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Issues and design factors concerning outer Melbourne bus vehicle design: a literature review

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Abstract

This paper will review the literature and technology concerning outer Melbourne bus operation and bus design through a designer's lens. Reviewing the literature with a design focus is not common within the transport field, therefore this paper aims to use this different focus to uncover gaps in knowledge and discover whether there is a suitable bus design for outer Melbourne bus operation. Currently, bus services within outer Melbourne environments have issues surrounding spatial coverage and temporal factors, leading to negative service perception. This type of problem is often tackled by transport planning, and route design, focusing on travel frequencies and new routes to improve the system. This review does not deal with route planning, but rather lies within industrial design, focusing on the design of a bus vehicle and or service. Specifically, how could the design be used to improve services in outer Melbourne, complementing the current efforts in transport planning. This review will, therefore, cover the topics; Melbourne's bus environment, bus vehicle classifications, outer Melbourne's population, user grievances and bus vehicle design, and design elements within the bus vehicle. The contribution this paper makes is in the discovery of knowledge gaps found from reviewing the literature. The key finding shows that there is currently a lack of understanding of Melbourne bus user and nonuser travel behaviours through design ethnography and generative design methods. These methods allow a more connected process from understanding how people engage with a system to creating innovative design solutions to help improve that system. Therefore, it has been concluded that in order to complement efforts in transport planning through design, these methods should be utilised to discover new information to help solve existing problems.

1. Introduction

Bus vehicles and services are often perceived negatively, even when compared with other public transport (PT) modes. This is caused by the speed, comfort, regularity and design of buses being seen as low performing (Tozzi et al., 2014). This is exacerbated in the outer Melbourne areas, due to low population density and a lack of PT services encouraging the dominance of the car (Frost and Dingle, 1995, Mees, 2010) and ensuing transport disadvantage (Currie et al., 2009).

Bus services traditionally cover these regions and are considered the most suitable form of PT for urban development (Tozzi et al., 2014), as a result of; being cheaper (Hensher, 2000), having 'greater penetration to where people want to go' (Hutchinson, 2000, p.63), being the most flexible (UITP, 2006), and not being track restricted (Cervero, 1993). However, bus service coverage of these outer fringe regions is considered one of PT's

biggest challenges. This is due to the sparse-development landscapes being 'unproductive environments for cost-effective transport services' (Currie et al., 2009, p.105), therefore, more feasible plans for coverage need to be developed.

As an attempt to mitigate this, it is now an ambition within Melbourne that all homes are within 400m of a bus stop. This ambition, developed by the Victorian State Government, is a result of the UK's Social Exclusion Unit (SEU) research, with outer suburbs being the most concerning areas (Stanley et al., 2011). Nevertheless, the outer regions, according to a study conducted in 2006, show outer Melbourne having 75% fewer services per stop, per week, compared to inner Melbourne, and 50% fewer stops compared to middle Melbourne (Currie and Senbergs, 2007b). This is often caused by spatial and temporal factors, in which infrequently served routes counteract the 400m bus stop distance ambition.

Melbourne's PT industry is now moving towards night services and orbital trunk smart bus routes, allowing for more time coverage, and cross-town linkage services (Loader and Stanley, 2009, PTV, 2016b). Through efficient route location, new and orbital routes can provide movement opportunities, which have proven successful (Curtis and Scheurer, 2016). However, these services do not reach the vast majority of the population and there is little literature surrounding how suitable bus vehicle and service designs could be influential in assisting this situation.

Service design is a relatively new field, with its principles starting to appear within the transport industry. This design discipline focuses on improving existing services holistically, through the use of design principles and a human-centred process. Creating for the users, more usable, useful and desirable services, and more effective and efficient services for the operators (Stickdorn et al., 2011). Therefore, these principles are key to creating a more holistic, user focused system.

Although this might be the case, currently within literature and practice, this problem is being tackled by transport planning and route design. These routes are expected to be plied mainly by 12.5m route bus vehicles, which are also expected to be suitable for both high and low density regions. An industrial/ service design approach will, therefore, be used to explore this problem, to elicit new information and complement the transport planning efforts through a designerly way of thinking. Designerly, referring to the understanding and utilisation of design principles and knowledge, through research and practice, with the focus here being on bus vehicle and service suitability and functionality. This allows for an opportunity for a more user-centric system to be discovered for these outer Melbourne regions. This review will use an exploratory style to help better understand the topic broadly and is organised into the following sections; Melbourne's bus environment, bus vehicle classifications, outer Melbourne's population, user grievances and bus vehicle design, and design elements within the bus vehicle.

2. Melbourne's bus environment

The bus operational system within Melbourne is currently fully privatised, with the bus services being managed by thirteen operators, running 346 routes (PTV, 2016a). The Melbourne bus fleet mainly consists of low floor route buses, travelling on feeder routes, connecting suburbs to rail lines, or the SMART and DART services acting as lite Bus Rapid Transit services (PTV, 2016c). It is important to note, that this review will not be covering these services, for they fall out of scope, which focuses more on vehicle design.

To perform their duties effectively, operators require suitable bus vehicles that can provide:

- appropriate resources for the PT system
- compliance with the necessary operational specifications (Fridman, 2016)
    - Australian Design Rules
    - Disability Standards for Accessible Public Transport

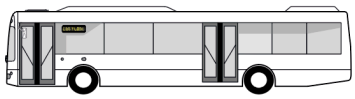
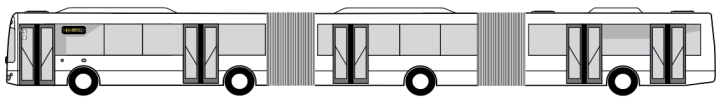
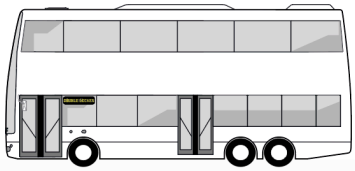
    - Australian Standards
- compliance with government contracts
- suitability for local environment and needs (Rohani et al., 2013)
- fulfilment of passenger and driver needs

Being experts within the bus industry, operators provide tenders and standards to the manufacturers. Unfortunately, this process does not connect passenger needs to the manufacturer, which may produce adverse bus design outcomes (Napper, 2007). Similarly Rochefort (1981), Schmitt (2015), and Hutchinson (2009) argue that operator, user, and nonuser perceptions of the service can often be different, playing a role in negative customer experience to the detriment of the system. Therefore, we must now ask ourselves, *'is there a suitable bus design for outer Melbourne operation, that will fit both the user, government, and operator's needs?'*
The following section will act as a technology review, giving further depth on this question.

