experience, identifying the interactions with the vehicle and service as well as identifying any problems that occur.	To further develop the knowledge from the previous two studies and gain deeper insights into the motivations and frustrations of Melbourne bus users.
Data limitations	Only discussed service failures and dissatisfiers.	Difficult to understand the motivations and experiences behind the interactions.	Small sample size
Findings			
Lack of information	Lack of information, caused uncertainty and confusion. Feedback showed users would ring the operator to fill these information gaps. For example, when will the service arrive or why did the bus not stop?	Desto sign placement causes users to walk to the front of the bus to confirm that it is the correct service. To gain information or confirm that they were in the correct location, users were observed asking the driver or other users for service information. For example, is this the correct bus or when do I need to alight?	The information presented was poorly rated. Use of other information as a confirmation. Desto sign needs to be located in a better position. Only placed at the front, making it difficult to confirm that it is the correct bus. Lack of information within the interior makes active wayfinding more difficult.

	Incorrect information caused by disruptions or services running late or early caused a lack of trust.	Users not being aware of a disruption and not being made aware by driver or signage can cause anxiety and concern, particularly when on the service.	The lack of real-time and printed timetables at stops were unreliable. Caused confusion.
Waiting	Being left at the stop and not knowing why. Caused system distrust and concern as to whether it would occur again.	Bus's presence encourages users to run for service to avoid missing it.	Being left at the stop was only mentioned once. Unreliability and how users did not trust services to be on time was more common.
	CFD	**Observations**	**Travel diaries**
Passenger flow on board		12.5m design causes catchment zones at the front wheel section and at the stairs.	Favourite places to stand were around the front wheel section. Least favourite location was beyond the stair section.
While travelling		Users were observed to zone out, listen to music, use phone or laptop, read. Active wayfinding was also observed using a smartphone.	Participants listed activities such as reading, using their phones and listening to music or podcasts as being a positive of bus use, as they did not have to pay attention to driving or be engaged with the act of transportation. Participants were able to relax and zone out.
Standing		Standing can limit ability to use devices. Standing was seen near stanchions.	Favourite places to stand are in areas with stanchions.
Vehicle accessibility	Timing points were often not understood.		Services being non-accessible due to lack of, distance or low frequency. Distrust of service can cause users to arrive earlier.
	Mobility-impaired users not being picked up.		
Bus vehicle	Older vehicles immediately caused dissatisfaction due to basic levels of service not being met.		
Antisocial behaviour			Perceived antisocial behaviour can cause travel plan altering, such as alighting at busier stop or not catching night services to prevent feeling unsafe.

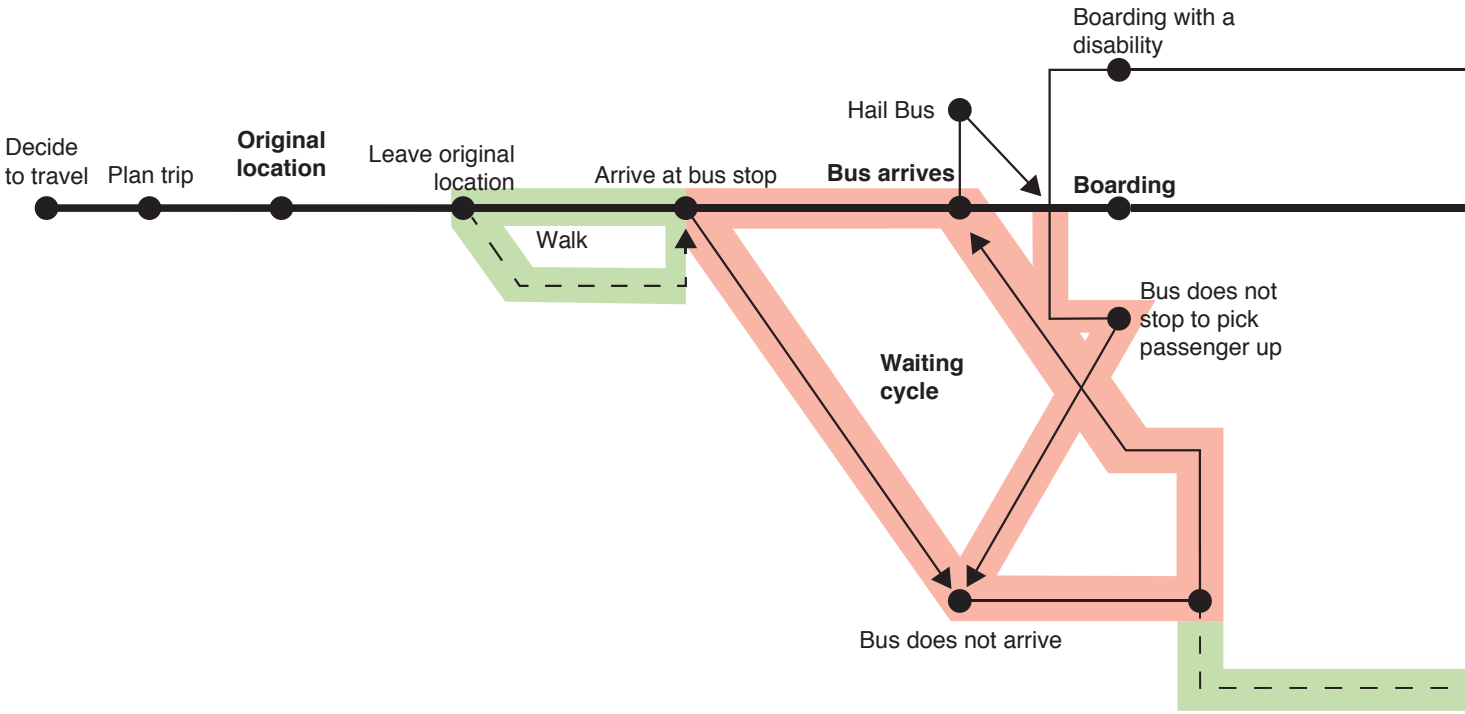


Figure 4.10: The bus journey map

The majority of issues and subthemes were found to recur across the different studies, validating their negative involvement with poor bus user experience. These findings were then categorised using a journey map, to visualise touchpoints and interactions more holistically.

4.4.2 Data visualisation and synthesis

The following journey maps shown in Figure 4.10, 4.11 and 4.12 present a visual – experience model – account of the studies' findings, highlighting the major touchpoints and interactions that users experienced when engaging with the bus network. The diagrams are a tool used to synthesise the findings, as well as presenting the data holistically, helping to identify the relationships and "find gaps in customer experiences and explore potential solutions" (Stickdorn et al. 2011, p. 44).

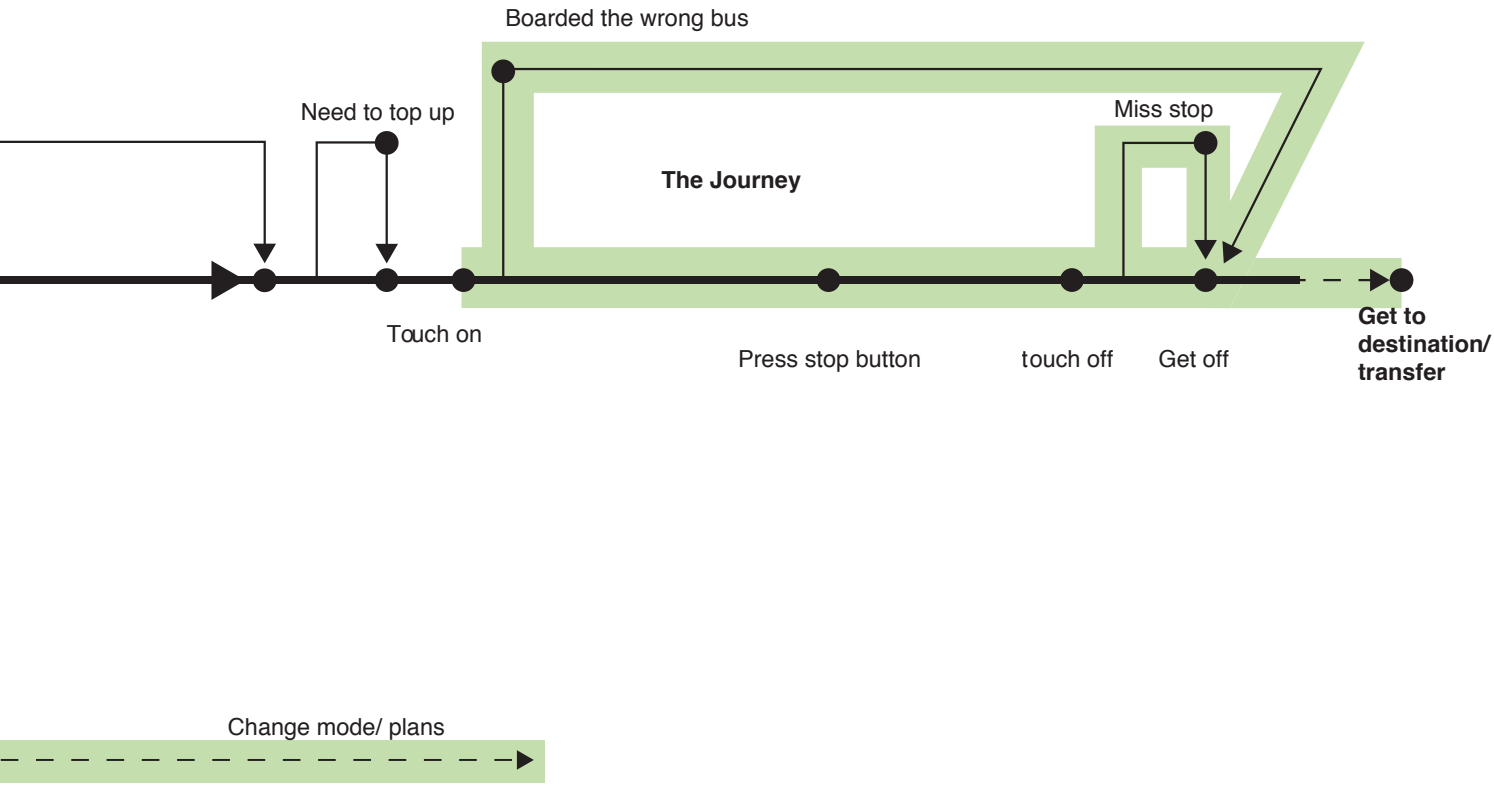


Figure 4.10 shows the journey map touchpoints, illustrating the bus user's end-to-end experience, from the point someone decides to make a journey to when they arrive at their destination. The middle horizontal line highlights the ideal journey, mainly consisting of an experience where nothing notable occurs; for example, the bus is not late or the bus driver is not rude. Deviations from the line represent alternative negative travel scenarios that require the user to engage and make further decisions to continue or abandon their journey, creating a less controlled experience. An extreme example is illustrated within the waiting cycle, where a bus has not arrived. Due to the lack of information presented by the operators, the user remains uninformed of their wait time, potentially creating a continuous waiting cycle. This is only broken if the bus arrives or the user changes their travel plan, which is often an uninformed gamble. An annotated version of the diagram, providing a synthesised depiction of the negative touchpoints and issues that emerged from the studies, visualising the points of their involvement can be found in Appendix F and G. Negative issues are focused upon as opposed to positive traits, as they highlight points of necessary improvement.

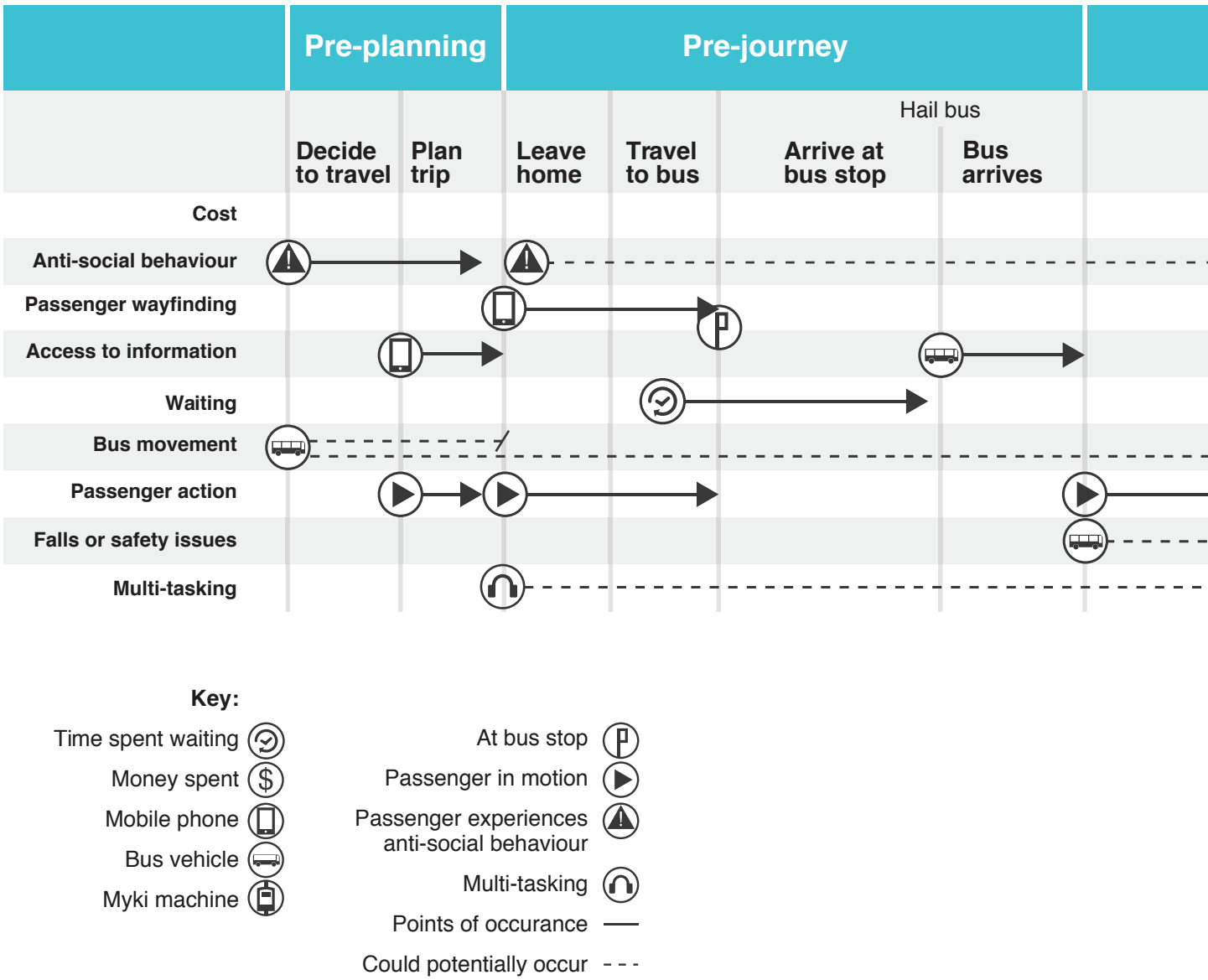
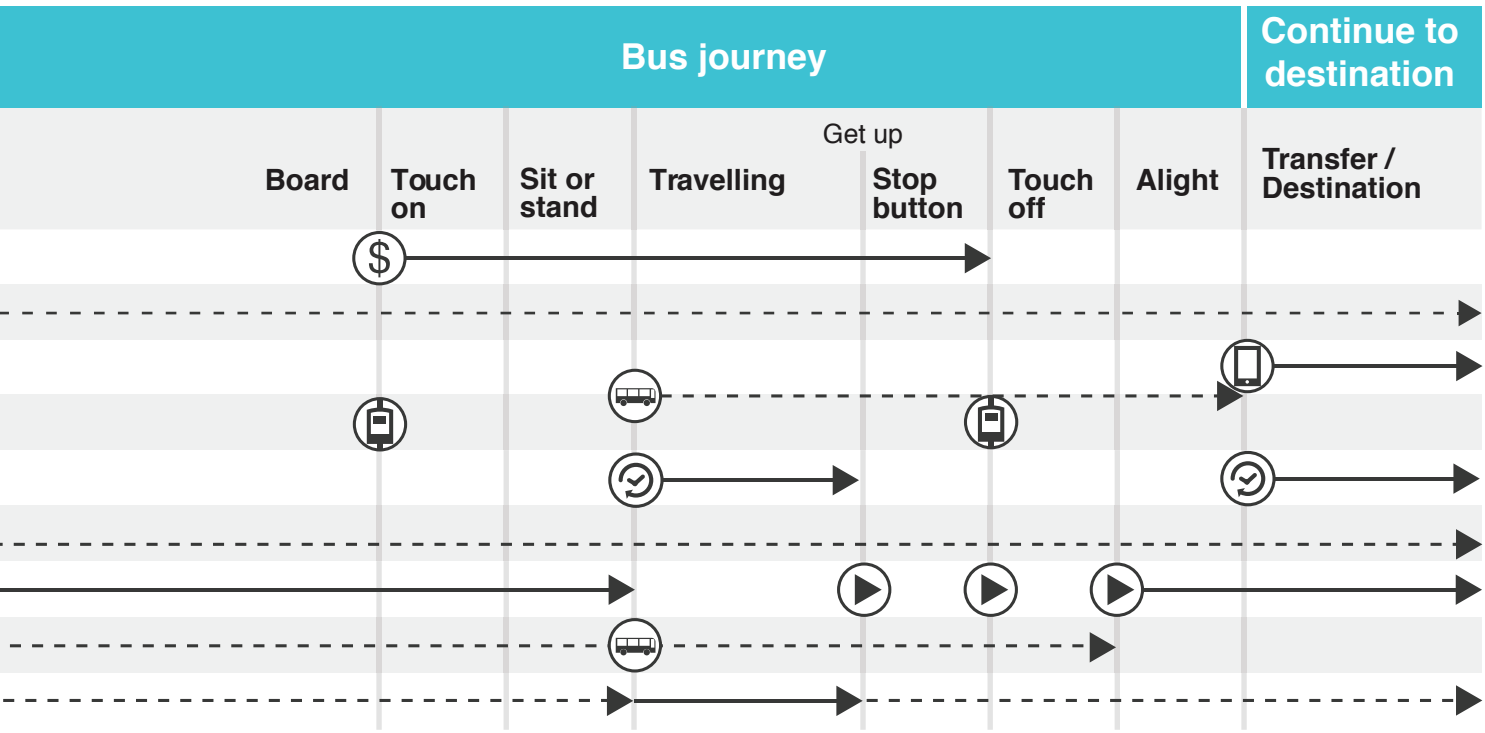


Figure 4.11: The bus journey map touchpoints

Similar to Figure 4.10, Figure 4.11 builds upon these insights, detailing the journey and the multiple attributes that are engaged at various points along the journey to reach a successful end. This diagram highlights points where users are expected to engage with the system and perform a physical task like walking to a bus stop, boarding the bus or perform active wayfinding. These interactions can be hubs of negativity where involvement might prove too difficult or cause feelings of awkwardness or uncertainty. These levels of engagement can also be affected by familiarity with the service, influencing the way someone undertakes a journey; for example, active wayfinding is more present with unfamiliar use. Together these diagrams highlight the magnitudes of the issues affecting both the services and vehicles, as well as multiple areas throughout the entire journey. The problems are also often interwoven; for example, the bus arriving late can affect user tardiness and safety attributes, increasing the complexities of the environment. All these areas are considered potential focuses for redesign.


Bus journey
Continue to destination
Board
Touch on
Sit or stand
Travelling
Get up
Stop button
Touch off
Alight
Transfer / Destination

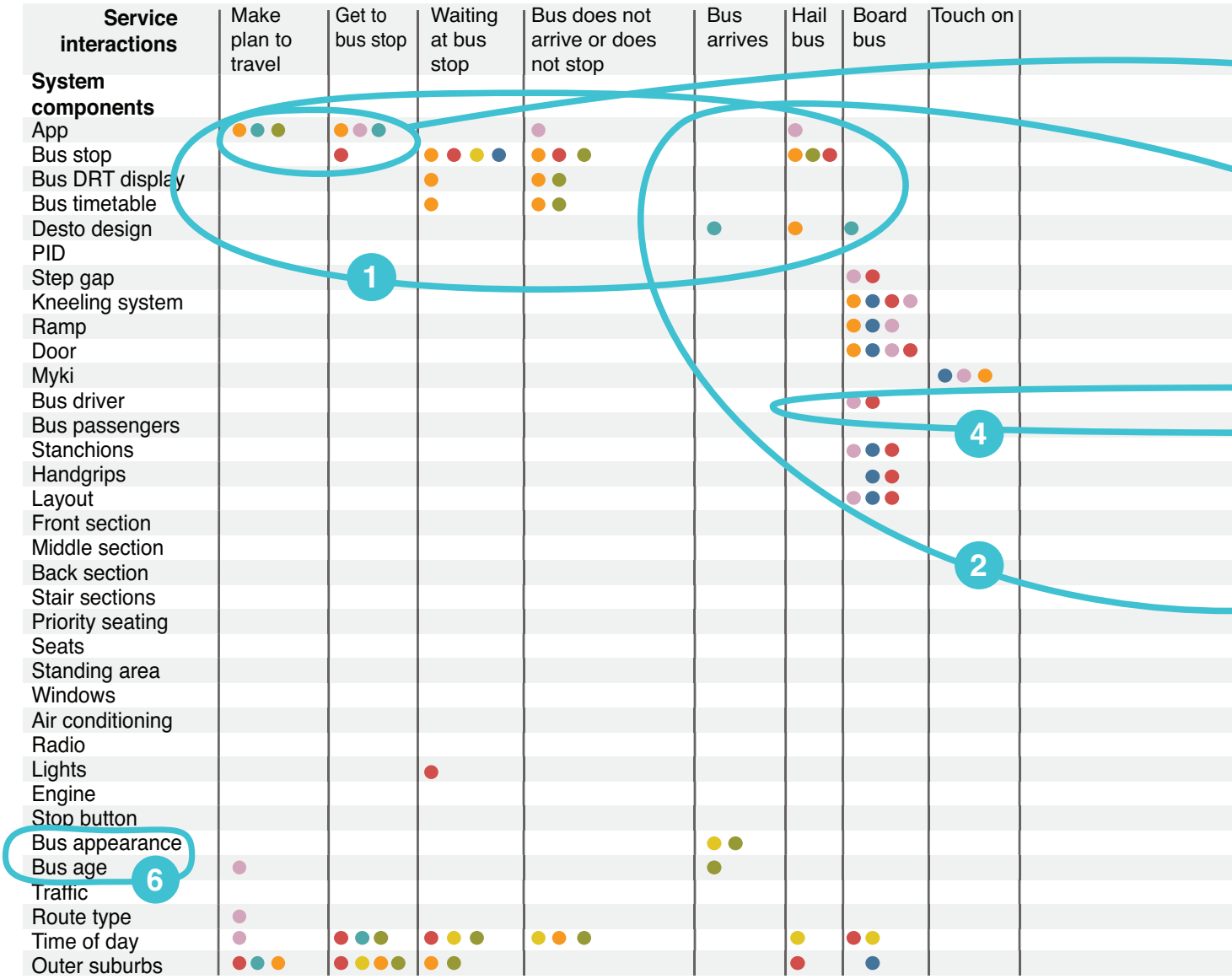
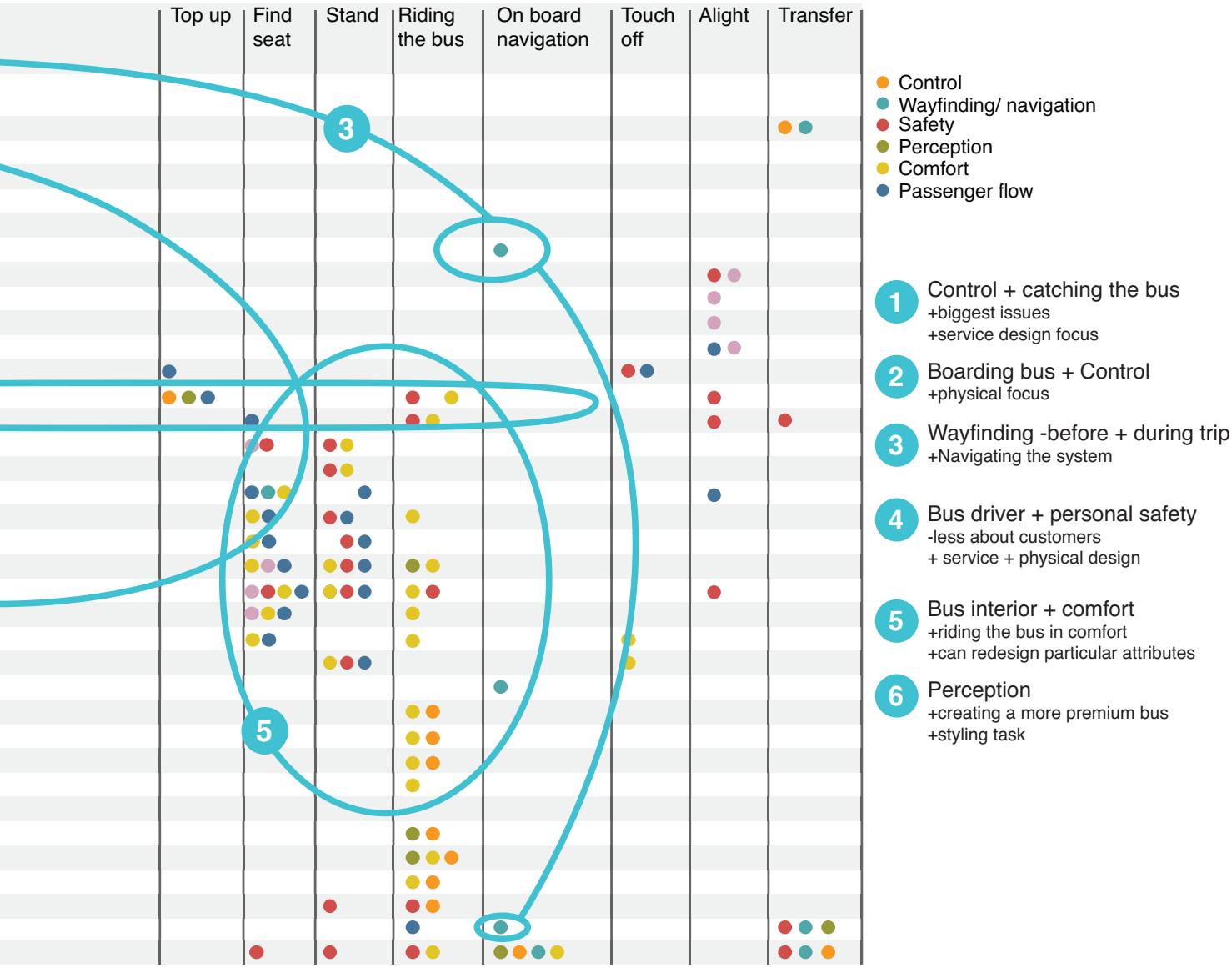


Figure 4.12: Matrix of potential areas design focus

To narrow the design focus and to further categorise the findings into themes, Figure 4.12 presents a journey matrix. The matrix axes consist of system components and service interactions, allowing all service and vehicle touchpoints to be mapped. The matrix is then filled according to the recurring themes presented in the studies: information; wayfinding and navigation; safety; perceptions; comfort and cleanliness; and passenger flow. The matrix is designed to allow multiple avenues of redesign focus to become apparent, something that is harder to see within the research and journey map. The matrix can be read in a number of ways. Any column or row can be chosen for design, with any intersecting node suggesting a themed problem. A part of the journey or grouping of themes can also be chosen, highlighting an area for redesign. All intersecting nodes are representations of issues and touchpoints for redesign. Section one was chosen for the redesign of this project as it deals with areas that were commonly attributed to dissatisfaction and barriers to bus usage within the three studies. Similarly, this section allows multiple touchpoints and themes to be addressed, providing a holistic design response. Even though the majority of themes fall outside bus operating scope, the researcher believes that the industry should move towards their development to deliver improved user experiences. Similarly, it should be noted that previously discussed themes such as comfort and passenger flow are now considered out of scope for this project. They are still considered areas for future research and passenger improvement; however, they will not be further discussed within this project.



4.4.3 Design focus

Across the studies, information, accessibility, reliability and safety were identified as the main barriers to suburban bus usage, with service delivery failures – presented in Figure 4.12 – causing user uncertainty, annoyance and distrust.

Within Figure 4.13 the red and orange sections highlight potential points of service failure, including points of service disruption, access issues and antisocial behaviour. These red sections are aligned with the main concerns and barriers expressed during the studies, and are identified as points where design intervention could add control and improve usability. Design intervention is particularly suited to improving these points as it allows service and vehicle integrations, as well as combined solutions that can encompass all touch points; for example, a single app interface that adds safety features as well as improved navigation. These phenomena were classified as control-based issues, with users having insufficient control and knowledge surrounding the bus environment. This causes user inability to positively deal with system failures if they arise, such as service disruptions.

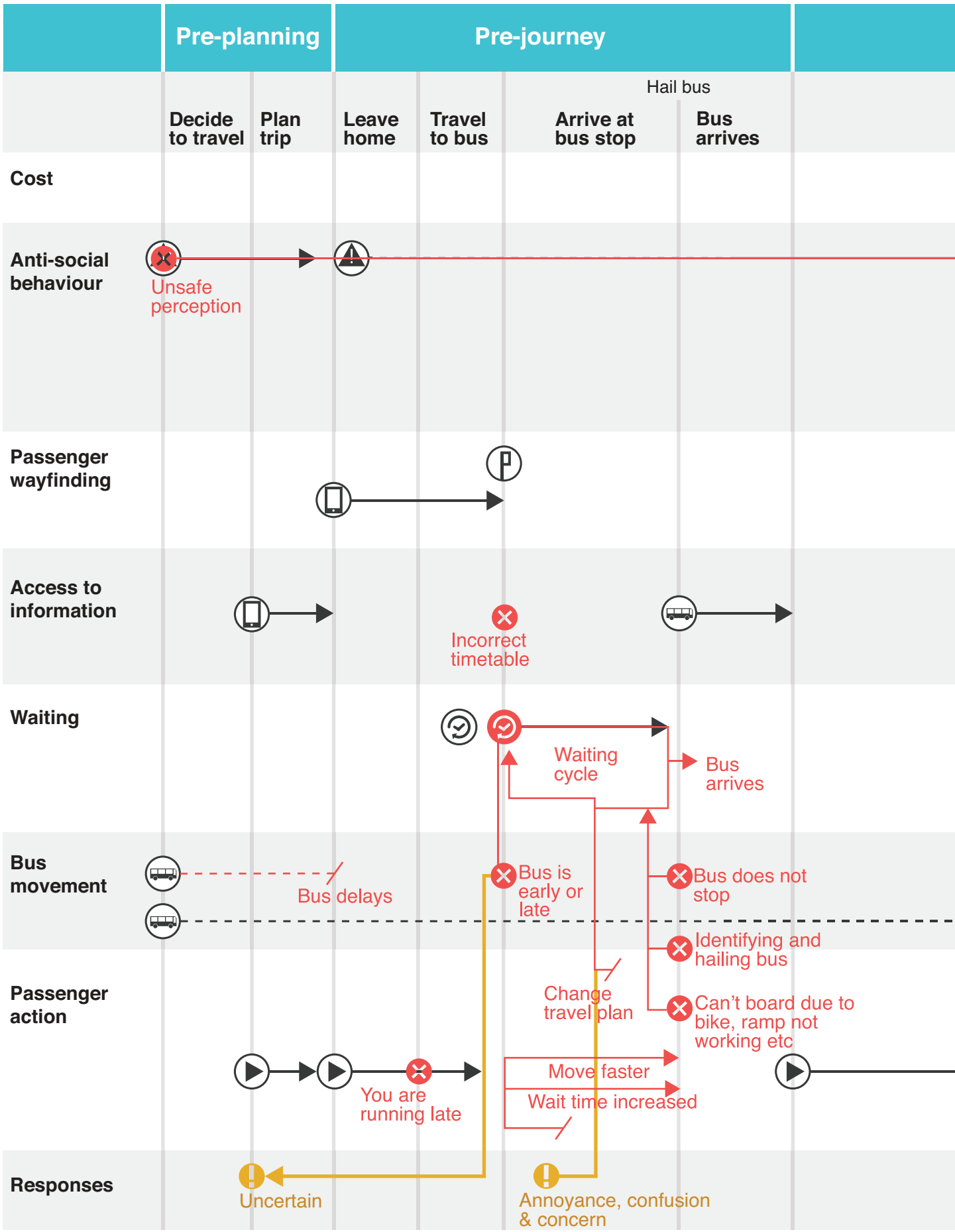
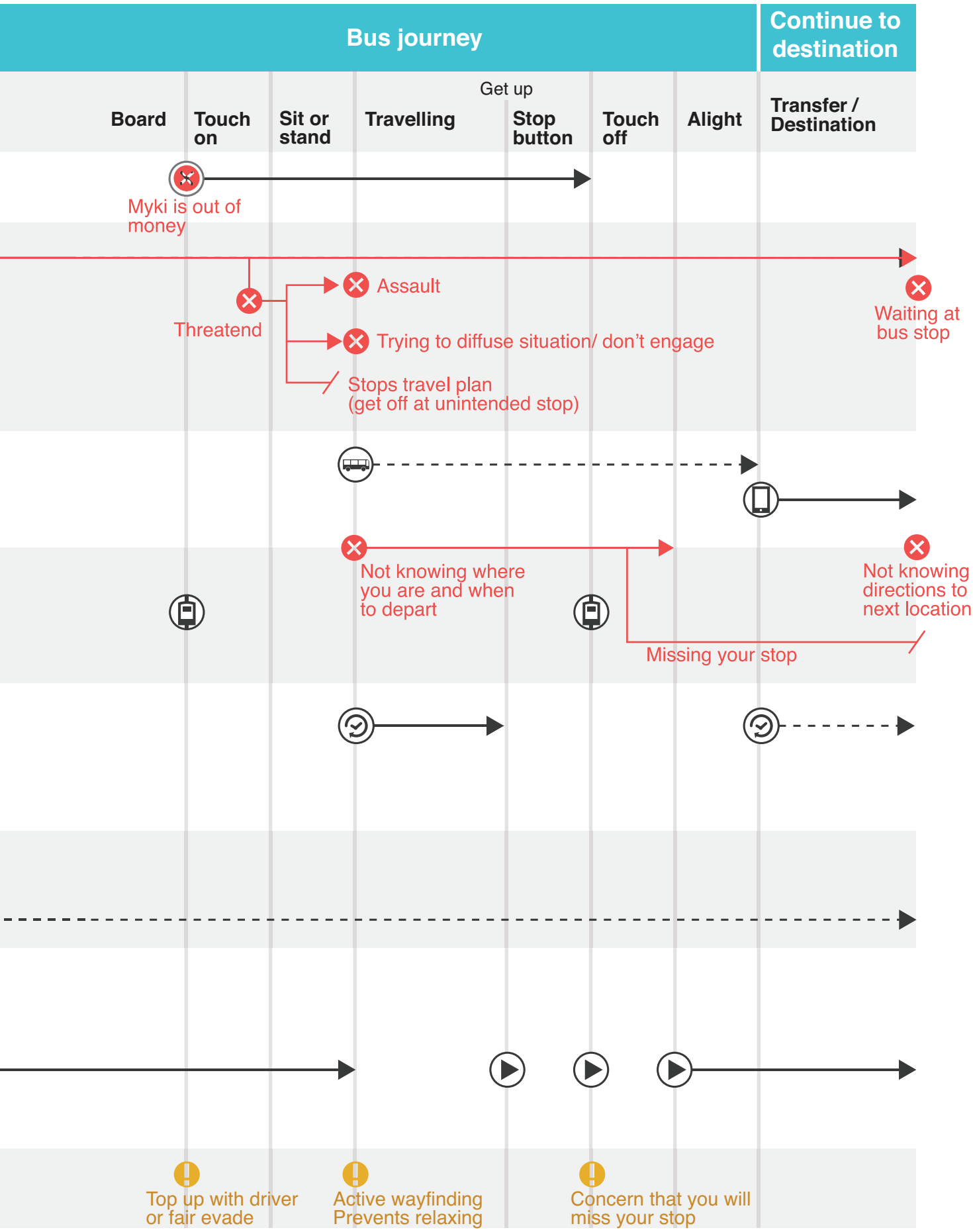


Figure 4.13: Control bus journey attributes and touchpoints


Bus journey
Continue to destination
Board
Touch on
Sit or stand
Travelling
Get up
Stop button
Touch off
Alight
Transfer / Destination
Myki is out of money
Threatend
Assault
Trying to diffuse situation/ don't engage
Stops travel plan
(get off at unintended stop)
Waiting at bus stop
Not knowing where you are and when to depart
Missing your stop
Not knowing directions to next location
Top up with driver or fair evade
Active wayfinding
Prevents relaxing
Concern that you will miss your stop

Control was initially identified during the literature review as a positive utility of car usage and, if correctly implemented, could improve overall user experience within the bus context (Gardner & Abraham 2007). Control was found to be underrepresented within PT literature, with few studies addressing what points during the journey are impacted on by a lack of control and how they can be improved through design interventions. This research will, therefore, discuss control in more depth, developing a clearer picture of its impact.

Control here refers to the feeling of being in control by being informed about the service and to have the power to change their own travel experience, as opposed to being subject to the inconsistency of the system. This refers to small, practical and proactive changes, giving users information about the service and keeping them informed. Based on insights discovered from the studies the following reimagines the problem concerning the lack of control and how it impacts on the bus experience.

Information provision
The level to which the user is informed deals with giving users the correct information at the correct time, so they can effectively interact with and navigate their journey (Lyons 2006). This is often affected by users having access to RTI, correct bus arrival and departure times, as well as knowing when to depart from their original location, knowing whether they are running early or late, and being given correct reassurances throughout their journey (studies 1, 2 & 3).

Information provision regarding wayfinding. This involves having suitable personalised wayfinding information to reassure the user that they are in the correct location and at the correct time, it is the correct bus, they will get off at the correct stop, they won't be late and they know where they are in the system, this being particularly important for first-time users (studies 2 & 3).

Information provision where users inform the system. This deals with users being able to change their environment, for example giving users an easy way to communicate their concerns with the operators in real time (study 1).

Safety from antisocial behaviour
All users should feel safe while out in the PT network. The main area of concern is the perception that something unsafe could occur. Inbuilt tools to minimise unsafe environments could help minimise negative safety perceptions and could be of assistance during a critical antisocial situation (studies 2 & 3).

Interior interactions
Interior interactions, although not directly tied to control, affect the way users are able to move and navigate through the space. How these spaces are designed influences users' ability to board and alight more quickly, find a comfortable place to stand and interact with the space. This influences their control over the space and how they use it (studies 2 & 3).

4.4.4 Design research hypothesis
From this design research focus, it is hypothesised that the problems associated with control can be improved through design practice, resulting in better bus user experience. Testing of this hypothesis will provide a new design solution and recommendations to be applied to the current operational landscape to improve user experiences. It will show the suitability of DE methodologies within another stage of the design process, eliciting further user understanding within future scenarios. A designed response will provide an evidence base for the main research question.

The identification of a lack of control as one of the main barriers to suburban Melbourne bus usage and the subsequent design focus has allowed the project's scope to be further narrowed. Design enquiry, vehicles and services, user experiences and the Melbourne suburban context will still be

applied; however, these themes are explored within the context of control and how control impacts on information, safety, reliability and accessibility.

4.4.5 Developing contribution to knowledge

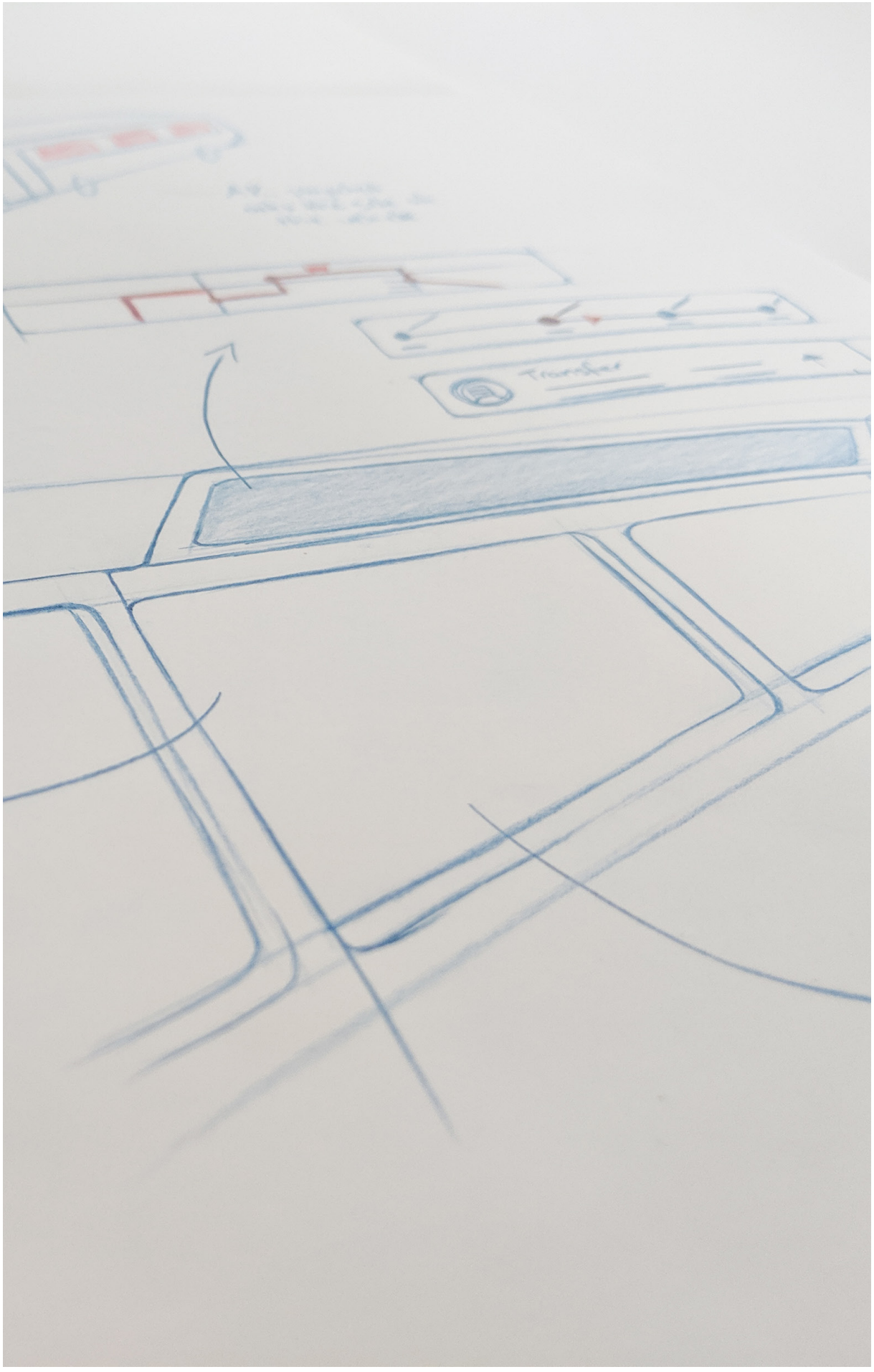
As discussed during the literature review, the literature on service quality and experience is rich, providing broad insight into bus behaviour and issues experienced on a global scale. Holistic journey experience literature based within a suburban Melbourne context was, however, found to be limited. The customer satisfaction monitor (Wallis 2017) and PTV's bus journey map (PTV n.d.) are examples of Melbourne-specific industry data that provides holistic, context-specific information detailing user satisfaction, experience and service issues. Although useful, these reports were limited in providing in-depth qualitative insights for product development. This gap provided the opportunity to explore bus user experiences holistically within a Melbourne context. By undertaking these studies research finding contributions have been made through the detailed representation of Melbourne's suburban bus user experience, problem points and areas of design impact, presented in figures found in Section 4.4. Findings have built upon the industry reports, providing a more detailed account of the user experience and specific vehicle and service touchpoints, with a focus on design intervention.

4.5 Summary

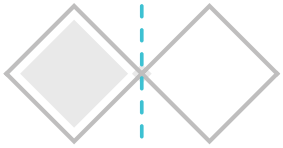
In summary, the three studies were developed and undertaken to discover knowledge surrounding bus user experience. Each study – customer feedback data analysis, observational data and travel diaries – used design ethnography methods to build upon existing bus user behavioural knowledge. These studies have developed a clearer picture of how users perceive their interactions with the bus service and how these experiences contribute to mode perception. Particular attention has focused on touchpoints, issues and possible solutions throughout the whole end-to-end journey process.

Through undertaking these studies and combining them with the knowledge gained from the literature review, the first subsidiary research question has been answered. The results are best summarised within the journey mapping diagram in Figure 4.13, as it shows the main issues and interactions of the bus user experience, indicating how the process connects as well as what areas to redesign for. The application of design ethnography methods has developed user-centred bus experience data.

The main finding is the lack of control users feel when entering the bus system. This has been identified as one of the main hindrances to service use. Control mainly focuses on the implementation of information to address the problems of service navigation, user safety and feedback. All of these are interconnected, making the bus service complex and difficult to improve without a holistic, end-to-end approach. The problem of control has been chosen to be designed for because it was identified as a main issue and barrier to suburban bus usage within all the studies conducted. Furthermore, the studies have developed information that could improve the control problem through design and improve the user experience for suburban bus use, the topic of this research. Control, therefore, is the main focus for the remainder of the project, with the design process discussed in the next chapter.


Transfer

Chapter 5
Design process: Vehicle and service concept development



Discussed within previous chapters, the lack of control experienced when using the bus service was found to be one of the main barriers to use, causing uncertainty, distrust, annoyance and overall negativity. Problems associated with control were identified and understood in detail across the whole journey, and were shown to impact on both service and vehicle interactions at multiple journey stages, shown in Figures 4.13. Lack of control and the associated problems within undertaking a bus trip will be the focus of this chapter, with the design process aiming to test the hypothesis that the problems associated with control can be ameliorated through design practice, resulting in improved bus user experience. This chapter will also respond to the third subsidiary research question: How can service and industrial design practice be used to respond to the research findings and improve the bus user experience? As detailed within the methodology chapter, this process will consist of a traditional design approach of exploration, creation and reflection stages. The iterative nature of the design process will help synthesise the research findings and problems into new knowledge and design solutions.

