Enhancing the Pedestrian Experience in Singapore: A Closer Look at MRT Transfers and CBD Walkability

by

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B.E. in Civil Engineering
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Submitted to the Department of Urban Studies and Planning
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ABSTRACT

In the small but highly developed city-state of Singapore, transportation interventions are primarily geared towards getting people to work efficiently, and finer aspects with regards to walkability had not received enough attention. In the area of work-related walking, two aspects have been identified for possible enhancement. First, with Singapore aggressively expanding her Mass Rapid Transit (MRT) system, more MRT transfers will result in future. The stress of transfers has been widely researched to influence modal shifts and psychological behavior, which in turn affects work performance and family relations – walking negativity in transfers is arguably as critical, if not more so than waiting. This thesis proposes using design enhancements to improve the walking experience when transferring between MRT lines that can be typically extended distances to walk. These include the use of landscaping, advertisements and colors to ameliorate the transfers that commuters have to do ad nauseum every day.

Another issue of walking in work-related trips is the inadequacy of walkability in downtown CBD where there is a high concentration of office workers who demand short walking trips. An enhanced pedestrianization scheme with shelter and cooling is proposed to address the walkability needs with respect to Singapore's hot, humid and rainy tropical weather. Other issues of walkability that are important and slated for further study include the lack of pedestrian priority in residential estates and the dichotomy between planning for both leisure walking and walking as a means of travelling.

Thesis Supervisor: Ralph Gakenheimer
Title: Professor of Urban Planning

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My interest in walking inspired this thesis, and even though the journey of writing it out is hardly a walk in the park, I am thankful for many individuals who helped made it possible.

First, I express my deepest gratitude to my thesis advisor, Professor Ralph Gakenheimer. His insightful pointers and constant guidance gave me depth and clear directions to pursue in my research and writing.

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I am very grateful to have my family as a pillar of strength too, even though they are thousands of miles away in Singapore. Dad, Mum and Sis, thank you for your words of encouragement and constant reminders for me to sleep more even though that was not much of an option for over-worked students like me. My brother, Weiming, thank you for being my eyes and ears in Singapore, and for patiently taking photos for me back home and putting up with my fussy requests.

Last but not least, I would like to thank my wife, Kimberly for whom I dedicate this thesis to. It was only through her constant support and understanding for the past year that I was able to produce this work. Now how about that second honeymoon any place you want where we can stroll for all we like and enjoy “enhanced pedestrian experiences”?

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List of Acronyms

HDB	Housing Development Board (Singapore)
LTA	Land Transport Authority (Singapore)
MRT	Mass Rapid Transit (Singapore's metro system)
MTR	Mass Transit Railway (Hong Kong's metro system)
NParks	National Parks Board (Singapore)
POB	Pedestrian Overhead Bridge
SLA	Singapore Land Authority
URA	Urban Redevelopment Authority (Singapore)
WEXiS	Walking Experience in Singapore (survey)

Chapter 1 Introduction

This thesis seeks to enhance the pedestrian experience in Singapore given her existing state of development with special consideration to her tropical climate. Due to the large scope of different aspects of walking in Singapore, the focus of this thesis will be narrowed to that of walking in Singaporeans' daily work lives specifically. However, short notes on leisure walking and residential walkability will be briefly mentioned due to their relevance to the thesis.

This first chapter will give a short introduction of Singapore and establish the objectives and scope of the research. The methodology and limitations of the thesis will be described next before the chapter is concluded with the research question that will be answered by this thesis.

Singapore in Brief

Singapore is a city-state situated in Southeast Asia, see Fig 1.1. One of the original Asian Tigers,[1] Singapore has been having strong economic growth since the 1960s, and her GDP per capita based on purchasing power parity of US$31,400 in 2006, is amongst the highest in Asia and on par with many other advanced economies of Europe and North America.[2] Singapore's population is around 4.6million in a land area of around 700 sqkm; other important statistics are tabulated in Appendix 1 in comparison with Japan, U.S. and other selected countries.

Fig 1.1 Map of Asia showing Singapore's location, together with other major countries/cities in the region

[1] A term originally coined for the rapidly growing Asian economies of Hong Kong, Korea Republic, Singapore and Taiwan. In recent times, some consider it to include growing economies of SE Asia like Thailand, Malaysia, etc.
[2] Central Intelligence Agency (CIA). (2007). *The World Factbook*, USA.

Despite her advanced economy status,[3] Singapore's urban form is still evolving, understandably so because of her relatively young age when it comes to city building. Future development plans that will dramatically shape Singapore's form include a new downtown area that will more than double the existing 3.8 million sqm of commercial floor area in the Central Business District (CBD),[4] see Fig 1.2. Ambitious transportation expansion plans also include doubling the rail transit network from its 138km today to 278km in 2020.[5]