3. Bus vehicle classifications

Bus style/ classifications are primarily dictated by the function the bus vehicle needs to perform, which is mainly centred around size variations. For example, as previously stated, the low entry route bus currently dominates the Melbourne market, making up 88.5% of the overall fleet (PTV, 2016a). On high demand routes, these buses can be substituted for articulated or double decker designs, that allow for larger passenger occupancy, without the need of more frequent services (Vuchic, 2007). The same reasoning is applied to low density areas such as the outer suburbs, which can be met with mini and midi sized buses. This outer suburban comparison is the focus of this section.

Table 1: Different styles of bus vehicle specifications (Vuchic, 2007, p.213)

Type	Length (M)	Seats	Total Capacity	
Mini	6-7	12-20	30	
Midi	8-10	16-30	50	
Standard	10-12	35-55	85	
Articulated	16-18	40-75	130	
Bi-Articulated	22-24	40-80	140	
Double-decker	10-12	60-95	125	

3.1. Low-entry route bus vehicle

Brought into service in 1976, this wheelchair-friendly design promotes universal accessibility within an urban cityscape (McKnight, 1995, King, 1998), encouraging PT travel with children and baggage, for the mobility impaired, and the elderly (Suen and Mitchell, 2000). However, the low-entry bus vehicle is not to be confused with the low-floor bus vehicle, which is more popular within European cities.

- Low-entry bus: Consisting of a lowered front section with two doors, leading to a raised back section.
- Low-floor bus: Consisting of a fully lowered saloon, commonly with three doors and more standing room.

Low-floor buses, due to their fully low-floor design are suitable within areas that have higher density/ patronage levels. Coupled with multiple doors, this allows passengers to be spread throughout the vehicle, allowing faster boarding and alighting times. In comparison, the low-entry bus experiences passenger catchment problems in the front section of the vehicle. This is caused by passengers being unwilling to stand beyond the staired section, an issue less prominent when patronage levels are lower. Therefore, the reason for the low-entry buses dominance within the Australian market, besides universal accessibility, is due to being more easily maintained, and the extra seated capacity (Fridman and Napper, 2016). Extra seating is more suitable within lower density environments, such as outer Melbourne, where longer trips and less patronage is more common, therefore higher levels of seating and comfort is expected.

3.2. Midi/ mini bus vehicle

Midi bus vehicles are a mini/ standard sized hybrid, suitable for regular transit within medium sized cities and suburbs. Similar to mini buses, when on short urban route trips the design should consist of a low-floor, larger doors, and fewer seats for heavy passenger exchange (Vuchic, 2007). It is commonly stated that smaller buses are more suitable for suburban areas, due to their manoeuvrability through narrow roads and sharper corners. They can provide higher frequencies to low density regions, and are currently being successfully utilised within developing countries (Oldfield and Bly, 1988), such as Uganda (Gwilliam, 2008). European bus operators are also suggesting that they would move towards purchasing more articulated and midi sized buses for these purposes (Tozzi et al., 2014). Conversely, they can cause higher traffic congestion, due to the need for an increased fleet size to accommodate higher frequency and passenger coverage (Oldfield and Bly, 1988). However, these issues are negated by the lower density/ passenger environments of outer Melbourne.

Cost efficiency is also an issue when comparing the midi to standard bus vehicles, due to the seat ratio, and the driver being 60-70% of the operating cost (Oldfield and Bly, 1988, Nash, 2015, Dell'olio et al., 2007), in developed countries. However, this could change with the use of premium services, trailer buses or with the advent of autonomous vehicles changing the landscape.

3.3. Trailer buses

Bus-trailer combinations and coupleable buses both consist of modular designs. The first consists of a tractor (engine/ driving compartment) and a detachable trailer combination, whilst the coupleable bus consists of two buses that can be connected. This allows the bus capacity to be flexible, fitting patronage levels, and helping to save on operational costs (Tozzi et al., 2014). The most suitable environment for such buses, according to the

European Bus System of the Future's (EBSF) final report, consists of environments with a changing patronage level (Guida, 2014). Outer Melbourne could be considered such an environment, due to the change in demand during peak and off peak times. Unfortunately, when discussing trailer buses there are limitations that need to be considered, including; the need for safe, fast and easy de/coupling procedures (Guida, 2014), parking near the lines (Tozzi et al., 2014), and less manoeuvrability.

From reviewing these different bus types, the literature currently suggests that midi buses are suitable for outer suburban environments. The following section will discuss this further, bringing optimal bus size and economics into the discussion.

3.4 Bus vehicle size

The concept of optimal bus vehicle size was greatly discussed in the 1980s PT literature and, as of the 2000s, is now being further investigated (Dell'olio et al., 2007). Optimal bus vehicle size refers to the capacity of a service in relation to the most suitable service frequency, including 'factors such as operating cost, level of demand, and demand elasticities' (Oldfield and Bly, 1988, p.319). This allows operators to run routes that 'maximise social benefit', whilst allowing for suitable cost effective ratios between seat availability and frequency (Oldfield and Bly, 1988, p.319). For example, when comparing the cost efficiency between standard and midi sized buses, the initial costs that first must be accounted for include:

- The driver: being independent of the bus size
- Running costs: fuel, repair and services
- Standing costs: capital costs and garaging cost (Nash, 2015, Jansson, 1980)

Although, according to a 2014 Sydney study, mini buses are considered roughly 15% more cost effective to run than standard buses (Tirachini et al., 2014). When using these factors, the profit margins are to be found within the operating cost per passenger, with the standard bus vehicles having the advantage of more seats (Dell'olio et al., 2007). Although this might be the case, the standard 12.5m route buses that dominate outer Melbourne areas are suitable during peak hours, however, run close to empty (Currie, 2010) the majority of the remaining time, negating the cost effectiveness. This is where a modular, trailer bus, is suggested to be suitable.