Following Dorst's (2015 p. 58) opinion on product innovation, to aid innovation delivery within this complex industry "radical ideas in design concepts, exhibitions, and publications" should be used to elicit conversation about potential futures and industry movement, as opposed to pragmatic finished designs. Therefore, this project's focus is not on the full development of a pragmatic design ready for production, but on the development of future concepts. This provides evidence-based suggestions about what sort of improvements and innovations the industry should be moving towards to become more user-centric. These designs are intended to initiate discussion and begin an innovative process to improve user control within the system, as opposed to being market-ready interventions. Despite these factors, these concepts are designed to be feasible within a technological horizon of the next five to ten

years, to provide a level of reality to concept development. The designs presented within this thesis are, therefore, not fully realised but ideas for stimulating discussion towards improving control.

This chapter details the creation and development stages of the design process, focused on generating design concepts in response to the hypothesis and research findings. This has been made easier via visualisation of the data and problem sets, with the research findings already promoting potential redesigns. The designer's role within this stage has been, therefore, to synthesise "a mass of fragmented bits of information and then… invent a coherent and often elegant proposition that embodies all or most of the rag-bag of bits" (Swann 2002, p. 54).

5.1 Preliminary design tasks

Initially, two preliminary design tasks were undertaken to develop more diverse design outputs and start to synthesise the collected data into design concepts. These tasks took place in the form of a bus interior redesign and a digital information investigation.

An outer suburban Melbourne bus interior and user interaction points was designed based on the literature and study recommendations. Design responses were initially broad, exploring all vehicle touchpoints. This approach helped to connect elements and problems to control that were not previously apparent, and provided a blank vehicle canvas upon which to build upcoming control designs. One such element was identifying the move towards fully segregated driver cabins to promote driver safety, as well as driver removal through autonomy-predicted futures. The observation study showed the driver acting as a link between passengers and service information. Limiting access to the driver has the potential to cause user and operator information-chain breakages. If drivers are expected to be separated or removed from the system due to either safety concerns or technological advances, these information gaps need to be considered and mended through alternative means, an area the design process will explore.

These elements provided the opportunity to use different types of information provision and navigational tools that rely less on human interaction and more on digital displays, with the segregated cabin being a space for information accessibility. It should be noted that all bus bodies used during this thesis are based on the Optare Solo 9.9m vehicle body, which includes the segregated driver cabin area. This project does not explore body, frame or chassis design. A vehicle template was simply required to explore the designs within. Future concepts can be translated to alternative vehicle types.

Exploration of apps and navigational tools within alternative fields was undertaken in order to identify what digital information could be implemented within a bus journey to add control. These initial tasks jump-start the design process by synthesising knowledge developed from the studies into service and vehicle outputs, as well as eliciting new avenues within which to design control. Figure 5.1 is an example of that design exploration process. The sketches presented in Figure 5.1 explored different points at which information can be offered throughout the vehicle interior, to combat information problems. For example, ways in which information can be presented to the driver and to the passengers. Layouts were also initially explored to synthesise study results, in order to demonstrate how passenger flow, ticketing, catchment points, and preferable seated and standing location problems could be responded to within a single design. For example, during the observations the stairs and front wheel hubs were identified as points that would holt passenger flow, with their removal helping to decrease catchment points. This initial iterative process helped to determine the suitability of the Optare Solo design and ideate areas where signage would be most applicable for responding to control problems.

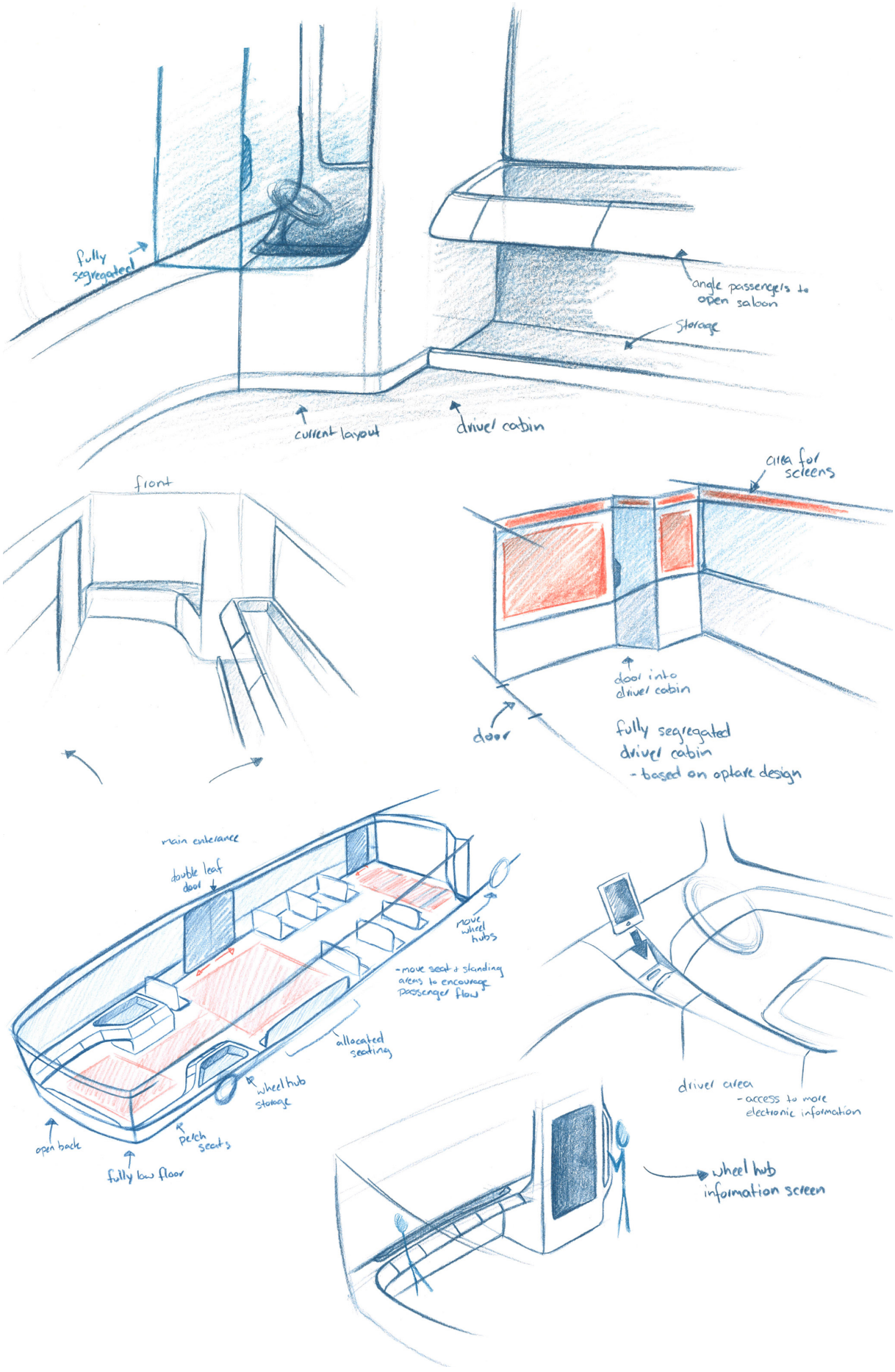


Figure 5.1: Preliminary design task sketches of bus interiors

5.2 Designing for control

Designing for control was considered the main design research task. The design process allowed the issues discovered throughout the literature review and studies to be explored in an iterative manner. This enabled the design responses to the problems to grow, creating new information surrounding the problems and the solutions. Problems associated with control were featured throughout the whole journey experience (as seen in Figure 4.13), influencing both vehicle and service capabilities. To successfully design for this subject matter, a combination of service and industrial design techniques were utilised, as well as the development and redesign of multiple small problem areas. Such an approach allowed a holistic focus across journey, service and vehicle to be made, as well as providing a realistic focus for better solutions and innovative developments. The issues associated with control cover many touchpoints, with Figure 4.13 identifying the areas for design intervention. These consist of: users being informed of bus movements and confident of arrival times; users' ability to hail and board services; users' safety; journey personalisation; network navigation; alighting; and transferring to final destination.

During the design process, both service and vehicle configurations underwent a generative and developmental process. The studies' findings were synthesised and explored to uncover a range of speculative and pragmatic ideas, balancing feasibility and suitability. Transitioning the broad user-centred findings into creative responses was made easier via the matrix in Figure 4.12. The matrix divided the problem areas across the journey progression, allowing problem points and experiences throughout the journey stages to be targeted and designed for. It should be noted that during this early design stage only points from group one: control + while catching bus, were targeted. This early design stage allowed broad concepts to be generated to explore each of the identified control problem points. For example, bus hailing could be engaged with via an app, at the bus stop or through the destination display, and was negatively influenced by information, poor perception and safety issues. Figure 5.2 and 5.3 are examples of the design development process. For more process images see Appendix H. For discussion on each app function and problems they respond to please see Section 5.3.

Generated concepts and their functionalities began to interconnect across the journey stages; for example, hailing the bus and disruption concepts were able to be engaged via the same interface. This provided more functionality and problem solutions could be incorporated within fewer designs and infrastructure changes. During the development, the leveraging of digital devices and MasS apps to answer control problems was favoured, as they were able to fill information gaps within the system, as well as being updatable during different environments and points of the journey.

This digital focus incorporated bidirectional app and vehicle concepts to deliver more personalised and controlled experiences. The application of vehicle and app bidirectional interactions was considered novel, working to improve aspects of control through positive information loops. Bidirectional interactions refer to the bus service and the app being able to inform and influence one another. Current relationships between apps, services and products within the context of PT are considered one way information flows, with transport apps working hard to communicate services and navigational requirements to users. The app and vehicle, however, are mostly unconnected, with some apps showing the number of users on board but unable to prompt service change or interaction with the vehicle.

It should be noted that although multiple topics have been discussed, it was their relationships with control that were the focus for the design response. For example, this project was not attempting to make transit free of threatening behaviour or environments. It was, however, trying to provide users with additional information and tools so they feel safer and more in control over their travel experiences. Additionally, during the literature review the incorporation of smartphones, the internet and other digital technology within the transport industry was seen to allow operators to provide

additional levels of service information and navigation to their users. Although phones provide new information channels, they also exclude bus users who do not have the access or ability to use such smartphone functionalities, such as the elderly. Future work should explore this issue further, integrating designs that add control for these user groups; this was, however, out of scope for this project. To limit these constraints, this project does not remove any current bus functionality – for example, bus stop buttons – and incorporates on-board signage to improve navigation for non-users of smartphones.

Figure 5.2: Early design stages

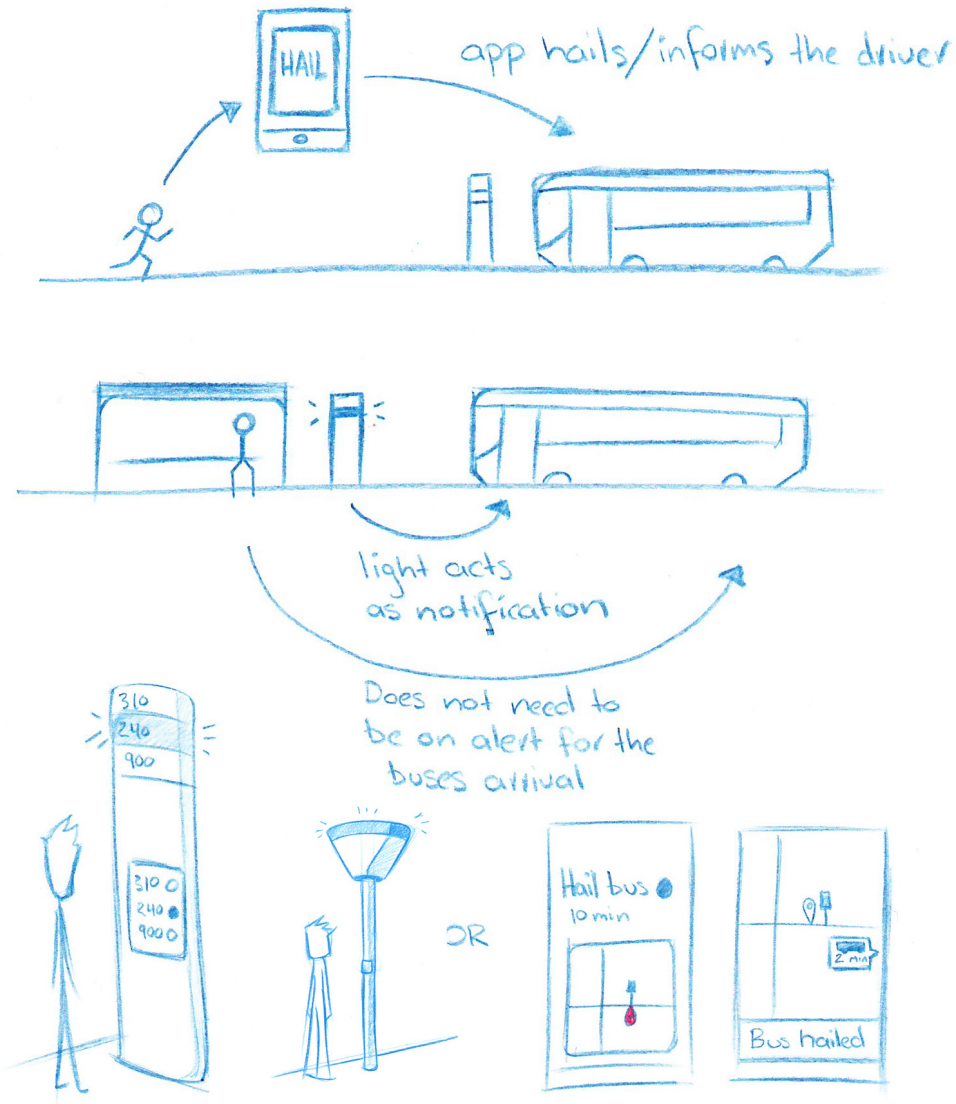
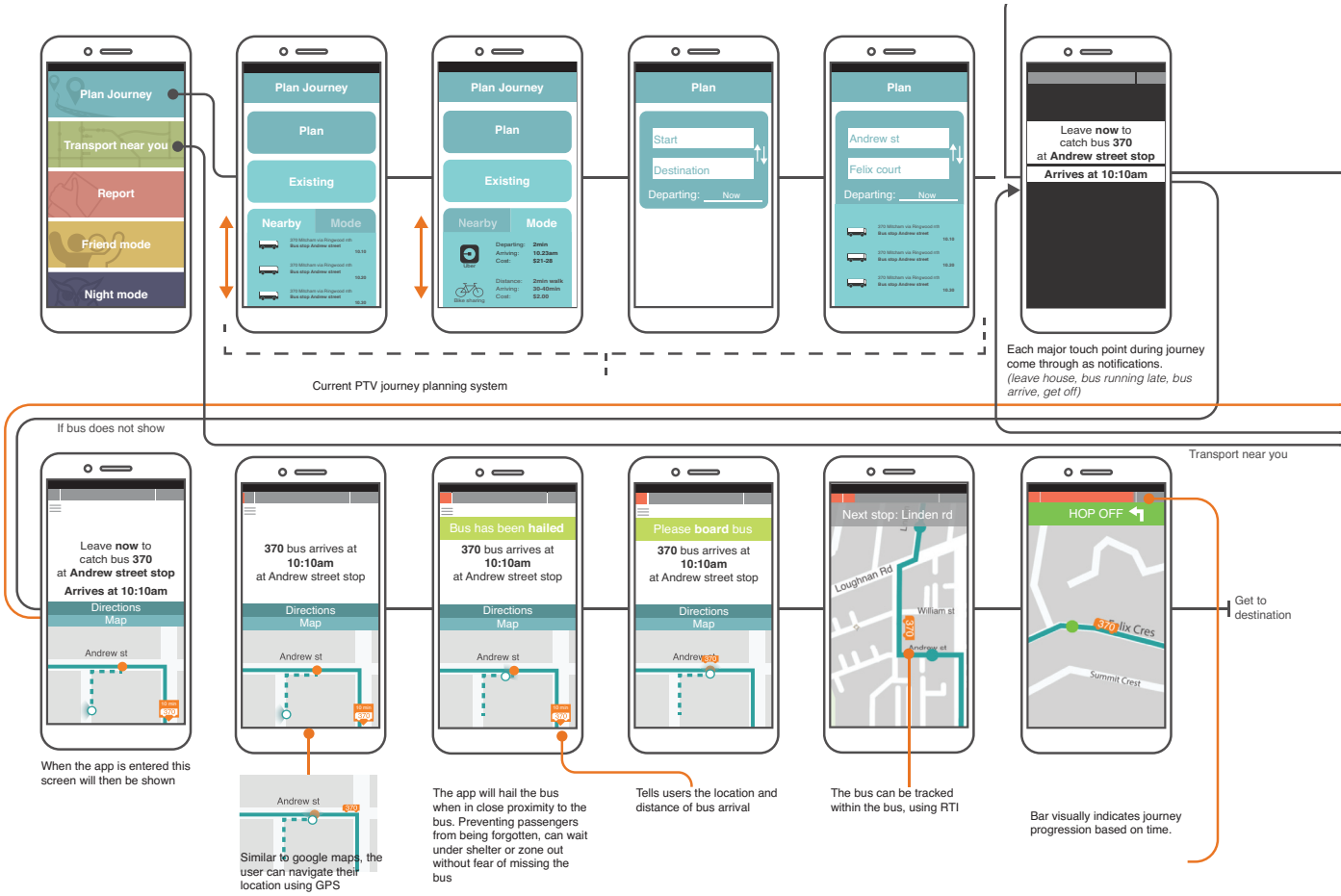
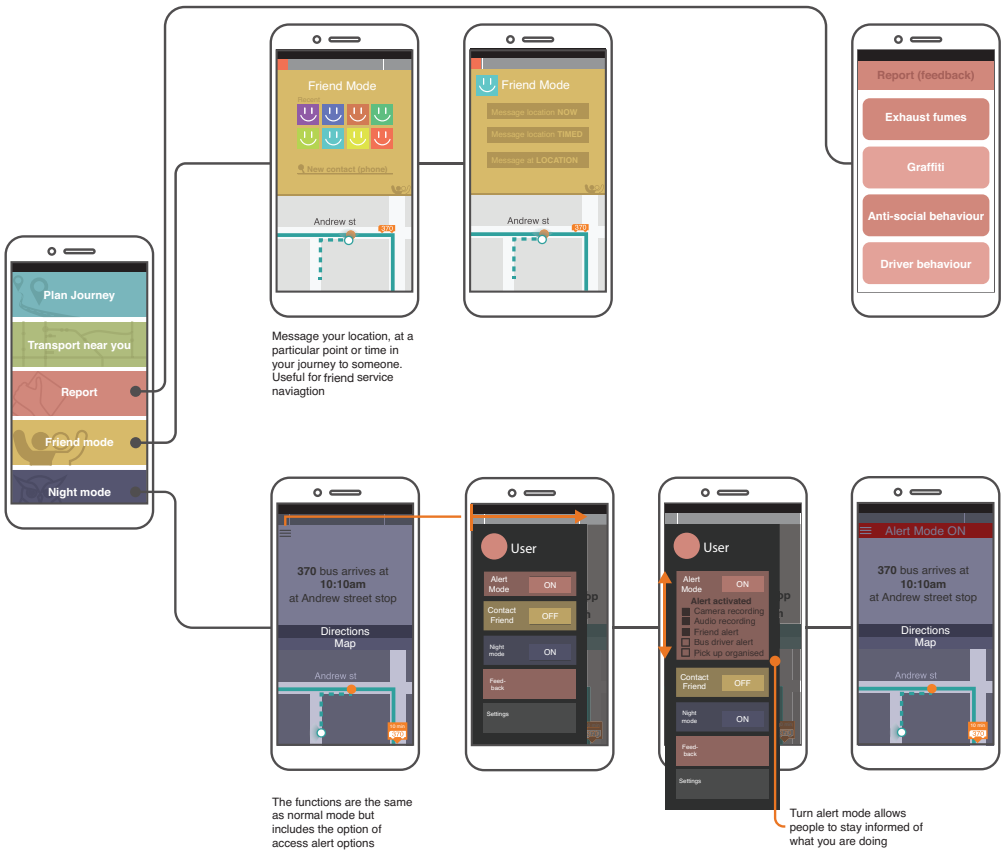


Figure 5.3: Hailing bus concepts and concept development across journey stages

5.3 Outcomes

5.3.1 App features





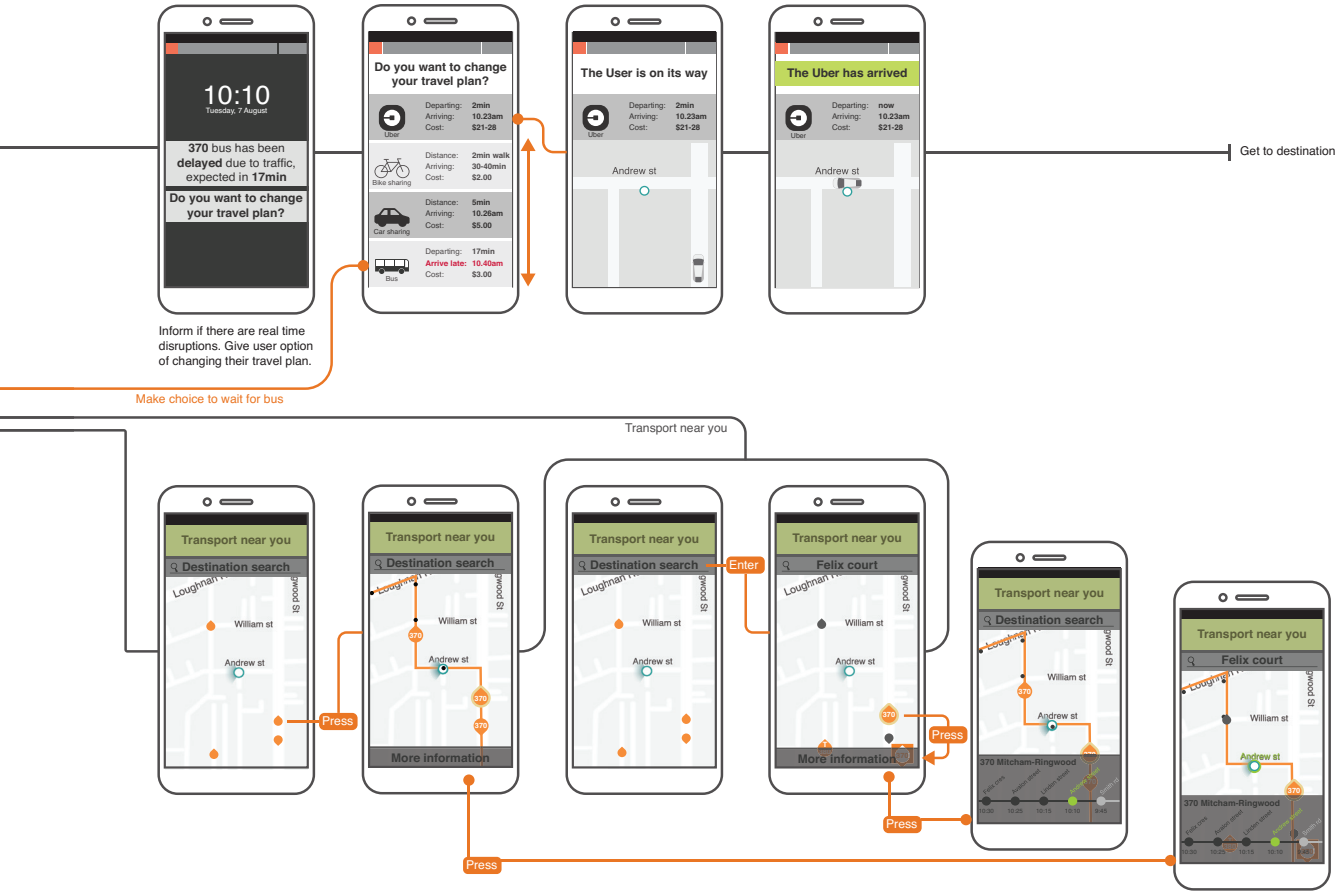


Figure 5.4: App workflow diagram

The app focused on incorporating a MaaS framework into the current bus operating system of a low-density suburban environment. The intention of this was to add control, clarity, flexibility and ease to the system by providing users with suitable information and mode integration. The app consists of five main functions: Journey Planning, Transport Near You, Reporting Mode, Friend Mode and Safety Mode; these will be discussed further below. A workflow diagram of the app concept is presented in Figure 5.4, illustrating the structure and features of the concept.

Journey Planning

Present within most travel apps, journey planning helps travellers to pre-plan their trips, keeping them updated and informed about the network while their journey is being undertaken. This Journey Planning function combines these principles with MaaS to create a more integrated, mobility-based service while addressing some of the identified problem gaps concerning information provision and lack of control. Problem gaps consisted of: being able to find the bus; knowing if the bus is early or late; if you are able to board; being reassured of bus route and directions; being informed about disruptions; and able to make informed travel decisions to name a few.

Transport Near You

The majority of transport apps include a central map, highlighting nearby mode options. These functions often only include PT modes, with MaaS functionality prompting calls to Uber or other services. Transport Near You functions generally do not include search capabilities, indicate whether the bus goes to the correct location or, if multiple services go to that location or which service will arrive first. This function often fails to include mobility-impaired access and other mobility needs information. These issues were responded to during the design process, developing a synthesised design of the needs.

Reporting Mode

When buses are out in the field, the operators rely on the driver and the public to keep them updated on service issues; for example, seat damage or graffiti. This helps alert operators to major issues and disruptions, resulting in a clearer picture of how their network is operating. The current reporting system within Melbourne was observed to be difficult to use, encouraged negative user responses and provided no incentive or encouragement to use. Redesigning the reporting system so it was easier and more encouraging to complete, as well as having the information distributed and prioritised to support service provision, could be beneficial. This will help to build a more detailed picture of the bus network, gaining insider knowledge on both service and vehicle problems.

Safety and Friend Modes

Safety Mode deals with the perception of being unsafe while in transit, identified during the literature review, observations and travel diary studies. This provides users with the opportunity to have their location tracked by loved ones, as well as having quick access to calling the police, the bus driver, or family and friends. Safety Mode is designed to give users peace of mind while they navigate the network, as well as giving their loved ones the knowledge that they have made it home safely. There are apps that provide this type of interface, for example Parachute and Life360; however, they are not incorporated within the transport app and are not focused on providing specific suburban bus-related features and not able to interface with the system. This provided the opportunity to incorporate safety features within a mobility app.

Similar to Safety Mode, Friend Mode is a tool for people to stay connected and inform one another of their location and travel plans, providing communication and connection convenience whilst out on the network. App location tracking and sharing features have become popular in recent years, with apps such as Strava, Facebook and Google using these functions to provide additional service capabilities. PT-specific apps and if utilised could help to fill travel communication gaps among users.

5.3.2 Bus features

Bus interior

The design process also looked at improving the interior of the bus regarding control, so it matched and complemented the information presented by the app. These services were designed for use without access to a smartphone or the redesigned app. However, the opportunity was presented to provide a fully integrated system. This gives users further reassurance when pre-trip planning information corresponds with infrastructure service information. Most people, when they ask for service information, already know the answer; they just want to be reassured of it (Beul-Leusmann, Jakobs & Ziefle 2013). The bus interior redesign builds upon these points. The following section goes into detail regarding the different features of the design concepts, discussing the problem in relation to the design solutions.

Map signage

It was identified during the experiment stage that users were often unsure of their location while on the bus and concerned that they would miss their stop. This issue was found to be caused by confusing and difficult-to-predict routes, lack of information present within the bus, as well as wet or night-time conditions causing the stop to be difficult to identify. To prevent this, users were observed using Google Maps as a tool to conduct active wayfinding, helping them to identify where they were within the system. This particular travel behaviour inspired the concept of on-board signage featuring a map of the network indicating the bus's movement. The map is displayed at the front of the bus on a large screen that is slightly transparent, allowing users to see the road ahead while preventing nausea from motion sickness; see Figure 5.5.

This type of wayfinding information is currently present within smartphones, which suggests that having additional screens on board may be redundant and add cost. This project was interested in discovering if this is the case, with future user testing tasked with discovering the sign's value to the user. Currently some hypothesised positives of such a screen include: improved wayfinding options for non-users of smartphones; being able to undertake alternative tasks during transit; and user reassurance. The following will discuss these points in greater detail.

Figure 5.5 Map signage

Exterior signage

Exterior signs on buses were found to be inconvenient due to their placement and minimal information provision, only including route name and number. This is the basic level of information required to find a service. However, this presented an opportunity to add greater information provision while improving user flow. The design response is similar to the exterior signage proposed in EBSF 2 (UITP 2018). The features include large, dynamic screens across the length of the vehicle that provide detailed bus number and route information, journey timelines and points of accessibility. As a differentiation, this project's concepts focus on vehicle and app integration, as well as providing information that is suitable for confusing suburban environments, as compared to higher density environments as with the EBSF 2; see Figures 5.6 and 5.7.

Figure 5.6: exterior signage

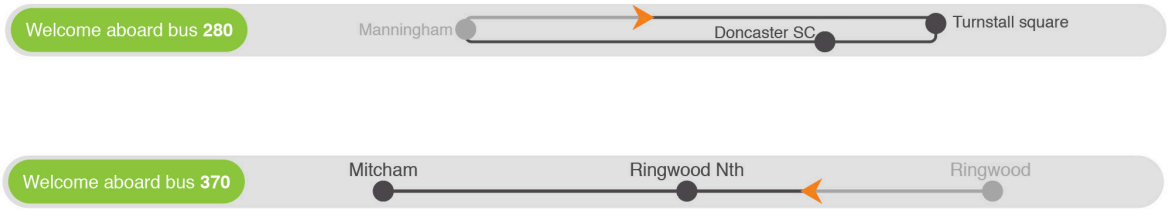
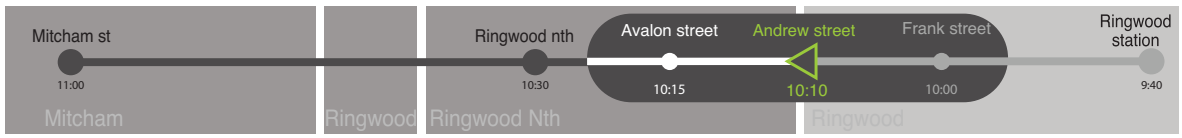


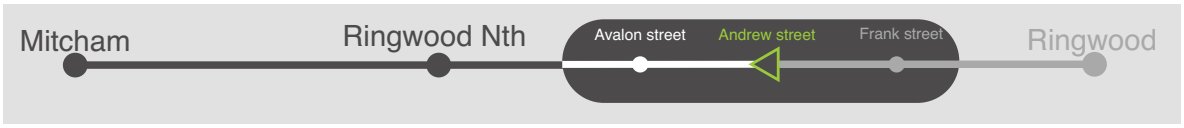
Figure 5.7: exterior signage

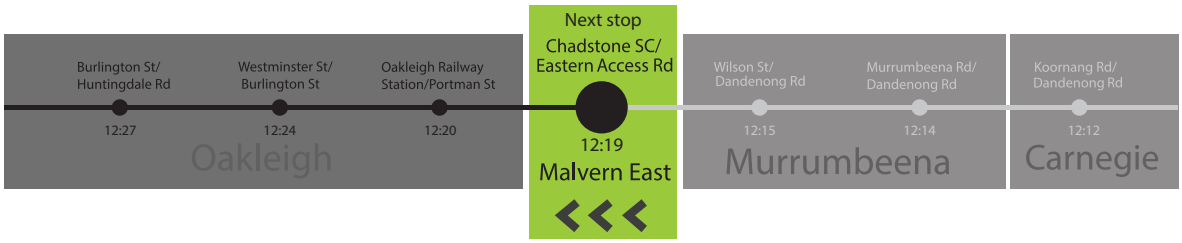
Interior passenger information displays

Current interior PIDs only show the bare minimum of next stop location within the Melbourne context. Although other global locations provide greater information within their PIDs – as identified in the Literature Review – there was still an opportunity to assess what information Melbourne suburban users require to improve their bus wayfinding experience. Interior PIDs were designed in response; see Figures 5.8 and 5.9.

Figure 5.8: Interior passenger information displays







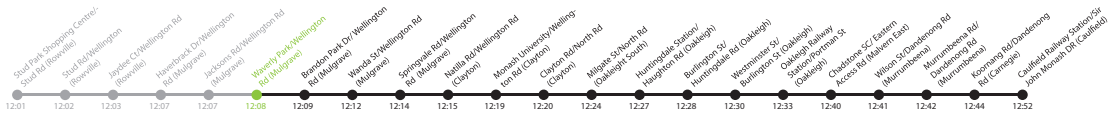


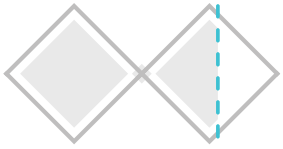
Figure 5.9: Additional interior passenger information displays

5.4 Summary

It was hypothesised that the problems associated with control can be improved through design practice and leveraging of digital information platforms, resulting in better bus user experience. To examine this, a design process was undertaken to synthesise the research and produce designs that respond to control problems. This process resulted in the development of digital, vehicle and app integrations. These designs intertwine and are present throughout the whole journey process, working to fill information gaps and respond to service failures. At this stage, it was assumed that these designs add control and ease of use to the bus environment, as they responded to the problems found during the study stage. However, to provide concept validation, as well as user-centred feedback for refinement, usability testing was necessary. As this project explores services, app and vehicle development, a scenario-based testing system was utilised to provide context and integration between the product and service, as well as to understand the service improvement. This is discussed in the next chapter.


htc
VIVE
Park & Ride

Chapter 6
Usability testing, refinement and design outcomes



This chapter documents the usability-testing approach and results, acting as a source of formative critique, encouraging refinement and validation of the concepts. The ideas and designs developed within the last chapter began to address the design research questions and problems surrounding the lack of control that users felt on buses and services. At this stage, it became necessary to critique the work's functionality and success in addressing the initial research and design questions, and its suitability with addressing issues associated with a lack of control within the bus network. The exploration of experiences, apps, vehicles and dynamic screens encouraged scenario-based usability testing to take place. Scenario testing has explored current and alternative bus-catching scenarios, including system failures, as well as new and current system designs. The testing was designed to understand how bus users engage with both regular and adverse bus environments, discovering whether the incorporation of the new designs helped to ease travel experience while providing added control. VR provided a platform for testing these complex environments from within, allowing multiple assets, scenes and experiences to be explored. Additionally, this style of testing has allowed the suitability of the new concepts to be assessed and for user behaviour to be further understood, as well as different ways to understand bus user interactions to be developed.

This chapter begins with an overview of the usability-testing context, which includes a review of testing methods within the public transport field and why VR was chosen as the main method of testing. The testing objectives will then be discussed, followed by detailing of the method, participant recruitment, testing structure, data analysis, benefits and limitations of this user testing. Finally, the refinement and discussion sections will detail the findings, highlighting the suitability of the design and the refinement that has been undertaken.

6.1 Usability-testing context

Usability testing is a useful tool for assessing the value of a product by measuring the satisfaction, suitability and efficiency of the new design (Sonderegger & Sauer 2010). This occurs via the interaction of product and service prototypes with both real-world users and potential users. The testing focuses on conducting scenarios that showcase how participants interact with the product and or service, highlighting faults and experiences as well as producing further behaviour knowledge. Usability testing is a valuable and necessary part of the UCD process. Formative-based iterative testing is preferred for user-centred development as it can be conducted at any point within the design process (Falcão & Soares 2013; Hannington & Martin 2012; Jerald 2016). It provides concept validation and the continuation of the design process with the incorporation of user participation and feedback (Falcão & Soares 2013; Hannington 2012), allowing user insights to be included at earlier stages of the design process. The researcher's role during the testing process is to: observe the participants, as opposed to suggesting solutions (Jerald 2016); make sure the participants stay on task; and keep track of performances, thoughts and attitudes (Gould & Lewis 1985).

The usability-testing process incorporates participant feedback through a think-out-loud approach (Hartson & Pyla 2012 cited in Jerald 2016). This approach encourages participants to express their opinions by engaging with design and service outputs, and offering critique, new ideas and redesign discussions. Design and scenario tasks help to drive feedback, providing an engaging platform for users to assess speculative designs and turn "abstract theories into tangible entities" (Cooper & Evans 2006, p. 71). To minimise bias, the participants' feedback is discussed post-activity as a reflection, to limit distractions during testing. Different methods in which to undertake the usability testing were considered to help identify the right method for the task. The suitable methods required the ability to test both products and services in unison, as well as digital interfaces and altering environments. The size of the bus vehicle - 9m - as well as the need for users to interact with the pre and post boarding environment was considered a possible restriction due to space and cost.

Prototyping tools as a means for undertaking usability testing were considered in two categories. Firstly, conventional tools, including physical realisation of the product using wood, paper and cardboard. Secondly virtual tools, including digital realisations, using CAD, virtual or augmented reality (Exner et al. 2014). Within the context of Melbourne public transport, usability testing is generally undertaken to inform the design, gain stakeholder acceptance and for project publicity. Testing is often undertaken using high fidelity prototyping towards the end of the development process (Jehan 2018). The novel high capacity metro train is an example of this methodology, which incorporated a prototype with structurally sound walls, seating, stanchions, moving displays, and finished material and trim to demonstrate the design to stakeholders and potential users (DEDJTR 2018).

Conventional prototyping methods, based on material choice and attention to detail, allow the creation of low to high fidelity mock ups. Advantages of physical prototyping allow the user to experience the designs and various features within 1:1 scale (Exner et al. 2014). Low fidelity models allow for quick and easy prototyping means (Bähr & Möller 2016), encouraging users to critique designs as they are noticeably unfinished (Snyder 2003 cited in Bähr & Möller 2016). Lastly, no expertise is required to undertake usability testing. Limitations regarding physical prototyping, based on fidelity level, can be considered rather costly due to complexity and time-consuming nature (Grieb 2010 cited in Exner et al. 2014) and can be considered "unfavourable for the aim of reducing development effort" (Exner et al. 2014, p. 70). Additionally, physical prototypes are more difficult, and costly to alter during the early stages of the product design process, where the design is rapidly evolving (ibid.). This can be considered a particular limitation for bus vehicle designs, which are large in size.

The following are examples of physical prototyping and testing used within the public transport field to gain user insights and design validation. Firstly, the 2019 Flinders street railway station

passenger information display redesign project. The signage concepts went through a rigorous user testing process, where a large space was converted into a train station layout, with various printed graphics and props to increase the environment's believability. TV screens were mounted to show changing information and participants were asked to undertake various activities. The benefits of the low- moderate fidelity allowed the testing team to update designs and change the environment depending on user critiques, whilst allowing a level of believability (Gaitan 2017). The project benefitted from having the budget to work within a large space and afford the props and participants. The PT wayfinding app described in Samsel et al. (2014), is an example of how a medium fidelity app prototype demonstrating wayfinding capabilities and digital interfaces can undergo successful usability testing. The prototype included a functioning app, displayed on a mobile device. The testing consisted of 3 activities, where participants were asked to gain information about various modes and make different trips on public transport. Lab and field test were conducted, with the field test requiring participants to navigate various transport systems. A think out loud approach was taken, as well as post testing interviews and surveys, to help solidify responses (Samsel et al. 2014). This testing allowed researchers to determine the success of the app within context.

Digital prototyping methods such as VR enable human engagement with virtual alternative environments. This provides a communication tool to conduct scenario-based testing within a realistic and controllable 1:1 scale environment (Caputo et al. 2017; Jerald 2016; Wallergård et al. 2008). This allows ethnography-based observations to provide insight into design usability, as well as deeper insight into user needs and expectations. When compared to physical prototyping, VR testing is said to reduce cost and time during the design development process (Caputo et al. 2017). VR is discussed by Peruzzini et al. (2016) as being a method that could be potentially suitable for developing "prototypes to support the integral development of both products and services... with the final aim to verify the [product and service system] behaviour and customer satisfaction'. This is due to the generation of realistic and immersive environments, allowing customer feedback to be undertaken in context (Rentzos et al. 2014), as well within alternative scenarios (Wallergård et al. 2008).

VR is becoming a popular means of analysing designs and conducting usability testing, particularly in the mobility field, allowing large-scale products to be quickly prototyped and tested. MAN Truck & Bus (2018) is an example of this evolution, where Cave Automatic Virtual Environments (CAVE) are used to design, iterate and test 1:1 scale vehicles, helping to reduce development time and eliminate 50% of design deviations prior to the first physical prototype. Although this production is less focused on user testing and more on engineering capabilities, other mobility companies such as Volvo (2019) use VR to test designs early in the design process to enhance the user experience. It must be noted that VR is still considered a new technology and does experience shortcomings, which are found within technology restrictions and participant biases which will be discussed in detail below.

Due to the novelty of VR usability testing and the risks associated with new technologies, many biases and limitations exist that traditional testing is not concerned with. These risks and biases must be considered if successful trials are to be conducted, with common biases listed below.

The lack of sensory attributes experienced when using VR headsets – this affects physical touch, causing indirect manipulation of the digital product to take place and making design evaluations such as ergonomics and tactile functions difficult to assess (Kuutti at el. 2001; Ran & Wang 2011). Mixed reality (Ran & Wang 2011) can bridge this gap between haptic feedback and the VR world, but was not required for this project as it was not dealing with touch or comfort attributes.

The lack of interaction between the participant and the facilitator, and the lack of control the facilitator has over the testing situation (Kuutti at el. 2001) – this is caused by the VR headset stopping interactions and communication between parties. As a way to prevent this, no audio (apart from a

notification alert) was present during the testing, allowing the researcher and participant to speak freely and the think-out-loud approach to be properly utilised.

Retesting bias – this occurs when data is collected multiple times from the same participant; for example, having each participant undergo multiple scenarios but in the same order. This particularly affects the first activity, as the participants are not used to the controls and the new technology. This effect is reduced over time; however, it still influences the initial responses (Jerald 2016). To reduce this bias, a primer activity was undertaken, allowing participants to become competent with the VR technology before they took part in any further activities. This bias could also affect the A and B testing style of the scenarios, which was something to take into consideration during the analysis stages.

Motion sickness and latency bias – if participants drop out due to motion sickness, this creates an attrition bias, where the characteristics of the participants become similar (Jerald 2016). This is particularly an issue here as motion sickness affects bus users, which might prevent a particular user group from being assessed. Latency and possible motion sickness only affected one scenario and if participants felt ill, they were able to move from VR to the desktop computer version.

Critical issues – due to the nature of digital technology, critical issues such as program crashes, errors, user confusion and discomfort can influence the outcome of testing. This could affect the overall design, usability and usefulness of the test. Being able to know when these problems occur and fixing them quickly are necessary for a successful study (Jerald 2016).

New technologies can influence participants' overall perception of a design based on inherent opinions such as high positivity and enthusiasm or confusion and negativity. To minimise this, participants were initially introduced to a primer activity. Participants were also asked to perform activities or explain how particular designs functioned. These approaches help to separate feelings about the designs from feelings and pre-existing perceptions concerning the testing medium.

VR scenarios are difficult to evaluate, with user and usability biases caused by technology familiarity. Due to technology capabilities and participant opinion, results may be highly variable amongst individuals, with larger sample sizes necessary to provide performance clarity. When unfamiliar users enter an environment, they are not just testing the design but also the equipment. Familiarising users with the tasks and encouraging exploration as opposed to only assessing singular tasks can help with this (Martens 2016).

The majority of these issues should disappear with the maturing of the technology, but at this early stage it is important to mitigate them where possible and to be aware of them during the analysis stage. Despite these biases and limitations, VR was still considered worth pursuing to determine if it is a suitable tool for bus vehicle design. It should be noted that the tests are catalyst of conversation. This helped to mitigate the associated biases, as the testing was designed to elicit concept discussion, rather than designed exclusively for determining the product functionality. If design usability by technologically impaired demographics such as the elderly is required, alternative methodology needs to be developed to help increase usability. Future testing in general needs to consider inherent biases and methods for achieving designed outcomes.

The foundation of the usability testing in this research project was framed to effectively evaluate the design of a vehicle, service and app all within the same setting, as each of the designs were interrelated and synchronised. The testing also evaluated the interactions and experiences, highlighting successes, faults and inconsistencies. Furthermore, to deliver a successful testing environment, it was necessary to create a scenario that placed the participants in the correct setting and emotional context. This

allowed the participants to properly experience the product, resulting in more informed responses and encouraging real-world comparisons (Cooper & Evans 2006; Jerald 2016; Lindley, Sharma, & Potts, 2014). This helped to determine if the problems surrounding control were being addressed. To develop an environment that encouraged feedback, low-fidelity products and environments were sought. This environment allowed clarity and understanding of the scenario while providing an engaging and playful aesthetic, encouraging creativity and critical thinking. These environments encourage the continuation of the design process and iteration, as opposed to the finalisation which high-resolution prototyping portrays. Despite the limitations associated with VR, the tool was chosen over physical construction means as it required less space, time and cost to implement, all which were limited resources. Additionally, literature reviewed discussing product service system validation methods, expressed the importance of representing "both the product and the service elements accurately and realistically" (Exner et al. 2014). It was considered important to develop a test that incorporated the product, service and digital elements in unison as it allowed users to comprehend the whole system simultaneously. This allowed the researcher to determine where participants were accessing information and its value during different trip stages and scenarios. Being able to control the testing environments was also considered important, as the information was meant to add control to uncertain and problematic situations.

New technologies provide the potential to assess and redevelop how research is conducted (Pink et al. 2016, p. 3). In the project presented here, VR was used to test a complex environment including multiple assets and different scenarios within the same space. This research subscribes to Lupton's (2014 cited in Pink et al. 2016, p. 5) four types of digital sociology practices, with the VR usability-testing process engaging, in some aspect, all four approaches. First, "new forms of professional practice where sociologists use digital tools to network and build conversations". The digital products, as well as the VR means of conducting research, were used as a way to discuss the bus environment and further build upon these ideas. Second, "researching how people are using digital media, technology and tools" relates to how people currently interact with the digital products being designed. Third, "using digital tools for analysis". This relates to VR being used as an analysis tool for product design. Last, "engaging in critical analysis of the use and consequences of digital media".

A limitation of PT vehicle design found during the literature review was the lack of communication manufacturers and users have during vehicle development processes. User testing, if included, is often undertaken towards the end of the design process, once a high-fidelity prototype has been established (Jehan 2018). Contrarily low fidelity testing during early design stages offer different opportunities, where user opinion can be observed and responded to repeatedly without the need for great investment in time or money (Rudd, Ken & Scott 1996). As VR is becoming more popular within this space, to help evaluate engineering requirements at earlier stages of design, VR could also be considered a tool for helping to promote user centred design and user testing at earlier stages of the design process. This project acknowledges that VR has limitations and is not suitable for all usability testing and that some of this projects' requirement could be tested through physical mock-ups. VR however presented an opportunity to show how usability can be achieved through this method within this context, with relatively low cost, time and space.

