FIFTY YEARS OF INCLUSIVE TRANSPORT BUILDING DESIGN RESEARCH

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Summary

Inclusivity is a core commitment of the New Urban Agenda of UN Habitat (adopted in 2016). Moreover, the Rail Sustainable Development Principles call for railway developments that are customer-driven, putting rail in reach of people, providing an end-to-end journey, being an employer of choice, reducing our environmental impact, carbon smart, supporting the economy, optimising the railway and being transparent (RSSB, 2016). However, research suggests there is still a long way to go before ‘‘we live and work in an inclusive world” (Clarkson and Coleman, 2015). To consider these matters, this review searched for on-line library sources employing keywords including transport, inclusivity, circulation, severance, level of service, pedestrian movement within journal articles, conference papers, theses, books and government papers. The review commences with a review of older views and goes on to critically assess potential innovations in contemporary scholarly literature. Earlier research discusses general factors that influence station design include context, location, platform, train length, and depth of construction, geological, engineering, property constraints and passenger demand (Harding, 2011). This critical review considers the scholarly literature concerning inclusive design issues in transport buildings. It explores, (i) gaps in canonical pedestrian movement theory affecting inclusivity, particularly vertical severance (VS), (ii) the size, shape and selection of circulation elements affecting Level of Service (LOS), and (iii) key measures of crowdedness and inclusivity. Potential innovations include, (i) new ‘designerly ways of knowing’ about lack of inclusivity, and, (ii) the use of Agent Based Modelling (ABM) for gaining insights into the movements of diverse agents over time (as well as the evaluation of rival cases). Anticipated benefits include a strengthened ‘transport chain’, less VS, enhanced empathy, and improved user experience and safety. More research is needed in this field, particularly owing to the significant cost and time in developing urban railway projects. This review identifies key research questions that require further investigation. It argues that integrating LOS theory and design praxis will result in safer and more inclusive stations that contribute more to society. It is hoped that this review contributes to this slowly growing body of knowledge of inclusivity within the field of transport.

Keywords: Inclusive Design, Service Design, Transport, congestion, severance, Agent Based Modelling

Abbreviations. ABM-Agent Based Modelling, LOS-Level of Service, PRM-Persons with Restricted Mobility, SD-Service Design, VS-Vertical Severance.

1.0 Introduction: First Generation Wheelchair Accessible Transport Buildings

Many passengers experience a broken ‘transport chain’ (From Exclusion to Inclusion by the Disability Rights Task Force (DRTF), 1999 Cited in Bichard, 2014: 90) including those who travel with bags, prams or heavy luggage, or are elderly or frail or have medical issues (GLA, 2010). An ‘end to end journey’ (RSSB, 2016) is practically impossible for some groups of people who wish to use public transport in London (Harding, 2011). Only ten London Underground (LU) stations provide an unbroken, step-free journey from street to train (GLA, 2010), 61 out of 270 stations provide step-free entry from street to platform level (ibid), and three stations are accessible from street to train in the three busiest employment centres in London (Harding et al., 2016). Recent research findings are that boarding or alighting a train is impossible for some groups of people owing to gaps at the train-platform interface (Atkins, 2005). Findings are (i) staff are unavailable to help with a portable ramp, (ii) wheelchair users and assistants attempt to board or alight unaided, (iii)

the ramp gradient is too steep, (iv) the platform vertical and horizontal gaps exceed the minimum distance (v) gaps are visible even when the most modern trains are employed, (vi) mobile ramps are forbidden at LU stations owing to a low LOS and frequent train service (GLA, 2010). However, the Disability Discrimination Act (1995) required wheelchair access in public buildings and soon after, the first generation of underground transport buildings had wheelchair access from street to platform for the first time (Harding, 2011). A possible reason for this delay is that earlier research claimed 'it was not essential' to make underground stations accessible for wheelchair users (Goldsmith, 1976: 401 item 77200). In his defence, Goldsmith, an influential researcher and architect who suffered from polio and used a walking stick, claimed the costs of lifts (US$10m for lifts on the BART in San Francisco, and US$44-60m for lifts on the Washington DC metro built In 1971) were excessive (1976: 60 para. 1411). He may have changed his mind owing to later editions of his book exclude these comments (cited in Harding, 2011). On the other hand his views were influential owing to his books formed the basis of the British Standard Code of Practice on Access for the Disabled to Buildings (CP96) in 1967, later revised to BS5810 (1979), that developed into Part M of the Building Regulations in 1987(Coleman et al., 2003: 5). The Equality Act (2010) has a wider remit to promote inclusivity across gender, age, disability and sexual orientation. On the other hand, lifts afford limited benefits to many users owing to small size, minimal quantity and poor location (Harding, 2011).