It is speculated from the literature that smaller sized buses would be the most suitable form of bus within low density environments, if patronage levels stay the same. However, further research must be undertaken on the suitability of these services, and if the outer Melbourne population would accept such a service. Therefore, the next section will aim to understand who is using these types of buses in outer Melbourne.

4. Melbourne's outer suburban population

According to Victorian Integrated Survey of Travel and Activity (VISTA) data, as of 2013, 81% of mobility used in outer Melbourne was by private motor vehicles. This is compared to 1.97% of mobility being achieved by bus services within the same region, and outer Melbourne showing the highest levels of bus patronage when compared to other regions. In regards to the demographic of these bus users, Hensher (1998) states that PT passengers often include;

- School children
- Elderly (without licence)
- People with low household incomes
- Special event attendees

Irrelevant to this region;

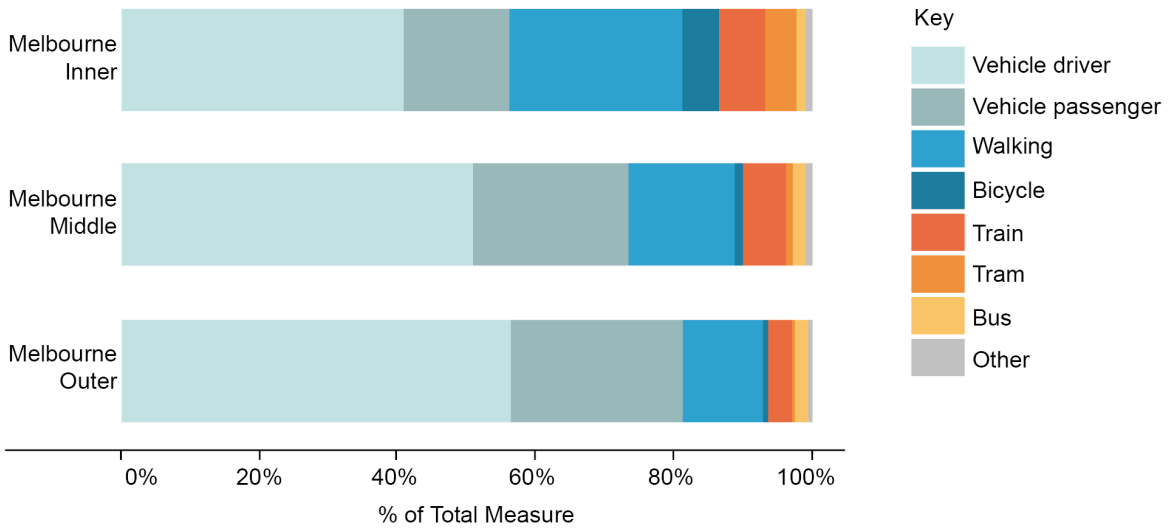
- People living within city centres
- Tourists

This demographic summary is confirmed by the VISTA data, which also indicates that the prominent trip activities for outer Melbourne bus service use is for the following purposes;

- Education
- Buying something
- Work related

It must be remembered that this differs based on age and gender. An example of this being that women are more likely to use bus services for shopping purposes rather than men (Transport for Victoria, 2013).

Figure 2: Weekday travel by mode and region (VISTA, 2013)



PT users, by their very definition, are a diverse group, consisting of all social backgrounds, with differing travel requirements and abilities. Designing a standard transport service that is suitable for each group becomes a challenge when trying to fulfil these 'different needs and expectations' (Stickdorn et al., 2011, p.30). However, Ruud and Nordbakke (2005) state that catering for a specific group's needs should not result in a worsened travel experience for the majority. This type of thinking is prominent within user-centred design fields, were the designer must accept that there are often multiple customer groups, with differing needs to be designed for (Stickdorn et al., 2011), and therefore a balance must be reached. Table 3 consists of synthesised literature, highlighting the specific/ differing needs of some of the dominant groups of bus users within this outer Melbourne environment.

Table 3: Synthesis of outer Melbourne bus user groups and design issues experienced.

Group	Background	Issues/ issues with the bus service and vehicle	Solutions
Transport Disadvantaged	Low income earners (spend high amount of income on vehicle ownership) (Loader and Stanley, 2009, Social Exclusion Unit, 2003) 'lack of effective PT services' (Currie and Senbergs, 2007a, p.1) Forced into car ownership	Social disadvantages Access to job prospects Access to health care Access to necessary services (Hurni, 2005, Dodson et al., 2004, Loader and Stanley, 2009)	Different transport mode options Updating services
Millennials (Gen Y) 1982 to 2005 (Howe and Strauss, 2007),	Largest generation Most technologically capable Largest users of PT Experiencing decreasing car ridership levels (Delbosc and Currie, 2013, Noble, 2005). This could change due to life events (Schmitt, 2015). More multimodal (APTA, 2013, Delbosc and Currie, 2012)	Comfort Access Safety Ticket cost Information/ signage Broome et al. (2010a)	Willingness to use technology/ adopt technological orientated services (Blumenberg et al., 2012) Wayfinding/ information: improved with technology
Disabled	Broad group 20-25% of PT passengers have a mobility handicap (Suen and Mitchell, 2000) Considered captive users	Broad group Being dependent Lack of mobility Issues can often go unnoticed (Haveman et al., 2013) Negative attitudes from bus drivers/ patrons (Haveman et al., 2013).	Physical assistance Physical interventions (Haveman et al., 2013). Thoughtful design Universal design factors (Suen and Mitchell, 2000) Disability Standards for Accessible Public Transport Australian design rules (Federal Register of Legislation, 2006, Federal Register of Legislation, 2002) Paratransit services (Suen and Mitchell, 2000)
Elderly (60+ years)	Reduced mobility (Metz, 2003) This generation is more mobile than previous generations Increasing licenses held (Haustein, 2012) Buses are one of the most important transports (Broome et al., 2010b)	PT can be harder to use than driving (Hjorthol, 2013) Loss of license or expensive cars can lead to loss of mobility (Haustein, 2012) Sole dependence can lead to transport disadvantages Negative health issues Social participation issues (Currie et al., 2009) Injuries (VAED, 2012- 2015)	Priority seating Small walking distances Friendly/ helpful drivers Being seated before the bus moves (Metz, 2003) Universal access Fewer stairs/ smaller access gaps (King, 1998) Well placed/ amount of hand rails (Broome et al., 2010b)