6.2 Objective

The objective of this testing stage was to understand the newly designed vehicle, service and app in relation to the user experience. This testing evaluated the usability and suitability of adding control to the bus journey from an outer suburban viewpoint. This test dealt with a range of tasks including: informing and reassuring users of bus arrivals; bus travel and directions; mode integrations and transfers; as well as test the outcome of the design hypothesis described in Chapter 4, Section 4.4.4. To achieve this, a clear systematic approach to testing through VR was developed and suitable participants recruited.

6.3 Method

The method of testing involved the development of an interactive digital environment which was accessed via a VR headset and controllers. Participants were required to complete a number of tasks within the virtual world, all of which were recorded via audio and screen capture. This method allowed participants to engage with new and existing bus designs through multiple scenarios and activities. Questions were designed to prompt participants to discuss product insights.

6.3.1 Virtual environment

The concepts and activities within the virtual environment needed to be carefully developed and executed to ensure that the right visuals and information were being translated. The environment and activities were created in the program Unity, a game-development software. The development of the virtual world and importation of previous designs – for example, maps, vehicles, apps and screens – acted as part of the iterative design process, helping to further develop the service and product interactions holistically. Assets such as buildings and people were imported from Unity's Asset Store to help provide a more immersive environment (Polyperfect & Padfield 2018; Polygon Land 2018). The SteamVR plugin (Valve corporation 2015) was also used to allow VR functionality and player movement. The testing environment consisted of a 360°, 1:1 scale, low-resolution, low-polygon, highly saturated cartoon aesthetic; see Figure 6.4. This aesthetic helped elicit creativity and critique through a playful manner and prevented latency and lag within the technology. Only app notification audio was used, to facilitate communication between researcher and participant. Participants were required to remain seated during testing to prevent injury. A swivel chair was provided to allow participants 360° access to the virtual world. Movement within the VR world was undertaken via a teleportation function controlled by the participants' handheld controllers; see Figure 6.1. The teleportation feature allowed participants to easily jump around the virtual environment, this was achieved by participants using the controllers to point and click to the area they wished to teleport to. The function was used as it allowed easy environment movement, prevented participants from physically needing to walk and reduced motion sickness by removing visual motion. The teleportation function was introduced during the primer activity training process, where participants were able to learn and become confident with the controls, with few issues occurring during actual testing.

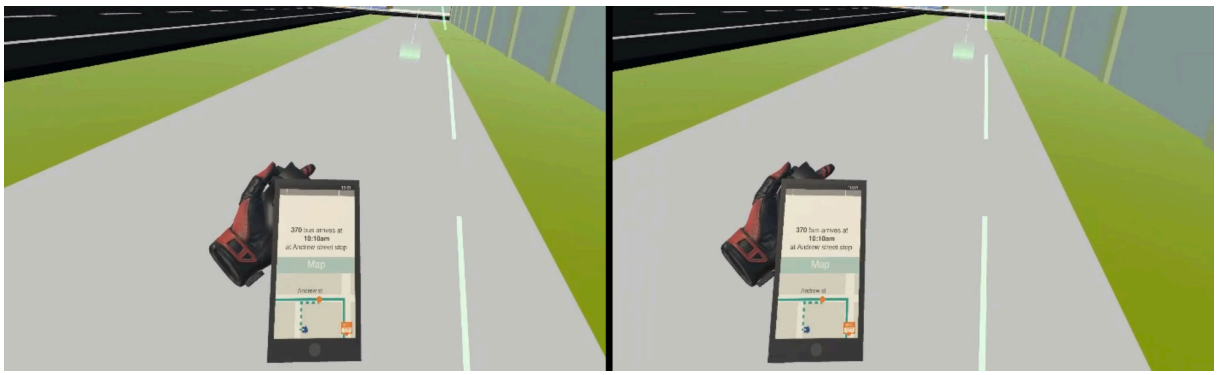


Figure 6.1: Activity 2, walking to the bus stop in VR, showing the walking mechanic

6.4 Pilot study

Once the test was suitably developed, it was piloted by six participants. The initial four pilots took place on the desktop version with no VR capabilities, determining the clarity of the activities without the distraction of the headset and VR controllers. This was to ensure that the activities were framed in a way as to elicit useful feedback. The remaining pilots used the VR headsets with a focus on understanding if similar feedback would be received; to clearly understand how participants interacted with the headsets and environments; if time was being correctly allocated; and if the recording approach was suitable.

The pilot test was considered successful, as all participants were able to understand and complete each activity while providing clear commentary and opinions. Useful feedback regarding the testing environment resulted in the introduction of an audio notification alert prompting participants to look at their phone. The second activity was lengthened, giving more time for participants to navigate the scene without it being too rushed. The second activity was also divided into two, giving more time for discussion and an activity restart point if any technology failures occurred. Participants were suggested to be seated during activities as a way to ground them. It was also suggested that the facilitator speak from a single location to centre headset-wearing participants. All of the above points were integrated into the primary test, helping to provide a more robust testing program.

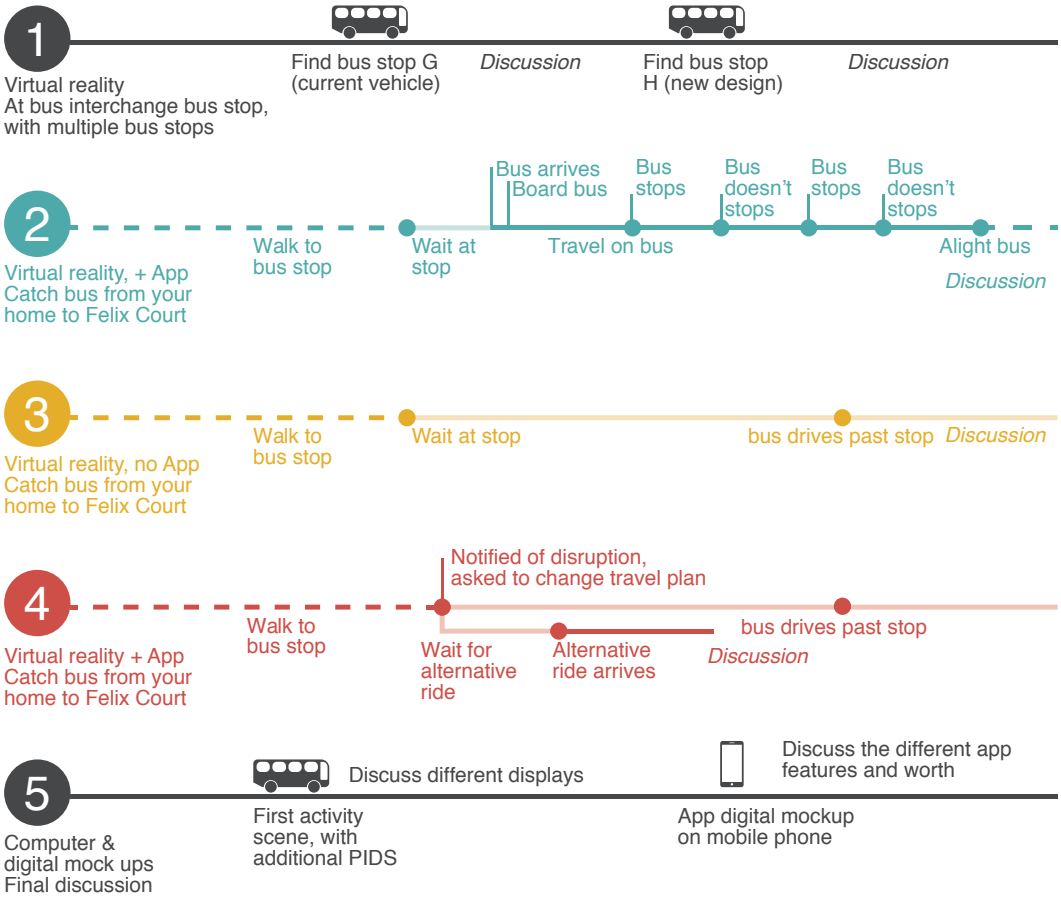
6.5 Recruitment

Similar to the previous user-centric studies, participants were recruited through the Mobility Design Lab participant pool or via word of mouth, with Monash University ethical approval of 9513. Recruitment was sought for both familiar and unfamiliar bus users, as well as industry experts and the general public. This allowed a range of expertise and opinions to be assessed and for the testing to capture industry requirements as well as target audience opinions. See Appendix I for study explanatory statement and consent forms.

13 participants agreed to take part in the study, with attributes broken down as follows; 38% women – this is not ideal but was not shown to be problematic during analysis, as gender did not appear to play a role in the disclosure of particular themes. 46% of participants were industry based, including one former bus driver. There was a 23–53 years age range, with an average age of 33. Testing was aimed at a younger, more technologically savvy, multimodal audience, as that is the focus for this research. 46% of participants were considered regular PT users. Low participant numbers for this testing was appropriate as the literature identifies that only five target audience participants are required for 80% of usability problems to be detected, with additional subjects found to repeat information (Virzi 1992).

6.6 Testing structure

The testing consisted of individual or paired sessions comprised of a single facilitator and participant or dual participants. Each session was allotted 1.5 hours, with 30–50 minutes of headset use.
It was an initial concern that participants would become visually and physically fatigued due to long headset use; this was not the case. Each session consisted of five different activities, each taking 10–15 minutes to complete. A think-out-loud approach (Jerald 2016) was applied, where the participants were encouraged to describe their thought processes. Audio and screenshots were captured for later data analysis. Figure 6.2 gives a breakdown of the VR testing structure, while Figure 6.3 shows the testing environment and Figure 6.4 shows the virtual usability-testing environment.



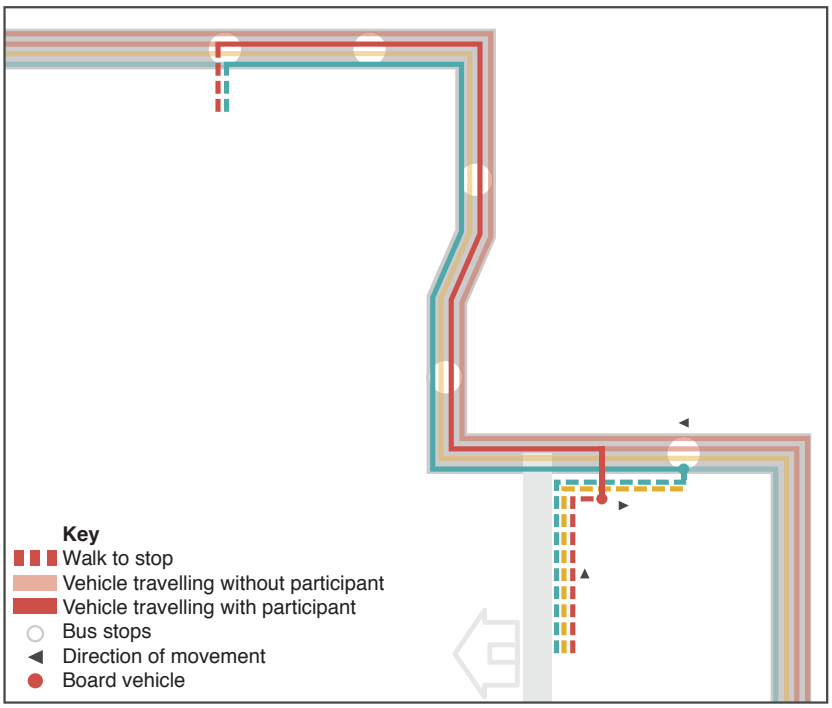


Figure 6.2: VR activity breakdown

Figure 6.3: Testing environment

Figure 6.4: Virtual usability-testing environment

First the participants were introduced to the project, the tasks they would need to complete and the equipment, with an emphasis on the process and the risks involved with using VR. The first activity, seen in Figure 6.5, was designed to act as a primer for participants, encouraging them to move around a bus stop complex to help them to become comfortable with the VR headset and the controls. As the majority of participants were first-time VR users, it was important to reduce the novelty bias of the technology and visuals, to improve their virtual coordination and sensory inputs, and to make sure their vision was clear. The secondary aim of the activity was getting participants to navigate a busy bus stop complex which included current and new bus designs and different signage, asking them to board the bus to Doncaster Shopping Centre. This required participants to move around the environment, highlighting what types of information they found most helpful and where they expected it to be located, showcasing wayfinding routines. The participants were then asked to describe as much service information as possible from buses G and J, being examples of the current and newly designed buses with different levels of information. They were then asked to compare the two designs and describe what information they would want to see regarding the topic of control.

Figure 6.5: Activity 2, bus stop layout

Once participants were competent with using the controls, the second activity began, placing participants in a suburban environment and asking them to catch a bus to Felix Court with the assistance of a newly designed app. Participants were tasked with navigating their way to the bus stop using the MaaS-based app and board the 370 bus to Felix Court. The goal of this activity was to encourage participant engagement with the process of catching the bus using the new app, vehicle and wayfinding inclusions. This task focused on the ability of participants to easily complete the journey while asking questions about which screens offered the most desired information, helping to narrow down the positives and negatives of the new design. Imagery from the second activity is shown in Figure 6.6.

Figure 6.6: Activity 2, Catching the bus in VR

Activity three repeated the second activity, placing the participants in the same environment with the same task, indicating that they had taken this journey previously. The key difference was that participants did not have access to an app and needed to rely on past experience. Participants were asked questions concerning confidence, if the service would turn up on time and if they would normally take a trip under these circumstances. The bus took longer to arrive and then eventually drove past the participants, which was designed to elicit an emotional reaction. This particular scenario was based heavily on the customer feedback data and the issues surrounding buses. The participants were asked how they felt and what they would generally do in a situation like this, with the majority expressing that they have experienced this in the past.

Activity four repeated the same scenario; however, this time it included the app. One minute into the journey, the app informed participants that the bus would be running 17 minutes late, encouraging the participants to change their travel plans while giving them information about other services. Questions were asked regarding the quality of the information provision, if control was added and other information they would require in such a situation.

For the final activity, the participants did not need to wear the headset and instead used the desktop version of the virtual environment and a mobile phone, seen in Figure 6.7. This activity acted as an opportunity to discuss any comments raised by the usability testing, as well as discussing each of the screens and wayfinding information in relation to how the participants interpreted them and their overall usefulness. Due to time and programming limitations, only the Journey Planning feature was tested within VR, with the additional app features viewed and discussed via a digital mockup during this final activity stage. The mockup used InVision, seen in Figure 6.8, to simulate the apps and allowed participants to view each screen and discuss in more detail their opinions and how it would relate to their travel experiences. Although this did not test app functionality, it provided insight into concepts' suitability. This final activity acted as the participant feedback section of the study, encouraging iteration, creativity and new design ideas.

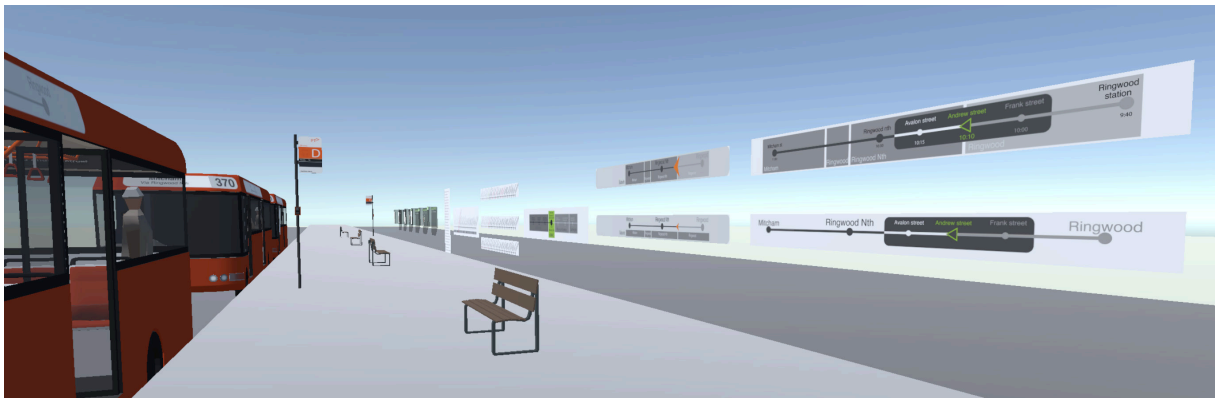


Figure 6.7: Activity 5, Discussion and participant feedback section

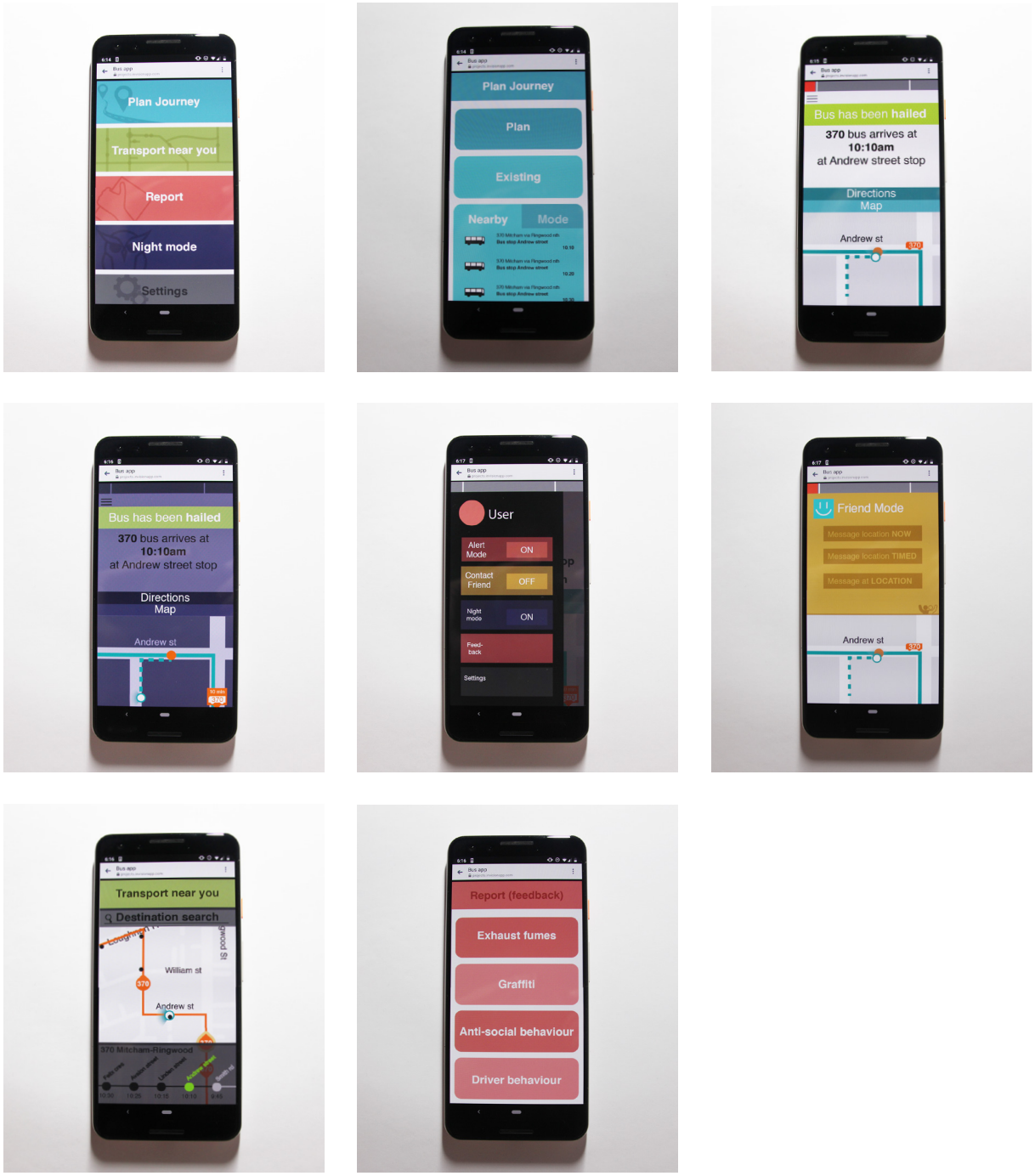


Figure 6.8: Activity 5, Example of app mock up used during testing

6.7 Data management

Each participant was given a number in order to keep their identity and testing data anonymous. Following each usability test, the audio and digital screen captures were uploaded to a secure folder.

6.7.1 Data analysis

All the usability-testing audio was fully transcribed and then analysed using Nvivo, by applying the same process as mentioned previously. This required line-by-line analysis into synthesised nodes, highlighting ease of use, positive and negative design attributes, new ideas and real-world examples. Emergent themes were revealed, resulting in a qualitative dataset suggesting key refinement points for each of the designs. Overall, the usability testing provided rich information about the strengths and weaknesses of the designs and how the refinement process should proceed.

6.8 Results

The usability-testing results are presented in relation to each design and the verbal and observed findings. This section acts as a brief overview of the testing findings, highlighting the usability and success of the design and the main pieces of feedback given. These results helped to improve the designs during the refinement stage.

6.8.1 The app

All app functions, apart from the Journey Planner, were reviewed during the final activity using the digital mockup tool as opposed to the VR. The Journey Planning tool was, however, reviewed using both methods.

Reporting

> *People who use public transport regularly tend to notice things more than the bus driver. With suggestions you would start to see trends… These can be used for future planning (Participant 6, activity 5, app discussion).*

The integration of an easy-to-use feedback system into the app was met with mixed reviews. Industry participants responded positively, as they recognised the benefits from an operations perspective. This would allow a greater level of visibility to be present when buses are out in service, helping to improve KPIs and discover route, vehicle and operation faults more quickly, as well as failures trending within the system. This could also improve data-sharing communications between operators and contractors.

> *The operators might have the data, but we don't get to see it. It's not very transparent, the relationships (Participant 4, activity 5, feedback feature discussion)*

The main usability concerns centred around participants not believing that they would use such a service, as well as participants identifying the users' ability to abuse the system, with nothing currently set into place to deter abuse or negative user behaviour. These concerns are well placed, with digital channels being places for potential user backlash and negative opinions. To help limit this type of response and develop a useful digital channel the incorporation and understanding of user motives and emotions to provide engagement and value to the service users is required (Wrigley & Straker 2018). Additionally, it was also noted that some participants desired the inclusion of multimedia upload features when giving service feedback.

> *I feel like that is going to be abused because you can sit on a bus and make complaints. it is very anonymous. I don't know… I feel that you would have to have some verification of it otherwise people will take advantage of it (Participant 1, activity 2, safety feature discussion).*

> *Well, it seems useful, but I'm just thinking because… I think there are many people who are unfair to drivers (Participant 8, activity 5, feedback feature discussion).*

> *Be also good if you could upload photos or other media, like someone fighting, one click and it's uploaded (Participant 4, activity 5, feedback feature discussion).*

Night Mode

Night Mode, also known as Safety Mode, was met positively once understood. It was suggested as a way to relieve some of the anxiety regarding negative safety perceptions while travelling on buses, particularly in suburban environments. Confusion arose surrounding the app's functionality and naming semantics, with clarity being a main area of redesign. The main pieces of feedback challenged the core functionality, expressing that the function should permanently be active and used during the whole journey. Additionally, this function should not be limited to safety, but could address the

challenge of timed pickup and general journey visibility, or include a parent mode to track children's movement when they are out in the network.

> *I guess some of those features aren't safety features. It was never a safety issue why I was picking up my wife, she could probably walk back from the station. So is there a way to get those features without going into Safety Mode (Participant 1, activity 5, safety feature discussion)?*

> *There are those creepy areas that during the day look perfectly safe. Like parks usually. Or it's night. It's dark. And it's really, you know, you don't know who you can meet in between. And I have to walk for 20 minutes. And it's really uncomfortable (Participant 8, activity 5, safety feature discussion).*

Transport Near You and Journey Planning

Transport Near You and the Journey Planning tool are not new developments, indicating that the participants had previous knowledge of using similar apps during previous journeys. Having a Transport Near You option was positively received, as it gave the participants different navigation tools. However, this must be performed with clarity, providing important information in a simplistic manner and at the appropriate time.

> *There are times that you think, how do I get to XYZ from here? Also having a location e.g. train, click on it and it tells you the services to catch... That would be very useful (Participant 6, activity 5, Transport near you feature discussion).*

It was no surprise that all participants felt more comfortable and confident with navigating the system and waiting at a bus stop if they had access to real-time bus arrival information. Likewise, the inclusion of MaaS and other travel options was viewed positively – particularly during service disruptions – providing participants with more control over their experience. Table 6.1 summarises the features tested and the feedback received.

Table 6.1: Transport Near You and Journey Planning

Component	Suitability	Design suggestions
Being told to leave the house as opposed to timetabling	Positive Changes travel plan and time arrived at the bus stop. Prevents long bus stop wait times.	
Journey progress bar	Mixed results The information is already provided on the app.	Needs to be more informative of what the sections relate to, walking, bus, etc. On-board, bus stop and app graphic and information integration to reassure users they are in the correct location.

Component	Suitability	Design suggestions
Real-time navigation for bus and user	Positive Kept users informed and helped with navigation. Issues: The information on the map needs to be clear and simple.	Including other services and transfers Knowing which side of the road the bus is on Having live tracking
App alerting you and bus driver of departure point	Positive Do not need to actively wayfind.	Being able to save favourite trips. Making the app personalised so the trips reflect the type of travel you undertake – with bike, safety concerned etc.
Hailing bus electronically	Positive Allowed users to not be actively waiting for the bus. Reassurance that users are catching the correct bus. Helps drivers notice user, preventing users from being left at the stop. Issues: Ordering the service pre-emptively. Changing mind and not catching the bus.	Also include cancel hailing option and manual bus stop hailing button.
MaaS – informing participants of delayed services and giving the option of changing travel plan	Positive Participants liked having alternative options visible, feeling more in control and informed, even if they kept the same travel plan. Allowed faster and more informed decisions to be made. Travel plan change was dependent on time, cost and point of journey. It gave visibility to modes participants did not consider.	Alternative bus routes and PT options. Give more information on the modes before they are ordered. Option of walking to the next bus stop to create productive wait time. Service late information. Only basic information such as traffic. Show traffic congestion, similar to Google Maps, as this might affect other services – Uber.

6.8.2 The vehicle

The passenger information display (PID)

A combination of different screens were used on the bus during testing in order to provide navigational information. Even with the addition of the phone, participants still wanted the inclusion of the PIDs, as they prevented the need for phone wayfinding and allowed the participants to perform other tasks, for example reading or texting. The common opinion among participants was that they wanted to be informed of the following: correct bus reassurance; direction of travel; departure times; and real-time arrivals. The majority of participants were able to understand and explain all of the signage correctly, with the components discussed in Table 6.2.

Table 6.2: The passenger information display

Component	Suitability	Design suggestions
Front map	Mixed results The majority of participants were positive as it was: good for wayfinding and spatial context (landmarks), gives information about transfers and navigation once departed on the bus. A phone was not required, but did display the same map, reassuring users of correct bus. The issues surrounding the design included: Not being able to fully see out of front window, which can cause motion sickness. Phones could be used instead of screens. Cost and feasibility are issues. Location and being able to see when bus is full.	Show deviations in route. Being able to see transfers. Transparency. Identification between major and minor stops. Having a mixture of zoomed in and out displays. Help users see where they are in the route, but also specific details, for example navigating to a train station.
Exterior screen	Positive compared to the current displays Need to match graphical style of other information being displayed. Does not need to display minor stops, only direction bus is going.	Change colour scheme.

Component	Suitability	Design suggestions
Side screens	The combination of the first and third screens is the most preferred as they include both macro and micro information. Macro allows reassurance of correct bus and direction. Micro allows information about bus stop location. Issues: Make the signage simple to understand. The amount of different screens could be overwhelming	Real time information is important. Suburb information is confusing; if used combine with major road information. Colour scheme, DSAPT compliant. Less grey. Map flow direction needs to be reassessed. Stop dots could be placed on line based on distance. Consistency with other network information is important. Countdown timer as opposed to times.

6.9 Findings discussion

The usability testing was built upon real-world bus user experiences, including journeys that were straightforward with no included problems, as well as journeys that had the perception of being uncontrolled and problematic. These journeys were designed to cause disruption and alternative planning. This allowed both service and vehicle concepts to be tested against the current system, as well as within alternative travel scenarios. This process allowed the development of information regarding four areas: concept validation, usability feedback, behaviour understanding regarding alternative scenarios, and validation of assumed knowledge. Assumed knowledge – as listed above – refers to points of redesign such as the hail feature that were not explicitly asked for by participants, but are based on insights drawn from the literature.

The designs and user behaviours were able to be observed through multiple alternative journey scenarios. This process provided a cost-effective tool for testing alternative travel environments, service failures and multiple designs across time, helping designs more readily move towards more positive and UCD outputs. Such a process, if incorporated during procurement, could allow UCD to be more readily available during earlier stages of design and manufacturing. This would help to bridge the gap between manufacturers and users identified in the Introduction. Other means of user testing such as cardboard mockups could have been used to elicit similar findings, for example using a gameboard to mimic various bus scenarios or the construction of a 1:1 scale vehicle to test passenger movement and signage usability. However, VR allowed for full immersion and exploration of controlled, to-scale scenarios as well as the application of dynamic signage, apps and bus movement. These were essential to producing a believable testing environment leading to suitable knowledge outcomes.

The results of the usability testing were viewed positively. Participants were asked if the function of being alerted to service delays and being able to change their travel plans gave them more control over their experiences, to which the majority of participants responded in the affirmative. Although this was the only specific mention of control within the study, the general participant responses were positive, with participants indicating their preference for the new designs and desire for such service integrations.

Definitely, when you are sitting there not knowing if your bus is coming at all, you have no control over that situation whatsoever and any decision you make is the wrong decision because you leave and a minute later the bus could come or you could stay there for an hour and the bus doesn't come, so you have no control. I like the update of when my bus was expected now e.g. 17 minutes. Now I could make a decision knowing what the outcome would be if I waited, and then having options is helpful as well (Participant 9, activity 4, discussion).

I feel like I can connect to where I want to go. The power to make a choice. That's far better than having, "poor me, I'm just going to have to wait here" (Participant 5, activity 4, discussion).

So I use the app that is up all the time [have phone open] so I think the map will be much better. So I don't have to be on my phone all the time (Participant 8, activity 2, during journey).

Although all participants commented on the added service value of the app, only one participant questioned and disagreed with the term added control. They stated that they already have control over the current experience, it is just difficult to locate due to the numerous apps present, which this design would help to alleviate.

It's not giving me control because that control I always had, it is just scattered through different apps, but it is helping me make the decision of what to do next faster by presenting all the information in front of me (Participant 12, activity 4, discussion).

The main emergent themes and suggested additions centred around system personalisation and succinct mode and app integration and interaction. Personalisation refers to users being able to customise the type of journey they wish to make, influencing: journey speed; journey cost; fitness capabilities; adding accessories to the journey such as prams, bikes and wheelchairs, to help users access services that respond to their individual needs; and re-identifying Safety Mode to provide broader tracking and communication capabilities.

Trip personalisation is increasing in popularity within the MaaS field, with apps such as Arevo including customisable options for cost, time and convenience, to name a few. However, the level of personalisation suggested within the user testing feedback is currently under-represented. Personalising a trip adds further complexity to the system, particularly within an app where inputs selected can be forgotten or underutilised. Providing a clear and integrated interface that is engaging and provides information when required is key to producing a successful outcome.

Additionally, information presentation was identified as being useful, with all but two participants listing the amount of signage and information presented as helpful. A comment was made by one participant discussing how information can be potentially overwhelming, as well as the general consensus that some signage (Figure 5.9, third from bottom) could be confusing.

Yeah, but you've got to be careful you don't make [signage] too busy or overwhelming (Participant 4, activity 4, discussion).

This insight is similar to Lyons' (2006) thoughts discussed during the literature where the integration of the information needs to be delivered succinctly and at necessary moments so users are informed but not overwhelmed. Despite the general acceptance of signage, it was considered necessary to reassess how information could be drip fed to passengers, to help provide better information communication.

6.9.1 Virtual reality experience

During the testing, attention was paid to how participants were interacting with the digital environment and the equipment. This was to determine whether VR biases were occurring and if results were being tainted by abnormal environments. Overall, it is believed that the VR element did not affect the results and was instead a way to explore environments and services that – if not for VR – would not have

been accessible to testing. VR provided an engaging environment that allowed participants to explore and navigate within the scenarios, highlighting the positives and negatives of the designs.

6.9.2 Initial behaviour

The primer activity, which consisted of multiple bus stops, was essential to providing an area for familiarity with the hardware and software to develop. Having participants engage with the environment through activities helped any sight, software or movement issues to be identified in an environment that was not overwhelming or time-sensitive. Likewise, participants were able to become familiar with the buses and wayfinding environments.

During the first scene following the primer activity, some participants did appear to be overly engaged within the world due to its novelty, moving about on the road as opposed to the footpath. This non-representative behaviour decreased quickly as the scene became more familiar. This type of behaviour was expected and planned for by the incorporation of the primer activity, and the lengthening of the second activity's start.

6.9.3 Environment interactions

The surprising part of the testing was that it actively reminded participants of past experiences and managed to evoke genuine emotional responses. This was shown during the third activity, in which the bus ran late and did not stop to pick the users up. Each participant showed an emotional response to this event, reacting in a similar way to what would be expected in the real world. This experience further prompted participants to discuss previous experiences and reactions they had had with buses leaving them at stops.

6.9.4 Limitations

This project acknowledges that in order for testing to beneficially influence the user-centred aspects of the iterative design process, multiple tests should be conducted throughout the project's life. Unfortunately, this project was only able to achieve one such test due to time and financial constraints. This aside, the project recommends multiple testing processes during industry product development.

Each activity was set to a pre-described scenario consisting of a linear path. This prevented participants from taking alternative routes; for example, choosing other mobility options than Uber or being able to hail and stop the bus. Participants could still say verbally that they wished to change transport modes to, for example, bike sharing. Although they would not be able to actively find and use that mode, their indication of this decision would be recorded as a trip change. Even though this information was stated at the beginning of the activities, these pre-described choices did cause some confusion and the alternative choice was discussed in full after completion. These restrictions created less freedom during testing; however, they did not appear to influence the results.

Multiple software glitches occurred, including participants moving through the bus's walls while they were both in motion. This issue was a main concern during time-sensitive moments, but participants resolved the issues quickly and continued the test to no apparent detriment. All issues were considered minor except for one, which consisted of the software freezing and resulted in a computer reboot and the need to restart the activity. Despite these problems, all testing was resumed and completed.

The usability-testing process was necessary in order to understand the suitability and limitations of the current concepts, giving further insight into travel behaviours, unforeseen problems and potential ideas and solutions. All this information was crucial for moving into the refinement stage, as it developed robust and holistic ideas, as well as validating the concepts and recommendations the project was moving towards.

6.9.5 Developing contribution to knowledge

As identified within the literature, there is a lack of evidence for how UCD methods are applied to the complex bus service context. Although user satisfaction is the central aim of bus service delivery, users' complex and often subjective needs can be difficult to understand and implement within the service. Additionally, as noted in van Hagen and Sauren's (2014) work, understanding and improving the user experience is of less priority, with the majority of resources and attention placed on delivering base-level service quality. This project's framework therefore provides evidence of a UCD process working within the bus service landscape. The process encouraged initial user-centred knowledge to be gathered and synthesised using the design iteration process, helping to transfer knowledge directly into design outcomes. VR usability testing allowed complex bus environments to be holistically tested, enabling services, environments, large vehicles and inherent service failures to be incorporated during testing. Additionally, bus operation and manufacturing are cost-constrained industries, so the utilisation of VR as opposed to physical full-scale prototyping allowed potentially financially risky innovations and scenarios to be more readily tested. This process, therefore, encourages user connections during multiple stages of the bus procurement process, an area that was originally lacking. The specific contribution to knowledge is the combined framework and evidence that UCD can be effectively applied within these highly complex industries.

6.10 Design refinement

The overall feedback received during usability testing was viewed as constructive and positive for both app and vehicle designs. The testing process provided concept validation as well as points of design refinement, improving the usability and design concept. The design refinement process was undertaken to incorporate the critical usability testing feedback into the designs, as well as responding to the more negative comments. For example: the careful implementation of signage to prevent passengers from being overwhelmed by information within the bus interior; the reimagining of the front navigational map to remove visibility restriction for the front window; and the renaming and expanding of the safety mode to incorporate communication as opposed to being purely anti-social behaviour driven. Additional features such as personalisation were incorporated into the app, developing a new section that interfaced with existing functions; for example, if a bike is integrated within the service, only modes that can store that bike will be suggested. As the transport system is already a visually noisy environment, app and PID graphics were simplified and made visually similar, helping to connect functionality. During this process, the information presented was also refined, with functions and information only presented when necessary. Additional navigational tools were implemented to provide final location information. Figure 6.9 is an example page of the refinement process, for a more detailed representation of the whole design process, see Appendix H.

The refinement process allowed the concepts to become more oriented towards a users' feeling of control through information provision, as well as providing updated interfaces and vehicle-to-app interactions. The following section presents these new concepts, displaying and discussing the features of the new app and vehicle designs and how they add control into the current bus system through the implementation of multiple small interventions.

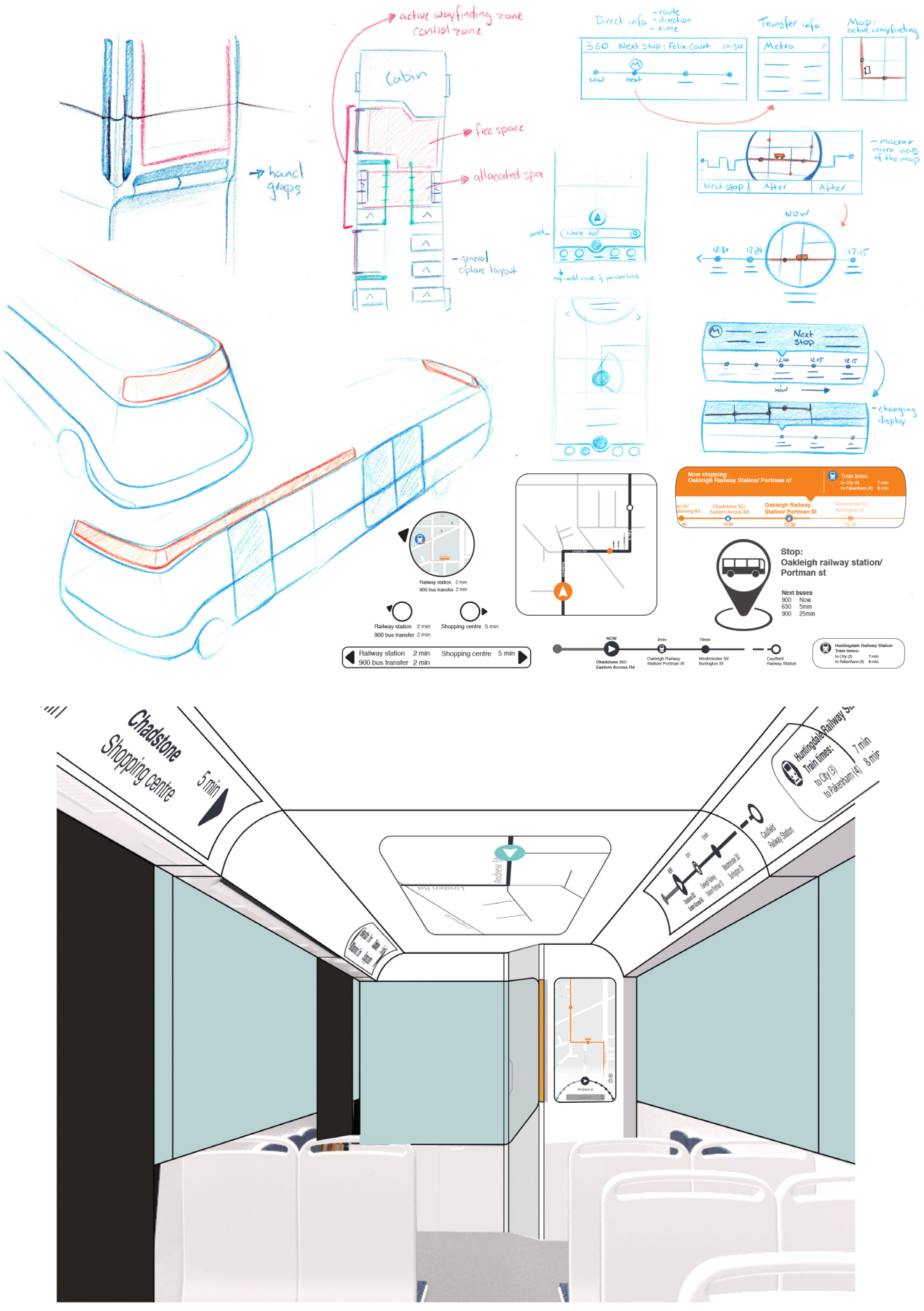


Figure 6.9: Design refinement

6.11 Outcomes

Refinement encompassing both the app and vehicle designs was undertaken based on usability-testing findings. These designs were intended to address the problems associated with the lack of control experienced when attempting to catch buses in suburban environments. Both app and vehicle were designed in unison to complement one another, creating a fully integrated and holistic bus experience. The integration between bus vehicle and app provided a unified interaction where both app and vehicle outputs influenced one another. This section will discuss the outcomes of the refinement process, detailing the designs' functionality in relation to the usability and experiment findings. All design features are summarised in the tables after each section. The tables list how the designs provided added control to the bus experience, the problem associations and knowledge informing the solutions, as well as the designs' connection with the service and user. Numbers presented in the figures correspond to sections within the tables. Figure 6.10, 6.11 and 6.12 show an overview of the vehicle designs. All digital people used within the following figures are works created or adapted from Loïc Norgeot (2018). At this stage, it should be reiterated that this project did not explore body, frame or chassis design, with the Optare Solo 9.9m body acting as a vehicle template to present the concepts. Driver cabin segregation is also present within this design as future trends are moving in this direction due to safety concerns and autonomy. This removal leaves potential information gaps, which were considered necessary to be explored.

Figure 6.10: Bus concept design featuring added control: App

Figure 6.11: Design concept featuring added control: Bus interior

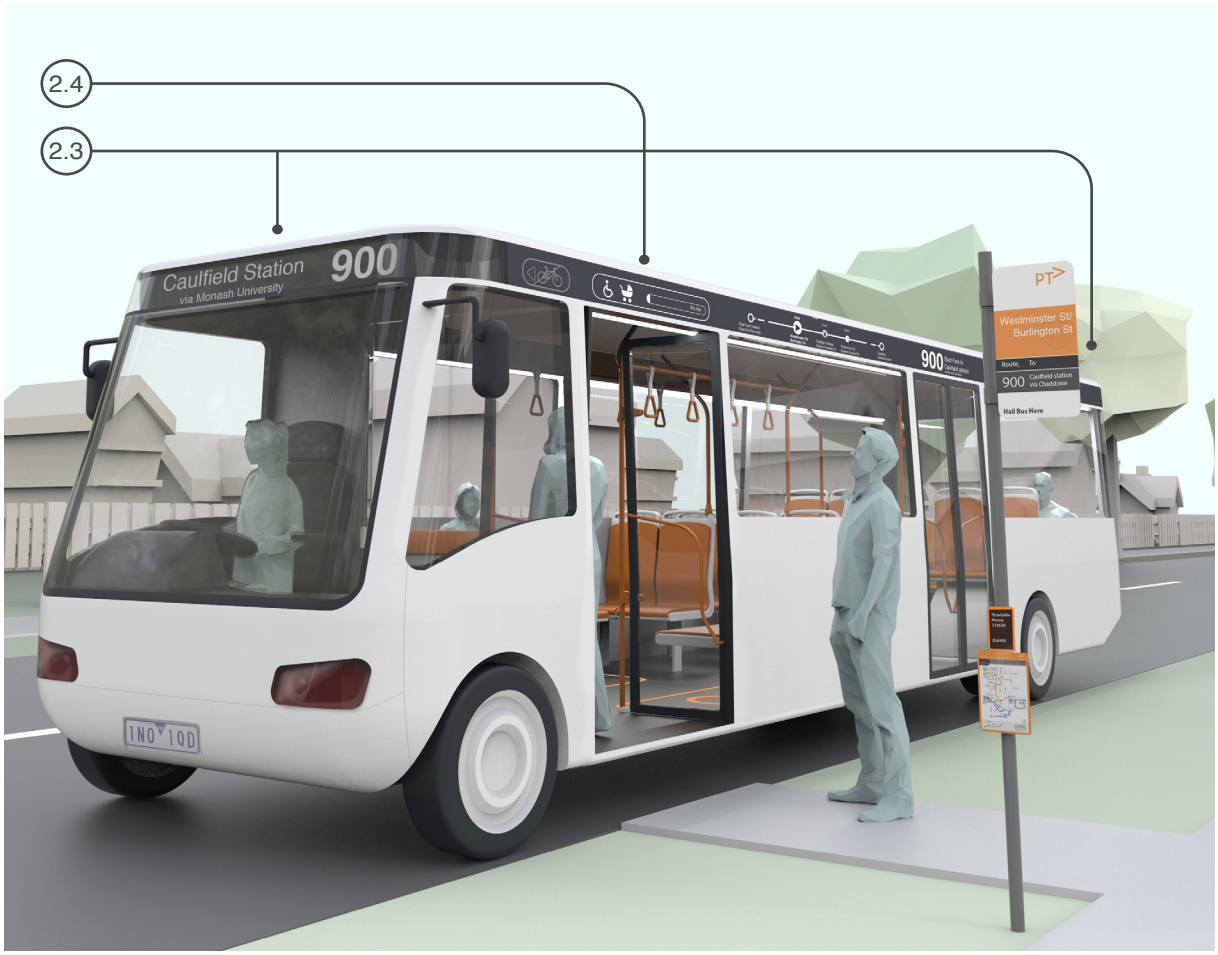


Figure 6.12: Design concept featuring added control: Bus exterior

6.11.1 Plan Journey

Beginning when someone decides to travel to a location, journey planning is their first interaction and information transaction with the system. The objective of the app is to deliver important information and interaction points at the correct time, helping to prevent inundation of service complexities while keeping users up to date with current service information. To provide this, the opening page delivers three features: map with user location, mobility options and the journey progression wheel. Of the three features, the journey progression wheel is considered the most novel.

The journey progression wheel emerged from the journey progression bar during the refinement stage, which allowed tailored service information to be visual and easy to read, responding to wayfinding and information difficulties. The journey progression wheel is a response to the: complex travel patterns users showed during the travel diary study; how the personalisation and trip planning functions can be better integrated into the system; users not wanting to be overwhelmed by information; and the need for service reassurance during transit. Figure 6.13 shows the development of the wheel concept.