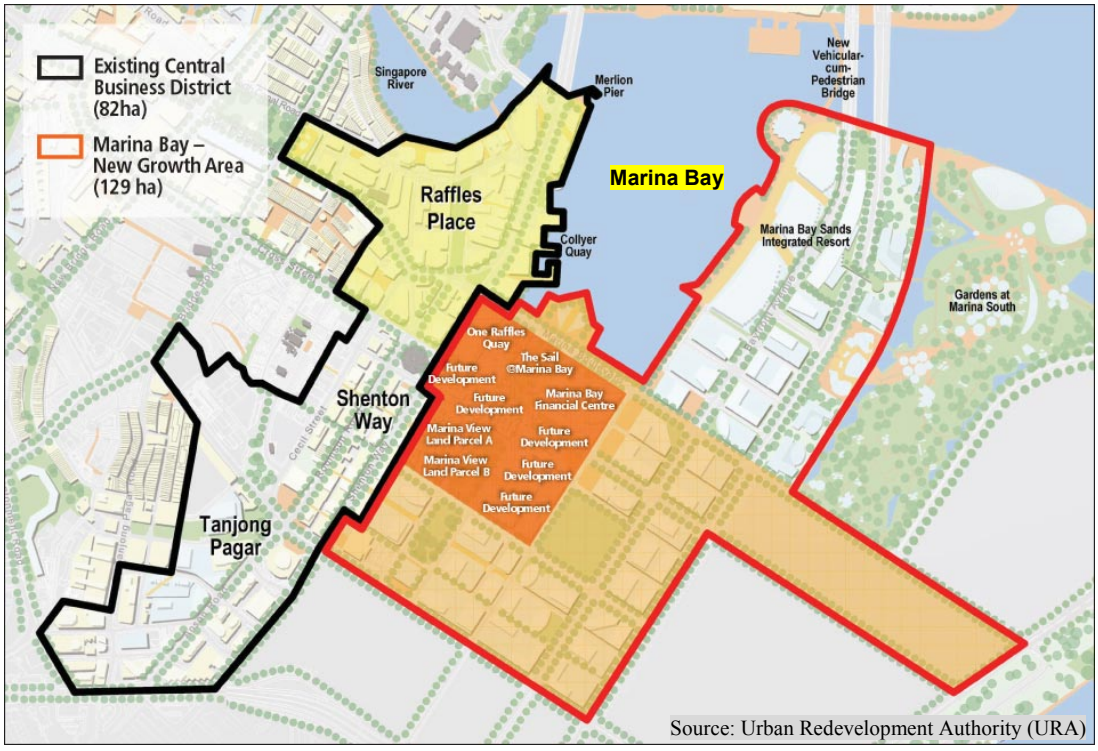

Fig 1.2 The existing CBD is outlined in black in the top diagram, southeast of which is Singapore's new downtown – a large piece of reclaimed land around 372ha. The immediate areas slated for upcoming development are those around Marina Bay. Besides offices, there will be high-end residential, retail, public gardens, an integrated resort with casino and convention, hotels, etc. The impressions at the bottom show the Marina Bay area before and after.

[3] As recognized by the International Monetary Fund and adopted in the CIA World Factbook 2007.
[4] Ministry of National Development (MND). (2002, August 15). Large Site Planned For Release Next Year for an Integrated Business and Financial Development in the New Downtown. Press release retrieved 1 March 2008 from http://www.mnd.gov.sg
[5] Lim, R. (Minister for Transport). (2008a, January 25). Doubling our Rail Network. Speech presented at the visit to Kim Chuan Depot. Transcript retrieved 1 March 2008 from http://www.mot.gov.sg

Motivation & Scope of Research

Singapore's evolving urban form and my personal experience of residing in Singapore has inspired this thesis. Undeniably, past development has achieved great success so far to bring Singapore to where she is today, but moving forward, it is timely to review the existing policies in order for Singapore to shape and influence future growth in a more sustainable fashion.

Why Walking?

The main focus of this thesis is to investigate and improve the pedestrian experience in Singapore. As Singapore developed, much effort was put into ensuring economic prosperity which has resulted in a highly efficient road and public transit system to move people to their jobs, schools, homes, etc. Despite this, there can be gaps in the transportation system, particularly with regards to walking, which is often a neglected area of even the most advanced transportation system. Walking constitutes a finer level of transportation, and while it may seem minute compared to mass transit or highways, it has the potential to influence people's travel behavior because it is so integral to not just the transportation system, but also human psychology and physiology.

The focus on facilitating transportation efficiency in Singapore may also have inherent conflicts with walking that do not contribute to economic success, but are important as quality of life indicators, i.e. walkability in residential areas and also leisure walking. Take for example, the pictures below show underutilized walking spaces in downtown Singapore. Is not enough being done to facilitate leisure walking? Are major roads alienating walking spaces on the pretext of priority to traffic? Is it the tropical weather in Singapore that is killing walking life with no possible respite? Facilitating walking in our daily working lives is important in that it achieves transportation efficiency and economic success, but if we can also improve walking in non-working context like residential areas and for leisure, it reflects a better quality of life and a better urban environment which makes it equally important for Singapore city planners to be mindful of.

As much as I loved walking, I never do enjoy my walks in Singapore as much as I do in some of the other countries that I have been in, be it for commuting or leisure, we will define and further elaborate the issues that exist with the Singapore pedestrian experience in the later chapters.

Source: philipmak on Flickr

Source: blog.pixnet.net/shirls/post/1911329

Fig 1.3 Some great walking spaces in Singapore which are underutilized

The Two Types of Walking

The previous paragraph introduced two concepts of pedestrian experience which underlie the basis of my thesis. The first type is how walking is a means of getting to a destination, and this is the type that is most critical to our everyday travelling needs and which is the main focus of this thesis. The most obvious instance of this type of walking is the daily commuting between home and work even though walking may be just part of the overall journey. Such walks are a derived demand, and due to its routine or mundane nature, is more often than not, a disutility to the commuter – like how the overall drive or transit trip is to him/her. Besides commuting walks, non-work trips like getting meals and running errands during office lunch hour also fall under this first type of walk. While such walking occurs in both private and public transit trips, a typical car user is minimally affected – usually just short walks between car-parks and destinations. Walking is usually more associated with inefficiencies of transit, such as inaccessibility of transit nodes (metro stations, bus-stops) and also the need to transfer. This form of walking is very widely studied by transportation planners and urban designers alike, because if understood effectively, one can promote walking or mitigate its ill-effects like transfers between transit modes, to improve the overall transportation and urban experience. This is the aim of this thesis too.