There is currently a wealth of literature aiming at understanding bus users' issues, needs, and their travel behaviours, some being indicated in the table above. There are fewer papers that focus on relating these issues with the design of the bus vehicle. Therefore, the next section of this review will focus on the users' issues. Frequencies are often one of the main issues surrounding this region, however this will not be a focus for it falls out of scope for this review, which focuses on design attributes.

5. User grievances and bus vehicle design

The literature surrounding bus users'/ nonusers' opinions are commonly found from conducting interviews, focus groups and surveys. The most common issues relating to bus services are listed below.

- Comfort (Corazza et al., G. Beira˜o and Cabral, 2007, Coxon et al., 2008, Broome et al., 2010a, Levis, 1978)
- Punctuality/ reliability (Bunting, 2004, HiTrans, 2005, G. Beira˜o and Cabral, 2007, Stradling et al., 2007, Broome et al., 2010a, Clayton et al., 2016)
- Information/education (Bunting, 2004, HiTrans, 2005, G. Beira˜o and Cabral, 2007, Hensher, 2007, Coxon et al., 2008, Hutchinson, 2009, Broome et al., 2010a, Scherer, 2010, Thomas, 2010).

Very few papers express what the actual cause of these issues are and how to fix them through a design intervention. This section will, therefore, break down and review these current user/ nonuser issues, in relation to design elements, giving an analysis of the issues and literature.

5.1. PT comparison

Currently bus vehicles and services are broadly criticised as being less reliable, uncomfortable, infrequent, having worse aesthetics, and being less innovative and modern when compared to other PT modes (UITP, 2006, G. Beira˜o and Cabral, 2007, Tozzi et al., 2014, Harrison et al., 1998). This thinking is counteracted by a PTV's *Customer satisfaction monitor: January-March 2017* report seen in table 4. Showing that in 2016-2017 buses scored the highest overall satisfaction and design, space, and comfort ratings when comparing the three modes (PTV, 2017).

Table 4: Customer satisfaction indices by financial year: 2016-17 overview (PTV, 2017, p.54-59)

Mode	Overall satisfaction score out of 100	Design, space and comfort score out of 100
Bus	76.5	77.6
Train	72.6	69.4
Tram	75.8	70.6

This scoring system is, however, not comparison based, with each modes' rating system being individual. Therefore, it might be suggested that buses are perceived worse when in direct comparison to other modes, or when users have different levels of regular usage, with regular users often being more accepting.

5.2. Information and wayfinding

Bus services can be difficult to navigate, with questions often being asked about which bus to take and around stop recognition (Woyciechowicz and Shliselberg, 2005). This is because wayfinding and navigation is based on the users' abilities, where information and familiarity is a key provision in tackling system navigation. Schmitt (2015) agrees with this, identifying from interviews performed in 2012 in Melbourne, that bus services when compared to other modes of PT, are less preferred due to the higher levels of uncertainty and being more difficult to navigate for first time users. These issues can be heightened in outer Melbourne areas due to the lack of visual route identifications, and less intensive infrastructure. An example of this is bus stops being in the form of poles.

Factors within the bus journey that contribute to poor wayfinding include; fogged windows, the dark, the full reliance of the passenger to indicate their departure before the arrival at the stop and the buses ability to turn down all streets. These are worsened by unfamiliar routes and unknown environments, causing the user to feel a lack of control (Schmitt, 2015, Dziekan and Dicke-Ogenia, 2010). These issues can be lessened by navigational aids, such as maps, signs, and technological interventions. These are often in the form of on-board destination signs/ other vehicle information systems and can be improved with correctly used design principles such as simplicity, standardised/repeated patterns, and symmetry (Woyciechowicz and Shliselberg, 2005, Napper et al.). Although there is a substantial amount of literature regarding this topic, little gives an understanding as to how to design for such factors.

5.3. Comfort

Often difficult to measure due to its intangible, subjective nature, (Oborne, 1978, Vink, 2004), and perceived by its absence (Branton, 2003), comfort relates to a whole raft of sensory factors. These include lighting, temperature (Coxon et al., 2008, G. Beira˜o and Cabral, 2007), noises, smells, and vibrations (Oborne, 1978, Vink, 2004), often affect the overall journey experience. Oborne (1978) suggests that these factors all inform the end users' opinion on the comfort of the system, being perceived at an individual level, with users/ nonusers opinions often differing (G. Beira˜o and Cabral, 2007). Beira`o and Cabral go further believing that experience, informedness and personal reaction to the vehicle are also key influences. This reaction is called the visceral effect, helping to identify the emotional responses to certain elements on a general basis (Norman, 2013). Table 5 shows positive and negative visceral elements in relation to the bus vehicle, it suggests that the bus inherently has multiple negative visceral elements within its current design. Again, according to G. Beira˜o and Cabral (2007, p.487), 'car users and occasional PT users' view these elements more negatively compared to their counterparts.