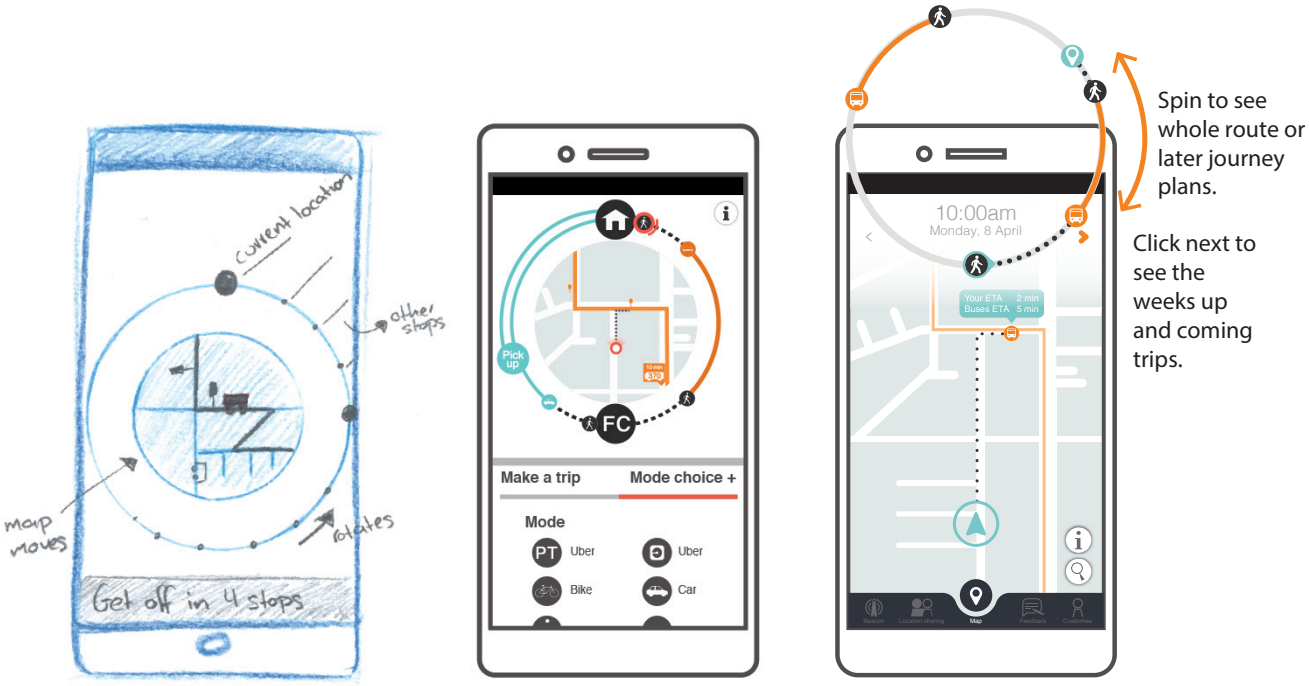


Figure 6.13: Journey progression wheel design evolution

The wheel visually stores any information inputs the user has previously made, their progression within the journey and any future journeys that have been planned. As journeys become more complex, people are actively using mobility differently through MaaS interventions. The wheel responds to this context, providing a way to visually keep track of trip progression and plans throughout the day and week. The features assist in better understanding and controlling the mobility environment during service disruptions by modifying and updating trip progression. Visually the wheel only shows the current part of the journey, with users able to scroll the wheel to gain access to further trip information. This provides an information hierarchy in order to avoid overwhelming users with unnecessary information. Similarly, future days can be accessed, allowing future trips to be planned. The wheel acts as the central control interface, visually showing the control the user has over their travel experience. Figure 6.14 places the wheel feature within the action of planning a journey. The journey progression wheel design was a response to the feedback uncovered during the usability testing stage, where more personalised information needed to be visible and simply represented. Due to this, the presented design has not been retested. Multiple retests and iterations of this design are suggested as future work to provide a more UCD appropriate output.

Figure 6.14: Plan journey

If pre-planning services are required, users are able to import traditional travel information such as current location, destination, time and mode choice into the app. At this point, new integrations, seen in Figure 6.15a and b, such as personal attributes can customise the service to the user's preference. This includes options for trip-tailoring featuring fitness, safety, pricing and speed, as well as trip accessories featuring mobility aids, prams, children or bikes.

These inputs allow the system to access detailed data, providing more tailored experiences and feedback, as well as updating of travel plans according to service changes. For example, for users who are fitness inclined, the app may suggest they alight at an earlier stop to provide more exercise or that during disruptions and periods of extra waiting time, users are encouraged to walk to the following stop.

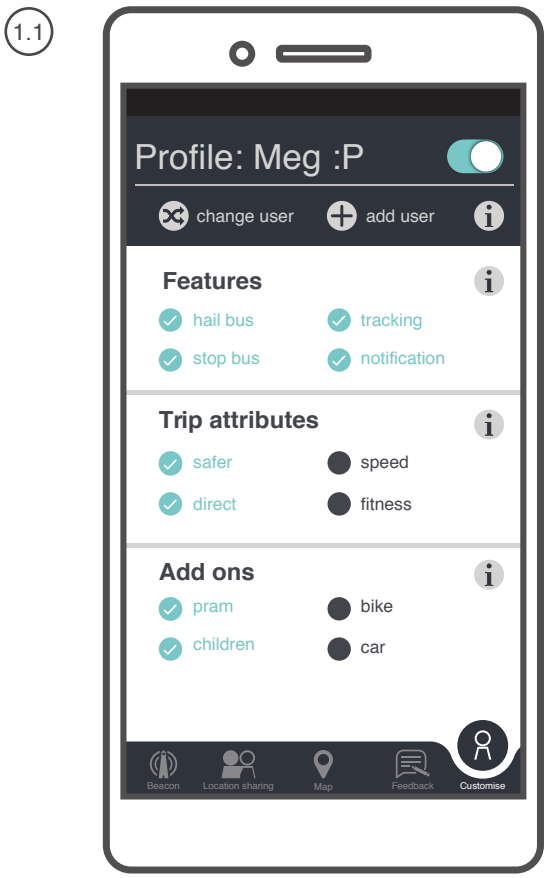


Figure 6.15a: Customisation features

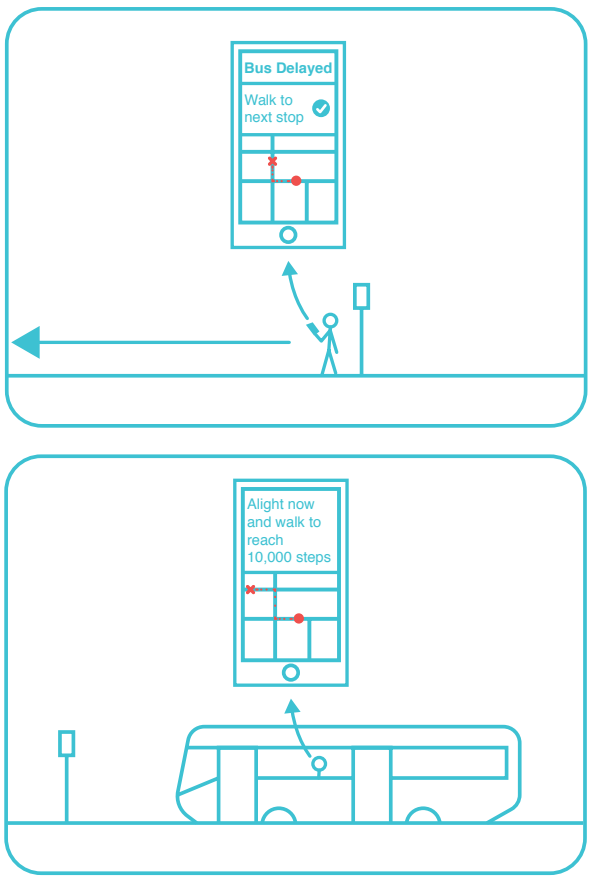


Figure 6.15b: Customisation features scenario of use

With this information provided, the system uses RTI to track the bus and user to inform about any service disruptions. If disruptions occur, the user will be provided with other mobility options to arrive at their destination on time. This transforms the current environment from the user being misinformed and unaware of disruptions to one of empowerment, giving the user the option to change their travel plan. Figure 6.16a and b shows this functionality.

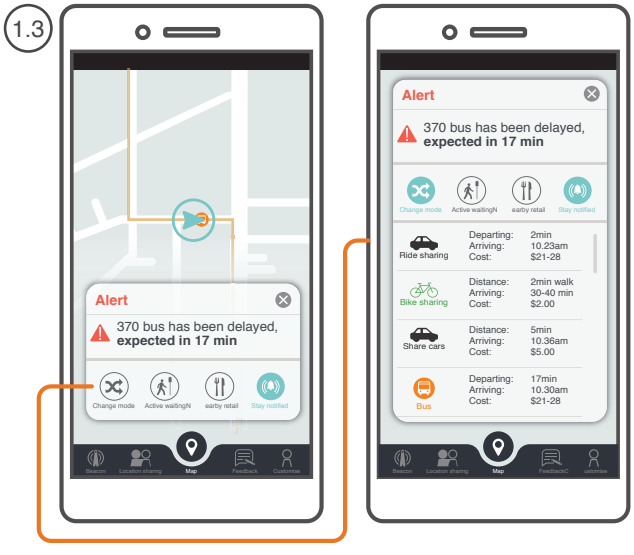


Figure 6.16:a Unplanned disruption

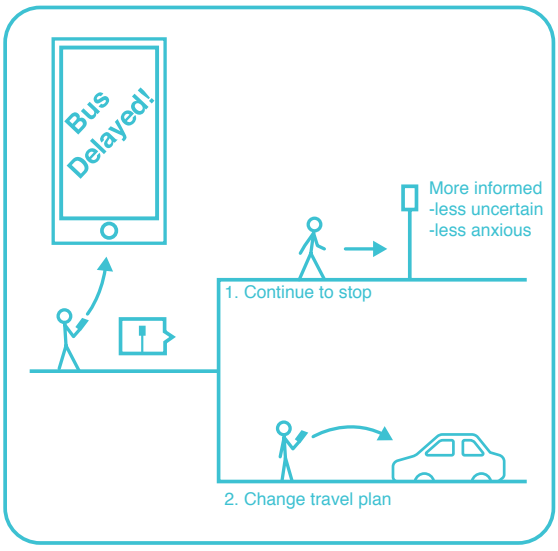


Figure 6.16b: Unplanned disruption scenario of use

This system is focused on providing information to unfamiliar users; however, service disruption is an issue that affects both familiar and unfamiliar users alike. Through regular tracking, predictive journeys can be further developed and used to alert regular users of a disruption. Table 6.3 shows the plan journey functionality in more detail.

Table 6.3: Plan Journey

		Type	Problems being mitigated	Innovation level (novel, uncommon, common)	Features
Personalise/ customise journey	1.1	App	Not knowing if boarding is possible with additional item (bike, mobility scooter, pram) *(study 1)*	Uncommon (personalisation and customisation for time, destination, walking, mode, cost, CO2 footprint, convenience and exercise are common (Jittrapirom et al. 2017). The Arevo app is an example of this. However, personalisation based on bus and environmental live updates is uncommon).	Control over more aspects of the journey. Personalise the trip to let app know of additional items being carried. Tailor the trip to suit user needs: Exercise: Will suggest alighting at different points so 10,000 steps is reached OR app suggests walking to the next stop if the bus is late. Personal safety concerned: Suggests particular routes and stops to alight at that are more populated and lit. Mobility impaired: Provides access to ramp deployment features, or driver assistance if necessary, only vehicles with access requirements are included.
Journey planner	1.2	APP	Current system is rigid to plan changes and journey disruptions *(studies 1,2,3)*	Common (Commonly featured in MaaS and journey planning apps. Used in Google Maps, Citymapper etc)	Provides users with the ability to plan and update their journey. Journey planning should be flexible and updatable without the instigation of the user. For example, the user does not need to stay in one location, the app will update their travel plans and let them know when to leave and how to get there. Only suggests trips that you can actually catch (have a bike, wheelchair, etc). All information is organised within the wheel feature. As journeys become more complex the wheel is a way to visually keep track of trip plans throughout the day/or week.
Change travel plan	1.3	APP	Not knowing what services are around and if travel plan should be changed *(study 2)*	Novel	During unplanned disruptions, the app provides mode alternatives, giving the option for users to be able to change their travel plans.

6.11.2 Bus stop

Getting to, waiting at and leaving the bus stop has been seen as the point where the user is most vulnerable to service change and disruptions. During this point, users have made the decision to use a particular mode at a certain time. Users are out in the network and are subject to environmental and infrastructure conditions, potential antisocial behaviour, and are often unaware of any service changes.

Once in proximity to the stop, users now have the option of hailing the service through the app, countering current system burdens such as being in line of sight of the driver and being aware of their surroundings, as well as being actively engaged in locating and hailing the correct bus.

Similarly, the usability testing suggested that this could help unburden drivers from determining if there are users at each stop. A hailing system would need to be developed for non-app users, such as a button on the bus stop; however, it was not considered as part of this final design as focus was centred on the app and vehicle. Furthermore, the CFD discussed users being missed at stops for unknown reasons, causing feelings of confusion and concerns that this would recur. It was also found that mobility scooters and users who are wheelchair bound are also likely to be left at stops due to ramps not working and services running late, as these users take longer to board. To add control to this environment, the app initially provided mobility options that included appropriate accessibility. The hailing feature provided operators and drivers with increased visibility of users with mobility aids, making it easier for the drivers to accommodate their needs, as well as providing an evidence base if services and vehicles are not at standard levels of operation. These interventions limited the uncertainty that an older, inaccessible vehicle would arrive or that the user would be left at the stop, providing more timed certainty to their travel plan. The app includes options for electronic ramp deployment as well as physical driver assistance, empowering these users during boarding and alighting processes. This customisation could also be utilised for users with prams. The hailing function can be seen in Figure 6.17a and b.

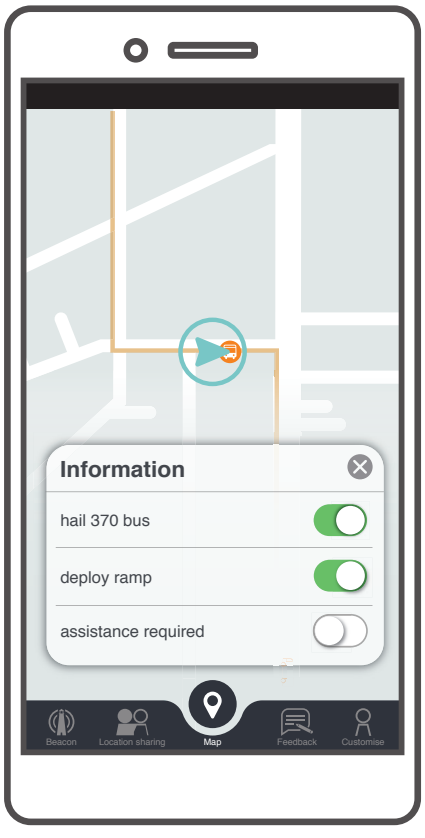


Figure 6.17a: hail bus feature

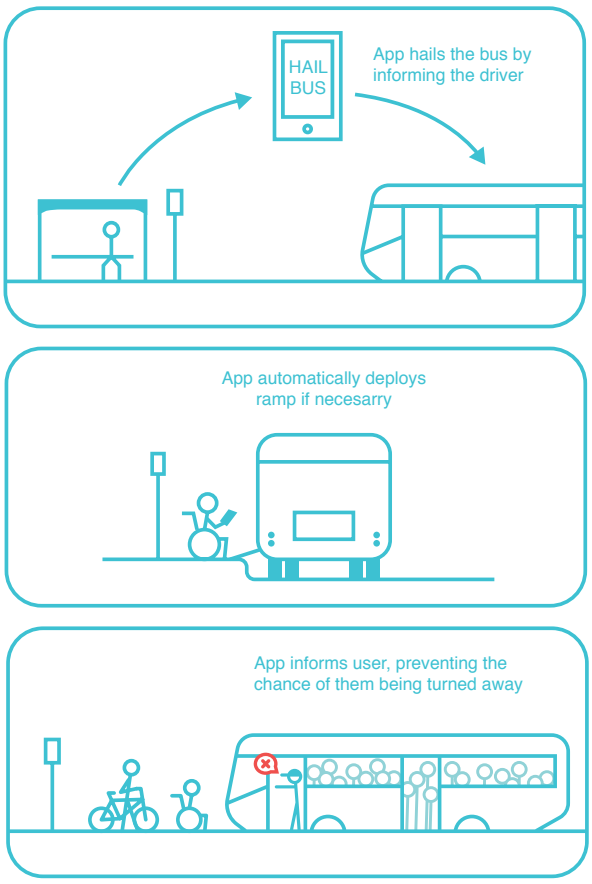


Figure 6.17b: hail bus scenario of use

Exterior destination displays on the bus add to the information provided on the app. The displays feature the bus number and destination, helping to confirm that this is the correct bus. A macro bus route map is included, highlighting the bus's location within the journey and its direction. The displays include bike storage, mobility aid and pram access areas, providing reassurance and correct area navigation to the users. In situations where these areas are full or not working, users are notified firstly on the app, with alternative travel options suggested. The signs on the bus replicate this information with a dash through the symbol. Bus capacity is also indicated. Figures 6.18a-d and Table 6.4 present the exterior signage. During boarding users are greeted with a welcome display indicating which route they are on, providing the user with further reassurance. To prevent passengers from being overwhelmed by information signs, some signs, such as the welcome display are only present at particular points of the trip when their information is required, for example during boarding. This responds to usability testing findings, where some information could overwhelm passengers.

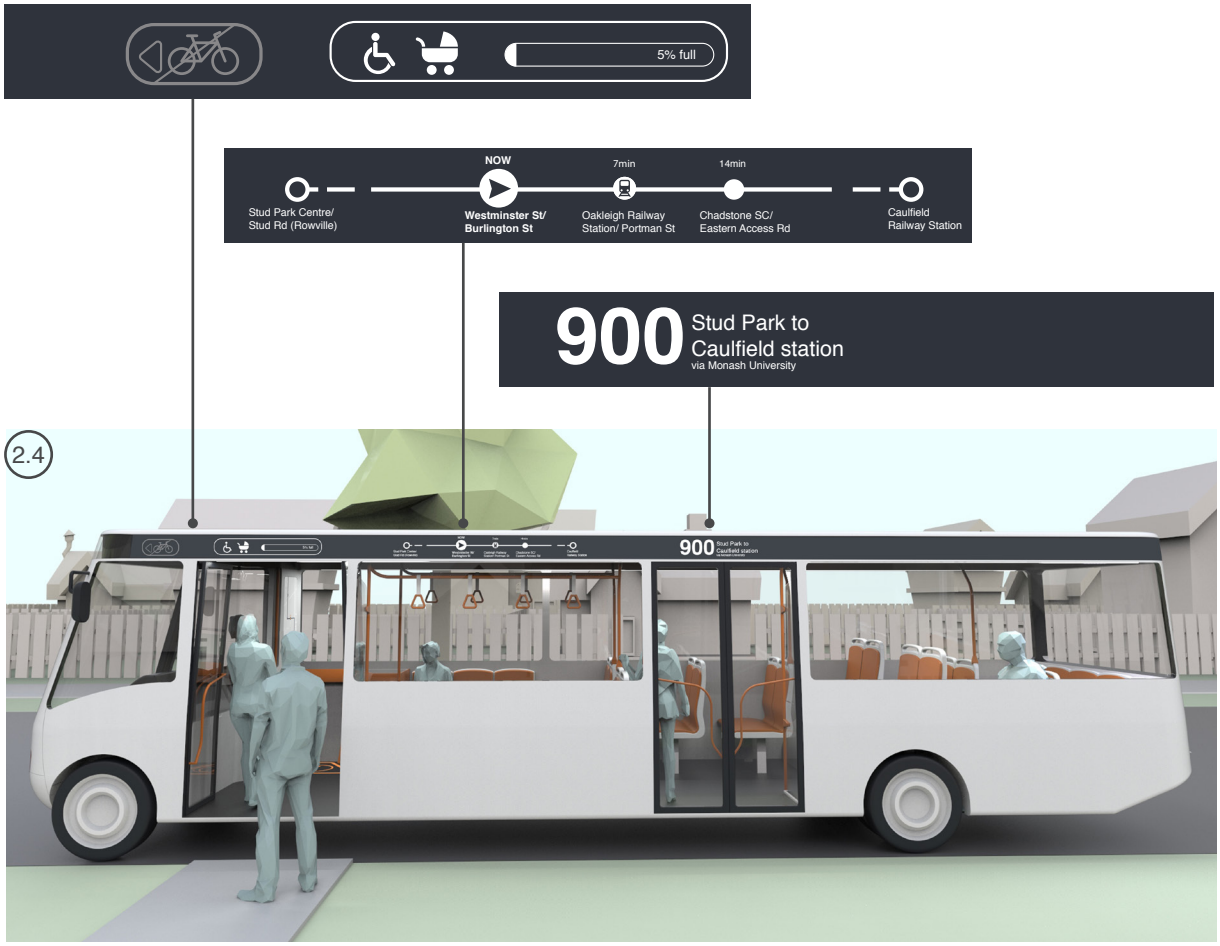


Figure 6.18a: Exterior signage

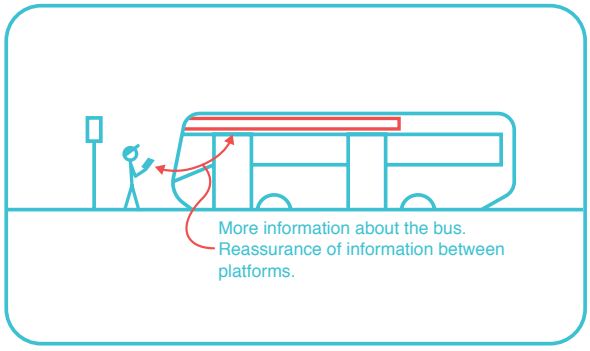


Figure 6.18b: Scenario of exterior signage

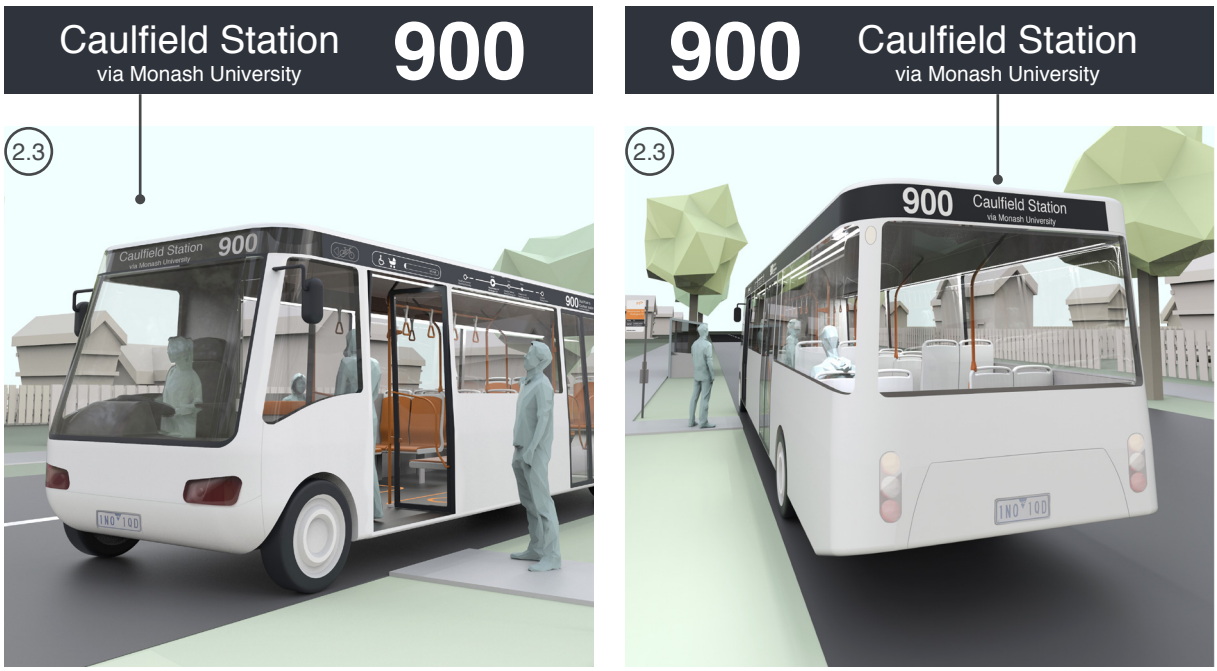


Figure 6.18c: Exterior signage front and back of vehicle

Figure 6.18d: Welcome bus sign

Table 6.4: Bus stop

		Type	Problems being mitigated	Innovation level	Features
Bus is hailed	2.1	APP	Automatic bus hailing was not explicitly asked for, but it helps to counter some of the burdens and problems observed and mentioned within the CFD *(study 1)*. The CFD discussed users being missed at stops for unknown reasons, which left them feeling confused and worried that it would recur *(study 1)*. Users noted a perceived need to stand near the stop to make sure they could hail the bus correctly *(studies 1,3)*. Mobility scooter and wheelchair users were also identified as likely candidates to be left at stops, with the causes noted as broken ramps and services running late *(study 1)*.	Novel	Once in close proximity to the stop, the app will automatically hail the bus. Preventing the need for users being actively engaged in locating the bus or needing to stand by the stop. If smartphones are not accessible hailing the bus normally or a hailing button at the stop could be alternative responses. This feature can be manually disabled or turned off on the app.
Use ramp/ Help required	2.2	APP	The CFD highlighted that mobility impaired users were being left at the stop because the driver was unable or did not have time to deploy the ramp *(study 1)*. Providing the user with the ability to deploy the ramp, places the power to board the bus with them.	Novel	App activates ramp or bus driver's attention if required for mobility impaired users. This feature providing more independence for mobility impaired users.
Exterior DESTO front and back screen	2.3	BUS	Users often have to walk past the door to the front of the bus to see the bus route. This has been improved within newer vehicle styles *(study 2)*.	Common	Shows bus number and direction.
Exterior DESTO side screen	2.4	BUS	Buses do not often include enough destination signs on board, making it more difficult to determine bus location *(study 2)*.	Uncommon (Similar to UITP 2 bus, bus capacity features are similar to google map app)	Includes: bus number and direction, macro bus route and buses location within the route, allocated space and bike rack location indicator (identifying if these spaces are being occupied or not. The user will already be noted of this information if it affects them, this signage acts as a reassurance of knowledge) and bus occupancy reader.
Welcome display	2.5	BUS	Bus users were observed to ask the driver if they were on the correct service *(studies 2)*.	Uncommon	Includes a route number and name display visible as a passenger enters the front door.

6.11.3 On board and alighting

Bus interior PIDs and the navigational mapping featured in the app provide similar graphical treatment and wayfinding information. This assists users to navigate the system as well as further reassuring them that they are on the correct bus. The inclusion of more visually informing PIDs within the bus

interior provides alternative means of wayfinding, rather than purely smartphone-based. Although smartphones currently fulfil this active wayfinding need, having an on-board display allows an alternative wayfinding option for non-users of smartphones, and allows smartphones to be used for other purposes during transit. As the bus, within this context, is seen as the source of anxiety, it is appropriate for the bus to provide the base of information as a usability gesture and reassurance to the user.

The PIDs include variations of journey information. Route navigation information includes a combination of macro – last stop – and micro – previous stop – and next 3 stops – route information, as well as user location and next stop arrival times. Having this information present allows the user to identify where they are within the route and the direction that the service is moving towards. This signage features dynamic information, including service connections to other modes, presented when the vehicle approaches particular areas such as a railway station. Figure 6.19 presents the route interior signage.

Figure 6.19: Interior signage

With the segregation of the driver, an interactive display that includes a map and navigation assistance was included to help fill information gaps that would normally be provided by the driver. This display is the evolution of the front screen navigational map. It allows users to gain further information concerning the environment they are within and or where they are going to, as well as route navigation; this is seen in Figure 6.20.

Figure 6.20: Interactive display

Above the door further navigational information is present, showing the distance and direction to main locations from the bus stop. This information scrolls vertically dependent on number of locations and resembles further wayfinding present on the app. Figure 6.21a, b and c presents the on board and app functionality of alighting the bus. The following table, Table 6.5 details the on-board and alighting process in greater detail.

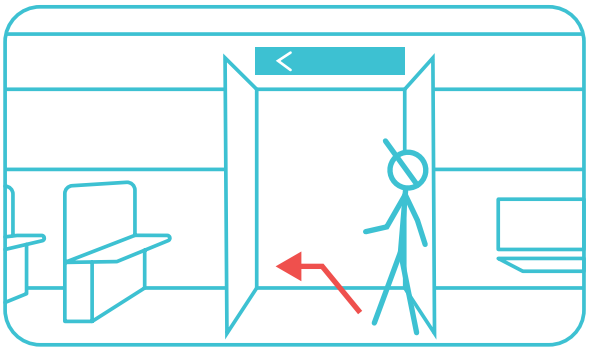


Figure 6.21a: Interior signage and alighting functions scenario of use

Figure 6.21b: Interior signage and alighting functions

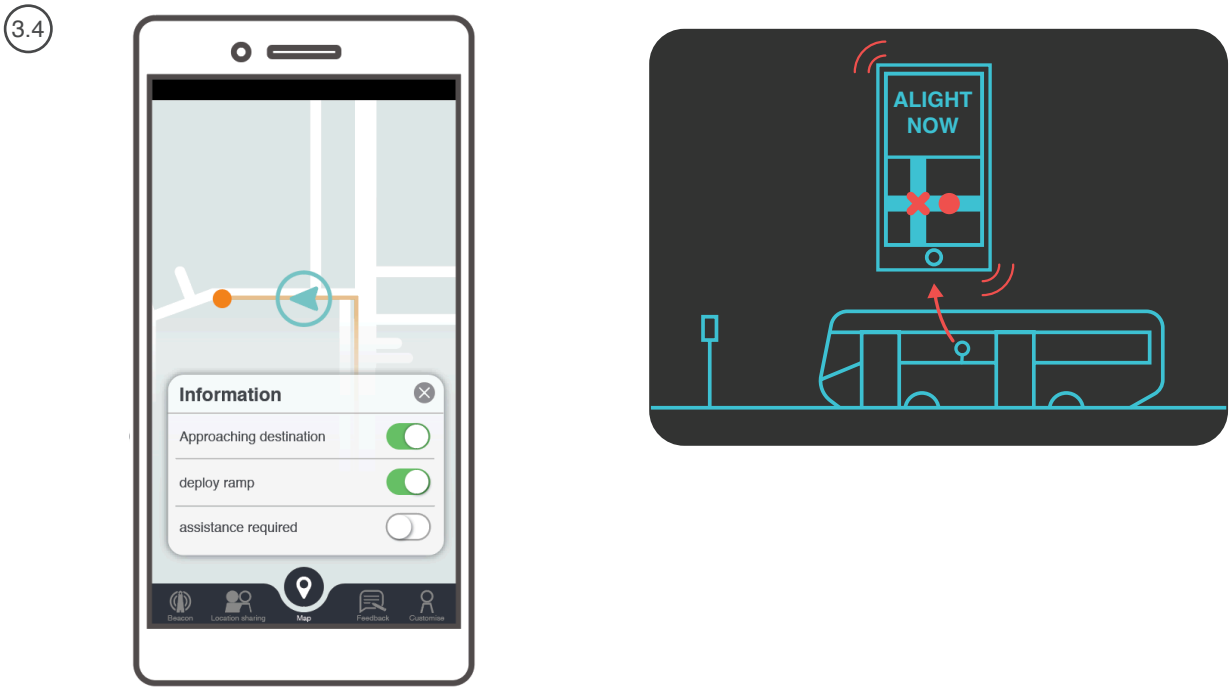


Figure 6.21c: App alighting function and scenario of use

Table 6.5: On board and alighting

		Type	Problems being mitigated	Innovation level	Features
Interior PIDs	3.1	Bus	Users were unsatisfied with the amount of signage present within the vehicle *(studies 2,3)*	Common: Current displays are commonly found within most buses Novel: level/ treatment of information presented within this concept.	Display includes: current location, next 2 stops, previous stop and the end point of the journey, as well as RTI timing points and train transfer times. The information displayed and the graphical treatment matches the information within the app, acting as a further reassurance. Based on vehicle size and layout the screen can scroll throughout the cabin or be stationary.
Interactive PIDs	3.2	Bus	Users are uncertain when to depart. The removal of the driver limits this interaction *(studies 2,3)*.	Novel for bus interiors.	An interactive screen allows users to find out more about the location they are going.
PID map/ information screen	3.3	APP		Common (Commonly featured in MaaS and journey planning apps. Used in Google Maps, Citymapper etc).	The app tracks the bus's location within a map and the navigation wheel feature, providing ability for active wayfinding. The information is the same as what is present on the interior screens, but is more personalised, based solely on the user's trip.
Bus stop alert	3.4	APP	Users uncertain when to depart the bus. This is caused by an unfamiliar route, wayfinding difficulties due to environment conditions, multitasking activities or being unable to reach the stop button *(studies 2,3)*.	Uncommon- (found within TransitApp, however it does not stop the bus, this interaction is still required by the user)	App notifies user that their stop is approaching, allowing the user time to prepare for departure. Reduces the need for active wayfinding, allowing users the option of zoning out or multitasking without fear of missing their stop. Prevents stop confusion for unfamiliar locations or hard to see environments (night time, wet conditions). App tells the driver to stop the bus, this feature can be disabled if plans change.
Interior door PIDS	3.5	BUS	A driver noted being asked often for directions from bus stop to user's final destination *(study 2)*.	Novel	When alighting, nearby popular landmark directions are visible above bus's door.
Front PID	3.6	BUS	Basic level of information	Common	Indicates next stop location visibly and audibly

All PIDs consist of Eink or E-paper technology as opposed to the current LED displays. This technology provides the ability to develop more detailed, refined and aesthetically pleasing information provision, and is commonly utilised within this industry. Eink, specifically, provides less glare and energy consumption, making it suitable for on-board PIDs. This technology is more commonly utilised for bus stop display signs, with Transport for London and within Sydney successful examples of implementation.

6.11.4 Throughout journey

Multiple other features were developed that can be used throughout the whole journey process. These features include location sharing, Beacon Mode - previously known as Safety Mode - and Feedback Mode.

Location tracking, seen in Figure 6.22, did not conceptually evolve past the previous design development stage, as the usability testing concluded its suitability. The location tracking provides the option for users to send their location to a designated person, keeping them informed of transit orientation. This feature is an alternative way for people to integrate transport into their daily lives, providing them with a tool to be more aware and in control of time and location sensitive information. For example, this feature provides a way to easily catch the same service as a friend, allowing coordinated pick-ups and meetings to occur. Additionally, this feature provides a way to determine travel progression for alternative plans, such as when to start preparing a meal in time for a friend's arrival. Location tracking can be prepared in advance during the pre-trip stage; when activated, a location tracking icon is visible on the navigation wheel, indicating when the person will be notified.

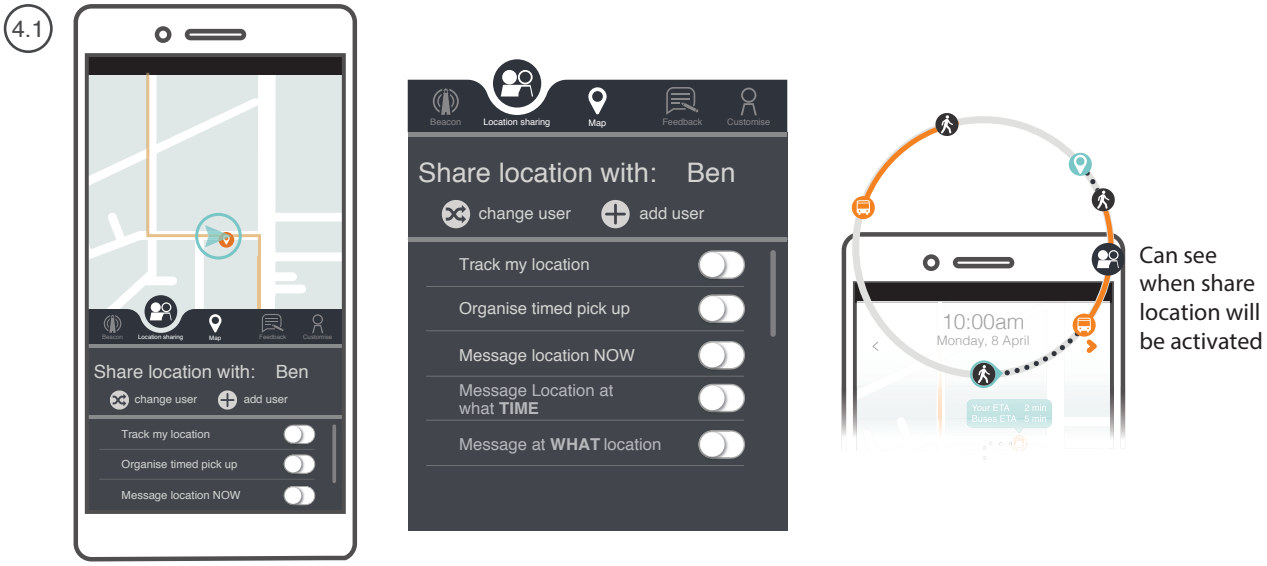


Figure 6.22: Location tracking

Beacon Mode, as recommended by the usability-testing participants, is primarily a location-tracking feature, allowing loved ones determine user location and if travel plans are proceeding correctly. For example, it could be used by schoolchildren or parents when unaccompanied minors are out in the network, providing both parties with peace of mind. This mode also includes safety options to limit perceived unsafe environments, such as walking to and waiting at isolated bus stops; being trapped on the bus with antisocial individuals; and being followed home. Although Beacon Mode does not stop antisocial behaviour from occurring, it helps to empower users by preventing them from feeling isolated within the network. Beacon Mode achieves this by including friend tracking and messaging options; the ability to easily record audio and footage; the ability to contact the driver discreetly; and the ability to organise on time pick-ups at bus stops, reducing waiting time.

Other safety apps currently available for purchase, for example Bsafe and Watch Over Me, provide safety features including tracking mode and location sharing, audio recording and environment safety ratings. They often do not include journey planning features, which offers an opportunity to develop an integrated journey planning and safety system allowing additional safety features to be developed. These features may include discreet communication with the driver during a threatening incident, timely connected transfers and reduced wait time. Use of Beacon Mode, seen in Figure 6.23, could

provide stronger safety integrations, helping users feel safer, giving them further control and hopefully limiting antisocial behaviour. Beacon Mode could be easily toggled on and off on the main screen, allowing location privacy if required. Beacon mode could potentially be used within a range of different mobility journeys, including non-bus related. However, for project scope, bus based trips were the central focus, with future research required to determine the alternative journey benefits and abilities.

Figure 6.23: Beacon Mode

As identified within the CFD and usability testing, the users of the transport system are the eyes and ears of field-based service performance. This data is essential to providing service updates and is key to delivering better, more user-centred service provision. To do this, more useful, less negative information needs to be collected. The utilisation of a feedback feature, seen in Figure 6.24, present within the app could be a solution, making it easier for users to signify their concerns, as compared with calling or going through website-based applications. Table 6.6 lists all these additional app functionalities in greater details.

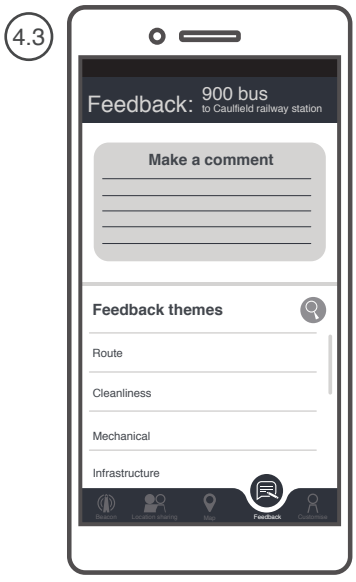


Figure 6.24: Feedback

Table 6.6: Throughout journey

		Type	Problems being mitigated	Innovation level	Features
Location sharing	4.1	APP	Users wanting to organise pickups, to catch the same service as a friend. *(suspected issue, confirmed usability test)*. Zoning out and multitasking while on the bus is considered commonplace. It was observed that during such activities it can be easy to forget to send location updates to loved ones, or (due to traffic) not knowing when to send location information *(study 2, confirmed during usability test)*.	Common in other apps (Strava, Snapchat, Google, Facebook)	Location sharing with loved ones. This provides on the spot/ timed sharing of your location. Features include multiple location sharing options to suit differing needs. Location sharing can also be pre-established before a journey. This will be indicated within the wheel feature, with a notification alert when the information has been sent.
Beacon Mode (Safety)	4.2	APP	Many users when travelling on PT feel vulnerable to threatening situations. This is more commonly felt at night time, in low isolated areas, both common in outer suburban bus areas. *(Flood 2006; Kalms, et al. 2017; Stradling et al. 2007; studies 2,3; usability test)*	Common within safety specific apps (Bsafe, Watch Over Me, Red Panic Button, etc). Novel within PT apps.	This feature is to make users feel less alone while navigating the PT system. Providing users with the ability to easily contact authority figures and keep loved ones updated on travel location.
Beacon Mode: Location sharing/ notify friends		APP	Reluctancy to use the network due to safety concerns (Moore 2011; Newton 2004; Taylor & Ampt 2003), as well as parents and loved ones being concerned when particular family members/loved ones are out on the network. This reassures them that they are safe or have made it home safely *(confirmed during usability test)*.	Common (Bsafe, Watch Over Me)	A loved one can be notified of the following: Location and route plan. When traveller arrives home safely. If the traveller has left the planned route unexpectedly. If alert mode is activated. Audio and video recording footage if turned on.
Beacon Mode: Alert mode		APP			Includes the following features: communication with driver, recording, safety routes and safe zones, and lifts and pick up points.

		Type	Problems being mitigated	Innovation level	Features
Alert mode: Communicate with driver		APP	Bus driver policy during antisocial situations is that they are not to engage as their safety is a priority. Drivers may also not be aware of antisocial behaviour occurring on the bus *(industry policy)*. If the driver is informed of the situation through the app, they are able to discreetly send out a distress call to authorities, with the operators being able to help the police find their location.	Novel	App can alert bus driver of situation, who can inform the police and operators.
Alert mode: Recording	4.2.4	APP	Alert mode helps to provide evidence of a situation *(usability test)*. This could be a way to prevent particular CCTV footage from being deleted too early.	Common (Red Panic Button, Circle of 6) Novel within PT apps.	App records video and audio on phone. Flags CCTV footage for review.
Alert mode: Safety routes and safe zones	4.2.5	APP	Being in environments that feels threatening *(Stradling et al. 2007, study 3)* Travel plans were seen to alter when somebody felt threatened *(Bissell 2018; Stradling et al. 2007, study 3)*.	Common (Safetypin) Novel within PT apps.	Route/ map displays perceived safer areas to walk/alight bus (more lights and people around). Safe zones are also displayed, including stores or areas with late opening hours eg. 7/11s.
Alert mode: Lifts and pick up points	4.2.6	APP	Waiting in the dark, isolated, for a lift to arrive *(study 3)*.	Novel	App can organise lifts with RTI and location tracking to minimise waiting at bus stops.
Feedback mode	4.3	APP	Bus operators being unaware of what is actually happening while the buses are out in the route *(industry, usability testing)*.. The current feedback system is difficult to use and attracts negative, unhelpful responses *(study 1)*. CFD respondents said they feel unheard and unimportant within the system *(study 1)*.	Novel Common on websites and discussed within the literature.	Bidirectional feedback loops. A way operators can gain more information and control over their bus network while they are out in operation. Not focused on bus failures but improvements.

Through adding control and information interventions, the design outcomes illustrate two main points, firstly necessary areas where control is required to improve user experiences; and secondly what these implementations might look like if the service and vehicles were to be designed around their integration. The following images, Figure 6.25 a-c, provide context of what added control might look like during periods of higher user capacities.

Figure 6.25a: Exterior designs within the current Melbourne environment

Figure 6.25b: Interior designs within the current Melbourne environment

Figure 6.25c: Interior designs within the current Melbourne environment

6.12 Developing contribution to knowledge

The concept of control was identified within the literature as a positive utility to travel, mainly associated with the flexibility and freedom of owning a car (Ben-Akiva & Morikawa 2002). Within specific PT literature, the lack of control was identified as a negative service attribute, poorly affecting user experiences (Fridman, Napper & Roberts 2018; van Hagen & Bron 2014; van Hagen & van der Made 2017). Besides these researchers, few studies identified areas where a lack of control is present and how it can be improved. This research has built upon this gap, identifying specific touchpoints and service failures within the network where lack of control is experienced, as well as highlighting points of redesign. The application of bidirectional service and vehicle interfaces, which allow the user to inform the vehicle – as well as the reverse scenario – was the design response to the lack of control problem. Bidirectional bus network integration is a novel concept which allows a platform for lack-of-control problems, such as service failures and information breaks, to be fixed. Bidirectional interfaces are therefore considered a contribution to knowledge within the Melbourne bus control and user experience space.

6.13 Summary

In summary, usability testing was necessary to validate the suitability of the designs and give feedback on the refinement process, with VR identified as the most appropriate tool for delivery. Furthermore, it helped to improve behavioural understanding of bus experience by testing alternative solutions and scenarios.

The testing incorporated some biases and limitations regarding the hardware and software; however, this type of testing is recommended by the literature if large-scale scenarios incorporating both services and products are in need of testing. This allowed flexibility to change environments and designs quickly, while encouraging formative feedback to take place.

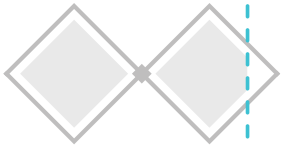
Refinement of the app and vehicle was undertaken based on the feedback provided from the testing. The main area of focus concerned being able to customise and personalise the vehicle and app to give users more information, reassurance and control over their environment. From this information, the designs were refined and the outcomes discussed holistically, combining the designs with the project's previous findings.

It should be noted that the concepts presented here discuss problematic areas within the Melbourne bus industry that need to be improved through design intervention. The concepts presented are potential versions of these solutions, showing how design impact can improve the control experience. However, they are still conceptual, with more work needing to be undertaken for implementation.

The next chapter will discuss these designs and the overall findings of this research project further. This will clarify the achievements and limitations of the project, the contributions the project has made to knowledge, as well as its success in answering the main and supplementary research questions.