1.1 Pedestrian Movement Theory

Another reason to explain the poor uptake of lifts in stations is that current protocols and pedestrian movement calculations disregard the contribution lifts could make in moving people vertically (Network-Rail, 2011). The methodology to validate designs for station concourses (Network-Rail, 2011: 12) and also for pavement areas (Atkins, 2010) uses canonical theory (Fruin, 1971). Fruin's methodology allows building designers to determine the sizes and shapes and arrangement of spaces, concourses and pavements, airport terminals, bus interchanges and train stations (ibid: 77-78). Level of Service (LOS) provides a measure of six congestion levels; a low LOS (E-F) describes a highly congested density level where it is difficult to change direction; in contrast a high LOS (A-C) describes a free-flowing space where a rapid change of direction is possible (Fruin, 1971: 71). However, a low LOS creates concerns for disabled pedestrians including, (i) they may delay other passengers, (ii) that other passengers may be unaware of their impairments, and (iii) their slower pace makes them more likely to be pushed or tripped in busy, congested, fast-moving spaces (ibid 177-178). To improve the disabled pedestrian's comfort and confidence he suggests increasing the LOS in congested circulation areas (ibid 177-178). Fruin's (1971) theory contains two main problems for inclusivity, (i) he does not develop his idea to offer a higher LOS for disabled people (ibid 177-178), possibly owing to the thought that increasing LOS is only possible by increasing the size of the transport building and that would increase destruction of historic built environments that he was against (ibid: 2-11), (ii) in transferring and adapting evaluation methods from highway design theory to pedestrian movement theory in his PhD thesis (Highway Capacity Manual, Highway Research Board, Special Report 87, Washington, D.C. (1965) cited in Fruin, 1971: 71), he misses a critical difference that whilst a vehicle easily moves up or down a hill, pedestrians face many difficulties moving vertically in train stations (GLA, 2010). Furthermore, current design guidance does not suggest increasing LOS in stations (Network-Rail, 2011: 12) or within the urban realm (Atkins, 2010) to improve inclusivity.

1.2 A 'Wicked' Problem

Designers need to know how many passengers would need to use a lift to ensure they specify the correct size and quantity of lifts (Al-Sharif and Al-Adem, 2014). The risk is, without knowing how many passengers would like to use a lift, designers may reuse past assumptions and prototypes owing to the lack of research (Harding, 2011), time pressures, and the Einstellung effect, or 'design fixation' (Crilly, 2015). Harding (2018a) claims knowing how many people require help with inclusivity is a 'wicked' problem that cannot be solved by traditional scientific and engineering methods (Cross, 2007). Next, we will review research that could addresses these concerns.