Table 5: Norman's (2004, pp.29-30) positive and negative visceral effects, when compared to the bus vehicle

Positive visceral elements	Negative visceral elements	Elements that appear on bus vehicles
Warm comfortable lit places	Height →	High sided
Temperate climate	Looming objects (about to hit the observer) →	Hanging hand holds, bus stop/ arrival experience
Sweet tastes and smells	Extreme hot and cold →	Subjective to bus driver
Bright highly saturated hues	Darkness	
Symmetrical objects	Extremely bright light/ loud sounds →	Glare/ traffic conditions
Rounded smooth objects	Sudden, unexpected bright lights/ loud sounds →	
Sensuous feelings, sounds, and shapes	Empty or crowded terrain →	Can be both extremes
	Sharp objects →	Traffic/bus vehicle condition
	Grating and discordant sounds →	
	Vomit	

5.4. Perception

Relating to the way users interpret PT, perceptions can be caused by a multitude of factors, including environmental and experienced-based considerations (Clayton et al., 2016). For example, waiting in the dark, or sitting next to an intoxicated passenger influences future expectations and preconceptions. These attributes, when negative, can lead to a 'poor image' of the mode, which can be countered by interventions such as mode familiarity, allowing a more accepting and positive perception to be formed (Scherer and Dziekan, 2012). HiTrans (2005) notes that users and nonusers show significantly varied perceptions of PT, due to their differing levels of familiarity and knowledge of a service. This indicates that if nonusers become familiar with a service their perception could become more positive. Rochefort (1981, p.76), however, noted in a 1977 study in France, that even though nonusers 'had a positive opinion of the [bus] system', they would still not consider changing modes. This statement is, however, broad, with the raft of nonusers being diverse, and with the right implementations some form of modal shift could occur. Therefore, it is important to consider both users and nonusers in research undertaken.

Other negative bus perceptions include passengers feeling vulnerable within services, due to a lack of perceived control in regards to other passenger intrusion and anti-social behaviour (Thomas, 2010). Also, previously stated, bus vehicles are considered the least attractive PT mode, in reference to 'regularity, speed, comfort and design' (Tozzi et al., 2014, p.2). While

negative perceptions are broadly acknowledged, there is little evidence in the literature of a deeper understanding, for example why these negative perceptions exist, or if they are caused by real experiences. The literature also lacks in identifying aesthetics and design principles behind these visual perceptions. Therefore, if designed correctly the bus vehicle and service could move away from having this negative perception and move towards creating a more positive experience. This could lead to a positive sense of place, something that the outer suburbs would benefit from. The next section will summarise the principles of aesthetics and sense of place, relating them to bus design and functionality.

6. Design elements within the bus vehicle

6.1. Aesthetics

Aesthetics can be divided into two attributes; firstly, the feature of the artefact, and secondly the reaction to the object, or in the case of transport, the whole service (Sonderegger and Sauer, 2010). These influence 'the degree to which a person believes that the [artefact] is aesthetically pleasing' (Van der Heijden, 2003, p.544), having a direct correlation with perceived usability and functionality (Sonderegger and Sauer, 2010). Therefore, the designer is able to use these elements, to influence the users' perception of the artefact (Brunel and Kumar, 2007).

In relation to the bus vehicle, the form is derived from the function of the users being able to stand whilst moving within, creating the high-sided box form. This is in contrast with the more appealing car forms, that can be designed lower for seated passengers, allowing visual reduction of the bulky form, whilst using horizontal lines to create a faster and sleeker look (Coxon et al., 2007). The superbus, sporting a sports car exterior and a limousine interior, is an example of using these principles within a bus vehicle context. However, the quoted high-speed of this vehicle ignores the functional necessity of frequent stopping if it were a suburban route bus. Pleasing aesthetics and good sense of place characteristics are very similar, utilising one another to create a more appealing service.

6.2. Sense of place

PT can be understood as a form of public space, where people congregate 'to carry out daily life', creating social interactions, community connection/ identity (Coxon et al., 2008, p.251) and could act as the next third place. The third place, in contrast to the first and second place (home and work), is a space within a public setting providing the opportunity for socialising, for example: a pub or coffee shop, often leading to a sense of connection/ ownership with the space (Oldenburg and Brissett, 1982). If designed correctly, the bus vehicle could act not just as a form of commuting between the first and second places, but act as a true third place.

PT, however, due to the interior layouts, creates close passenger proximities, resulting in more socially awkward situations for some cultures (Hall, 1966). This influences passengers to be more guarded, avoid eye contact, touch, interactions (Thomas, 2010, Hall, 1966) and leads to situational withdrawal (Zurcher Jr, 1979), with these factors being more prominent within higher capacity services.

There are many definitions of a sense of place and it can be defined loosely as an experience of a person within a particular setting (Steele, 1981), being broken down into four key areas:

1. The Self: the interpreter of the space
2. The Environment: the space

3. Social Interaction
4. Time: time spent in the space

(Beidler and Morrison, 2015)

Through the use of understanding the environment, temporal experiences and social encounters, a space can be turned into a place, helping to reinforce location identity, culture and history (Beidler and Morrison, 2015). Achieving this can also create identity and nostalgia, with London's buses and Melbourne's trams being an example of this, showing strong identity qualities, which Melbourne's buses currently lack. This leads to the idea that design interventions could change the perception of the bus vehicle in these outer environments from a low class service to an inclusive service. Although, as a counter-point, Tozzi et al. (2014, p.2) suggests that so far, even though 'genuine innovations have taken place' within this field, user perception has not changed. Therefore, more work needs to be done within this area to fully understand user and nonuser opinion.

7. Summary and discussion

This review aimed to understand how outer suburban bus service design could be improved by knowledge of users and nonusers. Six sections were chosen for focus, including Melbourne's bus environment, bus vehicle classifications, outer Melbourne's population, user grievances and bus vehicle design, and design elements within the bus vehicle as a way to broadly understand the subject.

Through the use of the Melbourne environment and bus classification sections, an understanding of the current bus environment and the reasons for different bus task suitability were discovered. Often revolving around bus vehicle sizes and the roles they need to fulfil. Currently 12.5m low-entry buses dominate the Melbourne market in both the high and low density environments, raising the question of their suitability within outer Melbourne during off peak hours. The literature expresses mini and midi buses being more suitable within such an environment, particularly in regards to passenger occupancy, small and hilly roads and being slightly more economical. This is a suitable area for further research, with little literature discussing suitable bus vehicle size for outer Melbourne and furthermore the design of such a vehicle. This raises questions of the operator's bus vehicle size options and the users' willingness to use a differently structured service.