PT
Eastrans
Route To
624 Kew
Hail Bus Here

Chapter 7
Discussion and conclusion



This project set out to better understand bus user experience within the Melbourne suburban landscape and to identify key usability problems through a design-inclusive research methodology. This topic exploration resulted in the identification of the lack of control as a main barrier and contributor to dissatisfaction among bus users. Design practice was then applied to develop solutions for the associated lack-of-control issues, with the intention of adding control and improving the user experience. By responding to the research aim and questions, new contributions to bus and design knowledge were identified.

Buses within Melbourne are currently poorly perceived, with users reporting negative journey experiences on vehicles and services (PTUA 2019). These negative associations have been linked to accessibility issues caused by the low-density environment, as well as the lack of information and understanding present (Frost & Dingle 1995; Mees 2010; PTUA 2019; Schmitt 2015). Bus service attributes have also been criticised as less reliable, comfortable, innovative and modern, as well as being infrequent, slower and less aesthetically pleasing compared to other mobility modes (Beira˜o & Cabral 2007; Harrison et al. 1998; Tozzi, Guida & Knote 2014, p. 2; UITP 2006). This project aimed to discover how the problem of negative bus user experience in Melbourne suburban environments can be better understood and improved through design research and intervention.

7.1 Project framing

Identified while reviewing the literature, user satisfaction and service quality have often been approached through a civil engineering focus, with operators using quantitative reports to assess user issues and areas in order to improve service dissatisfaction attributes (van Hagen & Sauren 2014). Safety, security and ease of use – as seen in Figure 7.1 the customer satisfaction pyramid – were identified as the main areas for scholarly and industry focus, as they form the foundations of an acceptable PT network. Less attention, during the literature review, was found to have centred on improving the user experience, with user-based design enquiry research methods found to be lacking within the operation and manufacturing sectors. This research gap provided the opportunity for this project to explore bus user experiences through design enquiry, responding to the above research aims through an iterative design process.

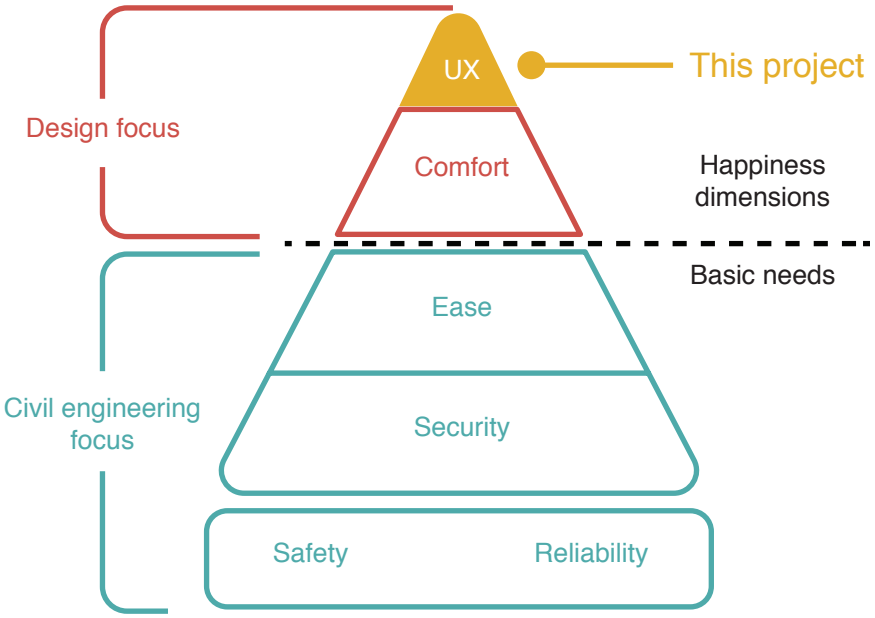


Figure 7.1: Customer satisfaction pyramid (adapted from van Hagen & Sauren 2014 and originally located in Section 3.1)

Furthermore, the majority of existing literature has been discussed within environments other than suburban Melbourne, with specific context being an important contributor to user acceptability and experience. To address the problems presented and knowledge gaps identified, the primary research question: *How can bus user experience in suburban environments be improved through design enquiry?* was developed as the focal point for the research. Further subsidiary questions were devised targeting specific unknowns, to contribute understanding and provide a knowledge base for answering the main question:

> *Sub 1: What is the current bus experience like for Melbourne suburban bus users and what are their main concerns?*
> *Sub 2: How can ethnographic methods be applied in design practice to develop user-centred bus services?*
> *Sub 3: How can design practice be used to respond to the research findings and improve the bus user experience?*

The project followed a design-inclusive research (DIR) methodology, which allowed design to be embedded within the PT context, providing new opportunities to be explored through design (Horváth 2007, 2008). Figure 7.2 - the repeated version of Figure 3.3 - is a summary of the project framework, detailing the various stages that were undertaken during the project and the points the research questions were explored. To help incorporate user centredness into the design framework, a UCD

focus was implemented onto the DIR methodology, allowing a user focus to be incorporated at all stages of the design process. This is also illustrated within Figure 7.2. The UCD focus was a response to the literature finding that identified a disconnection between vehicle design and user insights, as well as the limited formative user testing at early design stages.

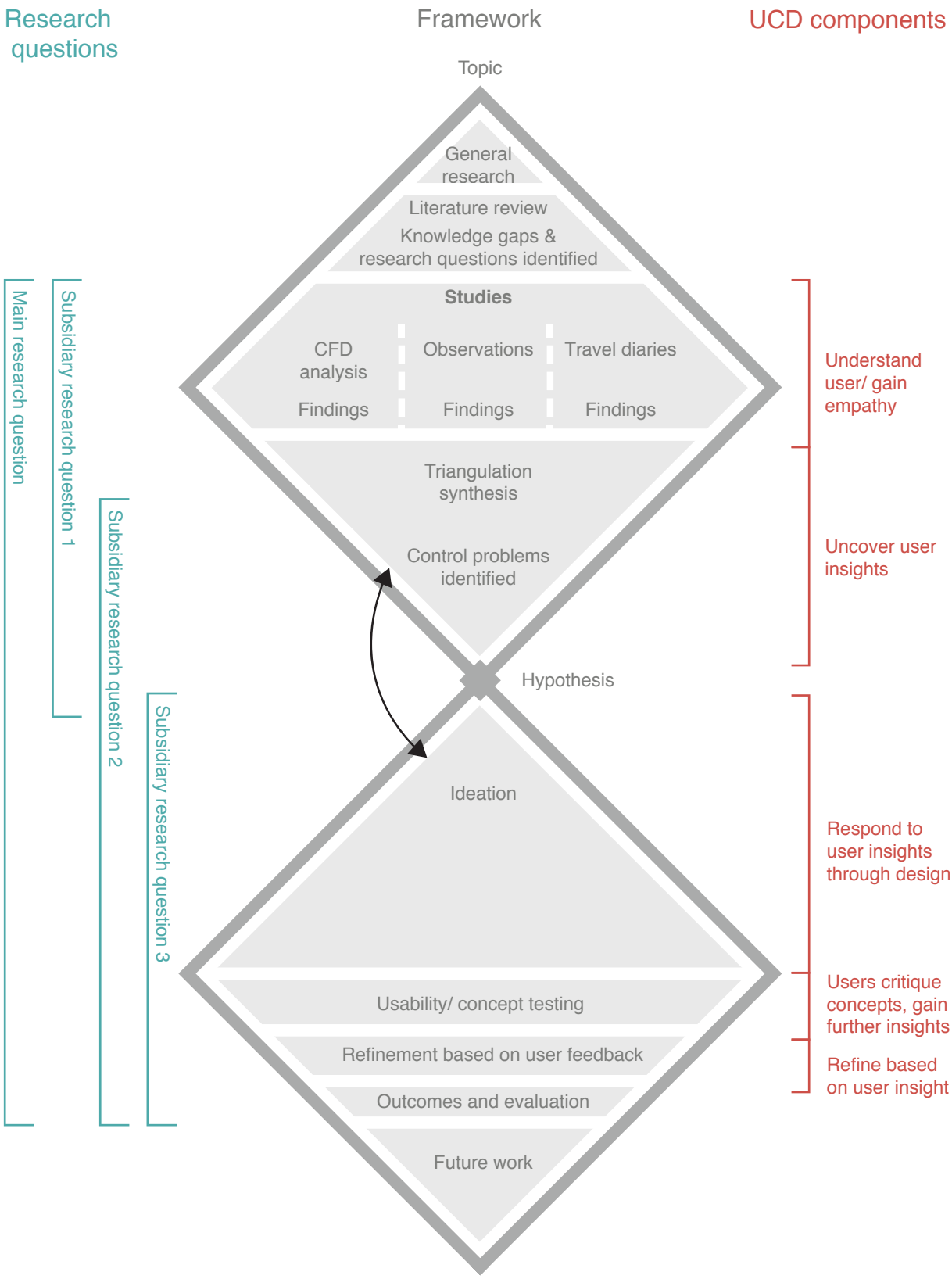


Figure 7.2: Project framework

In this chapter, the answers to the research questions and the project contributions to new knowledge will be discussed. The chapter will critically assess the research outcomes and methodology, offering insight into the limitations, practical applications and future directions. A final conclusion will then be drawn, presenting the potential impact of this work.

7.2 Sub 1: What is the current bus experience like for Melbourne suburban bus users and what are their main concerns?

The first subsidiary research question was developed from gaps found during the literature review process. Although service quality and user experience literature was abundant, little knowledge existed on specific Melbourne-based suburban bus experiences and barriers to usage, requiring further research to be undertaken. The answering of this question took place in Chapter 4 and consisted of three studies. As these studies focused on developing a holistic answer to the research question, they were designed to provide different perspectives, building upon the knowledge gained. This helped to triangulate the findings and build a broad picture of passenger experience and dissatisfaction.

The first study, presented in Section 4.1, consisted of a qualitative analysis of 2016 customer feedback data (CFD), focused specifically on vehicle and service feedback. The data provided a thorough account of pressing user complaints and service issues. The majority of feedback surrounded service failures and the lack of understanding and annoyance they produced. This service failure focus created a limitation within the data, as it did not reflect general passenger experiences and service interactions. Additional research was required to further understand passenger experiences. The second study (Section 4.2) consisted of observational field research intended to determine how passengers used these bus services. The observational studies were suitable for gaining an understanding of how passengers undertook their journeys, but were limited in providing understanding of the fundamental motivations and experiences felt. The findings surrounding journey observations were used to develop the third study (Section 4.3). This study's objective was to understand current travel behaviours, motives, dissatisfactions and design opinions through a travel diary tool. The diaries were designed using evocative tasks to produce deep qualitative information regarding user interactions with the bus service. This task produced useful information that can be designed for.

Triangulation of the three studies validated and combined the qualitative research findings (Visocky O'Grady & O'Grady 2009). During this stage, data was visually synthesised into three different journey maps (presented in Section 4.4 and repeated below in Figures 7.3, 7.4 and 7.5). These diagrams provide a clear overview of the complexities and interwoven problems present within the bus user experience, indicating negative points of user interaction, service failures and areas requiring design intervention. From these data visualisations and studies, the four main barriers to bus usage were identified as information, accessibility, reliability and safety, along with user uncertainty, annoyance and distrust caused by service delivery failures. This research has classified these problems and associated phenomena as control-based issues. The concept of control was initially identified within the literature as a positive utility to travel, mainly associated with the flexibility and freedom of owning a car (Ben-Akiva & Morikawa 2002). Within specific PT literature, the lack of control was identified as a negative service attribute, poorly affecting user experiences (Fridman, Napper & Roberts 2018; van Hagen & Bron 2014; van Hagen & van der Made 2017). Besides these researchers, few studies identified areas where a lack of control is present and how it can be improved. This research has built upon this work, identifying specific touchpoints and service failures within the network where lack of control is experienced, as well as highlighting points of redesign, as seen in Figure 7.6.

In answering this research question, the studies provided qualitative data on how Melbourne suburban bus environments are being experienced, with the lack of control identified as a main barrier to usage. The visualisation and synthesis process of the information can be seen in Figure 7.6. Through

conducting the studies, a broad range of travel experiences and perceptions from the Melbourne environment were collected and analysed, providing a specific overview of the current bus experience and the main problem points. In summary the current bus experience for Melbourne suburban bus users was deemed to be complicated and dependent on environmental and service conditions. Trips, as identified in Figure 7.3, can range from ideal, consisting of nothing notable occurring, to confusing and anxiety causing, for example during disruptions. These anxieties and problems were found to be exacerbated within suburban environments as less infrastructure and less frequent services cause heightened repercussions when problems occur. Qualitative data established that low-density bus networks are impacted by access, negative safety perceptions, information and reliability difficulties. These issues were identified as creating service uncertainty and a lack of perceived control within this environment, helping to fuel the negative service perception and experience.

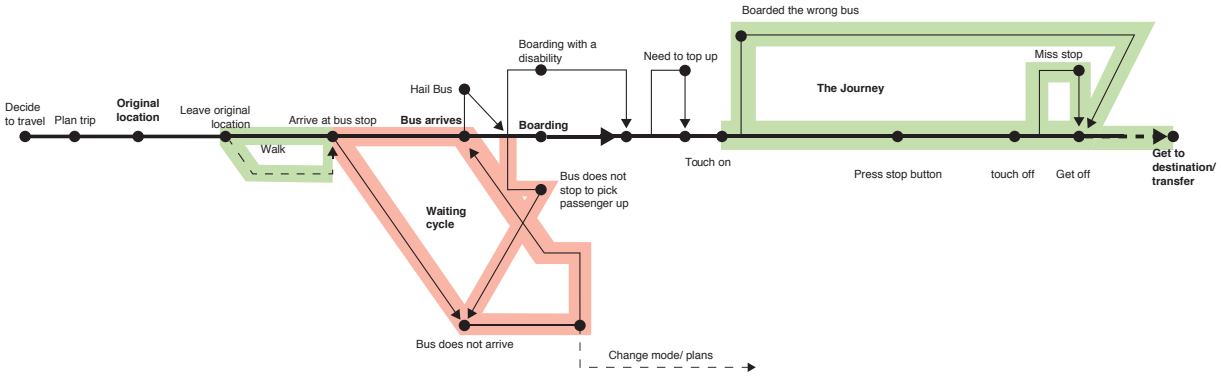


Figure 7.3: The bus journey map

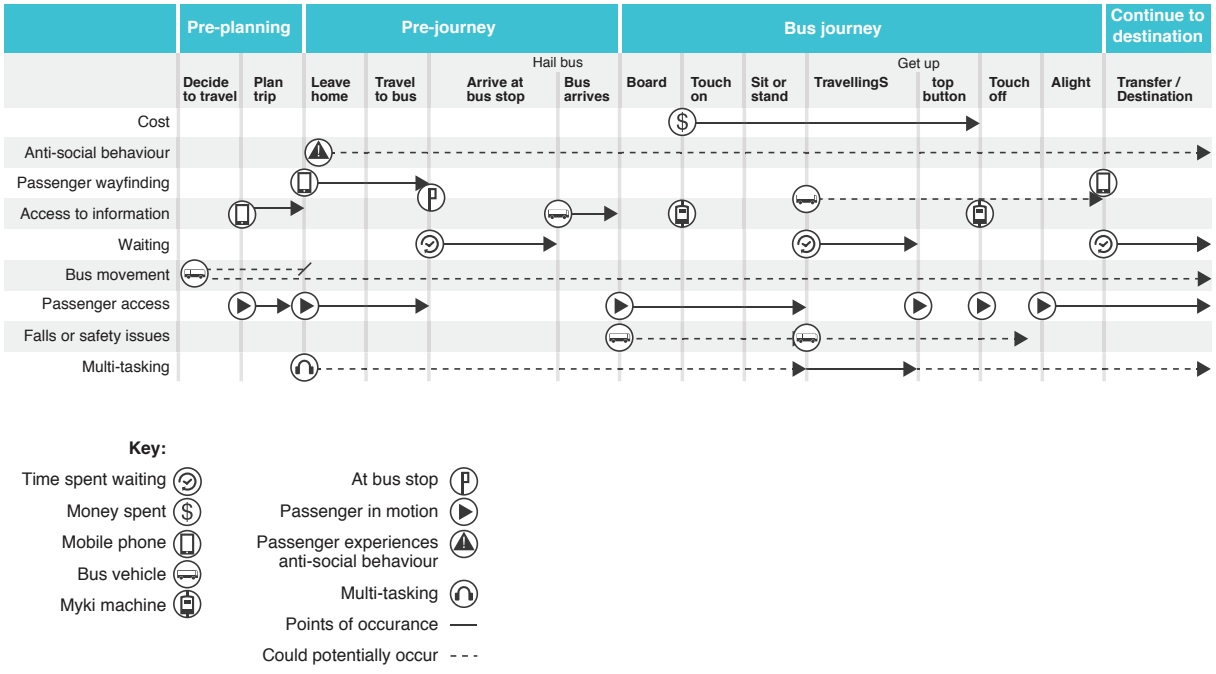


Figure 7.4: The bus journey map touchpoints, see Section 4.4 for for larger diagram

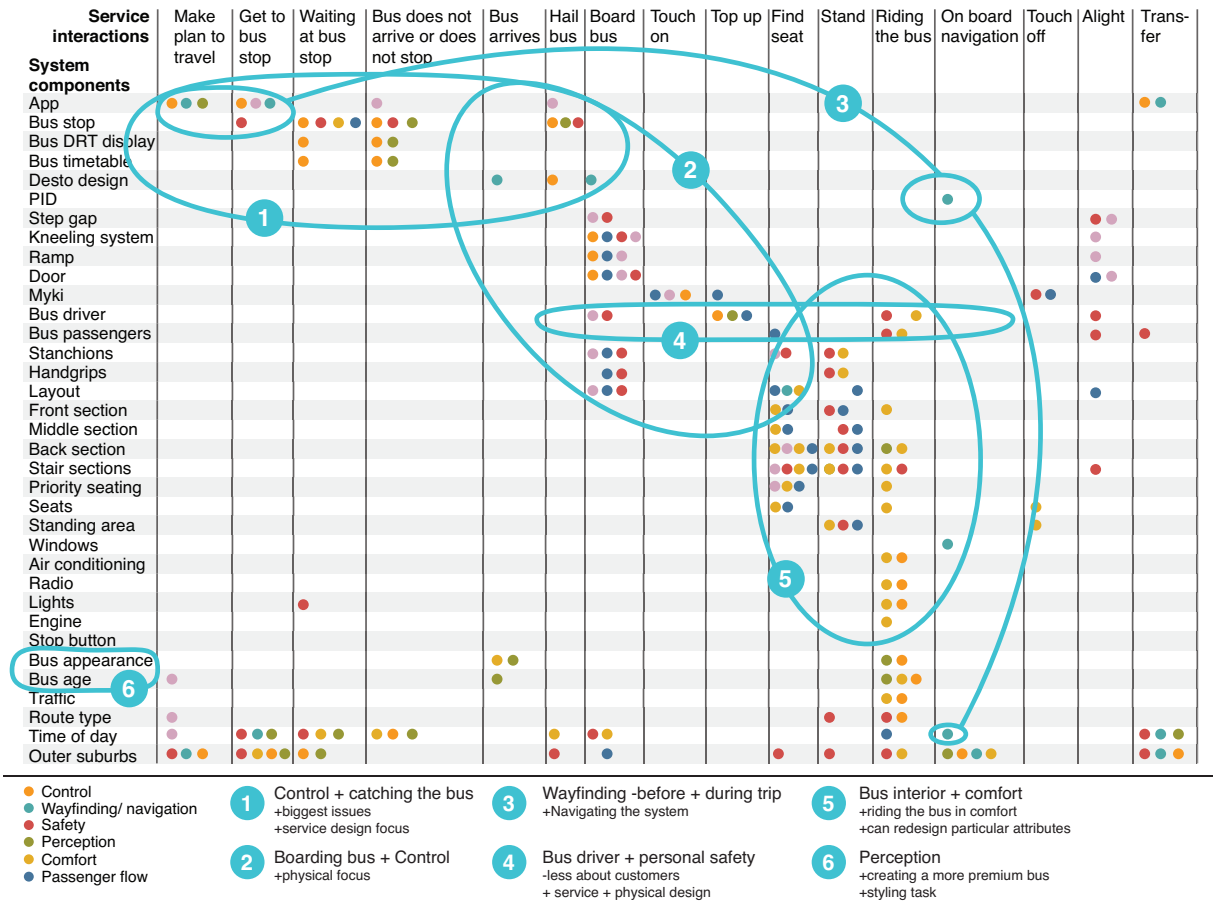


Figure 7.5: Matrix of potential areas design focus, see Section 4.4 for for larger diagram

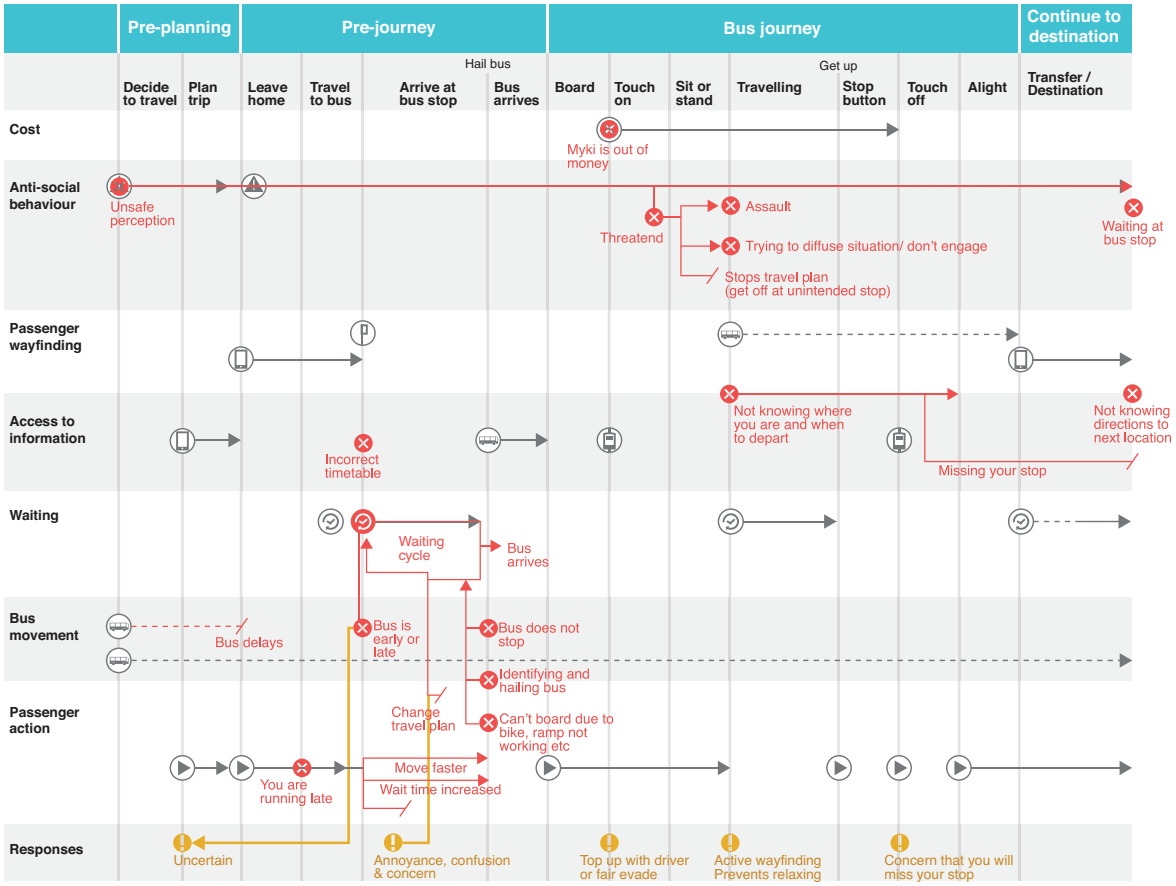


Figure 7.6: Control bus journey attributes and touchpoints, see Section 4.4 for larger diagram

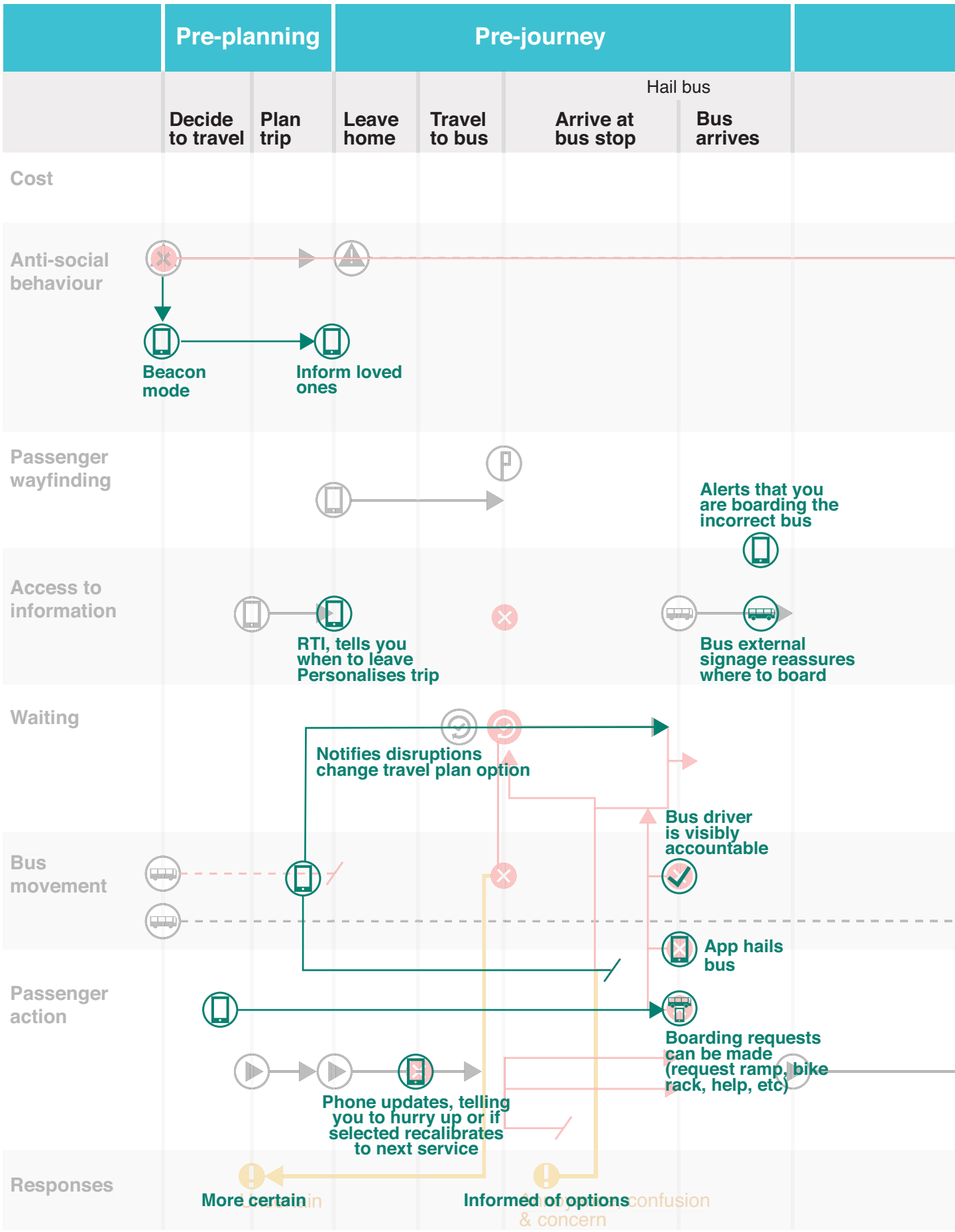
7.3 Sub 2: How can ethnographic methods be applied in design practice to develop user-centred bus services?

As mentioned in the last section and the methodology chapter (Chapter 3), a gap was found within the literature that identified a lack of evidence for how ethnographic methods could be applied to inform user centred design (UCD) processes within the bus context. An opportunity therefore presented itself to utilise a design-focused methodology and analyse how successfully it transferred to the bus field. A design-inclusive research methodology was chosen, as it provided a framework for design to be applied in other (bus) fields of study (Horváth 2007). Additionally, design ethnography methods supplemented the research framework in order to gather user-centred research by understanding users' needs, motivations and experiences on a deeper level (Steen 2011; Ventura 2011; Wasson 2000). The second subsidiary question allowed the benefits of design practice and design ethnography methods to be explored within a bus context. This enabled holistic, user-centred, novel research, as well as solution-based outputs.

The framework was undertaken in Chapters 4, 5 and 6. Each study focused on obtaining and reviewing human ecology based on travel behaviours, opinions and interaction points with the service and vehicle. The underlying focus on design targeted the data collection, which produced information that could be used to develop service improvement and design interventions. It also generated information that was more creative, streamlining the transformation from data to design. This was achieved by centring observations on interaction points, with a focus on iteration, as well as the inclusion of evocative tasks and questions surrounding specific design interventions and thoughts. These processes approached the subject areas in a creative manner, with participants helping to generate inventive responses and design suggestions. Transferring the holistic data collected into diagrams further synthesised the data into design outputs. This provided a clear structure for the service flow and interaction points, identifying areas of service failure and design focus. These service failures included control-based problems such as information, access, reliability and safety.

A disconnection between vehicle design and user insights, as well as limited formative user testing at early design stages, was identified as a current vehicle procurement issue during the literature review and within Chapter 6. Generally, Australian PT user testing is undertaken at later design stages and at higher fidelities, to provide visualisations for stakeholders and concept validation (Jehan 2018). Virtual reality (VR) was suggested and tested as a potential tool for encouraging early, low cost usability testing to take place, allowing user insights to inform design choices throughout the design process. VR usability testing allowed the designs and user behaviour to be observed through multiple alternative journey scenarios. This process provided a cost-effective tool for testing alternative travel environments, service failures and multiple large designs across time, allowing designs to more readily move towards more positive and user-centred design outputs. Such a process, if incorporated during vehicle procurement, could make a user-centred focus more readily available during earlier stages of the design and manufacturing process. This would help to bridge the gap between manufacturers and users identified in the Introduction.

Chapters 4, 5 and 6 are examples of how design ethnography methods including cultural probes, analytical approaches to customer feedback data analysis and to an extent usability testing can successfully provide a means of conducting user-centred, qualitative, design solution–focused research within the bus field. The link between the research and production of design solutions has strengthened this approach, providing a more streamlined means of communication, feedback loops and transfer of data. Furthermore, ethnography placed the user at the centre of the research, naturally influencing the design outcomes to be more user-centric at each stage of the project. This project by the methods used and project framing (Figure 7.2) suggests how a combination of ethnography and design can be used to encourage UCD within a bus context. Although outcomes were successful, it should be noted that this is only one example of a combined UCD methodology working within this field, with further tests required for validation.


Pre-planning
Pre-journey
Hail bus
Decide to travel
Plan trip
Leave home
Travel to bus
Arrive at bus stop
Bus arrives
Cost
Anti-social behaviour
Beacon mode
Inform loved ones
Passenger wayfinding
Alerts that you are boarding the incorrect bus
Access to information
RTI, tells you when to leave
Personalises trip
Bus external signage reassures where to board
Waiting
Notifies disruptions change travel plan option
Bus driver is visibly accountable
Bus movement
App hails bus
Passenger action
Boarding requests can be made (request ramp, bike rack, help, etc)
Phone updates, telling you to hurry up or if selected recalibrates to next service
Responses
More certain
Informed of options
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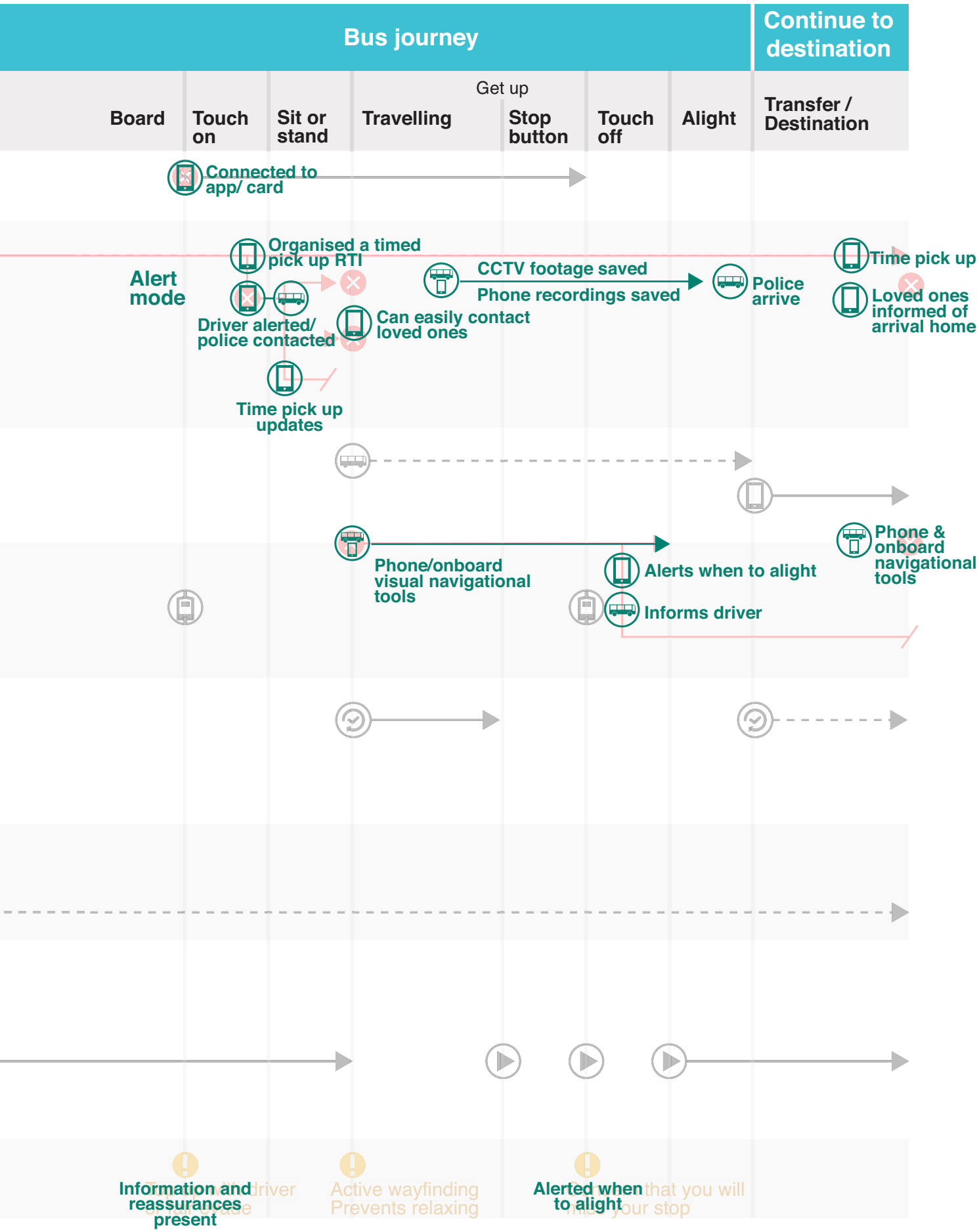

Figure 7.7: Design interventions mitigating control bus journey attributes and touchpoints

7.4 Sub 3: How can design practice be used to respond to the research findings and improve the bus user experience?

The third subsidiary research question was addressed in Chapters 5 and 6. The focus on the research topic of control and the need to redesign services to improve control-associated issues was developed from study findings detailed in Chapter 4. From this, a hypothesis was developed that the problems associated with control can be improved through design practice, resulting in better bus user experience. The findings highlighted the fundamental problems associated with the lack of control present within the system, causing access problems, uncertainty and negative perceptions among users. Holistic service and vehicle redesigns were established as a means of improving passenger control and therefore the usability of the system, providing an answer to the main research question and the initial research aims.

Practice-based methods commonly utilised in design including concept sketching, CAD modelling and service mapping were used to synthesise the knowledge collected within the iterative design process of idea generation, testing and refinement. These provided holistic service and vehicle outputs. Unity software facilitated this process and provided a means to assess the usability and flow of the combined vehicle and service designs, still within the iterative process. Usability testing using a VR headset provided a means of validating the suitability of the designs within an interactive, dynamic environment. This process allowed user testing to interweave within the design practice stage. Additionally, VR usability testing provided participants with an environment that allowed them to engage with both the vehicle and app redesigns, while requiring specific tasks such as bus travel to be undertaken. The testing highlighted failures within the designs and provided a platform for design critique, which produced feedback that was incorporated during the refinement stage.

Figure 7.6 (repeated from Section 4.4.3) is a representation of the control issues within the bus service. The figure identifies the points at which missing feedback loops occurred during the bus journey experience, leading to information and service failure as well as negative experiences. To respond to the problems identified in the figure, digital displays and apps, as well as bidirectional information chains, were developed to allow users to both inform and be informed by the bus service. These design outcomes allowed for a holistic redesign of the control problems, with Figure 7.7 representing through visual means the areas where design intervention occurred and the points where control gaps were filled. As the figure indicates, the majority of interventions occurred before a problem point, proactively working to reduce the problem before it became an issue, as opposed to the current reactive system. For example, the designs are not trying to make buses arrive on time; however, they equip passengers with information, such as delayed service updates and alternative travel plan options, to prevent passengers from feeling uncertain and falling into the waiting cycle. This figure, accompanied by the tables throughout Section 6.11, indicates the areas of design intervention. The points listed in the figure suggest areas of potential passenger experience improvement through service and design interventions.

Vehicle and service concepts generated from the previous studies and refined through the user-testing processes provided an answer to the third subsidiary research question. Unlike most transport projects, this project explored how bus user experience can be improved through virtual design interventions, by reimaging the vehicle and service to respond to user problems identified during the knowledge discovery stage. Using design processes, the topic of user experience was explored, with control identified as a main barrier to bus usage. Through app and vehicle integration, these problems were designed for and improved through the application of digital technologies and bidirectional – bus informs user, user informs bus – information channels. These designs focused on providing information and means of system engagement, equipping passengers with better understanding of service provision and the ability to more effectively control their journey experience. Figure 7.7 presents an overview of the improved design integration, overlaid on the specific control issues this

question intended to answer. This process allowed knowledge to be applied to create solutions to existing problems, helping to further understand and engage with user behaviour and positive bus experiences.

7.5 Project contribution

As established during initial topic exploration and literature review, this research has focused on answering and producing knowledge surrounding the main research question.

How can bus user experience in suburban environments be improved through design enquiry?

By successfully answering the three subsidiary research questions, the accumulated knowledge and design contributions produced by this research have formed an answer to the main research question.

Sub 1: What is the current bus experience like for Melbourne suburban bus users and what are their main concerns? Qualitative data established that low-density bus networks can be poorly experienced due to the uncertainty, lack of accessibility, safety perceptions and navigational problems the system produces which causes users to have a lack of perceived control over their journey experience. These main issues are exacerbated within these environments as less infrastructure and less frequent services cause heightened repercussions when problems occur, acting as barriers to use.

Sub 2: How can ethnographic methods be applied in design practice to develop user-centred bus services? Ethnographic methods including cultural probes, observations, analytical approaches to customer feedback data analysis and to an extent usability testing were applied within the design-inclusive research methodology to successfully conduct and encourage user-centred research and design responses. By undertaking this approach, the project allowed UCD to be applied at all stages of the bus design process.

Sub 3: How can design practice be used to respond to the research findings and improve the bus user experience? Unlike most transport projects, this project explored how bus user experience can be improved through physical design interventions, by reimaging the vehicle and service to respond to user problems identified during the knowledge discovery stage. Through app and vehicle integration, these problems were designed for and improved through the application of digital technologies and bidirectional – bus informs user, user informs bus – information channels. This process allowed knowledge to be applied to create solutions to existing problems, helping to further understand and engage with user behaviour and positive bus experiences.

Design enquiry provided the means to understand bus user experience within the suburban Melbourne context, identifying that user experience is currently being negatively influenced by the lack of perceived control the users have over the service. This understanding and project framing prompted design exploration and concept development to emerge, with creative solution based responses to the problems identified, resulting in improved user experience. The application of novel design processes and responses to the topic of bus user experience improvement has led to the development of three major contributions to bus and design knowledge. These contributions are presented below and in Figure 7.8:

1. Combined UCD framework and evidence applied within a Melbourne bus context.
2. Detailed representation of Melbourne's suburban bus user experience.
3. Bidirectional digital interface to enhance control experience for bus users within the Melbourne environment.

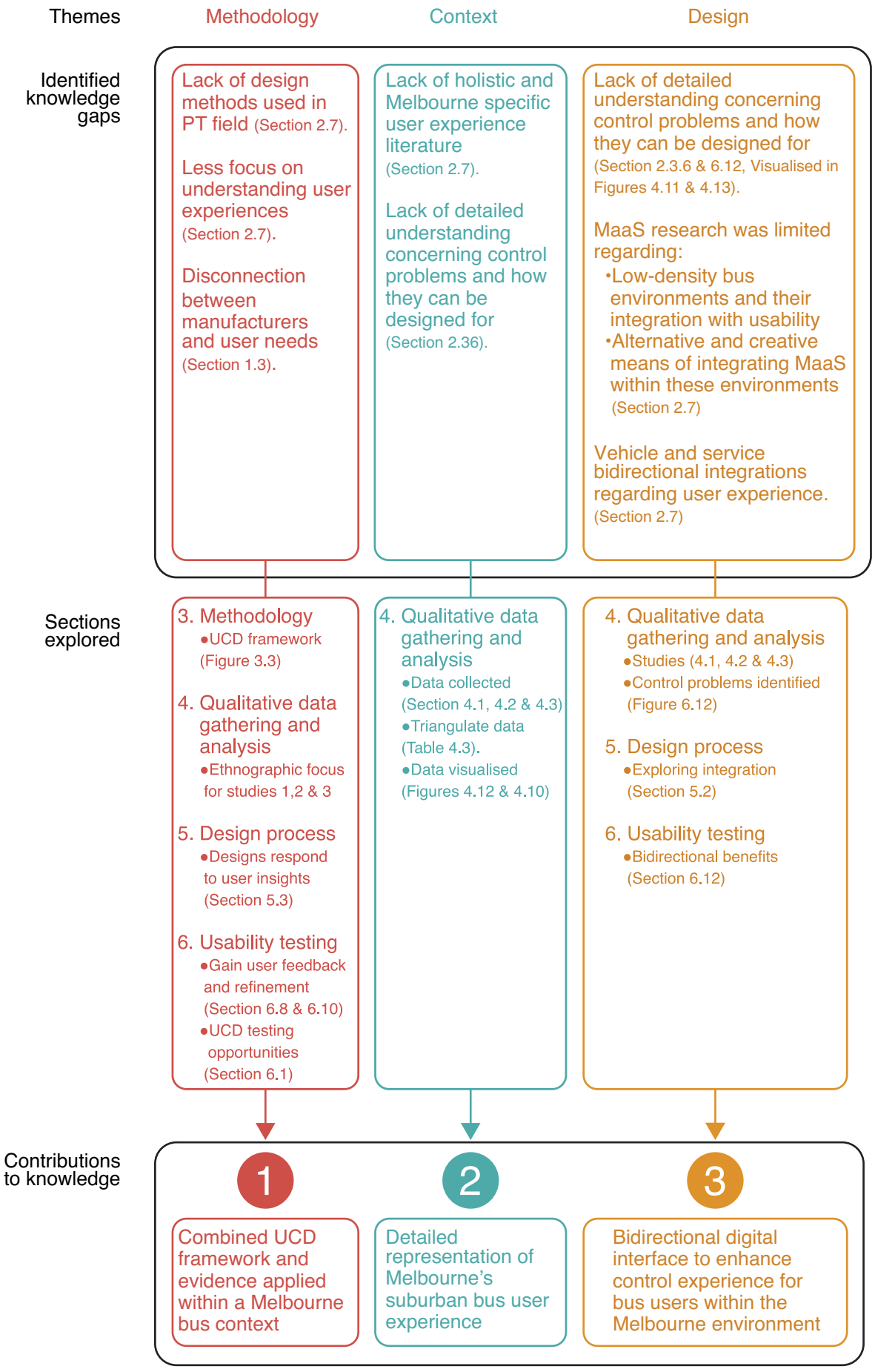

Figure 7.8: Contributions to knowledge explained

7.6 Research limitations and opportunities for future research

A number of limitations and future research opportunities regarding the research undertaken within this exegesis need to be raised and considered. The limitations discussed are products of scope, time, financial or technological constraints, and should be noted when reading this work.

Project scope was limited to the Melbourne suburban bus context as it was the main area of interest for the industry sponsors. This limited research scope, with problems and designs developed to be tailored to fit within this theme. The UCD methodology and designs presented here have the potential to improve other mobility modes and user experiences; however, further development and research needs to be undertaken. To help diversify the knowledge developed and place it within a usable context, future research needs to be undertaken to increase location understanding, mode integration, as well as demographic diversity such as the elderly. Similarly, due to research scope, rural bus networks were not mentioned during this project. Rural areas consist of unique PT systems, with similar low-density barriers and control issues. Rural PT networks might also benefit from this project's findings; however, further research needs to be undertaken.

Due to scope limitations, this project only focused on developing a control system in response to able-bodied, technologically savvy, bus users, recommending that diverse demographics need to be explored if designs are to be suitably integrated into the network. The reduction of driver contact and increase of passenger dependency and technology inclusion with bidirectional systems, is expected to be an increased barrier for the elderly when gaining transport information. It is unknown how these environments could be improved; however, they will need to be explored and resolved for passenger ease. Researchers such as Li and Voege (2017), are working to understand how mobile technologies and MaaS service can be implemented to improve mobility opportunities for the elderly.

The bus journeys observed during the second study were undertaken within Melbourne's eastern suburbs, centring around the Monash Clayton University and Chadstone shopping centre bus loops. The testing spanned multiple days during September, including both week days and weekends, peak and non-peak periods. The location and time period of the study were considered to be limitations, with some routes such as the 601 more likely to obtain a high proportion of university students. The study findings when compared against the customer feedback data did however show similar behaviour patterns.

Before the travel diary study commenced, limitations regarding small sample sizes were questioned by the researcher, as they can cause limited opinion. The study was considered appropriate as qualitative data was sought, which requires fewer participants before diminishing returns are seen (Mattelmäki 2006). A further limitation regarding participant distribution was also questioned by the researcher, as the travel diary and usability testing studies were unable to distribute diaries and tests to all bus user segments due to the enormity of demographic segmentation breakdown of PT. An even distribution across age, gender and service familiarity was instead sought as this was seen to provide more broad insight regarding passenger ability.