The second type of walking is a form of leisure. People obtain utility from this form of walking and it can range from a brisk walking exercise to a relaxing stroll along the beach. The design of such walking facilities is no longer from a transportation standpoint where efficiency matters most. Instead, considerations for pedestrians' sight, sound, smell and touch need to be factored in

the design for pedestrians to have an enjoyable walking experience.[6] Jan Gehl differentiates between these two types of walking as "necessary" and "optional" types of walking[7] which is very apt. However, due to the heavy scope of the first type of walking and its relatively greater importance to everyday life, the focus of this thesis will be mainly on the first type. We will discuss briefly about walking as a form of leisure in Chapter 4 to set the stage for future study, and also to be mindful that whatever we recommend to improve the first type of walking may be detrimental to leisure walking.

Most literature today focuses on improvement measures that encompass more of the first type of walking. Their objective is to make a place more "walkable" by improving the streetscape and creating a more pedestrian-friendly environment through a combination of land use, urban design and transportation measures. This way, people do not have to drive, but can walk to make their work and non-work trips. As defined by Michael Southworth, walkability is the extent to which the built environment supports and encourages walking by providing for pedestrian comfort and safety, connecting people with varied destinations within a reasonable amount of time and effort, and offering visual interest in journeys throughout the network.[8]

To improve the walking experience in Singapore, we need to consider multiple strategies since different people have different expectations of a good walking environment, which depends broadly on their walking purpose and context. People who walk as a means of travel value directness, speed, comfort and we need to keep their exposure to walking as little as possible. Walking for leisure on the other hand values aesthetics, scenery, comfort and people will take their time to enjoy their walk. However, as Southworth suggested earlier in his definition of walkability, considerations for leisure walking do not necessarily preclude walking as a means of travel, and vice versa. While leisure walkers love parks, commuting pedestrians would probably avoid them because their routes can be indirect and circuitous, but if there are some elements of the park design that we can transplant to commuting paths, then that would greatly enhance the experience of walking as a means of travel. Let me now propose a general model to understand the different walking needs which would frame the arguments for the rest of the thesis.

Hierarchy of Walking Needs

The derivation of this hierarchy was inspired by (Southworth, 2005), but it pieces today ideas and conception mainly from my own intuition. The purpose is to set up a relationship which lets us appreciate why people desire one walking characteristic over another. For example, why does one choose to walk a certain route when it is sunny, but this other route when it is raining, or totally give up walking when he becomes rich enough to own and drive a car?

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[6] Handy, S. (1996). Urban Form and Pedestrian Choices: Study of Austin Neighbourhoods. *Transportation Research Record, 155*: 135-144.
[7] Gehl, J. (1987). *Life between Buildings: Using Public Space.* New York: Van Nostrand Reinhold.
[8] Southworth, M. (2005). Designing the Walkable City*, Journal of Urban Planning and Development, 131*(4): 246-257.

I postulate that walking is demanded in four different levels, see figure 1.4. The first tier is the basic walking connectivity that is fundamentally required – people need to stay connected. In many developing cities, this is a genuine problem because as motorization increases, pedestrians are often neglected in infrastructure provision. Surveys in African cities trace pedestrians going through low-lying areas which are impassable during rainy days or are impeded by other physical barriers like highways and rivers.[9] However, the basic need to travel is often so strong that the pedestrian will detour to overcome any barriers unless they are really insurmountable. Even for affluent cities, as automobiles take priority, street block sizes increase, over-scaled highways form barriers and the street layout becomes disconnected, causing pedestrians to lose connectivity,[10] but this is naturally to a lesser extent as compared to the plight of developing cities. Often a phenomenon that is more peculiar to developed cities is that a lack of connectivity will not cause pedestrians to detour or to overcome barriers via walking, instead they give up and hop straight into their cars or taxis to gain "accessibility" which is the third tier of the hierarchy that we will cover two paragraphs from now. But take note, this leapfrogging is only for people who have an alternative choice other than walking, and is typically for the higher-income.

After there is a path to walk on, one then start worrying about the threat of vehicles or other physical danger along the path. This second tier of safety and security is derived from the fact that most of the key improvement initiatives in developing cities involve traffic separation, pedestrian crossings and traffic calming.[11] For developed cities, pedestrians can also be victims to crime and bad driving habits, and pedestrian safety is always of importance. Without being connected, safety is not an issue; hence safety is a secondary tier to the first connectivity layer.

The third tier of accessibility demand is established from the fact that many developed countries are involved in this after they have progressed beyond connectivity and safety considerations. As a society becomes affluent, people's expectations and mobility increase hence they demand getting to their destinations or transit nodes quicker and easier. There is also concern for universal accessibility for the mobility-impaired, and people demand better quality walkways to use too. Compact land use, pedestrianization, tactile strips, curb-cut ramps, non-slip tiles, wider paths are some of the features in this tier of walking. Note that this tier of walking demand is not usually considered by developing countries because of affordability reasons, and it reinforces how this is a higher level tier. Developed cities cannot expect that by just connecting pedestrians to a certain node (first tier – connectivity), pedestrians will be happy. They desire this connection to be accessible – usable by all, short and direct with least physical and mental effort to use. However, unlike connectivity and safety which are more fundamental desires, this third tier is less of a consideration for discretionary or leisure trips, or for lower income people with simple

[9] Langen, de M. and Tembele, R. (2001). *Productive and Liveable Cities: Guidelines for Pedestrian and Bicycle Traffic in African Cities.* Netherlands: A.A. Balkema Publishers.
[10] Southworth, M. and Ben-Joseph, E. (2003). *Streets and the Shaping of Towns and Cities.* Washington, D.C.: Island Press.
[11] Langen (2001)

lifestyles or who simply do not have a choice to switch from walking. I also theorize that accessibility desire can be influenced by enjoyment factors in the paragraph below.