User-centred design is becoming a more popular topic within industries, looking at understanding and making better products for their users, which in turn often returns higher levels of usage and profit. This literature review analysed VISTA data, in regards to who is using outer Melbourne bus services and reviewed the literature surrounding some of the prominent user groups. Including millennials, elderly, transport disadvantaged, and people with a disability in regards to their PT needs. It was found that the main concerns of millennials and the transport disadvantaged revolved around the service, whereas the elderly and disabled users were more influenced by physical attributes. The literature, though extensive, often only stated user opinions and issues with the bus vehicle and service, often not discussing how the service could be improved through design interventions. Therefore, further research could be undertaken using design ethnography and generative design principles to better understand users and nonusers within outer Melbourne, designing for their need.

The section user grievances and bus vehicle design, focused on the issues surrounding bus services found within the literature. This was used as a way to understand what can be done to make bus services more user friendly and suitable. The literature was focused on design elements in relation to comfort, information, and perception. Here, the review served to summarise some well-known information from surveys and interviews conducted and was not Melbourne or low density centric. Although the literature was plentiful in covering user

issues, these were often presented from the dominant viewpoint of transport planning. As such, and particularly from the viewpoint of this research, the literature lacked designerly approaches to the problems of outer Melbourne bus services, and did not show reasoning as to why these issues exist and how to fix them.

The last section, design elements with the bus vehicle, covered a basic linkage between the bus vehicle and design elements, suggesting how good design could help to improve such services through improved aesthetics and creating a sense of place within these outer suburbs. Therefore, a further discussion of these factors using design knowledge and psychological reasoning could be suitable to create a deeper understanding.

From this literature review it has become apparent that the knowledge gained is very transport planning centric. Therefore, to add to the value of this knowledge and to benefit the design process and outcomes, a more holistic, designerly methodology must be utilised. Design ethnography and generative methods are therefore proposed as suitable ways to allow deeper understanding of user needs to be found, and directly applied to the task of bus service design for the outer Melbourne region. These methods are currently not commonly utilised within transport research, although the industry appears to be moving towards more empathic ways of understanding users. Therefore, these methods, if applied, could potentially be a suitable way to understand and then design for these users.

8. Conclusion

Bus services in outer Melbourne are currently functional, but still have a negative association. While this deficiency is broadly acknowledged as being due to the spatial and temporal factors of economic bus operation, this review shows that there are great opportunities for improving such services in hitherto unconventional ways. Through reviewing the literature currently available on the topics; Melbourne's bus environment, bus vehicle classifications, outer Melbourne's population, user grievances and bus vehicle design, and design elements within the bus vehicle, it is apparent that there could be a more suitably designed bus vehicle, or bus service for this environment. Currently little research has been conducted through a design scope on this topic and future research could help to understand this problem further, helping to make a more relevant and effective bus design and or service for this environment. In particular, the next steps proposed after this review is the utilisation of a design ethnography and generative design approach to understand the underlying causes for dissatisfaction with a view to generating solutions.

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9. References

APTA 2013. Millennials and mobility: understanding the millennial mindset.

BEIDLER, K. J. & MORRISON, J. M. 2015. Sense of place: inquiry and application. *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*, 1-11.

BLUMENBERG, E., TAYLOR, B. D., SMART, M., RALPH, K., WANDER, M. & BRUMBAGH, S. 2012. What's youth got to do with it? Exploring the travel behavior of teens and young adults.

BRANTON, P. 2003. Ergonomic research contributions to design of the passenger environment. *Person-Centred Ergonomics: A Brantonian View Of Human Factors*, 111.

BROOME, K., NALDER, E., WORRALL, L. & BOLDY, D. 2010a. Age-friendly buses? A comparison of reported barriers and facilitators to bus use for younger and older adults. *Australasian Journal on Ageing,* 29**,** 33-38.

BROOME, K., WORRALL, L., MCKENNA, K. & BOLDY, D. 2010b. Priorities for an Age-Friendly Bus System. *Canadian Journal on Aging,* 29**,** 435-44.

BRUNEL, F. F. & KUMAR, R. 2007. Design and the Big Five: Linking Product Aesthetics to Product Personality. *NA-Advances in Consumer Research Volume 34*.

BUNTING 2004. *Making Public Transport Work,* Canada, McGill-Queen's University Press.

CERVERO, R. 1993. Surviving in the Suburbs: Transit's Untapped Frontier. University of California Transportation Center.

CLAYTON, W., JAIN, J. & PARKHURST, G. 2016. An ideal journey: making bus travel desirable. *Mobilities***,** 1-20.

CORAZZA, M. V., GUIDA, U., MUSSO, A. & TOZZI, M. A new generation of buses to support more sustainable urban transport policies: A path towards “greener” awareness among bus stakeholders in Europe. *Research in Transportation Economics*.

COXON, S., BURNS, K. & DE BONO, A. Can the design of effective public space inform the passenger experience of public transport. 31st Australasian Transport Research Forum, edited by Monash University Faculty of Art and Design, 2008.

COXON, S., NAPPER, R. & ALLEN, J. The Role of Industrial Design in Addressing the Disparity between User Perceptions of Public and Private Transport. Proceedings of the 30th Australasian Transport Research Forum, Melbourne, 2007.

CURRIE, G. 2010. Quantifying spatial gaps in public transport supply based on social needs. *Journal of Transport Geography,* 18**,** 39.

CURRIE, G., RICHARDSON, T., SMYTH, P., VELLA-BRODRICK, D., HINE, J., LUCAS, K., STANLEY, J., MORRIS, J., KINNEAR, R. & STANLEY, J. 2009. Investigating links between transport disadvantage, social exclusion and well-being in Melbourne—Preliminary results. *Transport Policy,* 16**,** 97-105.

CURRIE, G. & SENBERGS, Z. Exploring forced car ownership in metropolitan Melbourne. Australian Transport Resaerch Forum, Melbourne, from, 2007a.