VR usability testing can be influenced by a multitude of biases and limitations, discussed in Chapter 6. Specific biases and limitations that affected this study consisted, firstly, of the excitement and positivity participants showed when using the VR tool, minimised by the use of a primer activity. Secondly, the technological capabilities of VR required the use of low-polygon environments, resulting in less realistic environments. This was used to the project's advantage, creating a space that encouraged alternative design discussions. Thirdly, due to technological limitations, latency was experienced multiple times during testing. Latency and other usability issues can contribute to participant bias and reduce the validity of the participants responses to the product they are testing. Fortunately, latency experienced during testing did not stop participants from undertaking

each scenario, as well as providing useful and thought-provoking feedback. The tests are catalyst of conversation. This helped to mitigate the associated biases, as the testing was designed to elicit concept discussion, rather than designed exclusively for determining the product functionality. If design usability by technologically impaired demographics such as the elderly is required, alternative methodology needs to be developed to help increase usability. Wallergård and Johansson (2008), suggest methodologies for using VR tools for testing people with cognitive disabilities within PT environments, and provide a framework for future testing. Future testing in general needs to consider inherent biases and methods for achieving designed outcomes.

From the development of this research, five main areas have been identified for future research. Firstly, this project identified gaps within the literature, including: the limited number of design methods used to understand bus user experiences; the lack of specific, context-based research; and the lack of design investigation of bidirectional information channels. To respond to these gaps the research focused on the development of holistic information regarding passenger perceptions, behaviours and experiences concerning vehicle and service usage. This resulted in the eventual redesign of a narrow set of problem concerns. The matrix (Figure 7.5) featured in Section 4.4.2 lists multiple potential avenues for redesign, all of which are based within a research foundation and are seen as problematic areas within the bus system. Any area within this matrix can be considered suitable for future design development with the following list representing possible examples. Physical threat of antisocial behaviour throughout journey; how the vehicle form can help reduce perceived safety concerns; comfort throughout whole journey; ticketing systems; boarding accessibility and control issues regarding diverse demographics. Secondly, the designs developed within this project are expressed as concepts, suggesting possible solutions to improve the lack of control experienced within the network. Further conversation discussing the designs, as well as further development, is required to manufacture and integrate the concepts. Thirdly, during initial research stages it was noted that user and manufacturer communication was limited, as was the transfer of qualitative user-centred data into the manufacturing process. The development of a system to integrate manufacturers with design ethnography processes is a potential future focus that could drive bus UCD. Fourthly, the designs are predominantly based on smartphones and digital technology, which could result in access issues for non-users of smartphones or people with restricted ability to use smartphones. Further research should be undertaken to understand how lack-of-control issues can be improved for such users. Lastly, further development concerning the testing of alternative future scenarios through ethnographic means is required for improvement of design testing results. This is an exciting new area of study, with VR user testing becoming more prominent. Developing more processes to achieve such goals could simplify and so encourage qualitative usability testing within this industry. Researchers such as Salvatore and Christina (2008) are exploring methodologies and evaluation techniques of VR environments.

7.7 Conclusion

This project used design enquiry to establish bus travel behaviours and key usability problems within the suburban Melbourne landscape and has aimed to solve selected problems identified through UCD processes. This has led to the successful answering of the main research question, *How can bus user experience in suburban environments be improved through design enquiry?*

Identified during the literature review, there are limited examples present of how design enquiry can be used to supplement the vehicle and service design processes within the PT fields. By applying design enquiry to the transport field the complex bus environments and existing problems, contexts, and user behaviours and motivations can be understood and synthesised holistically. This knowledge informs concepts and helped to produce user-centred solutions and service innovations. By answering the research question, this project demonstrated a UCD framework (Figure 7.2) for how operators and designers within the PT field can develop more user-focused bus services and vehicles. The work

highlighted key usability problems, travel behaviours and motivations within the suburban Melbourne context and how they can be responded to through novel design solutions.

Initial review of the literature identified limited evidence of UCD methods used within the PT field, as well as a lack of holistic understanding concerning suburban bus user experiences. Three design ethnographic studies were undertaken in response, resulting in the identification of passenger behaviours, perceptions and concerns regarding the bus system. This information was synthesised into holistic journey maps (Figure 10,11,12 & 13), noting all passenger interaction points and potential areas of design intervention. These results allowed Melbourne suburban bus user experience to be catalogued holistically, providing new understandings regarding user experiences. From this process, a lack of perceived control was identified as a main contributor to dissatisfaction among bus users, which resulted in control being chosen as the design focus.

The design process allowed identified problems to be responded to through novel and creative solutions. For example, the application of bidirectional digital interfaces allowed new opportunities for information chains to be explored within low-density environments, an area that was identified as limited during the literature review. Not all implementations were considered novel, but were transferred from existing fields to transportation to improve the problems associated with control. Through these solutions, attributes causing the lack of control have been negated, with design responses focused on informing and empowering users during their journeys. This has led to proposals for an improved experience that are identified in Figure 7.7. Virtual reality was used as an evaluation tool, which encouraged formative user evaluation to be undertaken at earlier design stages. This is suggested as a way to incorporate user insights during the vehicle procurement processes which was identified to be limited during the literature review. The design outcomes presented utilise both service and industrial design practices, tackling the problems associated with control in an integrated and holistic manner. The development of digital interventions consisting of an app and bus PIDs includes features concerning information provision, journey planning and navigation, safety features, feedback loops and travel location sharing.

In summary, the application of novel design processes and responses to the topic of bus user experience improvement has led to the development of three major contributions to bus design knowledge:

1. *Combined UCD framework and evidence applied within a Melbourne bus context.*
2. *Detailed representation of Melbourne's suburban bus user experience.*
3. *Bidirectional digital interface to enhance control experience for bus users within the Melbourne environment.*

These contributions to knowledge have been built from existing literature knowledge and developed based on the study findings and synthesis. This research has demonstrated how user experiences, perspectives and interactions can be understood and improved through design research and interventions.

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Appendix A: Customer satisfaction report

The CSM (Wallis 2017) is produced annually, highlighting the successes and failures of the public transport industry. The report documents how bus attributes are performing, comparing performance rates of all operators, PT modes and previous years, as well as ranking attributes in level of importance for both the operator and passengers. The report creates an overview of the issues and concerns within the bus experience, encouraging areas of focus for operators to develop more improved services.

A brief overview of this report shows that the majority of vehicle performance attributes were found to fit within the scoring range of 70–79% satisfactory, with design, space, comfort and ticketing categories following this specific trend. Information provisions such as access to information was also viewed positively, averaging 72%, however information regarding unplanned service disruptions was considered unsatisfactory, 44.1%. Personal safety satisfaction fluctuated, receiving as 83% score for safety during the day and 68% for safety during the dark. Lastly, driver attributes were the most satisfactory attributes 81.8%. The table below shows the results from another section of the report, scoring the attribute importance for the operators and passengers.

Table: A1: Customer satisfaction

CSM Attributes	Performance rating		CSM Attributes	Performance rating
Comfort (satisfaction with design, space and comfort)	77.5		Information	72.2
Comfort of seats	75		PTV app (quality of info)	80.2
Access	79.1		PTV call centre	79.7
Temperature in winter	78.2		PTV website	75.7
Temperature in summer	75.4		Bus company's websites	79.4
Lighting	79.6		Timetables at stops (ease of reading and understanding)	79.1
Cleanliness	77.6		Timetables at stops (up to date printed)	71.2
Graffiti	75.2		Timetables at stops (Electronic displays)	74.6
Damage to seats, fittings and windows	75.8		Availability of info for planned disruptions	61.4
Crowding	76.9		Availability of info for unplanned disruptions	44.1
Smooth ride (jerk/bump)	73.6		Availability of carry-around timetables	53.8
Ticketing	71.8		Personal safety	
Ease of understanding myki system	70.3		on buses, during the day	83
Ease of topping up myki when needed	76		on buses, after dark	68.2
Sufficient places to top up myki	72.2		At bus stops, during the day	82.2
Ease of touching on and off	76.4		At bus stops, after dark	64

Satisfaction with price of bus	72.7		Presence/ visibility of security cameras on buses	64
Driver	81.8		Presence of staff (not including bus driver)	61.7
Courteous and helpful	81		Ability to call for assistance	68.2
Provision of useful info	80.7			
Easy to understand	80.6			
Safe and smooth driving	78.5			

CSM Categories	**Satisfaction drivers**	**Priority**
Info	4	Low priority
Bus stop	5	Low priority
Price	5	Low priority
Myki ticketing	5	Low priority
Design, space, and comfort	9	Maintain and grow
Running of service	38	High priority
Personal security	24	Maintain and grow
Drivers	9	Maintain and grow
Authorised officers		Maintain

Appendix B: Observations study explanatory statement

EXPLANATORY STATEMENT

Project: Public transport observations

Dr Robbie Napper
Department of Design
Phone:_____
email: _____

Sarah Roberts
Phone:_____
email: _____

Thank you for taking the time to consider participating in this study. My name is Sarah Roberts and I am a PhD student within the Monash Art, Design and Architecture faculty. I am currently conducting research into bus user experience, exploring user behaviours and interactions whilst catching the bus. This explanatory statement sets out how this research is being conducted and why it is being done. If you would like further information regarding any aspect of this project, you are encouraged to contact me via the phone number or email address listed above.

What does the research involve?
This project seeks to explore how people interact with the bus vehicle and service, as well as at bus stops. Particular focus is paid to how people board and alight the vehicle, how they interact with the interior environment, where passengers sit and stand, as well as the type of activities they engage with whilst travelling. The aim of this study is to better understand how people use the bus environment, and use that information to develop buses that better suit passenger needs.
Involvement in this research requires no direct input from participants, as the researcher will record – via notetaking – people in the course of their ordinary day. In order for the behavioural observations to be unbiased and authentic, it is a requirement of this method that participants are not aware that they are being observed. Since most participants will be unaware of the activity, steps are being taken to protect the identities. These steps include the researcher not asking for personal information and not taking photos or videos.

Why were you chosen for this research?
You were chosen for this study simply by engaging in bus travel, and by chance were part of this particular observation session. You are welcome to request that you are excluded from this study and any notes discussing your travel behaviour will be deleted. Children are not observed and will be excluded from this study.

Source of funding

This research has been sponsored by Transdev Melbourne and Monash university as part of the Sustainable and Effective Public Transport: Graduate Research Industry Program (SEPT-GRIP)

Consenting to participate in the project and withdrawing from the research
You are under no obligation to participate in this research and have the right to withdraw with no implications to you. You may also choose to withdraw data that you provided at any stage of the research. If you choose to withdraw data from the study, then any verbal responses identifiable as your own will be removed from the research.
Possible benefits and risks to participants
Your participation in this research may lead to better-informed bus vehicle and service designs. This may enhance your own, as well as others' mobility experience when choosing to commute using the bus. It will also contribute to the greater wealth of mobility and design knowledge across the broader transport community.

Confidentiality
No personal details will be created in this research. It is hoped that the study results will be published in a conference, journal and/or thesis, if so, no personal information will be included in the publication. All data will be de identified prior to publication.
Storage of data
Digital material will be kept on a computer only accessible by password on the Monash network. Physical material will be kept inside a locked draw, in a room with key card access that is permanently locked. Robbie Napper, Sarah Roberts, Selby Coxon and Ilya Fridman will be the only ones to have access to the raw data. After the data is no longer required it will be either deleted or destroyed

Results
If you would like to be informed of the research outcomes, please contact Sarah Roberts on 0409974128 or email sarah.roberts@monash.edu

Complaints
Should you have any concerns or complaints about the conduct of the project, you are welcome to contact the Executive Officer, Monash University Human Research Ethics (MUHREC):

Executive Officer
Monash University Human Research Ethics Committee (MUHREC) Room 111, Chancellery Building E, 24 Sports Walk, Clayton Campus, Research Office, Monash University VIC 3800

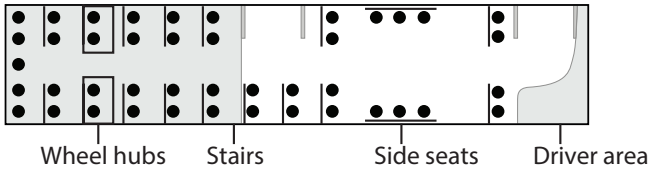
Tel: _____ Email: _____ Fax: _____

Thank you,
Robbie Napper

Appendix C: Observations raw data

Key

- Seated people
- Standing
- Pram
- Bag or trolley
- Observer position
- Direction facing

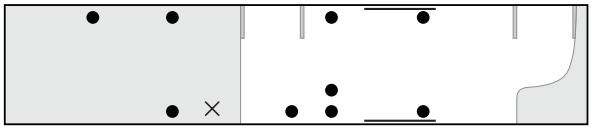


Trip	Data	Location	Bus Route	Time boarded and alighted	Familiar of unfamiliar journey	Weather conditions
1	17/09/2019	Monash University, Caulfield	601 to Huntingdale	6.30pm - 8.37pm	Familiar	24° Dark outside

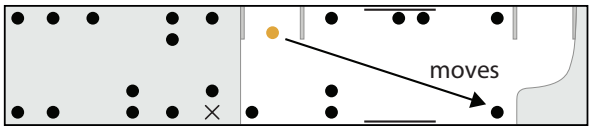
- It was dark outside and I was leaving uni.
- Bus was already there when I arrived at the bus loop, boarded the bus and sat in priority area
- The bus started before someone could be seated,
- Signage working
- 10 people on board the bus with 4 standing- it was a short journey
- 7 people where on phones, 5 with headphones
- Most of the standing people were on their phones or listening to music. They all leaned against some sort or railing or stanchion.
- The seated passengers were difficult to see and they were all behind me
- The bus was light inside (bright yellow lights) but outside was difficult to see due to the darkness.
- People near the myki machine touched off before we arrived at the stop. They then stood in anticipation of leaving.
- The bus stopped and everyone alighted. Most through the back door
- People started running for the train station. This indicated to me that the train was going to arrive very soon and I started running as well. The train arrived as I approached the platform and I would have missed it if it wasn't for the other passengers running. The wait would have been over 10 minutes because of the time of night.

2	19/09/2019	Monash University, Caulfield	700 to Rowville	8.13am - 8.50pm	Familiar	Sunny 23°

- Bus stop includes multiple signs along a span of 3 bus lengths. It is difficult to know exactly where to stand to wait for bus. 1 bus is at the stop, but there is no driver present. Passengers are spread throughout the different the length of the stop waiting for the bus.
- Bus driver arrives, turned bus on and people begin to board.



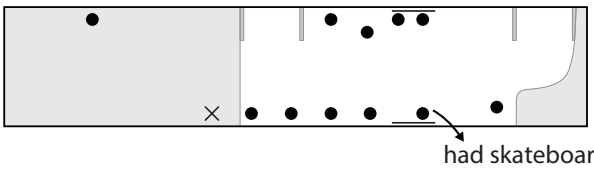
- Sign audio not working
- Myki machine took a few moments to turn on, this held up boarding as passengers waited
- First group of people to board sat in the front area.
- The door closed and had to be reopened to let another person on board (they were running toward the bus). Once boarded the person used the front seat to organise themselves (placed bag on seat found myki, touched on). This appeared more difficult as the driver began the trip whilst they were undertaking the task which jostled them.
- The bus is very rattly in the stair section. This was unnoticed until the bus started moving
- Activities taking place by passengers whilst onboard include, people listening to music, talking, looking out the window and eating.
- At minor stop, someone was running for the bus, the bus stopped abruptly to let them board.
- The majority of passengers alighted at Chadstone. People yelled thank you to the driver from both front and middle doors. I stayed on the bus



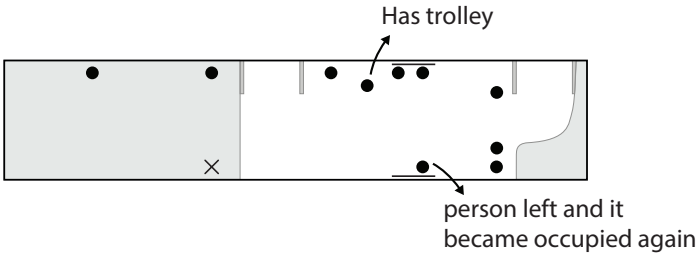
- Everyone who boarded appeared younger than 30
- Passengers were listening to music, on their phones (if not using still had in hand), talking (multi lingual),
- The bus route took multiple winding and small side streets, made it difficult to keep bearings. Made the bus rattle.
- 5 passengers have bags on seats next to them or on their lap
- Someone boarded and asked driver a question and then alighted immediately
- Only 5 passengers boarded from minor stops
- Nobody was standing during the trip
- Only one person sat in longitudinal seating
- Bus was making funny noises throughout the trip
- Someone boarded and needed to top up their myki, it only took 10 seconds for the interaction to happen
- Arrived at Clayton bus loop and observer departed

3	19/09/2019	Monash University, Clayton	703 to Middle Brighton	8.58am - 9.32am	Unfamiliar	Sunny 23°

- Boarding at minor stops 9
- Alighting at minor stops 8
- Walked over to the bus 703 bus stop and the bus arrived momentarily
- Passengers yelled out thank you to the bus driver as they alighted from the back door.
- Waited in line and boarded the bus from front door, sat down
- At least three bags were placed on seats next to passengers



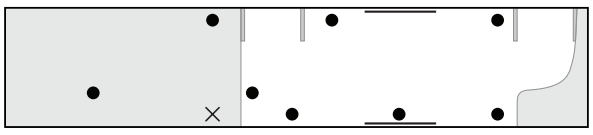
- People were either on their phones or listening to music.
- The majority of people sitting in the back seats were seen alighting at Clayton, leaving the bus majoritively empty towards the back of the bus
- Audio and signage was working
- One passenger boarded and was unable to sit down before the bus left the stop. Passenger grabbed the stanchion next to them (wheel hub) for support.
- A Passenger reached to press the stop button located behind them. They didn't appear to look for it, just knew it was located there.
- Nearing the train station and passengers begin to get ready to alight before the bus stops (picking up bags, touching off myki).



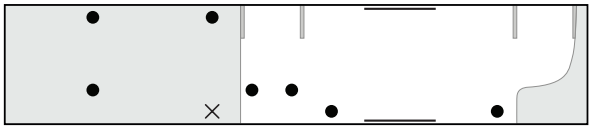
- At the approaching bus stop, a waiting elderly lady stood and then sat back down. It is guessed that she realised that this was not her bus.
- The radio is on very quietly
- Conversations on mobile (multilingual) is occuring
- Women at a minor bus stop shook their head towards the bus driver, indicating that this was not her bus, the bus drove on.
- The bus stopped quickly (traffic), a seated passenger grabbed a stanchion near them for extra support
- A boarding passenger topped up their myki through the bus driver
- A boarding mobility impaired passenger had to move quickly (appeared to exert energy) to catch up to the bus (had a cane). They then used both door handles to pull themselves onto the bus (same for alighting). They sat in the front seat. Didn't have to move far to get on and off the bus.
- Someone is looking at the PTV app on their phone during the trip
- A lady got up out of her seat and touched off before the bus arrived at the stop. She then sat close to the door in anticipation of alighting.
- The observer alighted the bus at Bentleigh station, exiting from the back door, with a group of other passengers.

4	19/09/2019	Bentleigh station	703 to Blackburn	9.34am-9.57am	Unfamiliar	Sunny 23°

- To catch the bus, I had to cross the road and find a bus stop. This was easy as it was close to the station, easily sign posted and there were people standing around waiting, acting as further visual indicators.
- The group of passengers including myself were waiting for the bus to arrive, we were standing around the stop sign, once the bus arrived the group merged to form an orderly queue
- Arriving at the bus stop I passed a man that was unkempt, I felt weary of the man, when the bus arrived they walked across and lined up behind myself, more closely than I would have liked.
- A lady with a walker alighted the bus from the front door a little roughly. Did not fall over, no one went to help her (although she didn't appear to need it).



- Boarded bus and touched on, and found a seat.
- The unkempt man sat in the front seat and announced his presence to the bus. He then spoke to the driver loudly about the rapture and how the driver would be saved for the service he was providing. This continued for the length of man's trip 3-6 minutes.
- The man told the driver when he wanted to alight (as opposed to pressing the button). The driver stopped and the man continued his conversation taking a minute to depart the bus.
- A man boarded (same stop) and sat in the unkempt man's old place. He joked to the driver about the situation that had just occurred, making jokes that he was a better passenger and then discussed the weather. The man leaned forward toward the drive during the conversation, holding onto the stanchion.
- A passenger waited until the moment the bus left one stop to press the button for the next stop. This gave them more time to stand up, and get ready to alight (they had a walker).
- The man having the conversation with the driver told him when he wanted to alight. Once alighted, the bus appeared to pick up speed. The driver ran a red light



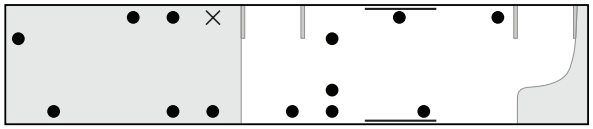
- Alight 5
- Board 8
- 2 passengers had bags on seats
- People boarded at a minor stop, and the driver waited until they had touched on, but not sat down before driving away.
- The bus was really jerky and fast. Someone almost tripped up the stairs, whilst trying to find a seat, but was saved by grabbing a stanchion for balance.
- The speed felt like the driver was trying to make up for lost time.
- The bus stopped at a random location. Both doors were opened (left opened) and dust from an empty car park blew onto the bus.
- The driver asked if anyone had any rubbish, one person responded and the driver approached them with a plastic bag, they put the rubbish in the bin.
- Driver turned the radio on and then alighted the bus. It was a bus driver change over, this was not announced, no one looked concerned, and people continued looking at their phones.
- We waited stationary for 5 minutes, in that time another driver boarded. He was doing paperwork at the front of the bus.
- Someone else boarded and asked the driver for directions. The driver responded and the person hopped off.
- Audio on bus was very quiet
- Arrived and alighted at Clayton station

5	19/09/2019	Clayton station	704 to Oakleigh	10.06am - 10.21am	Unfamiliar	Sunny 23°

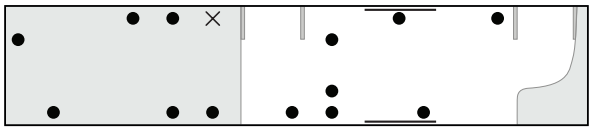
- Can't see PID at the bus stop, due to the bus stop walls being in the way. (built up bus stop)
- The sign shows the bus that has already left
- An unexpected bus turned up (was not indicated) at the same time as my bus. I had to walk down further to board my bus.
- Boarded the bus and had to squeeze passed an older passenger with a walker in the middle of the bus who was slow at alighting. Hadn't realised they were there when I boarded, otherwise I would have waited.
- The bus smelled of onions
- The bus was empty
- There was no signage onboard
- Bus stopped at Oakleigh station and the driver alighted to walk around and stretch his legs.
- The bus then drove back the way we had come.
- The bus zig zagged down random suburban streets and the observer became disorientated. I am unfamiliar with this route and where the bus was supposed to be going.
- Exited the bus at Huntingdale railway station. I was the only person on board and pressed the button to alight. This but took side streets but essentially followed the train line from one station to another.
- Walked from one bus stop to 601 location. The bus was already there, but I wasn't alarmed as the bus is very frequent.
- Someone alighted the bus at the backdoor but when I approached the driver shut the door, making me walk to the front to board.

6	19/09/2019	Monash Universty, Clayton bus loop	703 to Blackburn	10.33am-10.56am	Unfamiliar	Sunny 23°

- Arrived at stop 3 minutes early, however the bus was 5 minutes late. The researcher was not anxious about this, however did notice they were looking at the count down timer and adjacent buses more often.
- Boarded bus, touched on and found seat
- The onboard signage and ticketing system were working

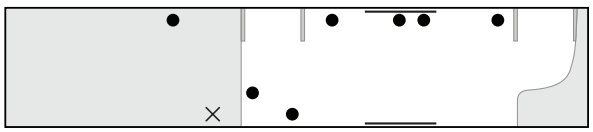


- All patrons were considered under the age of 30
- The route taken had larger trees on the side of the road, with their shadows flicking across the windows. This created harsh and moving shadows onboard, making focusing on writing difficult. This made the research feel ill.
- Driver stopped at various minor stops to let passengers board and alight.
- Older person boarded at a minor stop (above 50). Driver waited until they were seated before continuing driving. Despite this the person held stanchions and hand grips continuously until they reached the middle of the bus and sat down.
- Lady sitting near the bus stop button, when the bus driver immediately leaves one stop she pressed the button for the next stop. They appeared to be waiting for this in anticipation. NOTE: this appears to be a more common action by elderly bus users.
- Passengers have been observed to thank the driver from both front and middle doors.
- Conversations between bus passengers are multilingual.
- A person boarded sat down in middle seats, organized themselves and went to touch on, this didn't appear to work, but they returned to their seat
- I alighted the bus at Burwood highway, with the majority of the bus. Didn't need to press the button.
- Further observations, the route had not been undertaken by the researcher before, and they were therefore unaware of an appropriate stop to depart. The bus route ran relatively straight and it was easy to navigate their location without the help of google maps (google maps was still used). The university origin point and time of day could have affected passenger age.
- Boarded 8, Alighted 8



7	19/09/2019	Burwood highway	735 to Boxhill	11.07- 11.31	Unfamiliar	Sunny 23°

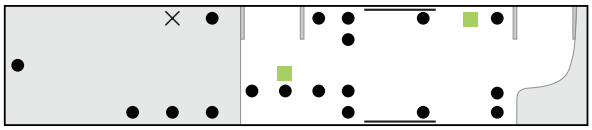
- Used citymapper to find where the bus stop location was. It was on side of highway, had to walk over to it
- No smart screen, only pole in ground and bus shelter
- 4 people (including the observer) waiting for the bus.
- A waiting person walked up and double checked the sign because multiple minutes (3-5) had passed.
- The bus arrived
- A lady pushed in front of me to board the bus, she had a trolley
- Really friendly driver. Greeted everyone who boarded and myself with a huge smile and welcome.
- For every passenger that would board, the bus driver would greet them enthusiastically, and then they would smile and continue their boarding process whilst smiling. It made the bus trip feel more enjoyable
- The radio was on and the driver whistled to the radio throughout the journey



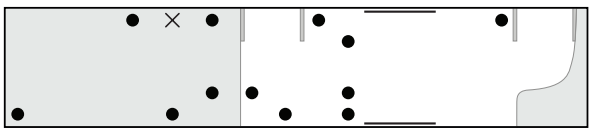
- No signage on board
- Arevo posters were present onboard bus
- The driver waited until passengers were seated before driving away
- An elderly couple boarded at a minor stop with a trolley. They held stanchions and rails near the seats to help them sit down. Sat in the priority area
- Tree shadows flickered on the bus, plus the windy roads made it difficult to write
- Board 7
- Alight 6
- Mixed group of ages on board
- Bilingual passengers, multiple bags on seats
- Someone boarded and couldn't work myki, the driver helped them do this. Then identifying that they didn't have enough money and topped up their myki
- The bus was dirty, chips and an apple core were on ground. Dirt scattered throughout
- Alighted bus and thanked driver at Box hill station. Other people alighted and I did not need to press stop button

8	19/09/2019	Boxhill station	903 to Mordialloc	11.37am-12.10pm	Unfamiliar	Sunny 23°

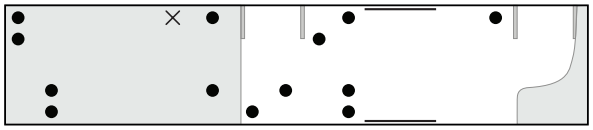
- Alighted at box hill station, due to the layout of the station, I didn't know where my bus was. Ran to stop (after checking city mapper for location), thinking I was going to miss the bus, but actually had plenty of time. (I ended up changing stop, when the sign indicated I had a 15 minute wait).
- The bus loop makes it really difficult to know what bus to catch and where it is leaving from. I saw two people changing stop locations, I did this 3 times.
- The city mapper app helped by displaying what buses are located where.
- Get to another suitable bus stop. Waited 5 minutes and boarded the bus when it arrived.



- Numerous people boarded, passengers lined up, orderly.
- Sign and audio were working on board
- Person was sitting next to the bus driver giving him directions (guessed this was a training exercise)
- A person sitting in the priority seated area stood and walked up to the bus driver, whilst the vehicle was in motion. She asked the driver how far away her stop was (limited language used). The driver consulted with the trainer, and the trainer informed her that there were a few stops to go and offered to tell her when they arrived. She then sat in the front right seat and placed her numerous bags in the aisle as opposed to the storage area that was next to her.
- The trainer indicated to the lady that her stop was approaching, she started to get ready and the driver pulled up at a minor stop and she alighted. During this interaction she didn't need to press the stop button
- Alighting person had to ask for the backdoor to be opened so they were able to alight. The door hit the person as it opened. Minor stop
- Activities taking place by passengers, reading, on phone, staring out window
- Someone boarded and the driver started driving before passenger had time to sit
- Boarding 11, Alighting 15
- Mix of people boarding and alighting. The bus generally maintained its level of fullness.
- Driver had to reverse to avoid being hit by a truck at a traffic light and was then told off by instructure.
- Signage displayed next stop and someone was observed to be searching for the stop button. Once they found it behind them, they pressed it.
- Person alighting hopped off the bus and then pulled their trolley down to the ground.
- 2 people boarded from the front and 2 additional people boarded from the back. Person struggled with myki machine
- Desto sign was glitching, couldn't read full stop names
- Passenger pressed stop button as soon as bus started

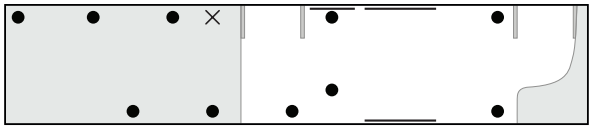


- Person at the back door had to indicate to the driver to open the back door. This place might be difficult to see for the driver, with the particular placement of standing passengers.
- People boarding asked the driver if the bus went to chadstone. The driver responded and they boarded.
- The distribution of the demographic of this bus was elderly and females near the front of the bus and young men towards the back.
- Alighted bus at Chadstone.



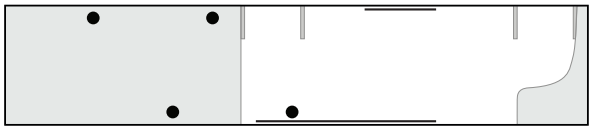
9	19/09/2019	Chadstone shopping center	900 to Rowville	12.14pm-12.29pm	Familiar	Sunny 23°

- I knew where the bus I wanted to catch was located, walked over to it and it was scheduled to arrive in 4 minutes. It was ontime.
- Bus arrived, boarded it with several other passengers
- Onboard signage was broken, it read nonsense
- Radio was playing
- Bags are on seats next to passengers
- Activities being undertaken by users headphones and using phones
- The driver honked his horn aggressively and it looked like there was almost a collision between the bus and a car. The honk startled me and appeared to startle other passengers.



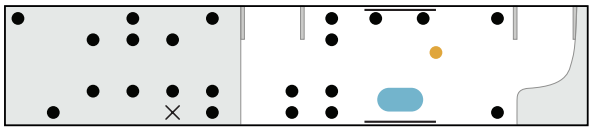
10	19/09/2019	Huntingdale	601 huntingdale shuttle	12.32pm-12.37pm	Familiar	Sunny 23°

- Alighted at huntingdale railway station. Pressed stop button
- Walked over to bus stop
- When the bus aligns with the trains arrival it is very full, with passengers lined up to board. When the bus does not align with the train it is relatively empty.
- This bus did not align with the train and felt like a wasted service.
- 2 passengers were on their phones. Nothing was unusual so I looked out the window
- Arrived at Clayton

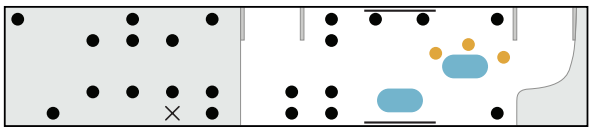


11	19/09/2019	Clayton bus loop	733 Middle Brighton	1.53pm-2.03pm	Familiar	Sunny 23°

- Departed bus
- Someone ran for Blackburn bus, the bus' doors were closed, but the driver opened them letting the person board. Once boarded the bus drove away.
- I arrived at the bus stop a minute late. I didn't see the bus drive away, and the bus stop signage indicated that the bus was 2 minutes away. I was unsure if the bus was running late, if it had already arrived or if the bus stop signage was incorrect. After a few minutes the bus stop countdown disappeared. The bus must have left earlier. I decided to change my travel plan and catch an alternative bus, that was going in the same direction.



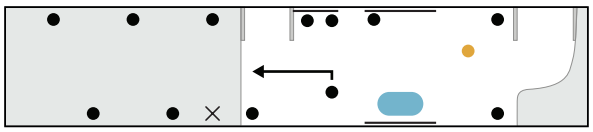
- Layout comment- The bus caught was running late and was full when boarded. The bus after this service, which was observed to arrive at the stop directly after this bus departed, was empty. If passengers had divided themselves between services it would have been a more comfortable journey, with less standing passengers (bus bunching, discussed in CFD)
- Someone with a pram was using the priority area
- At the bus loop when the bus arrived, people waiting at a different stop (across the rd), ran over to catch this service (it must have been an alternative bus for them, also going to the train station (location they alighted)).
- Person tried to top up myki with a credit card. The bus driver said that you should know you can't do this by now. He said it in a stern and somewhat rude way.
- A second lady boarded with a pram and stood in the walkway between wheel hubs, only available spot. An older man in the priority area tried to give up his seat but the lady declined.
- 2 people standing although there are seats free towards the back of the bus. They can't get to them because of the pram location.The pram user therefore had to stand near the wheel hub section. This acted as a catchment point for anyone boarding the bus, resulting in a passenger standing between the pram and the driver, instead of moving past and sitting on one of the many available seats (researcher's notes).



- The bus is very stuffy and full of vibrations towards the back. Making me feel queasy
- The majority of people alighted at the train station
- Someone by a window seat had to climb over another passenger to alight the bus
- After alighting a few people used the bench at the stop to gather their belongings and reorganise before moving.
- Elderly getting off, hold the bus door handle whilst stepping off the bus for support.
- I alighted the bus as well at Clayton central.

12	19/09/2019	Clayton central	703	2.06pm-2.21pm	Familiar	Sunny 23°

- At bus stop 6 people were waiting at the bus stop, 4 of the people were on their phones and listing to music, 1 person had 3 bags of full groceries, the other passenger had a pram, with groceries attached to the handles. Someone moved out of the priority area so it became free for the pram user. Person was not verbally prompted
- Whilst boarding lady with pram turned and asked the person behind them if the bus was going to the correct stop (did not ask the driver, although they were right in front of them). This lengthened the boarding process. No one complained. She received a confirmation from the person behind them and continued to board
- Observer received a compliment from a stranger as they boarded. Felt a little strange about it, and was happy when the person didn't follow them down to the back of the bus or try and continue the conversation
- The bus left the stop. The lady in the priority section with the pram was getting her bags ready and the pram

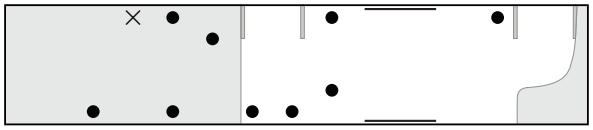


fell over. 2 people rushed forwards to help right the pram.

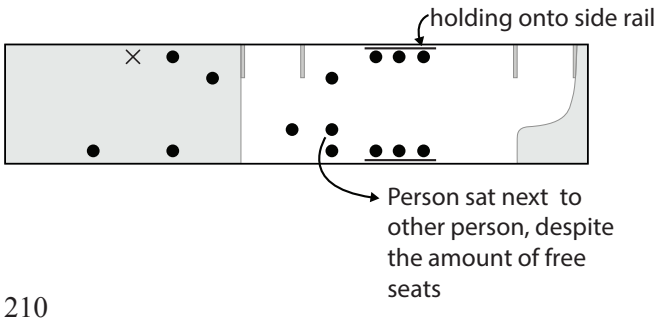
- Elderly man had his fingers placed over the stop button for several seconds before he decided it was the appropriate time to press it.
- Really loud beeping when the doors closed
- Boarding passengers 3, Alighting passenger 1
- The wayfinding audio was coming through all speakers not just the front ones
- Lady with the pram took a little while to alight, but the driver noticed and waited. She only began to move when the bus stopped, and alighted from the front door.
- Someone moved from the left side to the right side of the bus (the same seat). The sun might have been the cause as it was streaming through the left side windows. She then took her coat off once she had moved.
- The wheel hub makes it difficult to stand and alight the bus, I struggled to get myself and my bag out of the location.
- Arrived at clayton bus loop and alighted
- Bus loop is very large with specific information presented at the different stops
- 2 people walking around looking at printed signage trying to determine which stop to wait at. They were seen looking between their phones and signage until they confirmed (outloud) that it was the correct stop.
- Sun also appeared to play a part in this encounter with their hands shading the glare from their phones. No PIDs were present, just a printed timetable.
- Without the count down timer, it feels like the bus is taking longer than it should to arrive

13	19/09/2019	Clayton bus loop	802 to Chadstone	2.30pm-2.50pm	Unfamiliar	Sunny 23°

- At the stop, once the bus appeared in the distance, people began to stand and move towards the stop (this helped to indicate that the bus was arriving). At this point someone stood up and walked to the other 802 stop which ran in the alternative direction
- Boarded bus
- The bus is air conditioned, feels less stuffy than the other buses caught previously



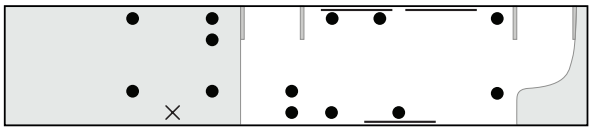
- Someone is doing their makeup onboard
- 5 out of 8 people have phone in hand
- Someone talking on phone
- Signage is not working
- Bus desto sign said it was going to chadstone via oakleigh, but it took a surprisingly (to the researcher) different route to get there
- Bus stopped at Oakleigh. Due to the long bus stop, a group of passengers at the stop had to see the bus arrive and then walk over to it.
- Someone boarded, put their backpack down in the seat and then went back to touch on.
- The majority of passengers are sitting on the shaded side of the bus. It is a warm day with the sun shining through the windows. This could be a coincidence though



- Alight 2 board 1
- Someone went to stand and their friend indicated not yet and they sat back down
- Alighted bus with the majority of passengers at chadstone, exited the back door.

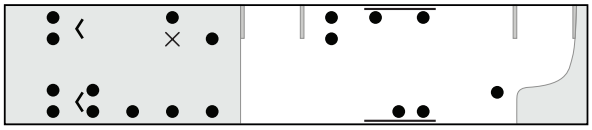
14	19/09/2019	Chadstone bus loop	900 Studpark	3.55pm-3.19pm	Familiar	Sunny 23°

- Walked over and boarded bus
- The bus is cold, no driver present, was just sitting at the stop



- Coming from Chadstone there appears to be a lot more pairs of people than other routes taken. Less mobiles used and more talking
- The signage does not appear to be working
- 2 people touch off before we arrived at the stop
- 2 people started talking to a guy 2 seats in front, to help the interaction he positioned himself sideways. Based on conversation these people did not know each other
- Person took their shoes off and rested their feet against a privacy panel.
- Bus arrived at Clayton and I alighted.

15	19/09/2019	Clayton Monash university	Middle Brighton	3.20pm-3.33pm	Unfamiliar	Sunny 23°

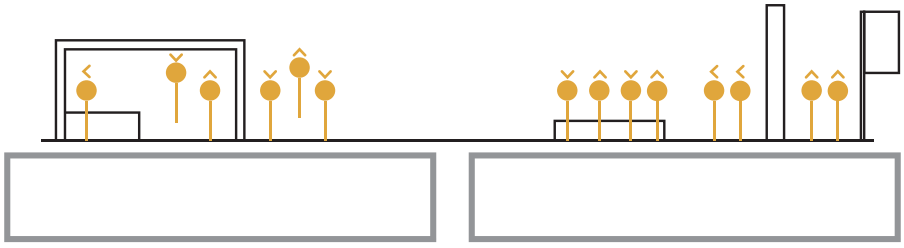


Seats facing backwards

- Bus was already at stop, walked over and boarded
- Air conditioned
- People talking to each other. 6 people on their phones
- 1 person has eyes closed and might be falling asleep
- 6 bags can be seen on chairs
- Signage not working. There is audio, but you can't hear over people talking and the bus rattling
- Bus stopped. Person standing in the doorway checked to see if anyone was alighting, he then moved out of the alighting passengers way and then moved back into the doorway.
- Alighting 2 boarding 4
- 2 boarding passengers made sure their friends were on before finding a seat. Waited at the front of the bus, to the side so other people could walk passed.
- Clayton. Had to move so the person next to me could alight. Most people alighted bus here as well.
- 3.33- person boarded the wrong bus, they asked the driver if it went to Monash, he said no.
- Alighted bus at the next stop
- Crossed the road

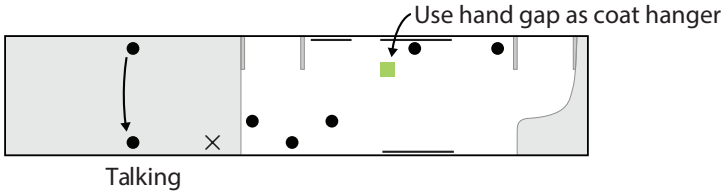
16	19/09/2019	Clayton central	704 Oakleigh	3.39pm-3.56pm	Unfamiliar	Sunny 23°

- Bus arrived, the bus is very empty
- The bus does a small loop around the train station to turn around. An older man on the bus did the whole loop before alighting (this could be so he didn't have to walk as far to his destination, or didn't know that it would have been faster to alight earlier
- Very uneventful tip. No one else boarded



17	19/09/2019	Clayton central	630	3.56pm-4.00pm	Unfamiliar	Sunny 23°

- Boarded 1 alighted 2
- After boarding the bus, it stayed at the stop for 5-10 minutes. During this time someone was observed to run for the bus. This turned out to be unnecessary as the bus didn't leave straight away
- Arrived at Monash bus loop, nothing notable happened during the trip
- After exiting 2 people were seen running for the mid Brighton bus. This ended up being unnecessary as the bus stayed there for several more minutes



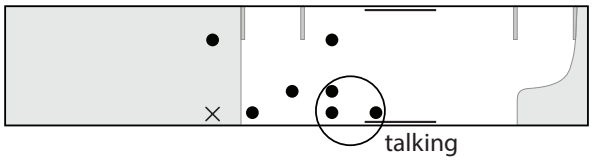
18	19/09/2019	Clayton bus loop	730 Blackburn	4.10pm-4.46pm	Unfamiliar	Sunny 23°

- The bus was 15 minutes late (making the amount of people boarding larger)
- All seats were taken
- 1 standing passenger brought a large model on board, they stood near the storage area so they were close to where it was being stored. He then held onto stanchions with one hand free for texting
- Air con is on
- 2 people with trolleys
- At least 8 people have bags on laps
- At least 8 people are using phones
- Driver listening to radio- audible
- Information signs are working
- Someone had to stand up and lean over someone to press the stop button. They didn't ask for help.
- At stop, no audio feedback, just flashing next stop sign.
- Bus started before boarding passengers could sit, causing them to grab a hand grab
- Bus stop- someone was standing rather close to the road and waved the bus down. Once on board they had to squeeze by someone standing to get a seat.
- This time of day the sun is shining directly into longitudinal passengers' eyes. One of them is seen shading eyes with hands.
- Person stood up during traffic and grabbed onto a grab handle, they then skipped along to the next one (had stuff in other hand), this looked funny compared to regular walking movement

- Person alighting tried to touch off myki, they had a couple of goes but didn't seem to be working.
- I pressed the stop button, it was right in front of me
- I alighted the next stop and it turns out the myki reader was broken and I could not touch off (worked when I touched on though).
- Walked across rd to board other bus

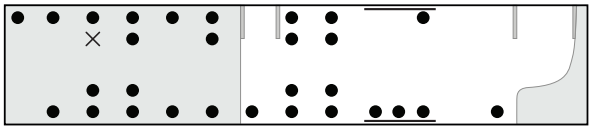
19	19/09/2019	Pinewood shopping center	703 Mid Brighton	4.15pm-5.19pm	Unfamiliar	Sunny 23°

- Arrived and the 4.41 bus stop sign was on 1 minute. I thought of myself as really lucky, as I had not checked the time.
- The stop faced away from the road- clear glass, so the rd was visible
- 2 people waited at stop, as time increased 9 people ended up waiting
- The bus was 20 minutes late
- Bus was essentially empty once it arrived,
- The myki machine at the front isn't working causing passengers to use the second door myki machine. This then caused disrupted passenger flow as passengers touched on and wanted to move by everyone to sit at the front of the bus.
- This almost caused someone to fall over as someone touched on and turned around quickly to retrace their steps.
- The next stop, minor, someone ran for the bus and thanked the driver when he stopped and waited for them to arrived
- I alighted at clayton

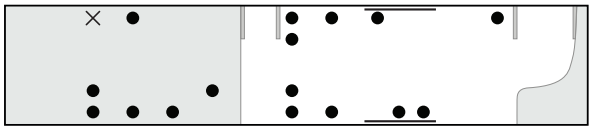


20	19/09/2019	Clayton bus loop	900 Caulfield	5.25pm-6.05pm	Familiar	Sunny 23°

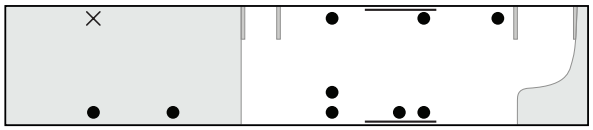
- Walked over to stop, didn't have to wait long
- Signage- audio- both very clear
- Bus is pretty full, no one is standing though



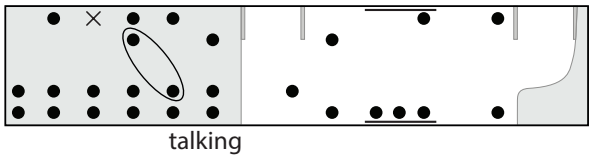
- Bags are mainly on laps
- Some aisle seated passengers have placed legs in aisle to allow more leg room
- 2 people are talking, everyone else is on phone or doing nothing
- Alight1
- Boarding 5
- 1 standing passenger is leaning against stanchion. There is an empty seat right next to her
- Most people alight at train station



- Women boarded, waited standing in priority zone until friend caught up with her, they then sat down together
- After Oakleigh



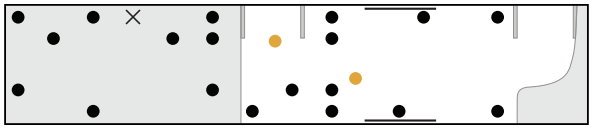
- After Chadstone



- Person with crutch sat in the priority area
- The front section was the first to become full.
- Bus became more talkative, although a number of passengers are still on phones
- Bus interior lights were on, this made the bus feel more open, easier to see signage
- Signage is broken, missing half the name
- The lights dim during travel, mood lighting
- Car almost hit bus- horn honked from the bus
- Alight 2, boarding 2
- Audio only triggers for major stops
- Alight bus at the stop,

21	20/09/2019	Caulfield	900 to Rowville	4.02pm-4.20pm	Familiar	Sunny 26°, Warm day

- New day
- Left work and arrived at the bus stop - I did not check the bus time prior and had to wait 13 minutes. I could have left my office slightly later, instead of waiting outside.
- The bus sign repeated the earlier bus departure time for 4 minutes, after the bus had departed.
- The next bus arrived and I boarded
- The bus interior was uncomfortably hot and stuffy. It felt like the heaters were left on and it made me feel ill. It was already a warm day
- I moved through the bus, noting that the back was more unpleasant with less of a breeze than the front. Despite this, I sat in the middle so I could observe the bus better.
- Person after me asked the driver if they could top up their myki with cash. Driver said yes and did this for them. The person then did not touch on their myki and found a seat
- Next passenger to board asked driver if the bus went to x (towards rowville), driver confirmed and passenger boarded
- Person with walking stick sat in priority area
- Door closed and had to be reopened for passengers, they asked if this bus went to X, and the driver confirmed.
- The passengers did not have time to sit down before the bus left the stop

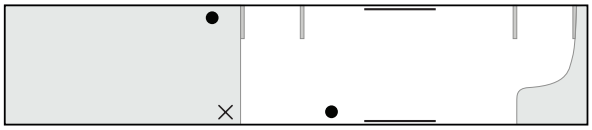


- At least 10 passengers are using their phones
- Storage area is not being used even though priority seat users have several shopping bags.
- The signage is not working
- The bus jerk accompanied by the heat is making me feel sick
- An older lady had to move from her seat to allow the person they were sitting next to to get up and alight. The bus came to a complete stop before she moved.
- Boarding 2 alighting 1
- Multilingual conversations
- Person sat and put backpack on in preparation of alighting

- When the bus arrived at chadstone, every person on board alighted through front and back doors.
- Someone waiting to board the service, asked someone alighting if this was x bus and went to x. They confirmed that it was.
- Two girls were seen boarding and then alighting the bus in quick succession. They were over heard saying that the bus was too warm
- Person was seen running for the bus. Doors were closed but were reopened on their approach.
- Another person was also seen running for the bus. The bus did not immediately leave when they boarded.