Lastly, the final level is the "holy grail" of walking needs – "enjoyment", where comfort, aesthetics of the walking environment, etc. come into play to derive the best walking experience. This is the tier that many developed countries are actively pursuing, e.g. beautifying the streetscapes, landscaping, etc. This last level is abstract since it is psychologically-driven and contextual too, and it has the ability to influence the third tier of walking both positively and negatively. Take for example a direct path which gives you the best walking experience one can imagine, except that is exposed to the hot sun. People who suffer long harsh winters would probably love the path even more (i.e. enjoyment reinforces third tier). For people living in hot equatorial climates, they may actually shun the path and take a less direct but sheltered route (enjoyment displaces third tier), but there would be some who can put up with the temporary discomfort and still value the third tier over enjoyment. My point is that given any urban walking environment that has connectivity and safety fulfilled, enjoyment is the key factor that can influence walking behavior with a reasonable level of accessibility needs being met. Using the same direct path with hot sun in the equatorial climate example, if we create a visual interest so irresistible that everybody has to see it, then it could displace all walking considerations and invite everybody to use that path regardless of the hot sun. It is also reasonable to think that if we have a path that is somewhat circuitous which may not embody the third tier fully, but perhaps we can create an environment so good to walk in that it displaces the third tier considerations and actually make people enjoy walking the less-than-direct route.

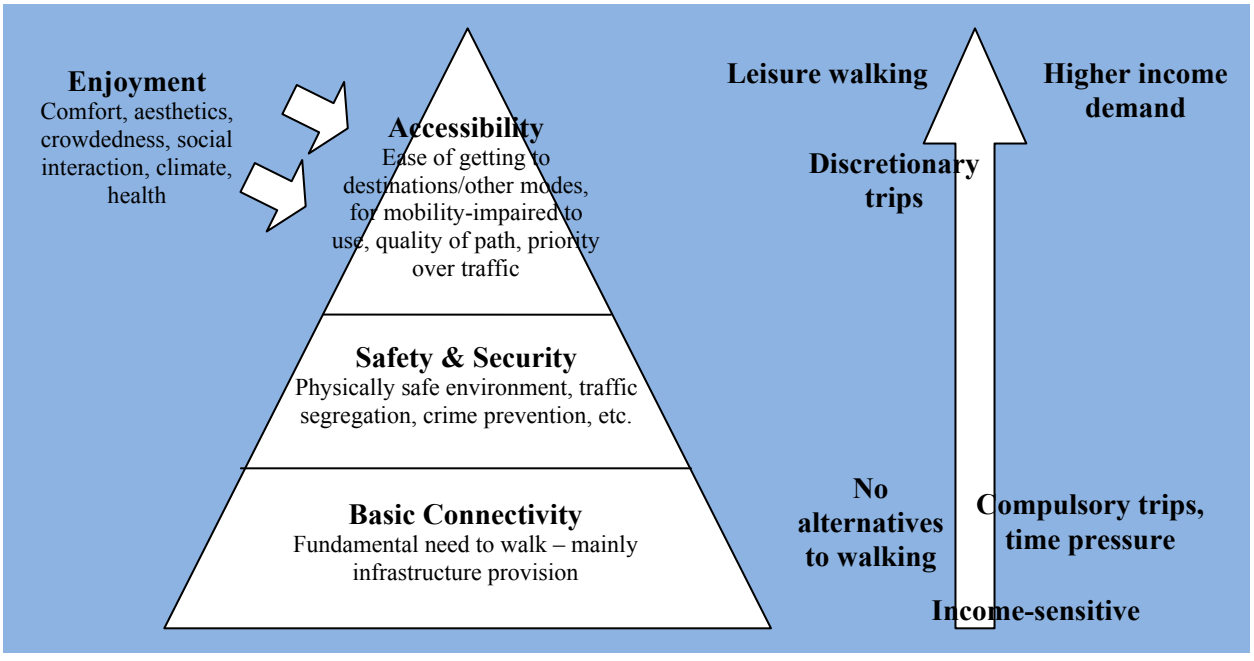


Fig 1.4 The hierarchy of walking needs on walking experience and infrastructure expectations

The hierarchy of walking needs is operationalized by applying it in a simplistic illustration, say Albert has an utmost need to walk from point A to point B every day.

1) In the presence of an insurmountable barrier between point A and point B, Albert will not be able to walk and make his trip, but one day his friend informed him about an alternative route which is a 1 km detour away, muddy and dangerous, Albert takes it because he needs to fulfill his first tier of walking need - connectivity. (Note: if Albert is rich enough to afford a car, he would have given up on walking already)

2) Through the use of this route, Albert walks alongside fast-moving cars and is harassed by hooligans. Feeling threatened, he makes fewer trips to point B than what he would have hoped for or he makes them still but they are frightful mental experiences. Now, assuming that the government intervenes and remove these threats, Albert will fulfill his second tier of walking need – safety and security.

3) Now even though the route is safe, it is still muddy and circuitous, Albert may complain but he will probably still make his daily trip to point B, or at least more frequent or less stressful than when he was in danger from traffic and hooligans. However if we open up a more direct paved path to point B, Michael will be very happy and he will make his daily trips for sure. Or we put it another way, say Albert has two paths to choose from, one dangerous but direct and the other indirect but safe, chances are Albert would choose the indirect path which underscores safety as a more fundamental need than accessibility. Back to the original case, once we open up a new route which is more direct, of good quality and safe to point B, Albert would have fulfilled his third tier of walking needs. If Albert had driven in view of scenarios 1 and 2 above, this is the point when he may consider switching back to walking.

4) Finally, if the city enhances the new path with trees, birds and performing buskers, Albert will reach his fourth tier of walking need – "enjoyment" and he will actually take pleasure in his walk and look forward to it every day! Alternatively, in lieu of the third tier improvement above, if the city was unable to provide a more accessible route, but instead enhances the 1km detour route with retail, streetscape, performers, then Albert may actually enjoy the walk and be oblivious to the fact that he is walking so much more per day. Of course 1km may too much of a detour for Albert not to perceive, but perhaps a 100-200m detour will be unperceivable with enjoyment needs being met, which brings us to the point that reasonable accessibility still needs to be met.