2.0 Researching Empathy

A possible explanation for the low take-up of inclusivity in transport buildings is that designers, clients and project managers who produce and control design all have differing experiences according to their age and gender (Harding, 2011). The problem, as Warburton (2003: 255-256) claims, is that mostly male young designers design primarily for themselves and other young people who they perceive as sexy. Similarly, younger transport planners design *'systems for the able-bodied, not for those who were frail. There was a desire for a gentler, more comfortable environment.'* (Marsden et al., 2008: 5). To investigate these claims, Harding (2011) quantitative study uses a questionnaire survey and a five-point Likert scale to study 'Tube' user experiences. All forty-seven respondents (34 men, 13 female) were frequent commuters, and influential participants who were employed to design and build several major new underground stations in London. The respondents were selected to reflect observed demographic composition of the organisation and the data were collected during a four-week period in 2010. None of the respondents claimed to have a disability. Findings are that a gentle journey affords clear announcements, low noise, lack of fear of being lost or splitting from a group, few changes of levels and easy orientation. Older men in influential positions were generally satisfied with their experience. Women and younger men have a poorer experience of security, confidence and comfort. Whilst all groups had confident experiences, their journeys were not gentle. Causes for concern are 17% of men experienced crime compared to 7% of women, whereas 76% women had a higher fear of crime, compared to 32% of men. Moreover, women talked to more strangers (46% compared to 20% of men) which suggests that men might be safer if they had greater awareness of crime and talked to strangers (Harding, 2011: 74). Interestingly, women experienced more anti-social behaviour (61%) then men (50%). That suggests anti-social behaviour might be less predictable and difficult to avoid (Harding, 2011: 74). Moreover, three gay male respondents completed survey forms. The data indicates no increased fear of crime or experience of crime for gay men compared to straight men. Thus, if both gay and straight men adopt female crime avoidance strategies by being warier both groups could experience less crime. Possible explanations for why males felt more secure were owing to, i) their physical strength, ability and confidence to deal with dangerous situations (Harding, 2011: 53), (ii) male respondents have the best experience of travelling on the Tube, (iii) males and engineers dominate the design of underground stations, (iv) males were more reluctant to learn about inclusivity (Harding, 2011: 83). Features that appear harmful, such as long, narrow or twisting corridors, may expose everyone to greater harm or fear of crime. However, men experienced less fear (17% Q13) and more crime (17% Q18). In contrast, women had more fear (53% Q13) and experienced less crime than men (7% Q18). Additional differences are women are around a third weaker than men, owing to their smaller physique and childbirth (Bassey, 1997: 289-297). As a consequence, specialists such as psychologist Huppert claim that 'older women should therefore be a priority in inclusive design' (2003: 35). However, safety guidelines disadvantage women who find it burdensome to carry a child and a folded pram and bags on an escalator (GLA, 2010). On the other hand, there is a risk and irony that men who may wish to develop designs that suit themselves, endanger themselves and others by creating less safe circulation spaces within stations (Harding, 2011). Limitations of this research are that the respondents were unrepresentative of the public because most were professionals, working and held degrees. Nobody declared a disability. Harding (2011) suggests this could be owing to disabled people having trouble travelling, gaining and keeping a job, and keeping silent about their disability (Payling, 2003: 395 cited in Harding, 2010). Research suggests a negative reply to this question is common in surveys (ibid). Additionally, a known weakness of using positivistic questionnaires that use inductive and deductive logics of enquiry is that they remove important details and differences to produce simplistic explanations (Stainton-Rogers, 2006: 81). In summary, this study provides many interesting observations using a straightforward way to measure intangible comfort, security, gentleness, confidence experiences by comparing differences between demographic groups, (i) male, (ii) female, (ii) less than age 25, (iii) between age 25 and 55, (iv) over age 55. A tool that compares experiences of different demographic groups, as Harding (2011) develops could promote reflexivity in practitioners who are working in

uncertain, unstable, unique areas with conflicting requirements and values (Schon cited in Cross, 2007: 3) and inform designers that other groups may have different experiences than their own (Warburton, 2003; Marsden et al., 2008). Further research could probe how comfort, security, gentleness and confidence factors impact inclusivity (Harding, 2011) in praxis.

2.1 Understanding User Experience

The influence behind this study was to investigate inclusivity concerns in the context of a busy, urban underground station using mobile methods by leaving *"… the design office and becoming-if briefly-immersed in the lives, environments, attitudes, experiences and dreams of the future users"* (Battarbee, 2004). Participant observation studies are frequently used in the fields of anthropology and sociology using methods developed by Malinowski (cited in Buzard, 1997).This is the first time this methodology, is applied to investigating passengers within a crowded urban underground railway context (Harding et al., 2016). Their qualitative study investigates how people in the 'rush hour' circulate in a low LOS, typically shallow station, which is in a busy urban location with one lift (Harding et al., 2016). Research questions are, in what ways do we find train passengers suggestible as they move through congested underground train stations, and how do passengers protect themselves against suggestions that do not help them survive or be included within the design? (Harding et al., 2016). This method allows a researcher to collect video data, using a chest mounted camera, whilst moving within the station with other passengers. The video data was transferred from the camera onto a computer and analysed approximately a month after the data was collected. The good quality of the recording allowed the researcher to recollect events and analyse results in a detached way. This exploratory study stores and preserves video files as an innovation Crichton and Childs (2005) that clips audio recordings to preserve original participants' voices and roughly codes audio files using Excel to store large files. Harding's modified approach saves research time by reducing the amount of transcription, preserves the original materials until explication, and allows a 'thick' or wordy description of the event. This immersive method allows a researcher to move spontaneously within a busy station during the evening peak-hour commute to observe passenger experiences directly (Harding, 2016a). It focuses our attention upon the qualitative aspects of the 'passenger journey' and identifies, from the user viewpoint surprising design or behaviour issues. These include glare from bright lights shining into the eyes of passengers, noise from announcements and the quietness of crowds waiting patiently for their next train. Findings highlight the difficulty to reach and find a lift when it is small and poorly located at the end of a long and congested route at platform level. In contrast, the lift location at concourse level has a higher LOS and is visible adjacent to busy escalators, however, there is lack of space in the lift to accommodate all the passengers who wish to use it. Other negative factors result from confusion, congestion, glaring lights, noisy announcements and warnings. A typical island platform configuration results in significant queuing when trains are insufficiently frequent or too congested to board. Findings from indirect methods using a questionnaire (Harding, 2011) exclude such details. Other advantages are preserving the video data allows other researchers and participants to make their own interpretation. It reports on subtle details of 'lived experiences' that may otherwise be lost, and provides a voice for the 'silenced' which may improve the autonomy, survivability and perhaps their inclusion in a next generation of station designs. The analysis focuses upon how to improve mobility in the station from a user's perspective. The use of auto-ethnography is discussed as part of a broader methodological debate about how to explore universal design issues from a user's perspective, and in the context of empathetic design (Harding et al., 2016). The video data and analysis is useful to either a researcher, or a designer, not living in London, or in a country without a railway, who wishes to experience a journey in a busy train station and may be unable to travel and gain an insightful experience in a 'real' station. Difficulties with this research method are no significant data should be taken without consent (Oates, 2006) and findings are un-generalisable owing to the participant observer had no impairment, is male and middle aged that risks unconscious bias.