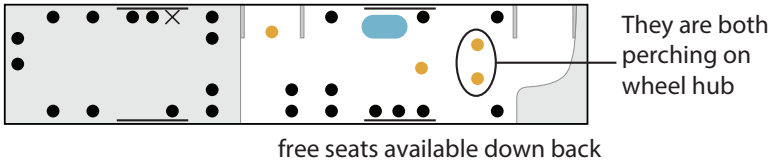
22	20/09/2019	Chadstone	624	4.30pm-4.35pm	Unfamiliar	Sunny 26°, Warm day

- Lady was waiting at the bus stop. When the bus arrived she boarded and spoke to the driver, who said she was on the wrong bus. And had to go to the other side of the bus loop. She responded by saying that she had already been over there and was told by someone else that she needed to catch this bus. She then said that she had been waiting a while for this bus to arrive. She departed the bus and was seen talking to another man who indicated for her to go back to the location she was previously waiting and she did.
- When the lady was speaking with the bus driver, she was taking up a large portion of the walk way. The first person squeezed passed her, but the person after waited, causing boarding to slow. Only three passengers boarded so it didn't cause any delays.
- The bus was mostly empty and nothing notable happened
- I pressed stop button and alighted
- Walked across road to catch other bus



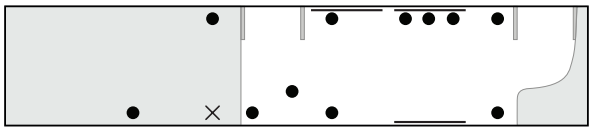
23	20/09/2019	Holmesglen	To Mordiallac	4.42pm	Unfamiliar	Sunny 26°, Warm day

- Alternative bus interior
- Bus was somewhat full when boarding
- Lady alighted with trolley, she got assistance from other passengers on board
- Person appears to be asleep
- Someone is using both hands to hold two sets of hand grips, everyone else is using stanchions
- 1 more person boards, they use hand grips
- Someone is reading, only few people are listening to music or on their phones
- The bus is dark and hot in the back section due to the full advertisement on both sides of the windows.
- There are free seats down the back of the bus, but people are standing in the front section.
- Departed bus, with majority of people



24	20/09/2019	Chadstone	900 to Rowville	4.50pm-5.18pm	Familiar	Sunny 26°, Warm day

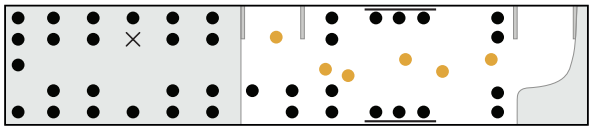
- Someone was alighting with a pram. Person waiting for the bus helped them alight by lifting the front of the pram and placing it onto the ground
- Person topped up myki with the bus driver's help. Boarding passenger wait until she has finished to board
- Bus interior signage not working
- The majority of passengers alighted bus at chadstone, making it relatively empty for the new passengers



- A lady moved from her seat to the driver area (during transit) and told the driver that she needed to go to caulfield and confirmed that she was on the wrong bus (the conversation was very polite).
  - The lady had luggage and was less mobile (she left luggage in the priority area as she spoke to the driver
  - The driver told her that once at Oakleigh she needed to catch the 900 bus on the other side of the road (this would retrace her steps and deliver her to caulfield). NOTE: The bus was stopped at the train station and it would have been faster and potentially easier for the lady to catch the train to Caulfield instead of the bus. It is interesting that some passengers within the network are restricted to driver knowledge during moments of uncertainty.
  - The lady was then observed alighting the bus, running across the road with her luggage to the wrong bus stop sign. She then looked at the sign and her phone (43 seconds) and then ran after the bus that just arrived. This bus also did not go to Caulfield and she would have ended up in the wrong location again.
- During the journey someone pressed the stop button and stood by the driver door. They had 2 minutes waiting until the bus arrived at the stop. They held the stanchion and the seat grip for stability.
- Board 2 alight 5
- Activities on board: reading and listing to music
- A guy was sitting at a bus stop. The bus slowed down and tooted the man. The guy looked up but gave no response. The driver continued
- There are rattling noises coming from above my head, they are really loud and distracting
- Person pressed button even through we arrived at a main stop
- I alighted

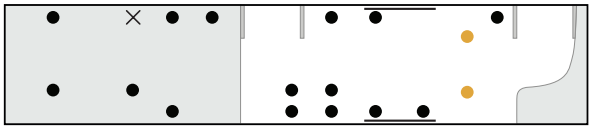
25	20/09/2019	Monash Clayton bus loop	703	5.26pm-5.51pm	Unfamiliar	Sunny 26°, Warm day

- At the bus loop, someone sprinted for the bus, which made additional people run for it. This was observed whilst on the bus
- The bus became full very quickly at the bus loop.
- A person stood in 2nd door zone and was told by the driver to move back
- Standees near the staired section were looking for seating at the back of the vehicle, but did not venture beyond the stairs.



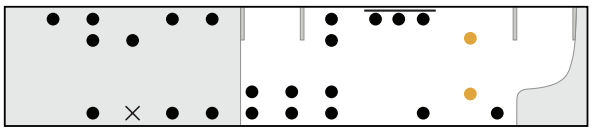
- Bus drove over a traffic light line and had to reverse back
- Most standees are clustered around stanchions, only 2 people are using the grab handles
- Person sitting in an aisle seat had a spare seat next to them. They did not let any of the standees take the seat though. She stayed looking at her phone.
- Signage is working, audio is not

- Person next to me indicated that they wanted to alight the bus by shuffling their bag. So I moved.
- Two people during alighting said thank you from the back door,
- Although the bus has emptied out. Two people remain standing, they both then alighted at the next stop, along with myself



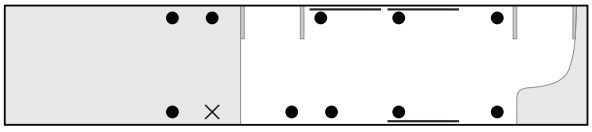
26	20/09/2019	Clayton rd	703 to Blackburn	5.45pm-5.57pm	Familiar	Sunny 26°, Warm day

- Someone seen periodically looking between PID and phone.
- You can tell when the bus should be arriving as people begin to move near the bus arrival location
- 1 bus arrived, and another one directly after. The second bus was more difficult to see.
- Sign was working, bus is cold and the floor is sticky
- Board 3, alight 8
- Immediately after leaving the stop the stop button was pressed.
- Person was going to board the bus with luggage, but then realised it was the wrong bus
- 4 passengers are standing around the front wheel hubs. This is creating a catchment zone, where people are struggling to move past it to find a seat. They are seen maneuvering through the crowd to the back of the bus.
- The only seats that are free are towards the back.
- Alighted bus at major stop with the majority of bus passengers.

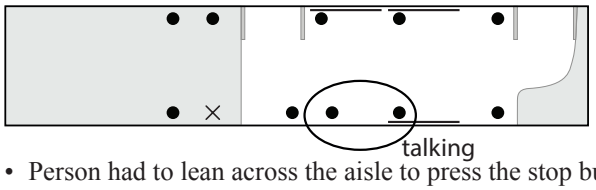


27	20/09/2019	Monash bus loop Clayton	900	6.10pm-6.35pm	Familiar	Sunny 26°, Warm day

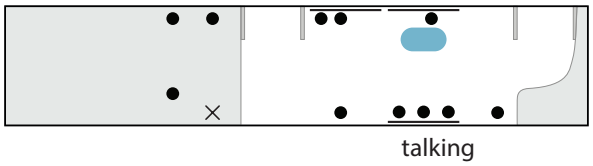
- Arrived at bus stop, bus arrived shortly after
- Lady with mobility issues tried to board, and couldn't step up onto the bus. She then placed her myki in her mouth and pulled herself up using both door rails. She then talked to the driver about topping up myki. She had two large bags with her, which blocked the path of other boarding passengers. People just waited behind her to board, it didn't take long. I boarded after
- When the doors open, they tell people to touch on (automated)
- The bus is dark, with blue lights inside the interior. Does not feel welcoming
- The signage is not working



- Board 4
- Alight 6
- People at minor bus stop see bus approaching, they stand and walk to where the bus door will arrive
- Person boarded and sat down in the priority zone, they then organised themselves, found their myki and went to touch on.

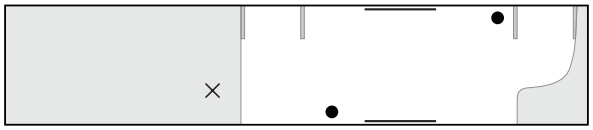


- Person had to lean across the aisle to press the stop button
- It would be difficult to read a book with these light conditions. They also make it difficult to write
- Oakleigh, lady boarded with pram and myki in her mouth. This allowed her hands to be free to push the pram. Only noticed this after she had touched on
- Alighted bus at Chadstone



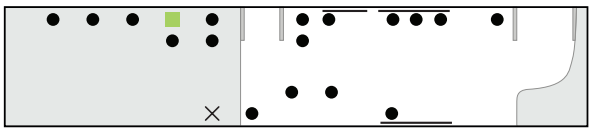
28	20/09/2019	Chadstone	822 to Murrumbeena	6.38pm-6.45pm	Unfamiliar	Sunny 26°, Warm day

- Alighted 900. I knew which bus I had to catch based on the PTV journey planner, but did not know where it was located. I had to go to the front of the bus loop and check the wayfinding signage. Only one of the possible buses I could catch was present on the signage. The bus was located two stops behind the bus I had just alighted. I had to retrace my steps. Noticed that the bus was already there, unaware of what time the bus left I made a run for it. This was unnecessary as the bus stayed sitting for another 5 minutes. Bus has lights on within the interior
- Didn't previously check the bus times and thought I was lucky that the bus happened to be waiting there
- No signage, which is annoying as I have to alight at an unfamiliar, minor stop, in the dark (difficult to see that I am at the right location).
- I used active wayfinding on my phone (city mapper) instead, this was straight forward and made navigation easy.
- Pressed button and alighted. The bus stop and surrounding area was not lit, and I couldn't really see where the stop was until the bus pulled over. This would make wayfinding difficult if it wasn't for my app.
- I was meeting with a friend, but the bus arrived earlier than expected and I missed texting them to organise meeting at the bus stop to walk to another location. I walked to their house and then to the other location instead which wasted time. Note this only happened once during this study but multiple times during the initial study.

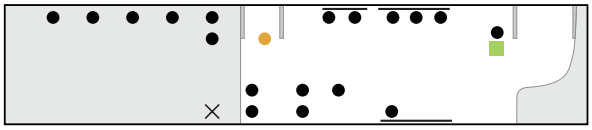


29	21/09/2019 Saturday	Caulfield	900 to Rowville	10.15am-10.40am	Familiar	Sunny 26°, Warm day

- New day
- 5 min before bus arrived people started to arrive at the stop (3 people waiting before 5 minute mark, 11 people at 5 minute mark)
- On board the bus, the front myki machine was broken. The driver encouraged people to move down and touch on the second reader. This caused a bottle neck for passengers who wanted to sit near the front



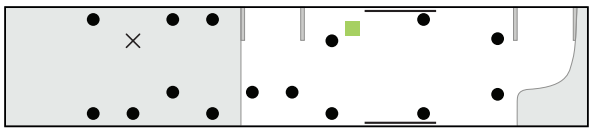
- Sign was working
- 5 people with phones- all appear young adults
- Someone was eating a yogurt
- Alight 1 board 8



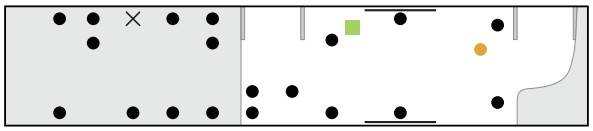
- Someone in front section had myki and moved towards back section to touch on, half way they must have changed their mind and turned around and sat at the front of the bus
- Person with a walker sat at the very front of the bus, people had to squeeze past the walker to get on board (it was placed on the ground in the walkway). Slowed boarding
- 10.40 chadstone loop most people alighted including the researcher.
- A man was seen crossing the bus loop and walked up to a driver's window (he was standing on the road) asked the driver somethinge (in audible), waved and walked back across the road. This felt unsafe.

30	21/09/2019 Saturday	Chadstone bus loop	903 Altona	11.00am-11.30am	Unfamiliar	Wet and cloudy cold, 16°

- At the bus loop, someone alighted the bus, walked toward the bus timetable (pole) read it, then proceeded into chadstone. They might have been checking departure times for later.
- Person was looking at bus map and then at phone
- 903 bus to altona arrived, boarded
- Person walking around looking for bus stop- the signage does not appear to be helping them, looks at names on buses instead
- Boarding, someone had to top up their myki, this halted people boarding.
- A lady offered to let me board the bus before her.
- First female driver I have seen during these observations
- Signage worked
- Someone is facetiming whilst on board
- Demographic for bus is older- middle aged users
- Bus number clearly labelled inside. All the information on buses is different and located in different places, makes it confusing
- Board 1
- Alight 7
- Minor stop, the bus went by the stop and the waiting person had to walk over to it. They had some trouble touching on and sat in the priority area.
- Door shut before the man had time to get off, he yelled out and the driver re opened the door.
- It started to rain
- Every second stop people were boarding
- Older lady stood, everyone else found a seat. The lady alighted after two stops
- Two passengers boarded the bus from a minor stop along the route. The young woman sat on an aisle seat next to the second door and the young man sat in the spare seat in the wheel hub section. The male was showing boisterous behaviour as he boarded the bus and moved down to the back section, swinging from handrails and hand grabs in the process. Once seated he tried to strike up conversations with surrounding passengers to no avail. Four minutes into the journey the male got back up and moved to stand in the second door area, opposite the young woman he had boarded with. He was trying to make conversation with her (leaning on the stanchions and moving closer to her), she was trying to ignore him looking at her phone. At this stage, I thought of intervening but didn't know if they did know each other as they boarded at the same location, as well as not knowing what to actually do in this situation.

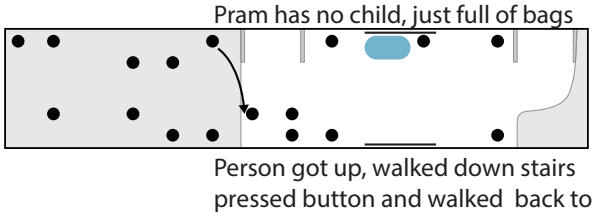


- At the next stop, multiple people alighted from the back door, during this process the man had to step away from the door and move to the priority section to let the people past. During this moment, the woman hopped off the bus with the other passengers and walked briskly behind them. At this point man also jumped off the bus walking beside her briskly trying to have a conversation, with exaggerated hand gestures.
- Bus pulled passed the two, the woman tried to turn and walk in the opposite direction as the man but he kept jumping in front of her. By this stage the other passengers who had alighted with them had moved on. The researcher had stayed on the bus for the whole encounter and was troubled by not knowing what to do and if it was appropriate to interject during the situation. It looked like the woman was uncomfortable for the whole encounter but again it was difficult to determine. No other bus passengers appeared to respond to the incident.
- Person at the minor stopped waved, and the bus pulled up. Hey had to squeeze through the bus and shelter to board.
- Most stops have one person waiting at them
- Older lady scanned both sides of priority seats before she decided to sit down on the left side
- Box hill shopping center 11.30
- At stop a full mordialloc bus arrived. The walkway was narrow and a full load of passengers both wanted to board and alight at the same time. People were everywhere. The driver also had to put ramp down for a wheelchair user to board during this time, which added to the poor passenger flow.



31	21/09/2019 Saturday	Boxhill shopping centre	733 to Oakleigh	12.00pm-12.45pm	Unfamiliar	Wet and cloudy cold, 16°

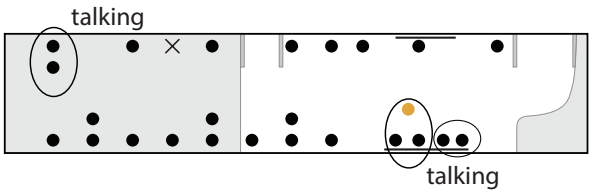
- Bus arrived
- Alighting lady swung trolley to get it up the horizontal gap and onto the bus, someone looked like they were going to assist, but the lady with the trolley had everything under control. Once boarded she proceeded to touch on and find seat.
- Older chinese man walked up to the driver saying the name Clayton 3 times, the driver said yes and the man touched on. The myki machine didn't register the myki the first two times. The man smiled and laughed in my direction when it did not work.
- NOTE: This type of reassurance with the driver appears to be a common occurrence. People already have the necessary information to make it to the correct bus at the right time, however they need the reassurance that it is the correct bus.
- Onboard someone is reading a newspaper, taking up the whole seat to do so. The bus is only moderately full so this doesn't affect anyone
- It is raining heavily outside, hard to see out the windows, the bus has its lights on. The grey and openness of the the interior does not make the bus feel cozy or comfortable.



- The bus arrived at a stop with a significant vertical gap. An older lady with a shopping cart wished to depart. She walked to the edge of the door, holding the hand grab and lifted her shopping cart off the bus (this took some effort as the ground was low). Once on the ground, she then proceeded to step down slowly, using the handrail and the shopping cart on the ground for support.
- 2 people in front of me realised they were getting wet because the access hatch was open. They asked politely

if I could close the window above them as it could also let water in. I obliged, not realising it was open. They would have gotten wet once the bus had left the shelter.
- The bus air con and radio are on
- The bus passed someone waiting at the bus stop with a bike. They did not hail the bus, they could have been sheltering from the rain
- Older users on the bus- only two are observed using phones.
- 1 person is on a laptop
- Someone is sitting in the middle of bench seats, even though they are 2 seat designs
- In location behind second door, an elderly man stood and walked down stairs to press stop button
- Later in the journey another passenger in the same location had to perform the same action. Due to the bumpiness of the route and the stairs, the observer was concerned that they might fall. Once the button was pressed they sat back down. At the next stop, the bus stopped, the passenger stood and walked to the driver and told them no it was the next stop, this happened twice. During this encounter the passenger stood and continued to speak with the driver. He continued to talk even after we arrived at his stop.
- Another passenger had to stretch across the aisle whilst holding on to press a stop button.
- A person was perching in the wheel hub area and placed a duffle bag in the luggage rack. They only went two stops
- Person with a pram began to stand in the priority section with their hand on the stop button, looking forward so she could tell when to press the stop button. They alighted at the back door. The pram was pushed off first and became caught in wet grass. The lady appeared to struggle to move it off the bus. No one helped, but someone gave motion to help, but she had alighted.
- A man stood up appearing so he could get a better view of his surrounding environment from the front bus window (active wayfinding) (it was very wet and only the front of the bus window could be easily seen through).
- Person on the street hailed the bus with their arm. The user had a large instrument case, this was placed on the ground of the priority area.
- 2 people at the following stop were on their phones and had headphones on. They did not hail the bus, but it stopped for them.
- Arrived at Clayton bus loop and I departed
- Boarded 17, Alighted 27
- Although 17 people boarded and alighted during the trip, the bus remained moderately empty, with people using the same seats as others left.

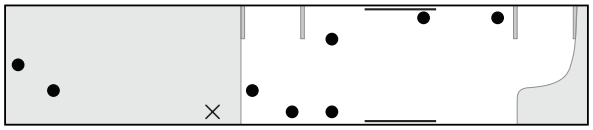
32	21/09/2019 Saturday	Clayton bus loop	900 Caulfield	12.45pm-12.55pm	Familiar	Wet and cloudy cold, 16°



- Walked to another bus stop and boarded
- Person asked the driver if the bus went to Clayton. He said Clayton rd. The person then asked how to get to the hospital. The bus driver said something, but I didn't catch what it was. The person hopped off the bus and walked away from the bus loop.
- Bus demographic is younger
- 8 mobiles can be seen being used
- Signage and audio only working for the main stops.
- Board 10, alight 15
- Rain stopped, and the sun has come out, it is still cold
- Someone is sitting facing the front and using a laptop
- Someone is speaking on their phone
- Someone boarded at stop and asked if the bus went to x location and the driver confirmed

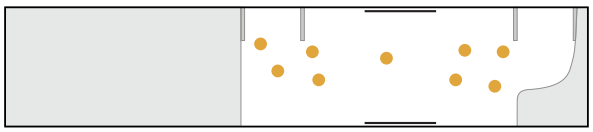
33	21/09/2019 Saturday	Chadstone	903	1.00pm-1.10pm	Familiar	Wet and cloudy cold, 16°

- Boarded, the man after me topped up his myki
- Whilst the bus waited a family ran for the bus
- Signage and audio were both working
- The radio played
- There was a sign at the front of the bus that read, smile you are on CCTV
- Man onboard packed up books and glasses ahead of arriving at the stop
- Alight bus at the same stop as the man



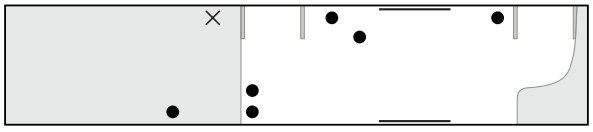
34	21/09/2019 Saturday	Oakleigh Railway station	900	1.20pm-1.31pm	Familiar	Wet and cloudy cold, 16°

- The bus pulled up to the very end of a bus stop bay, so everyone boarding had to walk the length of the bus stop (6 buses long) to board.
- Boarded. The bus was reasonably full when it arrived and was even more so when it left.
- 8 standing passengers
- The standing passengers were clustered in the lower section of the bus, before the staired section.
- From that position it is hard to tell if there are any free seats available.
- 3 out of 8 standing passengers held onto a hand grip, the rest were clustered around the stanchions
- Arrived at Chadstone and the bus emptied out, including myself



Clusters of standing passengers

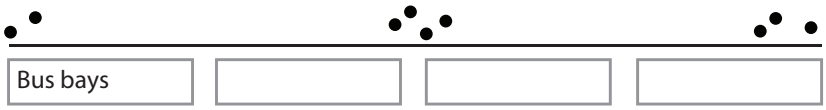
35	21/09/2019 Saturday	Chadstone	742 Eastland	1.38pm-1.40pm	Unfamiliar	Wet and cloudy cold, 16°



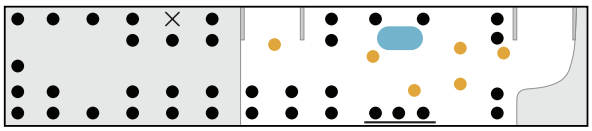
- Once boarded a lady was seen walking in front of and then stepping out in front of a bus, looking up at the bus desto sign. Even though there was a sign on the side of the bus that she walked by. She then boarded and double checked with the driver the location the bus was headed. She then sat in the front left seat, put her bag down and went back to touch on.
- Another person boarded with a map of the location they wanted to go presented on their phone. They showed the driver, who didn't know. The lady who boarded before (sitting in the front left seat), looked at the phone and confirmed that yes this was the correct bus. There could have been a language barrier
- The person sat down in priority seat, then moved their bag from priority area to the storage rack and then sat back down.
- 5 people on the bus were on their phones

36	21/09/2019 Saturday	Oakleigh junction	900 to Caulfield	1.45pm-1.50pm	Familiar	Wet and cloudy cold, 16°

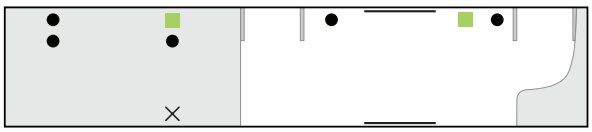
Bus stop



- Alighted bus. A group of people who alighted with me looked at the sign and said oh I think it's the other side of the rd. They then processed to cross the rd to catch a bus going in the opposite direction.
- Someone was looking at the bus timetable and map, pointing to various parts, whilst talking to another person.
- When the bus approached, people began to merge towards the middle point of the long bus stop. There was no signage signifying where the bus was going to stop and if we were all standing in the correct place.
- The front myki reader was down, which stopped passengers from touching on. This was made more difficult as the bus was pretty full, with passenger movement preventing people from moving to the second myki machine.
- Signage was working, but there was no audio
- Arrived at chadstone
- Someone with a pram wanted to alight. She approached the second door and cut me off as I walked down the stairs, she apologised. The back wheel was then caught on the side of the door. I tried to let her know and help, but she managed to pull it free with force.

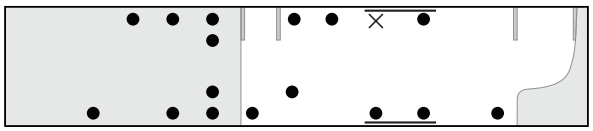


37	21/09/2019 Saturday	Oakleigh junction	627 to Moorabbin	1.55pm-2.18pm	Unfamiliar	Wet and cloudy cold, 16°



- Boarded the bus as it arrived
- A lady looked at the bus desto sign and went up to the bus and had a conversation with the driver, asking if this was the bus she was looking for. It wasn't, but the driver explained which bus to catch instead. The driver was standing out the front of the bus at the time, which might have made them more approachable.
- Board 0, alight1
- Someone was struggling to alight the bus at one of the minor stops. The driver jumped out of his seat and manually deployed the ramp so they could more easily alight. The person didn't ask for this, but appeared grateful, thanking the driver.

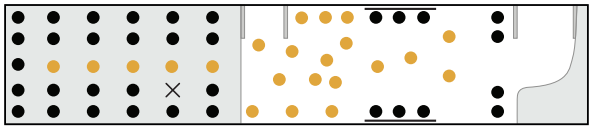
38	21/09/2019 Saturday	Murrumbeena	900 to Caulfield	2.18pm-2.40pm	Unfamiliar	Wet and cloudy cold, 16°



- I alighted the bus at a minor stop at murrumbeena and wanted to transfer to another bus. Had to walk 5 minutes to another minor stop. When I was walking to the stop, I didn't know if I should be running or relaxing, the transfer made me feel anxious, because I was unsure with how much time I had up my sleeve.
- I arrived at the stop, it was really nice. It faced the road, had glass walls, was under a tree and on a service rd, so it felt safe from oncoming traffic. The sun was also out at this point. I didn't know when the bus would arrive and checked the signage, didn't really trust it so I checked the PTV app. The bus was 14 minutes away.
- Decided to walk to the next bus stop. I didn't realise the next bus stop was so far away. It was express and missed multiple stops. After awhile I was concerned that the bus was going to fly by me. I kept checking the rd behind me.
- Made it to the bus stop. The bus was running late and I had 12 minutes to spare.
- I was at carnegie, minor stop
- The bus arrived and I boarded. Most single seats were taken
- Young adult demographic
- The majority of people (if not all) are on their phones
- The signage was not working but the audio was (quiet)
- I alighted from the front of the bus, causing the boarders to wait for me.
- With the bus being late, I would have been able to walk home quicker, if I didn't decide to wait.

39	26/09/2019 Saturday	Huntingdale	601 to Clayton	8.11am-8.15am	Familiar	17° Sunny

- Full vehicle, everyone boarded and alighted at the same stop (shuttle from train to uni)
- 4 people standing held onto grab handles, no stanchions were near them
- 4 standing middle passengers had bags between their legs, all other backpacks were on shoulders. The storage area was not being used
- Person had left their phone on the bus from the previous trip. They waved the bus down and asked the driver. He responded and the person moved quickly to the back of the bus and asked a seated person if the phone was still there. They said they had given it to the driver. She moved back down to the driver who said very sternly that "you didn't listen. I said it was back there but someone handed it in". Was awkward
- When we arrived at clayton people began moving out of the front and middle door evenly.



39	26/09/2019 Saturday	Clayton	601 to Huntingdale	8.37pm-8.42pm	Familiar	17° Dark outside

- Bus was already there when I arrived at the stop
- 7 people were scattered throughout the bus.
- I sat in the middle of a sideways priority seat. Someone who boarded after me sat next to me. There was so much room onboard the bus, they had strong BO and looked unkempt. I moved over so I was closer to the edge of the seat

- The trip was very jerky and it was dark outside, making it difficult to see beyond the interior of the bus
- The interior light was kept on for the whole journey
- Arrived at stop and alighted from front door

Appendix D: Travel diaries testing study explanatory statement and consent form

EXPLANATORY STATEMENT

(For irregular/ non bus user participants)

Project: Design ethnographic field work concerning bus users and potential users

Dr Robbie Napper
Department of Design
Phone:_____
email: _____

Sarah Roberts
Phone:_____
email: _____

You are invited to take part in this study. Please read this Explanatory Statement in full before deciding whether or not to participate in this research. If you would like further information regarding any aspect of this project, you are encouraged to contact the researchers via the phone numbers or email addresses listed above.

What does the research involve?

This project seeks to explore irregular/ non bus users' current travel behaviours, their experiences with bus travel, and any issues they currently have with this service. Participants will be encouraged to reflect upon their travel journeys, indicating their thoughts, wants and needs within an urban bus service.

Participants will be asked to fill out a travel diary for 7 days, with different activities to complete each day. Each day should take a total of 10-15 minutes.

Based on the participant's willingness and the depth of their responses, participants might be asked to take part in a 1-2 hour co-design workshop, to help us turn your ideas into actual designs and innovations. The co-design workshop is not compulsory and participants can be involved with only the travel diary.

Why were you chosen for this research?

People who are irregular/ non users, who have an interest in helping to better the bus system have been sought. This is due to our interest in understanding irregular/ non users' travel habits and thoughts about the current bus service.

Source of funding

This research has been sponsored by Transdev Melbourne and Monash University as part of the Sustainable and Effective Public Transport: Graduate Research Industry Program (SEPT-GRIP)

Consenting to participate in the project and withdrawing from the research

If you consent to take part in this study you will need to sign and return to the chief investigator the consent form
which will be emailed to you. You may withdraw at any time from further participation at any stage of the travel diary or co-design workshop.

Possible benefits and risks to participants

Currently the bus services within Melbourne have multiple draw backs, focusing on getting passengers from A to B. This projects main aim is to put the users first, redesigning the bus vehicle and system, helping it to become more practically suited for regular and irregular bus users. These projects grant the opportunity for irregular bus users to give voice on their current concerns and annoyances of the bus vehicle and service. This data has the potential to help improve the bus service, however, this is not guaranteed.

Participants are inconvenienced to the extent that you, If agreeable, will be spending 10-15 minutes

or so a day for 7 days completing your travel diary and might be asked to take part in a 1-2 hour long co-design workshop.
The travel diary has a range of activities, some of which are recommended to take place during a journey, if you are uncomfortable doing this, feel no pressure to follow the location guidelines.
If you are operating a vehicle, do not fill out the diary during the journey, this is also indicated on the relevant activities.

Confidentiality
Opinions offered voluntarily in the travel diary or co-design workshop could also be used within a publication or thesis. Participants will be de-identified in any data that is published or shared with Transdev Melbourne.

Storage of data
Digital material will be kept on a computer only accessible by password on the Monash network. Physical material will be kept inside a locked draw, in a room with key card access that is permanently locked. Robbie Napper, Sarah Roberts and Selby Coxon will be the only ones to have access to the raw data. After the data is no longer required it will be either deleted or destroyed.

Results
If you would like to be informed of the research outcomes, please contact Sarah Roberts on 0409974128 or email sarah.roberts@monash.edu

Complaints
Should you have any concerns or complaints about the conduct of the project, you are welcome to contact the Executive Officer, Monash University Human Research Ethics (MUHREC):

Executive Officer
Monash University Human Research Ethics Committee (MUHREC) Room 111, Chancellery Building E, 24 Sports Walk, Clayton Campus, Research Office, Monash University VIC 3800

Tel: _____ Email: _____ Fax: _____

Thank you,
Robbie Napper

CONSENT FORM

(For irregular/ non bus user participants)
Project: ‘Design ethnographic field work concerning bus users and potential users
Chief Investigator: Robbie Napper

I have been asked to take part in the Monash University research project specified above. I have read and understood the Explanatory Statement and I hereby consent to participate in this project.

I consent to the following:	Yes	No
Taking part in the travel diary		
Taking part in a co-design workshop		
Audio recording during the co-design workshop		

Name of Participant_____

Participant Signature_____Date_____

EXPLANATORY STATEMENT
(For regular bus user participants)
Project: Design ethnographic field work concerning bus users and potential users

Dr Robbie Napper
Department of Design
Phone:_____
email: _____

Sarah Roberts
Phone:_____
email: _____

You are invited to take part in this study. Please read this Explanatory Statement in full before deciding whether or not to participate in this research. If you would like further information regarding any aspect of this project, you are encouraged to contact the researchers via the phone numbers or email addresses listed above.

What does the research involve?
This project seeks to explore regular bus users' current travel behaviours, their experiences with bus travel, and any issues they currently have with this service. Participants will be encouraged to reflect upon the whole journey, indicating their thoughts, wants and needs within an urban bus service.

Participants will be asked to fill out a travel diary for 7 days, with different activities to complete each day. Each day should take a total of 10-15 minutes.
Based on the participant's willingness and the depth of their responses, participants might be asked to take part in a 1-2 hour co-design workshop, to help us turn your ideas into actual designs and innovations. The co-design workshop is not compulsory and participants can be involved with only the travel diary.

Why were you chosen for this research?
People who catch the bus regularly, who have an interest in helping to better the bus system have been sought due to their insight knowledge and willingness to participate.

Source of funding
This research has been sponsored by Transdev Melbourne and Monash university as part of the Sustainable and Effective Public Transport: Graduate Research Industry Program (SEPT-GRIP)

Consenting to participate in the project and withdrawing from the research
If you consent to take part in this study you will need to sign and return to the chief investigator the consent form which will be emailed to you. You may withdraw at any time from further participation at any stage of the travel diary or co-design workshop.

Possible benefits and risks to participants
Currently the bus services within Melbourne have multiple draw backs, focusing on getting passengers from A to B. This projects main aim is to put the users first, redesigning the bus vehicle and system, helping it become more practically suited for the users needs. This project grants the opportunity for regular users to give voice on their current concerns and annoyances of using the bus vehicle and service. This data has the potential to help improve the bus service, however, this is not guaranteed.

Participants are inconvenienced to the extent that you, If agreeable, will be spending 10-15 minutes or so a day for 7 days completing your travel diary and might be asked to take part in an hour long co-design workshop.
The travel diary has a range of activities, some of which are recommended to take place during a

journey, if you are uncomfortable doing this, feel no pressure to follow the location guidelines. There may also be inconvenience if you miss your stop or bus due to filling out the diary.

Confidentiality
Opinions offered voluntarily in the travel diary or co-design workshop could be used within a publication or thesis. Participants will be de-identified in any data that is published or shared with Transdev Melbourne.

Storage of data
Digital material will be kept on a computer only accessible by password on the Monash network. Physical material will be kept inside a locked draw, in a room with key card access that is permanently locked. Robbie Napper, Sarah Roberts and Selby Coxon will be the only ones to have access to the raw data. After the data is no longer required it will be either deleted or destroyed

Results
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Executive Officer
Monash University Human Research Ethics Committee (MUHREC) Room 111, Chancellery Building E, 24 Sports Walk, Clayton Campus, Research Office, Monash University VIC 3800

Tel: _____ Email: _____ Fax: _____

Thank you,
Robbie Napper

CONSENT FORM
(For regular bus user participants)
Project: 'Design ethnographic field work concerning bus users and potential users
Chief Investigator: Robbie Napper

I have been asked to take part in the Monash University research project specified above. I have read and understood the Explanatory Statement and I hereby consent to participate in this project.

I consent to the following:	Yes	No
Taking part in the travel diary		
Taking part in a co-design workshop		
Audio recording during the co-design workshop		

Name of Participant_____

Participant Signature_____Date_____

Appendix E: Travel diary documentation

INTRODUCTION

Thank you for agreeing to take part in this travel diary.
The aim of this diary is to help Melbourne bus operators better understand how Melbournians, like yourself, travel throughout the city. Our main focus is to better understand your travel habits in general, and discover your needs and opinions of Melbourne's current bus services and vehicle designs.

This diary is designed to do just that in hopefully a fun and engaging way. This diary includes different tasks for you to complete, ranging from factual information to more creative, self expressive tasks, some which require filling out during your travels. Each day you will have different task/s to complete and a regular 'today's journey information' section to fill out.

Please don't feel pressured to complete every task, but the more you complete the more you will be helping us to understand your mobility needs and travel behaviours better.

It is recommended that you complete tasks day by day and at the location specified. However, days 1, 2 and 4 require you to use your dominant mode of travel or the bus, if this does not suit your schedule please fill out the diary in an order so it does.
Example: If today is the 2nd day and you are not using your dominant mode of transport, move on to the 3rd day. You will however need to go back and complete the 2nd day when you next use your dominant mode of transport.

Each days worth of tasks should take about 10-15 minutes in total to complete, but feel free to spend more or less time.

Remember that there are no wrong or right answers and anything you express will be valuable to us. We hope you enjoy the tasks as much as we look forward to reading your answers.

FURTHER INFORMATION

If you do not understand a particular task please contact us at:
Email: sarah.roberts@monash.edu
Phone: 0409974128

Terminology used within this diary:

DMT: Dominant mode of transport

- Please use the same DMT for all questions
- Some questions ask you to compare your DMT with a bus. If this is asked and your DMT is the bus, change bus in the question/ task to car and continue the task.

Mobility: Moving from one place to another in a particular mode of transport (car, bus, bike, etc)

Trip/ Journey: Consists of:

- A trip from A to B over 500m
- 1 trip can include multiple modes (if so please list all modes used)
- Includes walking

Activities: Work, leisure, shopping. The activity/ place you are going to.

Important information about each section can be found within a box like this.

ABOUT YOU AND THE BUS

This section will help us get to know you a bit better, allowing us to set the scene and understand your current travel habits.

• Gender?.....

• Age?.....

• Suburb of residence?.....

• Residents within your home/ their relationship with you?.....

.....

.....

• Do you work within the same suburb that you live?.....

• How long, roughly, does it take you to get to work?.....

• Do you find travel easy? why is this?.....

.....

.....

• What are your dominant modes of mobility?

Your first answer will be used in later questions.

1 ..... 2 .....

3 ..... 4 .....

• Tell us why you use these modes? .....

.....

.....

.....

• How often do you take the bus? Please explain why this is .....

.....

.....

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.....

Some of the following questions might not apply to you, please answer the questions that you believe do.

• Tell us about the types of activities you use the bus for?.....

.....

• If you have previously taken the bus regularly (once or more a week), tell us why this has changed.....

.....

.....

• What would need to change for you to become a more regular bus user and move from your current mode of transport? .....

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• Do you use other public transport modes often?.....

If so, how would you compare these against the bus service? .....

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.....

• What is your current opinion of bus services in Melbourne and do they currently suit your needs? Please give detail .....

.....

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.....

• What elements within the bus vehicle, if any, would you like improved or kept the same?.....

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DAY ONE Date: / /

- *For **task 1A** you need to carry the diary with you all day*
- ***Task 1B** can be filled out from any location*

TODAY'S TASKS

Task 1A: Day in the life of you

Today you need to take notes about your day. Focus on the travel you undertook and the activities you went to (eg: work).
Please give as much detail as possible.

7.00am .....

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8.00 .....

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9.00 .....

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10:00 .....

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11:00 .....

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12.00pm .....

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1:00 .....

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DAY ONE

2:00 .....

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3:00 .....

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4:00 .....

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5:00 .....

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6:00 .....

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7:00 .....

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8:00 - 10.00 .....

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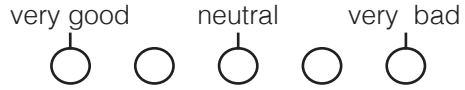
Task 1B: Day in the life of you

• Mark in the scale how you felt about travelling today.



★ Draw a star next to the best part of your day

✕ Draw a cross next to the worst part of your day

■ Draw a square next to an abnormal part of your day

● Draw a circle next to the best trip you took

DAY TWO Date: / /

- *For **today's task** you need to carry the diary with you during a journey*
- ***Today's journey information** should be filled out at the end of the day.*

TODAY'S TASK

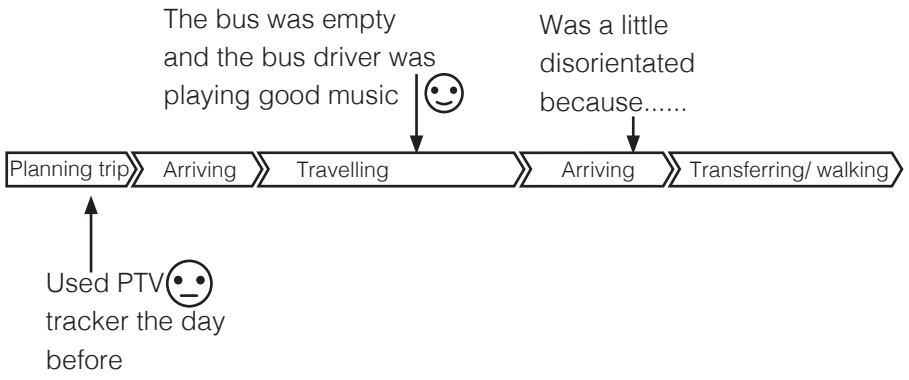
Task 1: Journey mapping instructions

Carry the diary with you for one trip on your DMT.

Whilst performing this trip, fill out your travel experiences in detail on the timeline, this can be in the form of annotations and drawings. The timeline is found on pages **10-11**.

WARNING: If you are operating your dominant mode of travel, please complete this task after the journey has been made.

Example of how to complete this task:



DAY TWO

TODAY'S JOURNEY INFORMATION

• How did you feel about travelling today?

very good neutral very bad

Tell us about each trip you took today? Please list:

- Time travelled
- Activity you went to
- Most annoying thing that occurred during the trip
- What modes you used
- If someone was with you
- What you carried with you

• Trip 1 .....

.....

.....

• Trip 2 .....

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• Trip 3 .....

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• Trip 4 .....

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• Trip 5 .....

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• Trip 6 .....

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DAY TWO

Task 1: Journey mapping

Things to think about whilst on the journey:

- How you complete each stage of the trip
- Your experience/ anything that stood out
- The mood you are in
- Getting on/off the transport
- Paying for the service
- If you feel safe and happy
- What are you doing on the mode
- Waiting for your mode to arrive
- Getting a seat/ where you sat
- Parking
- Your mood ☺ 😐 ☹

DAY TWO


Arriving at destination
Transferring/ walking to destination

DAY THREE Date: / /

- *For **today's tasks** you do not need to use your DMT*
- ***Today's journey information** should be filled out at the end of the day.*

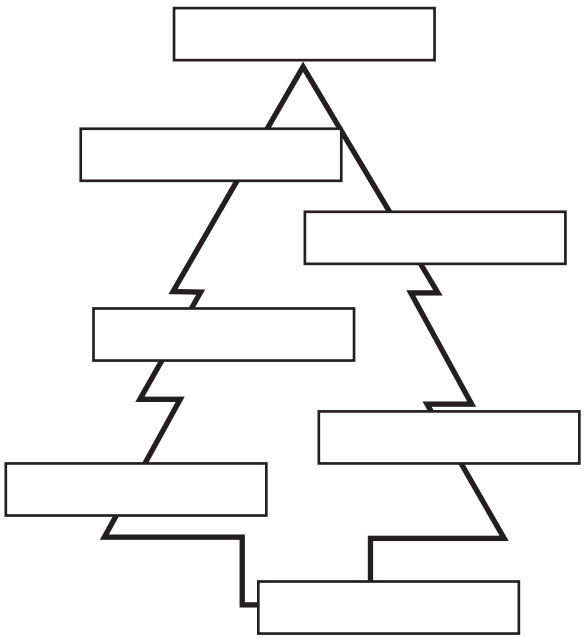
TODAY'S TASKS

Task 1: Priority tree

Please place the following listed items on the priority tree in order of importance to you in relation to a bus trip. The higher the word is on the tree, the more important it is.

List:

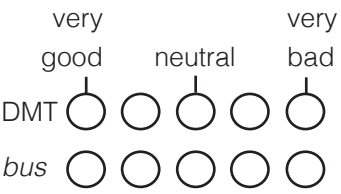
1. Comfort 1 (having a seat)
2. Comfort 2 (temperature, smooth ride, lighting)
3. Cleanliness (graffiti, seat damage, rubbish on the bus)
4. Information (knowing about the service/ timetabling)
5. Access
6. Safety 1 (from other passengers, eg a violent passenger)
7. Safety 2 (from the vehicle, eg the bus being in an accident)



DAY THREE

Task 2: Travel attitude

Please rate each of the factors against how you believe your dominant mode of transport (DMT) and the bus service currently performs.
(If your DMT is the bus, change ***bus*** to car and continue)



Comfort 1
• Why .....
.....
.....
.....