The derivation of the hierarchy of walking needs is essentially based on the progression from a developing country to a developed one and is partly related to income levels. However, that is not to say that developed cities are free from connectivity and safety considerations. In the US, with high auto-dependency, cities are not designed as being walkable but that is slowly coming

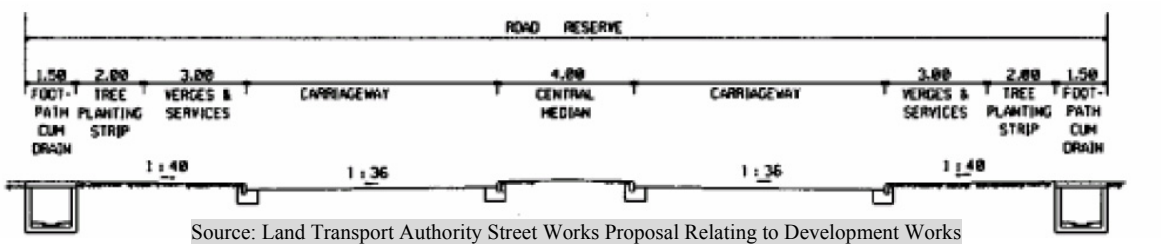
around with Federal legislation and the onslaught of concepts like New Urbanism, Smart Growth, etc.[12] The hierarchical concept of the walking needs also draws reference from Maslow's Hierarchy of Needs which relates how motivation evolves from physiological needs to psychological fulfillment.

Singapore's Walking Experience – What needs improvement?

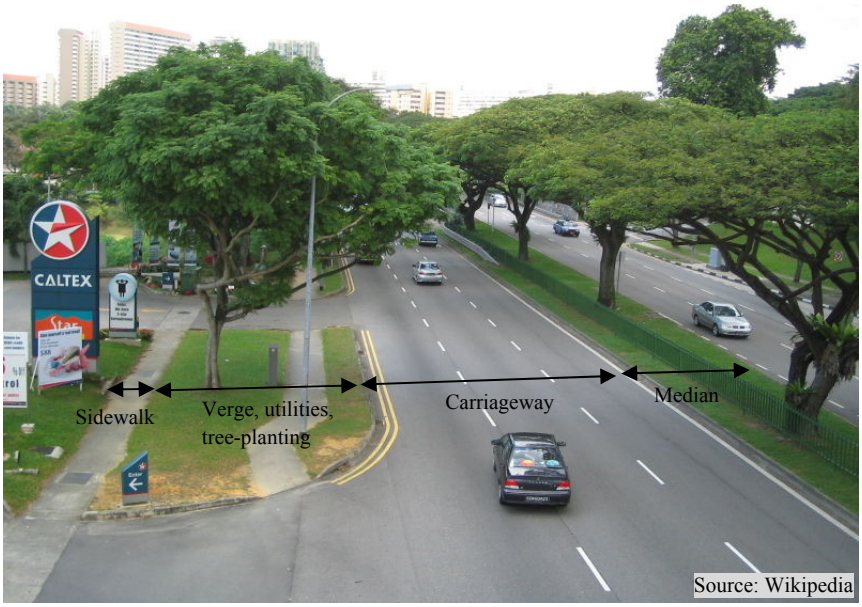
Singapore's development of the pedestrian infrastructure so far has been excellent. Pedestrian sidewalks are ubiquitous all around the city with adequate street-lighting and segregation from traffic, see Fig 1.5 below. Motorists are law-abiding and traffic safety for pedestrians is reasonably good. The pedestrian system is well-maintained and the country is in the midst of spending S$60 million over three to four years to upgrade her road facilities to meet the needs of the elderly, less-mobile, wheelchair users and those with strollers.[13] Even for the final tier of walking needs, the beautiful tree-lined streets of Singapore is testament of her efforts to make the pedestrian experience better both visually and also for the practical purpose of shading from the tropical sunshine.

Yet despite Singapore's efforts to improve the walking environment, the perennial complaints that we hear from people are that Singapore is too hot to walk around, be it for commuting or for leisure. Indeed the Singapore climate is a key aspect which will need to be addressed in order to enhance the pedestrian experience. However, besides the weather, are there other fundamental walking aspects that we can leverage to enhance the walking experience? As we will establish later, too much auto priority, lack of downtown walkability and the increasing need for mass transit transfer walks are some of the other issues that we need to address.

[12] Southworth (2005)
[13] Land Transport Authority (LTA). (2006, February 15). LTA Announces Plan To Introduce Wheelchair-Accessible Buses And Programme To Upgrade Road Facilities. Press release retrieved 1 March 2008 from http://www.lta.gov.sg



Source: Land Transport Authority Street Works Proposal Relating to Development Works



Source: Wikipedia

Fig 1.5 Typical right-of-way of a major arterial road in Singapore with center median for tree-planting. On the sides: 3m green buffer for utilities, another 2m for tree-planting and a 1.5m pedestrian sidewalk.

Singapore's Climate

Singapore is located in the equatorial belt, about 1.2º north of the equator. Her climate is classified as "Af – equatorial fully humid" according to the Köppen-Geiger Climate Classification System.[14] In general, equatorial climates in the Köppen-Geiger system have mean annual temperatures of more than 18ºC (64ºF). What distinguishes Singapore from the other three equatorial types is that she has year-round heavy rainfall of at least 60mm (2.36") per month. The other three are monsoonal or savannah-like with dry seasons of varying extents during a year, so at least they have some respite from high humidity during these drier months.

[14] The Köppen-Geiger system is the most widely used climate classification system in the world and it has various adaptations although the underlying classification is consistent. The one used in this thesis is the version updated by Kottek, M., Grieser, J., Beck, C., Rudolf, B., and Rubel, F. (2006). *World Map of the Köppen-Geiger climate classification updated*. Meteorol. Z.