2.2 Safer Stations

Train stations are the riskiest place for accidents on the entire rail network in the UK and cost the industry approximately £90m per year (RSSB, 2015). Slips, trips and falls are common accidents. A 'fatality weighted index' (FWI) quantifies all the, albeit few, fatalities and the frequent minor and major injuries into approximately and occur most often on stairs (10), platforms (8), concourses (4), escalators (4) and other (2). There are approximately 30 FWI per year (excluding suicides). The data shows almost 50% (14) of FWIs occur on stairs and escalators (refer to Chart 39 RSSB, 2015). However interviews with station managers and traveller key station design issues regard vertical circulation as less important design factors to minimise slips trips and falls; instead flooring materials, waiting rooms, lighting; signage, cleaning and housekeeping are considered more important (Victoria; et al., 2014: 39 Table 8). In contrast worldwide research papers show that elderly people, children, women with high heels and inebriated people as the most at risk from slips, trips and falls on escalators. (Greenberg and Sherman, 2005). Unfortunately mixed methods studies from Hong Kong (Chi et al., 2006) and USA (O'Neil et al., 2008), where escalators are common, do not explain why these groups are most at risk; nor do they suggest measures that could prevent harm. Rubenstein (2006) identifies in a meta-analysis study the causes of falls in elderly adults, describes the interaction of environmental, medical and age factors that cause the falls (ibid ii38). Slips, trips and falls should be considered a significant issue in train station design because '…. [unintentional] *injuries are the fifth leading cause of death in older adults (after cardiovascular disease, cancer, stroke and pulmonary disorders), and falls constitute two-thirds of these deaths'* (ibid ii37). It is recommended that further design research probes factors including circulation and LOS that could result in safer stations.

2.3 Reduce Vertical Severance (VS)

To address the risks and issues of moving vertically, Harding (2013) synthesises earlier observations and literature (Harding, 2011) by defining this phenomenon as **Vertical Severance.** The "*…separation from ground level to the platform that creates spatial mobility and socio-economic concerns for individuals. VS results in less diversity and more exclusivity within transport modes and the cities they serve."*(Harding, 2013: 13). For new VS free transport buildings, Harding (2013) recommends the following solutions: *"….1) Accept Maynard's claim that well designed lifts are beneficial to almost all individuals (2007), consequently develop designs with more and faster lifts. 2) Consider other property types that solved VS, for example, Heathrow Terminal 5* [that provides many large lifts to serve passengers carrying luggage… *6) Consider* [either] *omitting or provid*[ing] *fewer spatially inefficient escalators to deeper stations, or where passenger exit and entrance numbers are relatively low, provide more space for lifts and evacuation stairs. Note that escalators cost more to build, maintain and consume far more energy than lifts. … In summary, such changes require a paradigm shift to provide VS-free designs …"* (Harding, 2013: 12). Some scholars argue that vertically separating the pedestrian from the vehicle is beneficial to pedestrian comfort and safety (Fruin, 1971: 183-196); others prefer active streets and pavements and oppose vertical segregation (Hillier, 2004: 45). Other scholars argue severance or the 'wrong side of the tracks' phenomenon barely exists (Mitchell and Lee, 2014) – they tentatively argue that socio-economic divisions in neighbourhoods on opposite sides of the Clyde River valley in Glasgow are explained by their steep banks. Further research could probe how different circulation choices could satisfy either 10% or 25% of overall passenger numbers who may wish to use a lift at stations (Harding, 2013: 11), and identify actionable insights for LOS, inclusivity and VS theory and praxis.