Comfort 2
• Why .....
.....
.....
.....

Cleanliness
• Why .....
.....
.....
.....

Information
• Why .....
.....
.....
.....

DAY THREE

Access
• Why .....
.....
DMT ○ ○ ○ ○ ○
bus ○ ○ ○ ○ ○

.....

.....

Safety 1
• Why .....
.....
DMT ○ ○ ○ ○ ○
bus ○ ○ ○ ○ ○

.....

.....

Safety 2
• Why .....
.....
DMT ○ ○ ○ ○ ○
bus ○ ○ ○ ○ ○

.....

.....

Vehicle/ mode appearance
• Why .....
.....
DMT ○ ○ ○ ○ ○
bus ○ ○ ○ ○ ○

.....

.....

Experience in general
• Why .....
.....
DMT ○ ○ ○ ○ ○
bus ○ ○ ○ ○ ○

.....

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.....

DAY THREE

TODAY'S JOURNEY INFORMATION

• How did you feel about travelling today?

very good neutral very bad

Tell us about each trip you took today? Please list:

- Time travelled
- Activity you went to
- Most annoying thing that occurred during the trip
- What modes you used
- If someone was with you
- What you carried with you

• Trip 1 .....

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• Trip 2 .....

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• Trip 3 .....

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• Trip 4 .....

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• Trip 5 .....

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• Trip 6 .....

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DAY FOUR Date: / /

- *One of **today's tasks** should be filled out during a bus trip*
- ***Today's journey information** should be filled out at the end of the day.*

TODAY'S TASK

Task 1: Postcards

You have been given 5 postcards with different images relating to the bus vehicle and other forms of mobility. On the back of each postcard there is a set of questions, please fill these out.

One postcard asks you to fill it out whilst on a bus trip. Please do this if it is convenient for you to do so, otherwise think back to your last bus trip and answer the questions accordingly.

DAY FOUR

TODAY'S JOURNEY INFORMATION

• How did you feel about travelling today?

very good neutral very bad

Tell us about each trip you took today? Please list:

- Time travelled
- Activity you went to
- Most annoying thing that occurred during the trip
- What modes you used
- If someone was with you
- What you carried with you

• Trip 1 .....

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• Trip 2 .....

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• Trip 3 .....

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• Trip 4 .....

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• Trip 5 .....

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• Trip 6 .....

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(Mercedes Benz 2016)

(Napper n.d.)

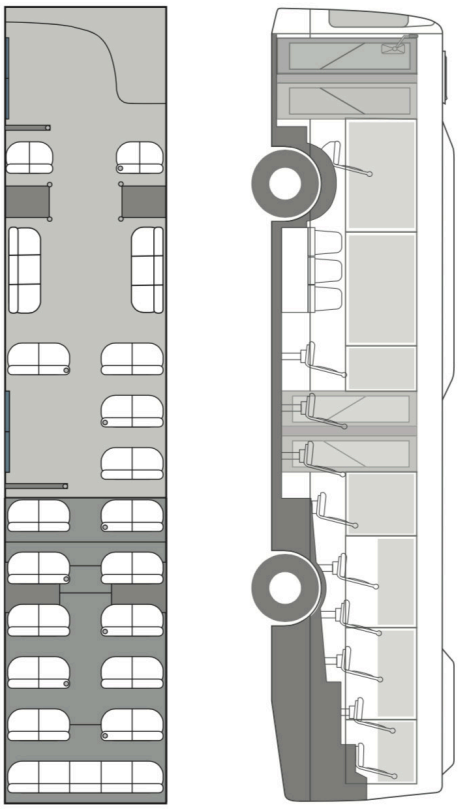
These are both bus interiors

- What are the first things that come to mind when looking at the two images?

A)

B)

- Which interior do you perceive as more;
  - Appealing: A ◯ B ◯
    Why
  - Comfortable (seats): A ◯ B ◯
    Why
  - Practical: A ◯ B ◯
    Why
  - Safe: A ◯ B ◯
    Why



Using the numbers please mark on the postcard the areas that you believe are the:

1. Safest (when the driver breaks heavily)
2. Where the most violence/ antisocial behaviour takes place
3. Easiest place to fall over
4. Favourite place to sit
5. Least faviourite place to sit
6. Favourite place to stand
7. Least favourite place to stand
8. Areas you notice have the most graffiti

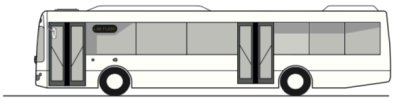
Place for writing notes:

A) size:12-20 seats

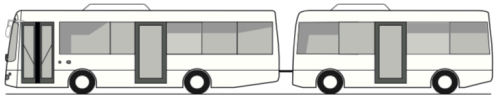
(adapted from Localmotors (2016)

B) size:16-30 seats

C) size:25-55 seats



D) size:40-75 seats



- What are the first things that come to mind when looking at the 4 bus types?

A)

B)

C)

D)

- Which bus do you perceive as most;
  - Appealing: A ◯ B ◯ C ◯ D ◯
    Why
  - Comfortable: A ◯ B ◯ C ◯ D ◯
    Why
  - Safest A ◯ B ◯ C ◯ D ◯
    Why

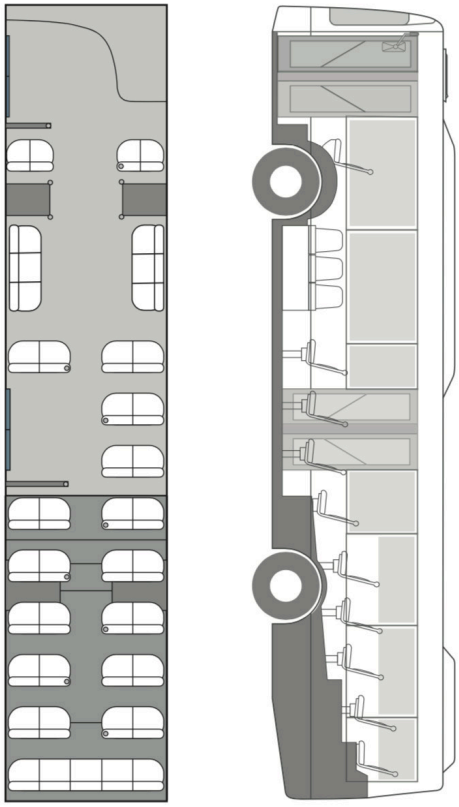
(Fitzhume 2009)

(itnews 2014)

What are the first things that come to mind when looking at these image?

Which mode do you perceive as more;

- Comfortable: A ◯ B ◯ C ◯
  Why
- Cost effective: A ◯ B ◯ C ◯
  Why
- Appealing:
  - Interior: A ◯ B ◯ C ◯
    Why
  - Exterior: A ◯ B ◯ C ◯
    Why
- Safe: A ◯ B ◯ C ◯
  Why



Whilst on a bus trip, use the front image of this postcard to draw the interactions you had with the bus.
Annotations can also be helpful to show different elements of your trip

Place for writing notes:

DAY FIVE Date: / /

- *For **today's task** you do not need to use your DMT*
- ***Today's journey information** should be filled out at the end of the day.*

TODAY'S TASK

1. Break up/ love letter

It's time to get creative.
Please write a love or break up letter to the bus in the space below. It can be based on any service or attribute of a bus.

Dear .....

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DAY FIVE

TODAY'S JOURNEY INFORMATION

• How did you feel about travelling today?

very good neutral very bad

Tell us about each trip you took today? Please list:

- Time travelled
- Activity you went to
- Most annoying thing that occurred during the trip
- What modes you used
- If someone was with you
- What you carried with you

• Trip 1 .....

.....

.....

• Trip 2 .....

.....

.....

• Trip 3 .....

.....

.....

• Trip 4 .....

.....

.....

• Trip 5 .....

.....

.....

• Trip 6 .....

.....

.....

.....

.....

DAY SIX Date: / /

- *For **today's task** you do not need to use your DMT*
- ***Today's journey information** should be filled out at the end of the day.*

TODAY'S TASK

1. Story time

Tell us a true story about the best of worst bus journey you have ever experienced. .....

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DAY SIX

TODAY'S JOURNEY INFORMATION

• How did you feel about travelling today?

very good neutral very bad

Tell us about each trip you took today? Please list:

- Time travelled
- Activity you went to
- Most annoying thing that occurred during the trip
- What modes you used
- If someone was with you
- What you carried with you

• Trip 1 .....

.....

.....

• Trip 2 .....

.....

.....

• Trip 3 .....

.....

.....

• Trip 4 .....

.....

.....

• Trip 5 .....

.....

.....

• Trip 6 .....

.....

.....

.....

.....

DAY SEVEN Date: / /

- *For **today's task** you do not need to use your DMT*
- ***Today's journey information** should be filled out at the end of the day.*

TODAY'S TASKS

1. What I like about you

Create a mindmap of your favourite 30 things about your DMT

My favourite things about

.....

DAY SEVEN

2. What I hate about you

Create a mindmap of your most hated 30 things about your DMT

My most hated things about

.....

DAY SEVEN

TODAY'S JOURNEY INFORMATION

• How did you feel about travelling today?

very good neutral very bad

Tell us about each trip you took today? Please list:

- Time travelled
- Activity you went to
- Most annoying thing that occurred during the trip
- What modes you used
- If someone was with you
- What you carried with you

• Trip 1 .....

.....

.....

• Trip 2 .....

.....

.....

• Trip 3 .....

.....

.....

• Trip 4 .....

.....

.....

• Trip 5 .....

.....

.....

• Trip 6 .....

.....

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.....

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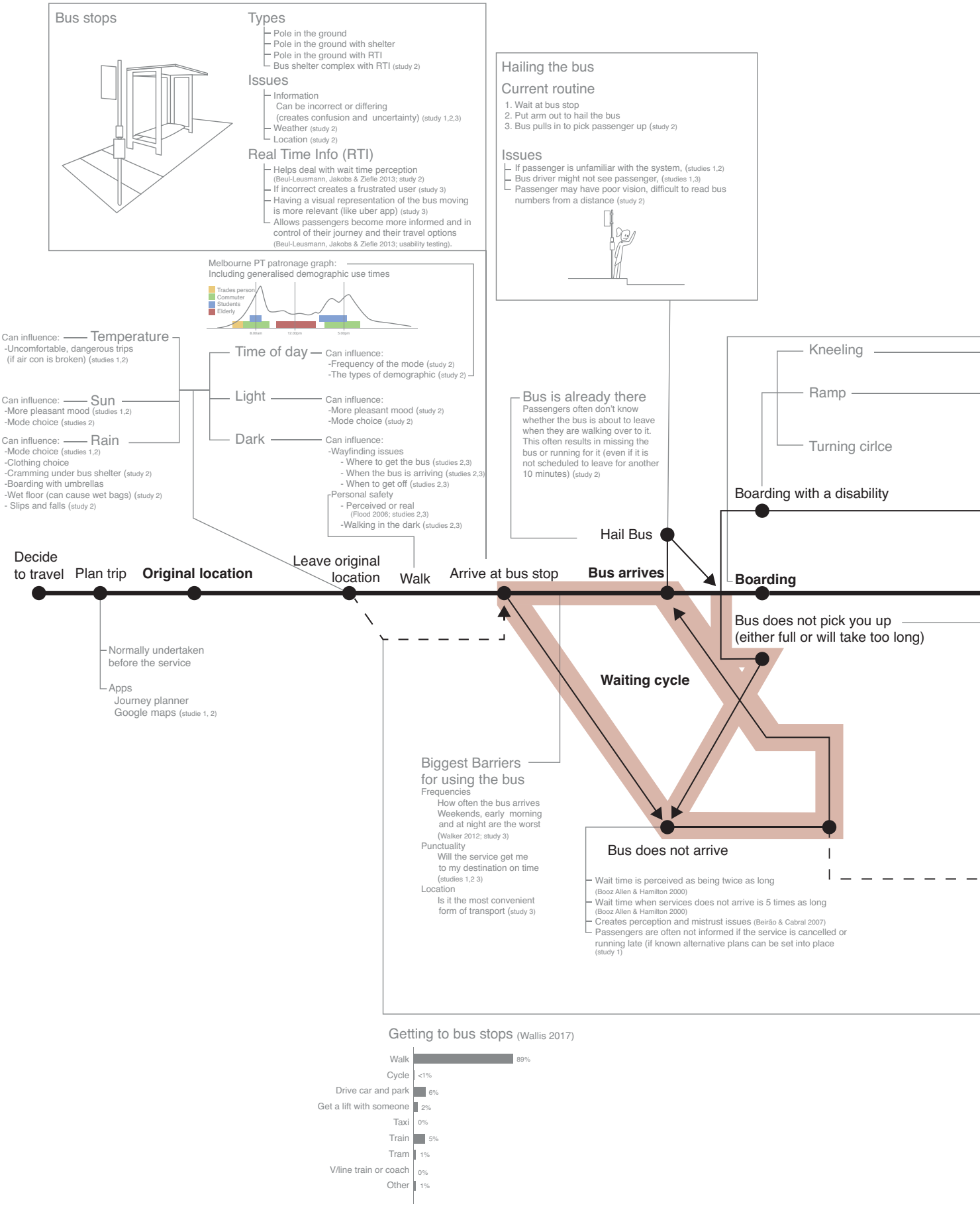
FREE SPACE

Appendix F: Synthesis of study results: Journey map annotations



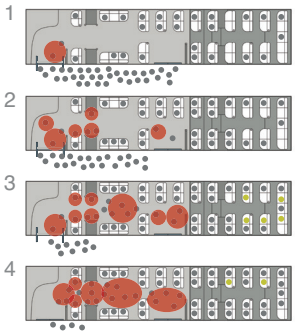
Boarding the bus

- Check to see if this is the correct bus (might require asking driver, checking the front desto screen (study 2).
- Step up onto the bus, find myki, touch on and find a seat (study 2).
- Topping up: need to have a conversation with the driver, this slows traffic and forces the driver to deal with money (study 2).

Passenger flow

- The front standing section creates a bottle neck for passengers to manoeuvre through (study 2).
- From the front it is difficult to see if the back seats are free (study 2).
- If the driver or other passengers do not ask standing passengers to move further back, most passengers will stop before the stairs (study 2).

Basic bus passenger flow



- -Bus lowers
- -Great for reducing the gap
- -Uneven surfaces sometimes cause issue (study 2).
- -Great for mobility restricted when deployed
- -Bus driver needs to physically deploy ramp
- -This is a problem for drivers with back issues & sometimes they are unable to deploy ramp (study 1).

Boarded the wrong bus

Need to top up

Miss stop

The Journey

Touch on

Get to destination/ transfer

Creates uncertainty and mistrust of the service. If you are not informed that the service is not running, you are uncertain to whether the following service is running, or if the bus is just late.
The next service will most likely be full as it is picking up two routes worth of passengers. (study 1,2,3)

Press stop button

touch off

Get off

Wayfinding

- Bus can go down any route (study 3)
- Not visually shown by tracks
- It is on the individual to recognise their stop and press the stop button (pre-emptively) (study 2)

Forms of wayfinding

- Recognise landscapes (difficult at night) (study 2)
- Use google maps (this helps keep track of your location and the buses) (study 2,3)
- Learn the stop name and wait for it to be displayed on the buses destination sign or audio. (This is helpful, but does tell the passenger how far away their stop is) (study 2)

Bus route

Alighting

- -Don't want to stand up before the bus has stopped (study 2).
- -Touching off. When it takes awhile and passengers are waiting for you. (study 2)
- -When the driver does not open the door (study 2).

- Get up or lean over to touch off myki while the bus is still moving (study 2).
- Passengers with reduced mobility need to wait until bus has stopped (reduces risk of fall) (study 2).

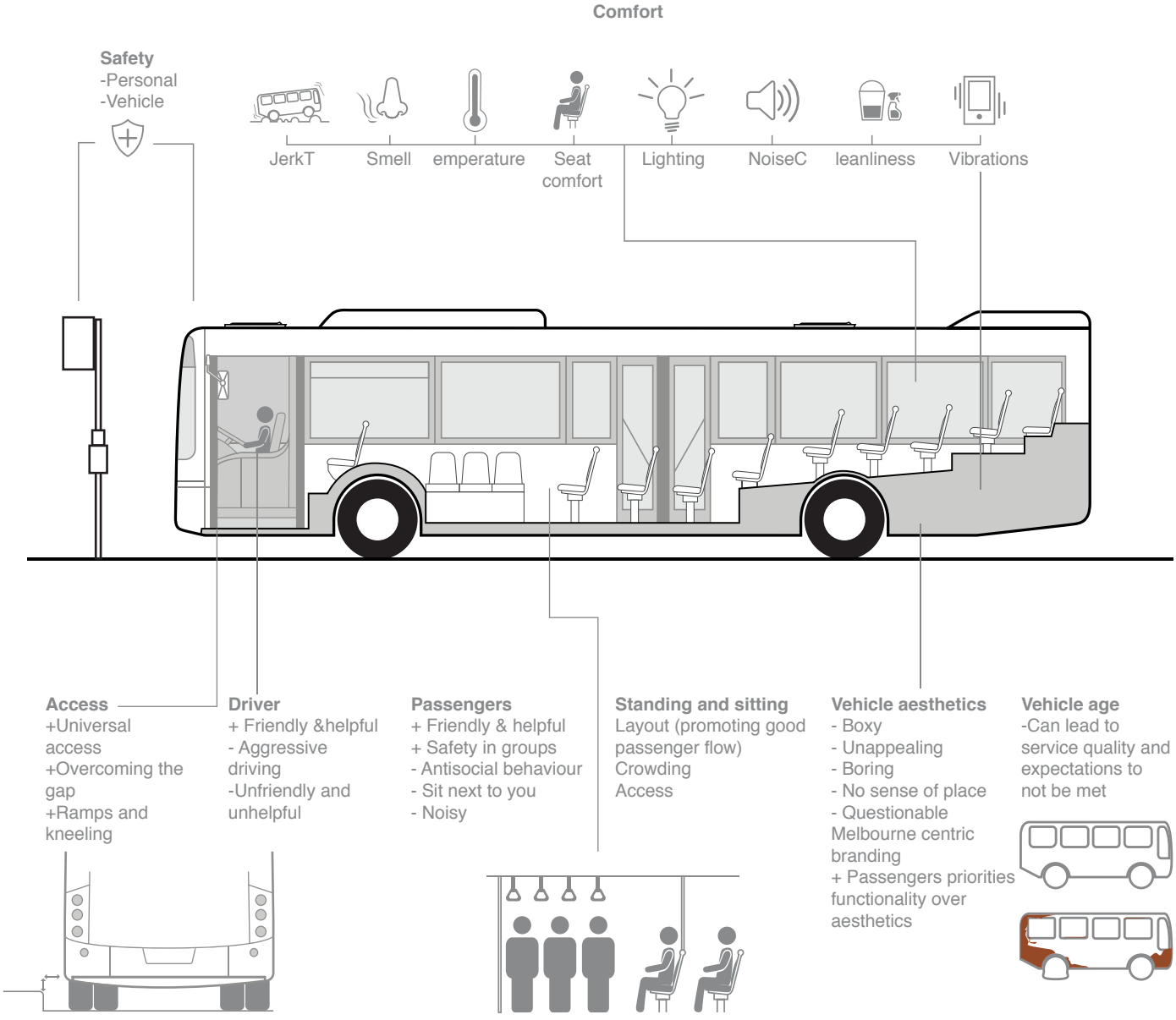
Not an issue for the majority
Need to take passengers with reduced mobility and passengers with mobility aids or baggage into account.

Change mode/ plans

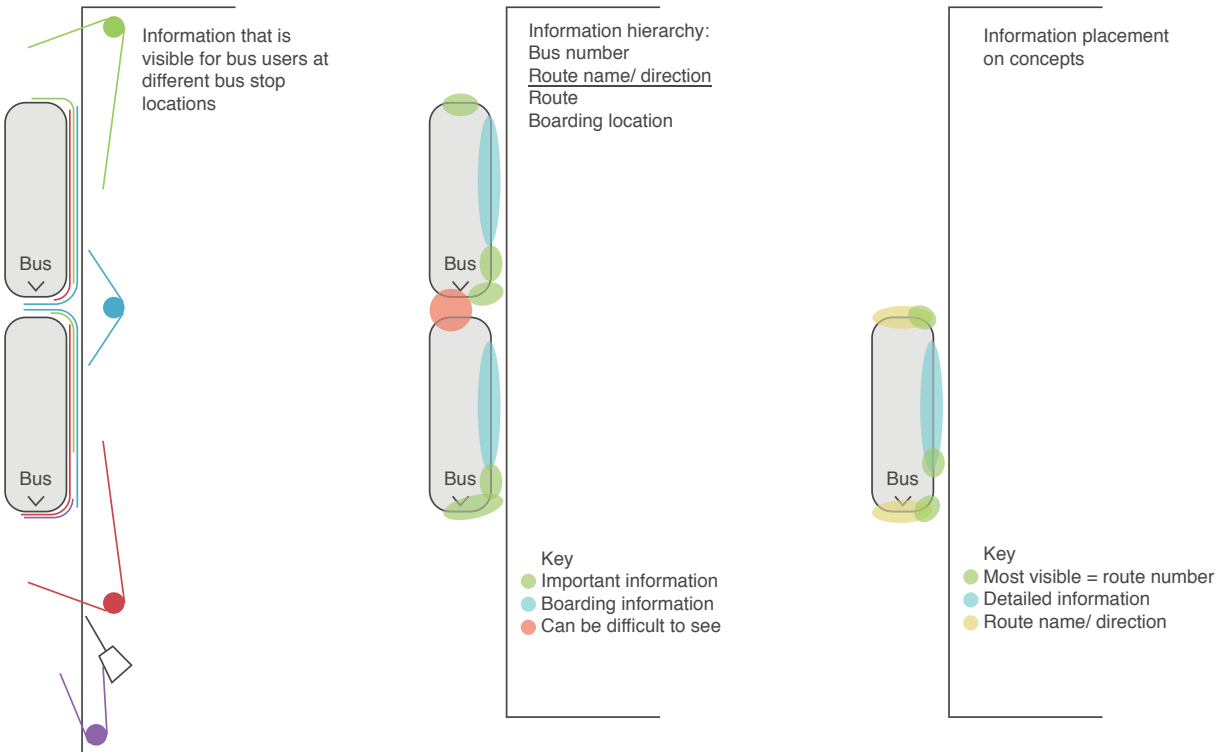
Different modes

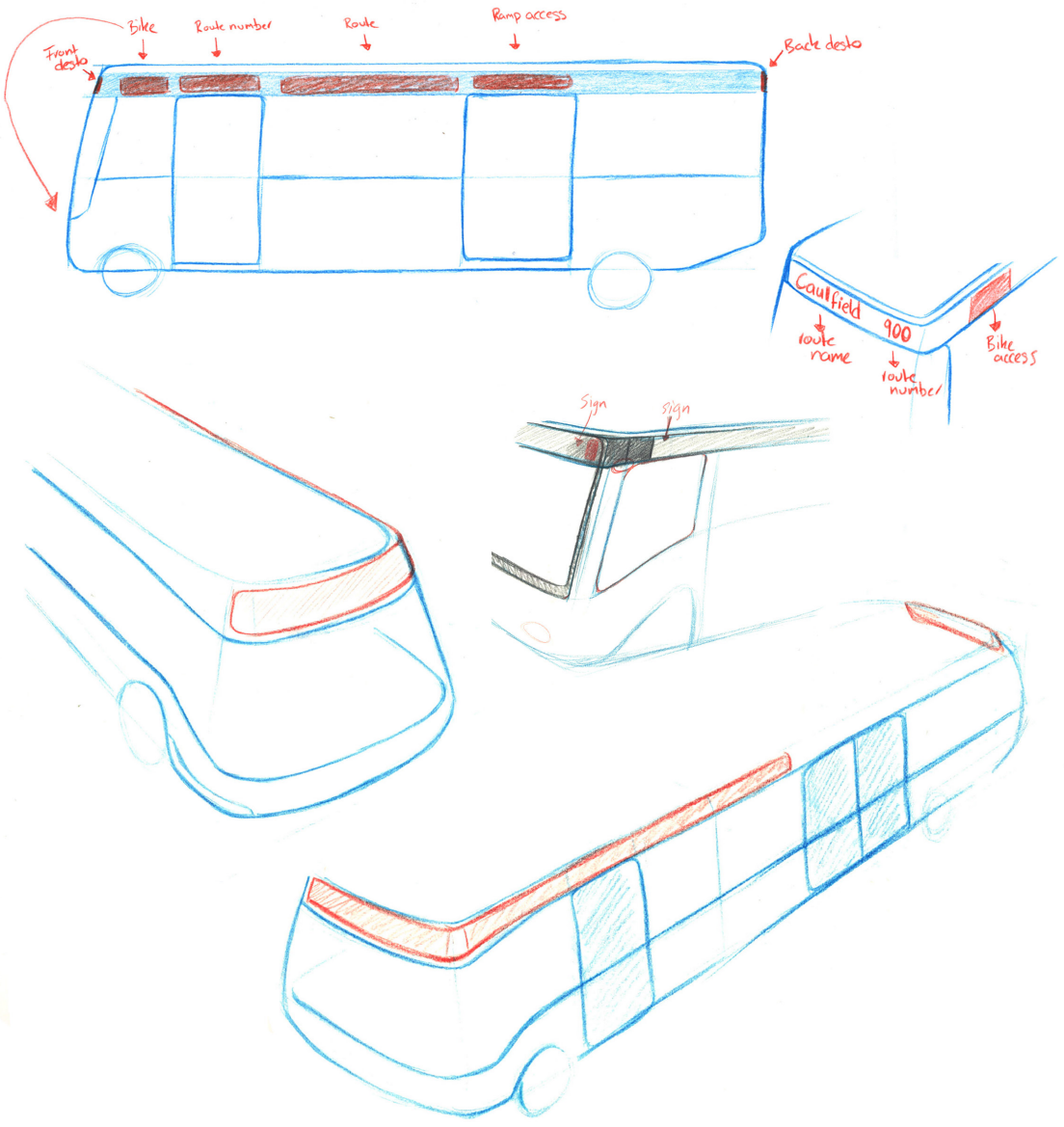
- **Walk**
- **Bike**
  - Integrated services
  - Buses with bike racks
- **Car**
  - Uber
  - Car sharing
  - Driving or kiss and ride
- **Train**
  - Transfer information on the bus
- **Tram**
  - Transfer information on the bus

Appendix G: Synthesis of study results: Vehicle annotations, Adapted from Roberts, Napper, Coxon (2017).



Appendix H: Design development and refinement

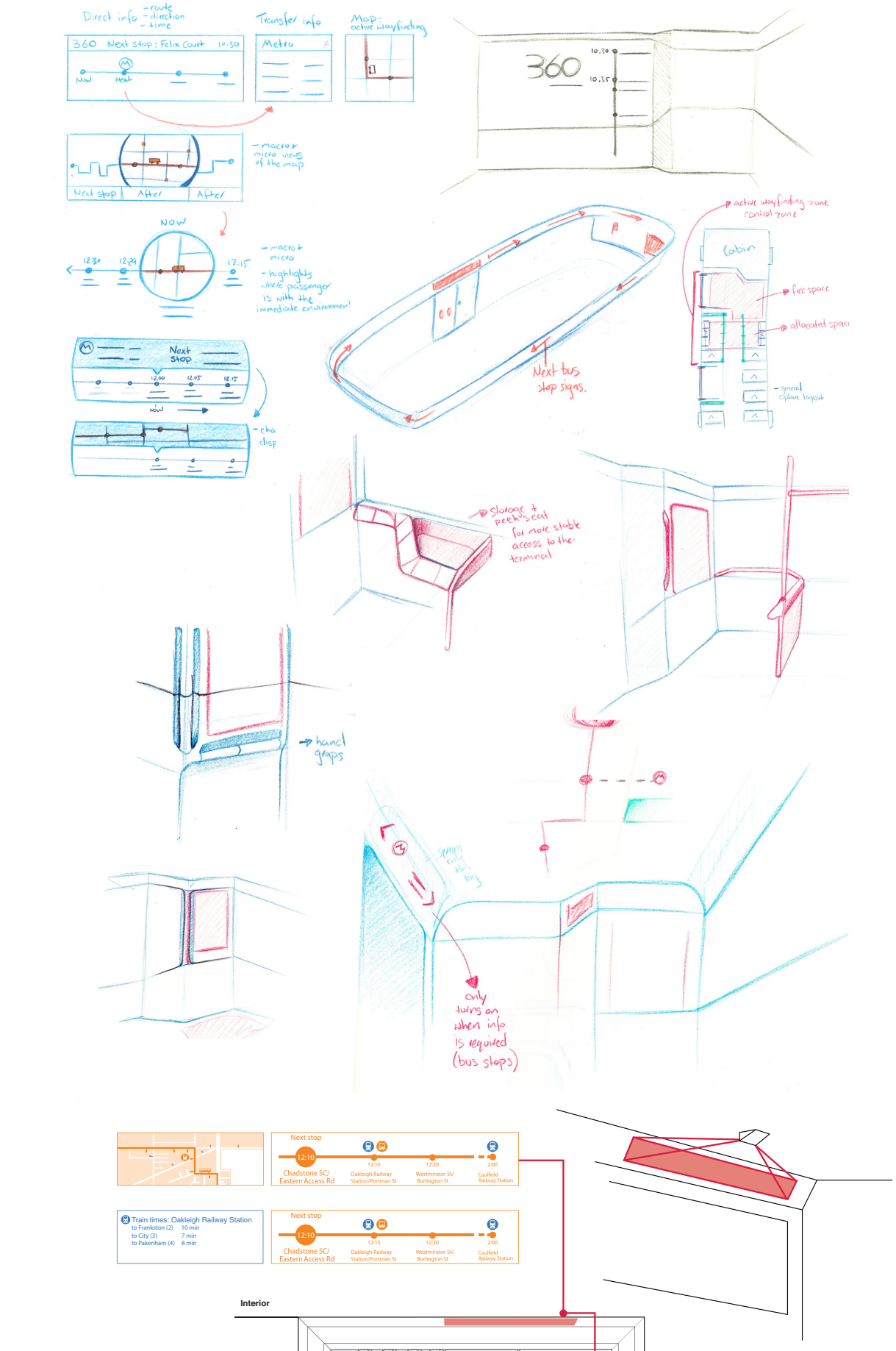





Welcome aboard bus 370
MitchamR
ingwood Nth
Ringwood
Welcome aboard bus 280
Turnstall square


900
Monash University


HUNRASH shuttle 601
900

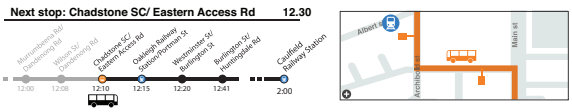

Direct info
- route
- direction
- time
360 Next stop: Felix Court 10:50
Now
Next
Transfer info
Metro
Map:
active wayfinding
- macro micro views of the map
Next stop
After
After
NOW
12:30
12:24
12:15
- macro micro
- highlights where passenger is with the immediate environment
Next stop
12:00
12:05
12:15
NOW
- cha
disp
360
10:30
10:35
Next bus stop signs.
active wayfinding zone
control zone
cabin
free space
allocated space
- general
space layout
storage +
perches at
for more stable
access to the
terminal
hand
grabs
only
turns on
when info
is required
(bus stops)
Next stop
12:10
Chadstone SC/
Eastern Access Rd
12:15
Oakleigh Railway
Station/Portman St
12:20
Westminster St/
Burlington St
2:00
Caulfield
Railway Station
Train times: Oakleigh Railway Station
to Frankston (2) 10 min
to City (3) 7 min
to Pakenham (4) 8 min
Next stop
12:10
Chadstone SC/
Eastern Access Rd
12:15
Oakleigh Railway
Station/Portman St
12:20
Westminster St/
Burlington St
2:00
Caulfield
Railway Station
Interior
900 Bus
Caulfield to Stud Park
Next stop
Oakleigh Railway Station/ Portman st
S
W
N
ROUTE DEVIATION
S
W
N


Next stop
Chadstone SC/
Eastern Access Rd
12:19
Malvern East
Stud Park Centre/
Stud Rd (Rowville)
10:00
Wilson St/
Dandenong Rd
12:20
Oakleigh Railway
Station/Portman St
12:15
Westminster St/
Burlington St
12:14
Caulfield
Railway Station
2:00

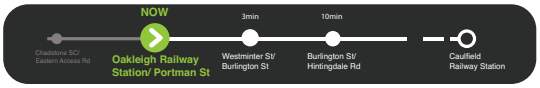

Now stopping
Oakleigh Railway Station/ Portman st
Train times
to City (3) 7 min
to Pakenham (4) 8 min
on St/
denong Rd
.40
Chadstone SC/
Eastern Access Rd
12.35
Oakleigh Railway
Station/ Portman St
12.30
Westminster St/
Burlington St
12.15

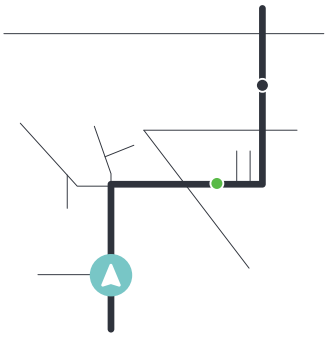

Next stop: Chadstone SC/ Eastern Access Rd 12.30
Train times: Oakleigh railway station
to Frankston (2) 10 min
to City (3) 7 min
to Pakenham (4) 8 min

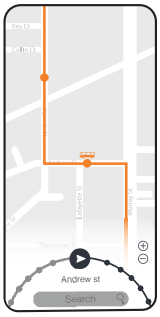

Next stop
12:10
Chadstone SC/
Eastern Access Rd
12:15
Oakleigh Railway
Station/Portman St
12:20
Westminster St/
Burlington St
2:00
Caulfield
Railway Station

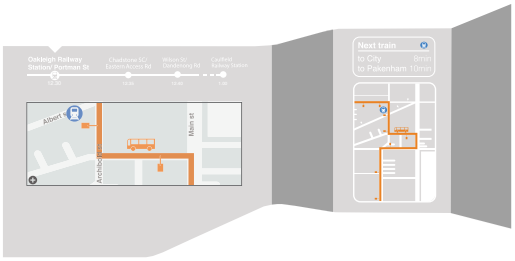

Next stop: Chadstone SC/ Eastern Access Rd 12.30
Albert st
Main st
Architects

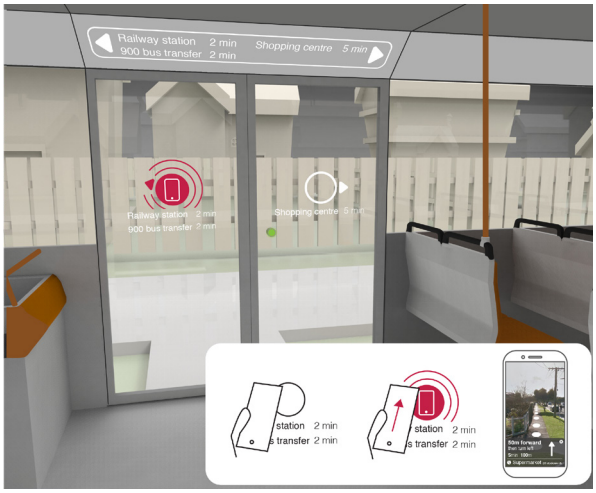

Train times: Oakleigh Railway Station
to Frankston (2) 10 min
to City (3) 7 min
to Pakenham (4) 8 min
Next stop
12:10
Chadstone SC/
Eastern Access Rd
12:15
Oakleigh Railway
Station/Portman St
12:20
Westminster St/
Burlington St
2:00
Caulfield
Railway Station


NOW
3min
10min
Chadstone SC/
Eastern Access Rd
Oakleigh Railway
Station/ Portman St
Westminster St/
Burlington St
Burlington St/
Hintingdale Rd
Caulfield
Railway Station

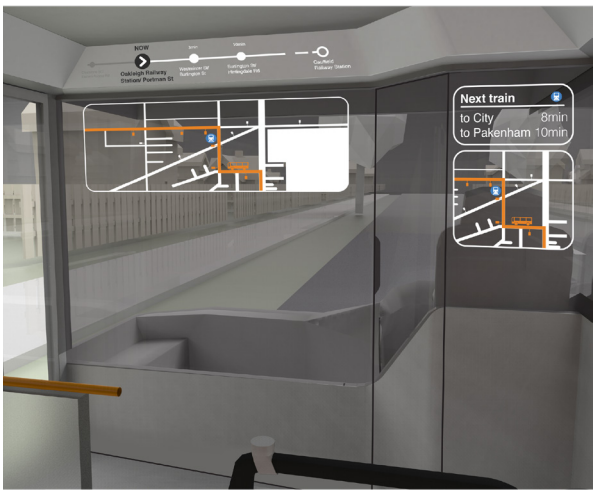



Andrew st
Search


Next train
to City 8min
to Pakenham 10min
Albert st
Main st
Architects

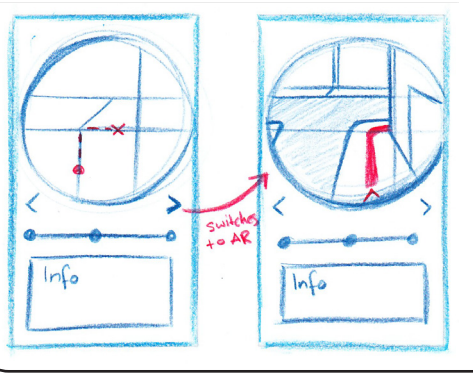

Railway station 2 min
900 bus transfer 2 min
Shopping centre 5 min
station 2 min
s transfer 2 min

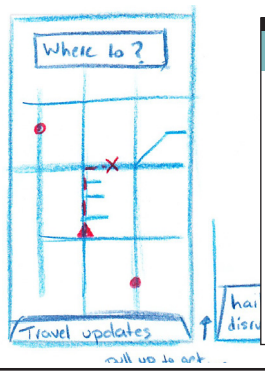

Railway station 2 min
900 bus transfer 2 min
Shopping centre 5 min

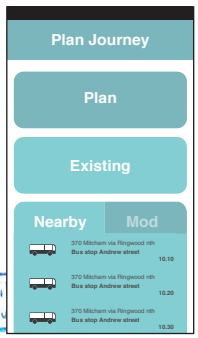

Next train
to City 8min
to Pakenham 10min


Stop:
Oakleigh railway station/
Portman st
Next buses
900 Now
630 5min
900 25min
Next train
to City 8min
to Parkenham 10min

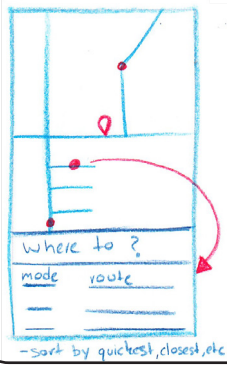
Plan journey

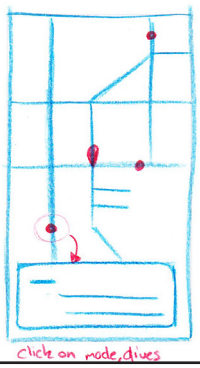


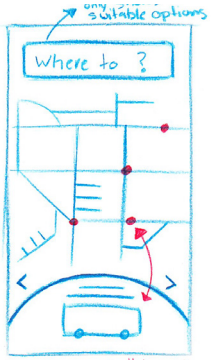


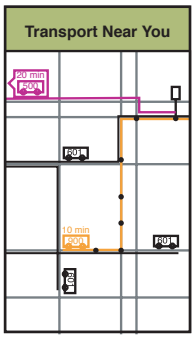


Transport near you

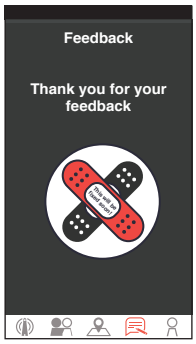


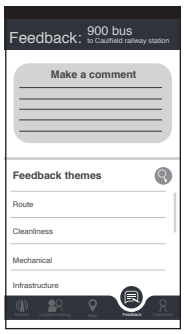




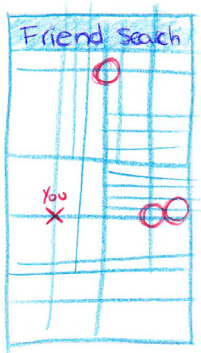


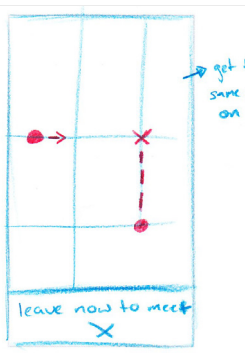
Feedback

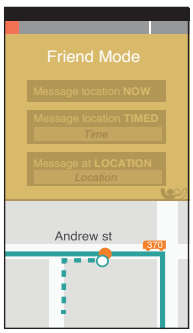




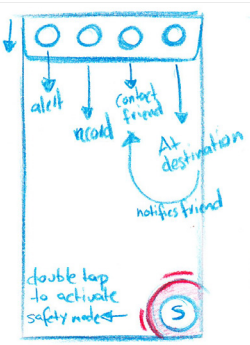
Location sharing

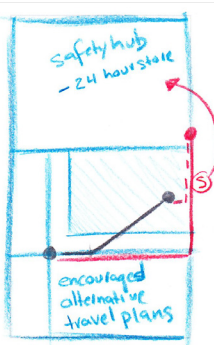


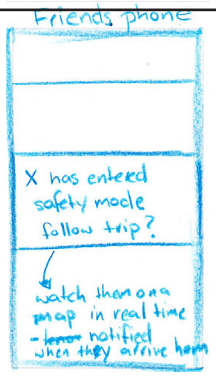


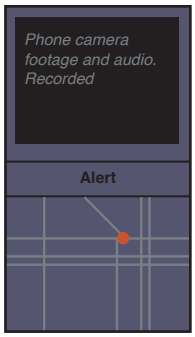


Beacon mode










Where to?
modes
10:00am
Monday, 8 April
Where to?
deploy ramp
Information
hail 370 bus
deploy ramp
assistance required
meet friend
get to location
pull down to see whole trip
swivel
Make a trip
Mode choice +
Mode
Uber
Bike
Walk
Car
Car sharing
Trip attributes
safer
direct
speed
fitness
User profile
Personalise
Pram
Kids
Bike
Safety
fast
Active
pull
Profile: Meg :P
Features
hail bus
stop bus
tracking
notification
Add ons
pram
children
bike
car
notify x of location at this point of the trip
other person joins the trip - app tells them when to leave so
map shows friends
Friend Mode
add contact (phone)
Rob
Mum
Ben
Erin
Friend Mode: Ben
Message location NOW
Message location TIMED
Message at Location
Share location with: Ben
change user
add user
Track my location
Organise timed pick up
Message location NOW
Message Location at what TIME
Message at WHAT location
Felix court [370]
10 min
30 min
Leave now to catch bus 370 at Andrew street stop
Beacon mode [MEG]
Beacon Mode
feeling unsafe
inform friend
pick up organised
camera recording
audio recording
alert bus driver
parent mode
React Mode
Police are being notified
Emergency contact being notified
Turn off alarm
Turn off video recording
Turn off audio recording
friend
organise
call

Appendix I: Usability testing study explanatory statement and consent form

EXPLANATORY STATEMENT

(For all participants)

Project: Design ethnographic field work concerning bus users and potential users

Dr Robbie Napper
Department of Design
Phone:_____
email: _____

Sarah Roberts
Phone:_____
email: _____

You are invited to take part in this study. Please read this Explanatory Statement in full before deciding whether or not to participate in this research. If you would like further information regarding any aspect of this project, you are encouraged to contact the researchers via the phone numbers or email addresses listed above.

What does the research involve?

This project through a co-design/usability testing workshop seeks to explore how participants interact with new and existing bus designs and journey experiences. Using bus journey experience data collected previously during this project, the research team has redesigned the bus vehicle and service to better suit the needs discovered. This part of the project seeks to discover the suitability of these redesigns through a virtual reality (computer or head set) setting. Participants will be encouraged to take part in each usability and co-designing activity and reflect upon the designs and the journey presented. The workshops will be individual, including a single participant and researcher and will take 1–2 hours to complete.

Why were you chosen for this research?

People who have an interest in helping us critique and better design bus vehicles and systems have been sought. This is due to our interest in understanding how our design compares to the current bus design in response to people's travel needs and experiences.

Source of funding

This research has been sponsored by Transdev Melbourne and Monash University as part of the Sustainable and Effective Public Transport: Graduate Research Industry Program (SEPT-GRIP).

Consenting to participate in the project and withdrawing from the research

If you consent to take part in this study you will need to sign and return to the chief investigator the consent form which will be emailed to you. You may withdraw at any time from further participation at any stage of the co-design/usability testing workshop.

Possible benefits and risks to participants

Currently the bus services within Melbourne have multiple draw backs, focusing on getting passengers from A to B. This project's main aim is to put the users first, redesigning the bus vehicle and system, helping it to become more practically suited. This project grants the opportunity for participants to give voice on their opinion of the new bus design and service, so that we can improve the design and make it better suited to their needs.

Participants are inconvenienced to the extent that you, if agreeable, will be spending 1–2 hours at a co-design/usability testing workshop. The workshop will consist of you using a virtual reality headset or a computer to view and interact with the designs. The headset might result in motion sickness, if you are uncomfortable in using a headset feel free to use the computer option instead. If you feel motion sick, it is recommended that we conclude the workshop. An introductory stage is included during the

workshop to help you become familiar with the controls you will be using.

Confidentiality
Opinions offered voluntarily in the co-design/usability testing workshop could also be used within a publication or thesis. Participants will be de-identified in any data that is published or shared with Transdev Melbourne.

Storage of data
Digital material will be kept on a computer only accessible by password on the Monash network. Physical material will be kept inside a locked drawer, in a room with key card access that is permanently locked. Robbie Napper, Sarah Roberts and Selby Coxon will be the only ones to have access to the raw data. After the data is no longer required it will be either deleted or destroyed.

Results
If you would like to be informed of the research outcomes, please contact Sarah Roberts on 0409 974 128 or email sarah.roberts@monash.edu

Complaints
Should you have any concerns or complaints about the conduct of the project, you are welcome to contact the Executive Officer, Monash University Human Research Ethics (MUHREC):

CONSENT FORM
(For all participants)
Project: 'Design ethnographic field work concerning bus users and potential users
Chief Investigator: Robbie Napper
I have been asked to take part in the Monash University research project specified above. I have read and understood the Explanatory Statement and I hereby consent to participate in this project.

I consent to the following:	Yes	No
Taking part in a co-design/usability testing workshop		
Audio and digital recording during the co-design/usability testing workshop		

Name of Participant_____

Participant Signature_____Date_____