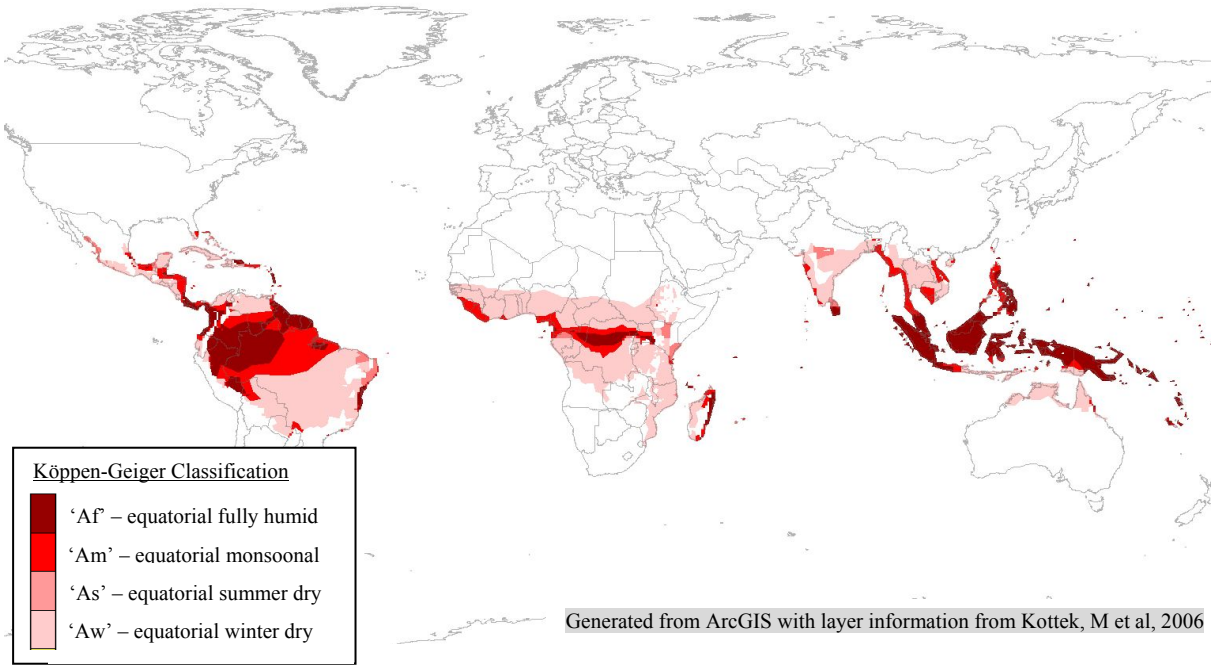


Fig 1.6 Regions of the four equatorial categories of the Köppen-Geiger system

Fig 1.6 shows that Singapore is in the unique position of being one of the few countries in the world to have year-round hot and wet climate. South American cities are generally on higher altitudes with the areas experiencing the same climate as Singapore largely occupied by the Amazon rainforest. A small part of central Africa (Congo) and South Asia (Sri Lanka) shares Singapore's weather, but the majority of countries which have year-round hot and wet climate are from South East Asia, i.e. Malaysia, Indonesia and Singapore. The uniqueness of Singapore's climate meant that there are no readily equivalent precedents in other cities for Singapore to emulate when it comes to building a good pedestrian experience. Many available literatures from European and American cities about improving walkability of streets are fantastic, such as reclaiming roads for pedestrians, designing beautiful street malls at the human scale, etc. However when you picture them in Singapore's hot and humid context, it is doubtful if those initiatives will succeed without substantial tropicalized adaptation. The temperate cities have their own weather extremities too like freezing winters and humid summers, but it is because of these that when the weather changes for the better, people are more inclined to enjoy them to the fullest by being out in the streets. For Singapore, the year-round constant climatic conditions provide no such respite for her people to look forward to.

Take for example, Dubai, known for its lavish expenditure on infrastructure. Recently they introduced air-conditioned bus shelters as a way to beat the hot desert summer heat – a world first. Yet interestingly, in an interview with a source from the Dubai Roads and Transport

Authority (RTA),[15] it was revealed that Dubai is also busy building 1400km of bikeway. The source admitted that it is too hot in summer and the RTA does not expect anybody to use the bicycle lanes then. However, they are planning it for winter when everybody will be out to play in full force!

Fig 1.7 World's first air-conditioned bus shelters in Dubai

Singapore's tropical climate has its advantage in that it allows Singapore to complement her economic success with a Garden City vision to have lush landscaping all around the island. Even with an extensive and efficient road system, tree-planting along the roads help to mollify the environmental impacts and serve to beautify the streetscape tremendously. This is a perfect harmonization of transportation efficiency without its usual consequence of barren asphalt landscapes. Singapore's climate also allows for easier greening of buildings and developers are incentivized by government policies to adopt green technology and incorporate green roofs on buildings. However, Singapore's climate is a double-edged sword. While images of Singapore streetscape may show picturesque tree-lined roads, the reality for pedestrians actually using those streets is not that pleasant despite the shadiness. The perennial heat and rainy conditions for Singapore give rise to high humidity averaging 84%[16] which makes strolling along the streets of Singapore a "hot and sticky" affair. Add to that frequent occurrences of tropical downpours, and one can appreciate the plight of pedestrians walking the streets of Singapore.

[15] Dubai Roads and Transport Authority (RTA) Source, personal communication, 18 March 2008.
[16] Metrology Services Division, National Environment Agency Singapore. Climatology of Singapore. Retrieved 1 March 2008 from http://app.nea.gov.sg/cms/htdocs/article.asp?pid=1088.