CURRIE, G. & SENBERGS, Z. Identifying Spatial Gaps in Public Transport Provision for Socially Disadvantaged Australians: The Melbourne 'Needs Gap' Study. Australasian Transport Research Forum. Melbourne, Australia, 2007b.

CURTIS, C. & SCHEURER, J. 2016. *Planning for Public Transport Accessibility: An International Sourcebook*, Routledge.

DELBOSC, A. & CURRIE, G. Using online discussion forums to study attitudes toward cars and transit among young people in Victoria. proceedings of the Australasian Transport Research Forum, Perth, Australia, 2012.

DELBOSC, A. & CURRIE, G. 2013. Causes of youth licensing decline: a synthesis of evidence. *Transport Reviews,* 33**,** 271-290.

DELL’OLIO, L., IBEAS, A., MOURA, J. L. & BORRI, D. Optimizing Bus Size in an Urban Public Transport Network. 11th World Conference on Transport Research, 2007.

DODSON, J., GLEESON, B. & SIPE, N. G. 2004. *Transport Disadvantage and Social Status: A Review of Literature and Methods*, Urban Policy Program, Griffith University Australia.

DZIEKAN, K. & DICKE-OGENIA, M. 2010. Reducing uncertainty and supporting cognitive maps in travel information for public transport. *World Review of Intermodal Transportation Research,* 3**,** 73-90.

FEDERAL REGISTER OF LEGISLATION 2002. Disability standards for accessible public transport 2002. Canberra: Australian government,.

FEDERAL REGISTER OF LEGISLATION 2006. Vehicle Standard (Australian Design Rule 68/00- Occupant Protection in Buses) 2006. Canberra: Australian Government.

FRIDMAN, I. 2016. Battery-electric route bus: a platform for vehicle design. *In:* PRINCIPAL SUPERVISOR: ROBBIE, N., SUPERVISOR: ARTHUR DE, B. & SUPERVISOR:

MICHAEL, K. (eds.). Monash University. Faculty of Art, Design and Architecture. Department of Design.
FRIDMAN, I. & NAPPER, R. 2016. An analysis of bus interior headroom for future design applications.
FROST, L. & DINGLE, T. 1995. Sustaining Suburbia: an historical perspective on Australia's Urban Growth. *Australian Cities: Issues, strategies and policies for urban Australia in the 1990s*, 20.
G. BEIRA˜O & CABRAL, J. A. S. 2007. Understanding attitudes towards public transport and private car: A qualitative study.
GUIDA, U. 2014. EBSF Final Report. EBSF.
GWILLIAM, K. 2008. Bus transport: Is there a regulatory cycle? *Transportation Research Part A: Policy and Practice,* 42**,** 1183-1194.
HALL, E. T. 1966. *The hidden dimension,* Garden City, N. Y., Garden City, N. Y. : Doubleday.
HARRISON, S., HENDERSON, G., HUMPHREYS, E. & SMYTH, A. Quality bus corridors and green routes: can they achieve a public perception of "permanence" of bus services? Public transport planning and operations. Proceedinngs of seminar F held at the European transport conference, Loughborough university, England, 14-18 September 1998. Volume P425, 1998.
HAUSTEIN, S. 2012. Mobility behavior of the elderly: an attitude-based segmentation approach for a heterogeneous target group. *Transportation,* 39**,** 1079-1103.
HAVEMAN, M., TILLMANN, V., STÖPPLER, R., KVAS, Š. & MONNINGER, D. 2013. Mobility and Public Transport Use Abilities of Children and Young Adults With Intellectual Disabilities: Results From the 3-Year Nordhorn Public Transportation Intervention Study. *Journal of Policy and Practice in Intellectual Disabilities,* 10**,** 289-299.
HENSHER, D. A. 1998. The imbalance between car and public transport use in urban Australia: why does it exist?1. *Transport Policy,* 5**,** 193-204.
HENSHER, D. A. 2000. Urban public transport challenges. *The Drawing Board: An Australian Review of Public Affairs,* 1**,** 47-62.
HENSHER, D. A. 2007. Sustainable public transport systems: Moving towards a value for money and network-based approach and away from blind commitment. *Transport Policy,* 14**,** 98.
HITRANS 2005. *Public transport : citizens' requirements,* Stavanger, Norway], Stavanger, Norway : HiTrans.
HJORTHOL, R. 2013. Transport resources, mobility and unmet transport needs in old age. *Ageing and Society,* 33**,** 1190-1211.
HOWE, N. & STRAUSS, W. 2007. The next 20 years: how customer and workforce attitudes will evolve. *Harvard Business Review,* 85.
HURNI, A. Transport and social exclusion in Western Sydney. Transporting the Future: Transport in a Changing Environment: Conference Proceedings of the 28th Australasian Transport Research Forum, 2005.
HUTCHINSON, T. 2000. A syllabus for transport studies. *Road & Transport Research,* 9**,** 63.
HUTCHINSON, T. P. 2009. The customer experience when using public transport: a review. *Proceedings of the ICE - Municipal Engineer,* 162**,** 149-157.
JANSSON, J. O. 1980. A simple bus line model for optimisation of service frequency and bus size. *Journal of Transport Economics and Policy***,** 53-80.
KING, R. D. 1998. *New designs and operating experiences with low-floor buses*, Transportation Research Board.
LEVIS, J. A. 1978. The seated bus passenger — a review. *Applied Ergonomics,* 9**,** 143-150.
LOADER, C. & STANLEY, J. 2009. Growing bus patronage and addressing transport disadvantage—The Melbourne experience. *Transport Policy,* 16**,** 106-114.
MCKNIGHT, J. 1995. The Development of a Low Floor Citybus—Volvo B10L. *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering,* 209**,** 77-93.

MEES, P. 2010. *Transport for suburbia : beyond the automobile age,* London

METZ, D. 2003. Transport policy for an ageing population. *Transport Reviews,* 23**,** 375-386.

NAPPER, R. Route bus transport–stakeholders, vehicles and new design directions. Proceedings of the 29th Conference of Australian Institutes of Transport Research, Adelaide, 2007.