2.4 New Disability Discourses

No discussion of inclusivity would be complete without a brief review of recent discourses in disability studies that developed earlier medical and social models of disability to current interactional models (Riddle, 2013: 33-35). The Medical Model claims the "impaired body must be restored, adapted and cured" (Scullion(2009) quoted in Gomez et al., 2014: 272). In contrast, the Social Model of Disability claims society's actions and inactions cause a

person's disability. The particular trouble with Social Model theory is that owing to its insistence that society causes disability it ignores the possibility that advances in medical technology developed within the medical and technological field may remove the impairment (e.g. glasses, wearable technology, or prosthetics) (Corker and French, 1999). Similarly, Watson and Woods (2005: 104) argue that wheelchair technology has an emancipatory impact upon the lives of wheelchair users and the use of technology is often neglected as an aid for social justice. The weakness in the social model argument is that "*… the horse before the disability studies carriage is often politics, not science* " (Vehmas, 2008: 21 Quoted in Riddle 2013:2028). Recent inclusive design (Boys, 2014) and interactional theory focuses upon removing the impairment from both the built environment and the body (Riddle, 2013). Interactional theory also expands the discourse to more complex socio-political contexts (not just disability) including feminist, racial, gender, ethnicity and sexual topics (Stainton, 2000); non-disabled concerns (Slack, 1999: 23) and challenges us to consider questions about sufficiency; and medical-socio-material-economic-political challenges (Slack, 1999). Socio-material-environmental thinking found in recent research takes a more holistic view (Bichard, 2014). Consequently, many philosophers and bioethicists support this interactional approach (Riddle, 2013: 23). Further research could probe how different circulation choices that reflect social model logic vs. latest interactional logic may settle these rival discourses and may develop actionable insights in praxis.

2.5 'Next, Next Generation' design research methods

First generation design research methods that used 'systematic, rational 'scientific' methods sought to optimise design, however these approaches did not solve 'wicked' design problems (Cross, 2007: 1). 'Next, next generation' methods are 'more relevant to architecture and planning rather than engineering and industrial design' (Horst Rittel (1973) cited in Cross, 2007: 1). These include an idea from business studies called 'satisficing' that aims to develop satisfactory and appropriate solutions and not 'optimising' solutions (Simon, 1979). 'Service design' (SD) research by the design and research company IDEO strengthens the 'passenger journey' by developing knowledge of each activity or ' customer touch points' as the passenger obtains information, plans the journey, travels to the station, enters the station, buys tickets, waits, boards the train, travels on the train, alights, and continues the journey (Bhavnani and Sosa, 2008). However, integrating this concept is untested in recent underground train station design research (Harding, 2018a). Further design research could probe how new 'designerly' methods (Cross, 2007) could address the aforementioned 'wicked' design problems of inclusivity by incorporating SD and the passenger journey concepts (Bhavnani and Sosa, 2008).

2.6 New Tools

New research inquiry tools that could aid inclusivity research and praxis include, (i) 'Bit Kit' is a tool to assist visually impaired users with navigating in buildings (McIntyre and Hanson, 2014), (ii) Wayfindr is an assistive navigation tool useful for visually impaired people to navigate by themselves in unfamiliar buildings including transport buildings (Giannoumis G.A. et al., 2018), (iii) Space Syntax is a tool that evaluates connectivity of streets within urban areas (Hillier, 2004) but does not model congestion, (iv) However, Legion is an ABM-based pedestrian modelling trusted by many transit authorities to interpret and validate train station design (Network-Rail, 2011: 53). Recent ABM research recommends further *'integration of simulation results with accessibility requirements for persons with restricted mobility* [PRM] *…for all pedestrian simulation modelling to ensure an equitable assessment of transport interchanges'* (Clifford et al., 2016: 16). However, restricting studies to PRM passengers appears to generate problems of exclusivity that this paper argues against. Instead this paper argues new ABM research should probe the 'wicked' problem of not knowing how many people require help with inclusivity (Harding, 2013), how rival circulation choices impact agents' behaviour (Harding, 2018a).

3. Conclusion

Findings from this review suggest that researching inclusivity is a 'wicked' problem and that 'design thinking' and 'next, next generation' methods (Horst Rittel (1973) cited in Cross, 2007: 1) and Service Design (Bhavnani and Sosa, 2008) could advance 'satisficing' solutions (Simon, 1979) for inclusivity. This review also highlights the concern that VS is a problem that can be seen in transport buildings (Harding, 2013) and urban areas (Mitchell and Lee, 2014). The impact of congestion upon inclusivity in transport buildings and urban areas appear under researched suggesting that canonical pedestrian movement (Fruin, 1971) and VS (Harding, 2013) require further research to satisfy inclusivity needs in society. A future study aims to address these questions.

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