Fig 1.8 Two major arterial roads in Singapore with picturesque green canopies

Research Methodology, Limitations and Structure of the Thesis

Approach

Traditional literature in walking enhancements, especially those investigated by transportation planners, tend to focus largely on quantifying the characteristics of walkability in order to understand their influences and to improve on them. For example, there is a study conducted by a university in Singapore to quantify the accessibility to MRT stations with a walking time index.[17] Using information from research like this, I approach the issue of enhancing the walking experience from a design standpoint, which is a largely unresearched field due to the difficulty of assessment and subjectivity amongst users. I attempted to understand and appreciate the walking experience that a Singapore pedestrian goes through, and then suggest design solutions which are intended for more in-depth study or pilot-testing. By virtue of the design nature of this thesis, it would be unable to fully test out and substantiate my hypotheses of how successful the design enhancements would be, but it will provide a basis for further engagement of the Singapore planning agencies to enhance the walking experience of Singaporeans.

WEXiS Survey

To understand how Singaporeans feel about their walks, a survey was conducted on Singaporeans who are economically active to assess their experience of the walking components of their travel needs, and there were 103 respondents in total (see Appendix 2 for the questionnaire and results). Termed the "Walking Experience in Singapore" (WEXiS) survey, we will constantly be referring to the results of the survey as we go along this thesis. The rationale of targeting the economically active is because of the larger focus of this thesis on walks in daily working lives. Majority of the WEXiS survey respondents have higher education (83% has a

[17] Olszewski, P., Yip, YB. and Fock, WT. (2005). Measuring Walking Accessibility to Public Transport. *Journal of The Institution of Engineers, Singapore 45*(2): 64-77.

university degree or higher) and belong to the 25-34 age band (89%), which is reflective of the economically active sample population. In addition, amongst the survey respondents, the mix of gender (male to female ratio is 42:58) and marital status (single to married ratio is 57:43) is rather balanced, which eliminates any bias of walking preference to any particular gender or marital status. Supported by the WEXiS survey, I would define the existing issues that Singaporeans have with the pedestrian system. Next, using case studies and best practices from around the world, I would consider their application in Singapore to address the identified issues. Interviews from urban planners and designers would also be interspersed throughout the thesis to provide insights on relevant issues.

Limitations of Thesis

There are some limitations to this thesis. First of all, due to lack of definitive research on the qualitative aspects of pedestrian experience and also on tropical humid climates specifically, as mentioned earlier, many of the propositions in this thesis would need further study or actual pilot-testing by the Singapore government. Also, a larger survey sample size, particularly with a more diverse demographic mix would also enable a varied understanding of the pedestrian needs in Singapore. Nevertheless, for the purpose of this thesis which has a stronger focus on commuting walks; it is reasonable and intentional that a sample size of majority economically active Singaporeans was collected.

The other limitation of this thesis is in its geographical scope. The focus is mainly to enhance the walking experience in the most prevalent travelling pattern which is commuting from an outlying public housing estate to the CBD and also for subsequent intra-CBD trips for these commuters. Due to the characteristics and concentration of pedestrians for trips to and within the CBD, it would be hard to apply the enhancements to other parts of Singapore. However, enhancements proposed for CBD-related trips would be the most impactful, and these enhancements, if tried and tested for the CBD area, would then have a stronger case to be extended to other parts of the city state where necessary.

It is my intention to continue my research on my thesis when I return to Singapore, and I plan to address these limitations listed and see through some of my recommendations by following up with the relevant government agencies. This follow-up work will be detailed in Chapter 5.

Definition of Walking

Though walking and pedestrians form the entire scope of this thesis, they are by no means restricted to their traditional definition which involves using ones' legs. The walking experience or our definition of the everyday pedestrian will consider wheelchair users, stroller users - basically everybody in general.

Thesis Structure

After this introductory chapter, Chapter 2 will be on walking as a means of travel where we will establish its issues in Singapore currently. Chapter 3 will then discuss and propose the solutions to these identified issues supplemented with literature review and case studies. Chapter 4 will be a short one to discuss briefly the issues that are equally important but not able to be included in the scope of this thesis – i.e. the walking needs of private residents and walking as a form of leisure. Finally Chapter 5 will conclude and lay out the follow-up study or implementation that needs to be done.

Research Question

To wrap up this introductory chapter, I would reiterate my research question which is to investigate the extent in which the pedestrian system of Singapore can be improved, given her state of infrastructure provision and hot humid tropical climate. Through the study of worldwide case studies and best practices, I will evaluate applicable improvement measures in order to recommend policy and design directions to enhance the future pedestrian experience in Singapore.

Chapter 2 Understanding Walking in Singapore's Context

As defined in the previous chapter, walking in this thesis is categorized into two broad types. The first type of walking is a means of travelling that forms the main focus of our thesis. Such walking is most intimately linked to our everyday lives. Imagine your daily journey to work or school – walking invariably features as part of your trip, if not entirely. Besides that, getting your meals during lunch break, buying newspapers, groceries, running errands to the bank, post office, etc will involve you walking some amount of distance to your chosen destination.

Going back to the hierarchy of walking needs first introduced in Chapter 1 (Fig 1.4), we will treat the first two tiers of walking in Singapore as a given, and our aim of this chapter is to assess the third tier on its accessibility and also the added enjoyment consideration. In Chapter 3, we will propose solutions to the issues we will identify later in this chapter.

If one can plan and design at the onset, walking infrastructure that covers all four considerations of the hierarchy, then people will probably be more inclined to walk regardless of income. Conversely, if the first two tiers were neglected and people had already switched to other more convenient modes like cars as in the case of US and some developed economies, then it can be an uphill task to bring people back to walking. Besides enhancing the basic connectivity and safety needs, auto-oriented communities have to leverage on accessibility and enjoyment needs to discourage the use of automobile travel.