NAPPER, R., DE BONO, A., BURNS, K. & COXON, S. Bus design guidelines: Complementing planning with vehicle design.

NASH, C. 2015. *Handbook of Research Methods and Applications in Transport Economics and Policy*, Edward Elgar Publishing.

NOBLE, B. 2005. Why are some young people choosing not to drive? *Proceedings of etc 2005, Strasboourg, France 18-20 September 2005- Transport policy and operations-European policy and research- access to transport and future issues*.

NORMAN, D. A. 2004. *Emotional design: Why we love (or hate) everyday things*, Basic books.

NORMAN, D. A. 2013. *The design of everyday things: Revised and expanded edition*, Basic books.

OBORNE, D. J. 1978. Passenger comfort — an overview. *Applied Ergonomics,* 9**,** 131-136.

OLDENBURG, R. & BRISSETT, D. 1982. The third place. *Qualitative sociology,* 5**,** 265-284.

OLDFIELD, R. & BLY, P. 1988. An analytic investigation of optimal bus size. *Transportation Research Part B: Methodological,* 22**,** 319, 322.

PTV. 2016a. *Network statistics* [Online]. Melbourne: PTV. Available: https://www.ptv.vic.gov.au/about-ptv/victoria-s-pt-network/network-statistics/ [Accessed September 7 2016].

PTV. 2016b. *Night Bus* [Online]. Melbourne: PTV. Available: https://www.ptv.vic.gov.au/search/getSearchForm?Search=night+service&UserFilter%5B0%5D=0&UserFilter%5B1%5D=1&action_getSearchResults.x=0&action_getSearchResults.y=0&action_getSearchResults=Search [Accessed Nov 15 2016].

PTV. 2016c. *Timetables* [Online]. PTV. Available: https://www.ptv.vic.gov.au/timetables [Accessed Nov 7 2016].

PTV 2017. Customer satisfaction monitor: January-March 2017. Melbourne.

ROCHEFORT, P. 1981. Psychosociological techniques for mass transit development: A french experience. *Interfaces,* 11**,** 75-77.

ROHANI, M. M., WIJEYESEKERA, D. C. & KARIM, A. T. A. 2013. Bus operation, quality service and the role of bus provider and driver. *Procedia Engineering,* 53**,** 167-178.

RUUD, A. & NORDBAKKE, S. 2005. Decreasing driving licence rates among young people-consequences for local public transport. *Proceedings of etc 2005, Strasboug, FRance 18-20 September 2005- Transport policy and research- Access to transport and future issues*.

SCHERER, M. 2010. Is Light Rail More Attractive to Users Than Bus Transit? Arguments Based on Cognition and Rational Choice. *Transp. Res. Record***,** 11-19.

SCHERER, M. & DZIEKAN, K. 2012. Bus or rail: an approach to explain the psychological rail factor. *Journal of Public Transportation,* 15**,** 5.

SCHMITT, L. 2015. Do first trips matter? exploring unfamiliar public transport travel. *In:* PRINCIPAL SUPERVISOR: GRAHAM, C. (ed.). Monash University. Faculty of Engineering. Department of Civil Engineering.

SOCIAL EXCLUSION UNIT 2003. Making the connections Final report on transport and social exclusion: summary.

SONDEREGGER, A. & SAUER, J. 2010. The influence of design aesthetics in usability testing: Effects on user performance and perceived usability. *Applied ergonomics,* 41**,** 403-410.

STANLEY, J., HENSHER, D. A., STANLEY, J., CURRIE, G., GREENE, W. H. & VELLA-BRODRICK, D. 2011. Social exclusion and the value of mobility. *Journal of Transport Economics and Policy,* 45**,** 198- 199.

STEELE, F. 1981. *The sense of place*, Cbi Pub Co.

STICKDORN, M., SCHNEIDER, J., ANDREWS, K. & LAWRENCE, A. 2011. *This is service design thinking: Basics, tools, cases*, Wiley Hoboken, NJ.

STRADLING, S., CARRENO, M., RYE, T. & NOBLE, A. 2007. Passenger perceptions and the ideal urban bus journey experience. *Transport Policy,* 14**,** 283-292.

SUEN, S. L. & MITCHELL, C. 2000. Accessible transportation and mobility. *Transportation in the New Millennium*.

THOMAS, J. 2010. *The social environment of public transport : why don't we talk to strangers?* , Thesis (Ph.D.)--Victoria University of Wellington, 2009.

TIRACHINI, A., HENSHER, D. A. & BLIEMER, M. C. 2014. Accounting for travel time variability in the optimal pricing of cars and buses. *Transportation,* 41**,** 947-971.

TOZZI, M., GUIDA, U. & KNOTE, T. 3iBS: the intelligent, innovative integrated bus systems. Transport Research Arena (TRA) 5th Conference: Transport Solutions from Research to Deployment, 2014.

TRANSPORT FOR VICTORIA 2013. VISTA 2013. *In:* GOVERNMENT, V. S. (ed.). Victoria: Victorian State Government.

UITP 2006. *European bus of the future- functional features and recommendations,* Brussels, International Association of Public Transport,.

VAED 2012- 2015. Unintentional hospital admitted bus related injury. *In:* VAED (ed.) *Victoria 2012/13-2014/15 (3 years).*

VAN DER HEIJDEN, H. 2003. Factors influencing the usage of websites: the case of a generic portal in The Netherlands. *Information & management,* 40**,** 541-549.

VINK, P. 2004. *Comfort and design: principles and good practice*, CRC press.

VISTA 2013. Weekday travel by region and transport mode. *Tableau public.* Tableau public.

VUCHIC, V. R. 2007. *Urban transit systems and technology,* Hoboken, N.J., Hoboken, N.J. : John Wiley & Sons.

WOYCIECHOWICZ, A. & SHLISELBERG, R. 2005. Wayfinding in public transportation. *Transportation Research Record: Journal of the Transportation Research Board***,** 35-42.

ZURCHER JR, L. A. 1979. The airplane passenger: Protection of self in an encapsulated group. *Qualitative Sociology,* 1**,** 77-99.