For a rising economy like Singapore and faced with land constraints leading to tight car-ownership and usage policies, people do not really have a choice and they may be stuck with public transit and walking for now. However, eventually these pedestrians may "revolt" one day and switch to cars when they can finally afford it. Of course automobile usage can be suppressed by a host of other measures like congestion charging, parking restrictions, ownership restraint, etc., but if walking is integral to almost every trip, particularly public transit,[1] Singapore should leverage it as a pull factor towards public transit to avoid having to resort to drastic demand management measures or to reverse any modal shifts in future.

Sustainable walking design - Walkability defined

Because walking as a means of travelling for people straddles multiple considerations like where to go, which route/mode to use, when to travel, etc., a good sustainable design to all four tiers of the hierarchy of walking needs involve multi-faceted strategies. Earlier in Chapter 1, we have defined walkability and examined its definition given by Michael Southworth. Building on his definition, we identify three broad aspects of achieving good walkable design. First of all, land

[1] Wibowo, S. S. and Olszewski, P. (2005). Modelling Walking Accessibility to Public Transport Terminals: Case Study of Singapore Mass Rapid Transit. *Journal of the Eastern Asia Society for Transportation Studies. 6*: 147-156.

use planning needs to site density and retail in a complementary way which reduces the need to travel extensively and encourage walking in a safe environment. Secondly, transportation planning will have to consider the system impact and complement walking to other transportation modes and possibly even accord necessary priority to pedestrians over traffic. Lastly, good urban design will need to ensure that the walking experience is enhanced with visual pleasure, comfort, etc. Often, these multi-disciplinary considerations overlap and the lines between them are indistinct.

The Singaporean Context of Walking as a Means of Travelling

Before we consider what type of approach will help to improve Singapore's pedestrian experience, let us first understand her current context in terms of how people walk as a means to travel when it comes to work-related trips. In this chapter, we will examine the typical work commuting trips between home and office, and also understand the trips during the daily working hours that Singaporeans need to make.

Commuting trips usually involve long distances, hence walking is not the usual main mode of travel, but we will look at it in the context of the overall transportation system. To simplify the analysis, we will examine the walking experience for a typical worker who lives in an outlying residential estate and who works in the Singapore CBD. Therefore aside from the morning and evening peak commuting hours, the rest of the trips for that revolve around his working life takes place in the downtown central area. Results from the Walking Experience in Singapore (WEXiS) survey will be used where appropriate.

Singapore's key implementations relevant to walking

Singapore has done much in her planning and provision of infrastructure to facilitate walking and some of the key initiatives are listed below. It has been envisaged at the onset that public transit is the only sustainable mode of transportation to move people around due to Singapore's high density population and scarcity of land,[2] therefore most of the pedestrian initiatives are tailored towards moving people through public transit, It has also been recognized that the hot, humid and rainy tropical weather is an aspect that needs to be addressed, and it is featured in many of Singapore's key walking-related implementations.

- Tree planting - As mentioned previously in Chapter 1, tree planting has always been one of the top priorities in Singapore, be it to enhance the streetscape or to provide shade for pedestrians. However, the amount of shade that trees can provide depend a lot on their species and their age, so not all tree-lined streets are shady. At times, there may not be enough space to plant trees too, e.g., in most parts of the CBD.

[2] Ibrahim, M. F. (2003). Improvements and Integration of a Public Transport System: The Case of Singapore. *Cities.* 20(3): 205-216.

- Integrated land use and transportation planning – By planning land use and transportation in an integral manner, travelling needs are minimized. Transportation nodes are close to where most people want them to be for easy access and land use is densified around transportation nodes to maximize the accessibility catchment.

- Sheltered walkways: A unique streetscape phenomenon in Singapore[3] – Europeans have their covered arcades; Singapore has her own variant known as "five-foot-ways" which were introduced by British colonists in Singapore's early history. During those days, shophouses were planned to have a five-foot wide corridor along their shop fronts to protect pedestrians from the tropical sun and rain.[4] While five-foot-ways have evolved to become spaces where shop owners place their wares or set up tables to seat their customers, its principles have been continued in other forms. In modern times, the URA has guidelines that require building developers to provide shelter along its periphery to provide a shaded walk.[5] In the design of public housing, HDB also simulates the five-foot-way concept along the ground floor of every public housing building which are public areas for people to utilize. The LTA builds "covered linkways" which connect transportation nodes and as of 2006, they have constructed 21.2km length of covered linkways island wide.[6] The LTA's covered linkway network is also connected to the shelters provided by individual buildings where possible.

Fig 2.1 From L to R: Arcade in Bologna; traditional five–foot way in Singapore; covered linkways by LTA which link transportation nodes; and HDB's sheltered walkways

[3] Tong, C. Y. (2004). Covered Linkway: A Unique Streetscape Phenomenon in Singapore. Proceedings of the *3rd Great Asian Streets Symposium.* Singapore: National University of Singapore.
[4] Thulaja, N. R. (1997). Five-foot-way Traders. Retrieved 29 April 2008 from http://infopedia.nlb.gov.sg/articles/SIP_105_2005-01-04.html
[5] URA. Development Control Parameters for Non-Residential Development. Retrieved from http://www.ura.gov.sg/circulars/text/dcdnrhb_d0e7136.htm
[6] LTA. (2007). Singapore Land Transportation Statistics in Brief 2007. Singapore: LTA.

- Underground pedestrian infrastructure – This comes in two forms: one is an extended access/egress from subterranean transit nodes; the other is to connect buildings through underground links. Due to the prohibitive costs of constructing underground infrastructure, these are only cost-effective in the downtown area where land is valuable and human traffic is high. Besides land value, there are also other advantages of providing an extensive underground pedestrian network. From the transportation viewpoint, it provides all-weather protection and makes it safer for pedestrians to cross major roads which benefits traffic flow as well. Where retail space is provided within these links, they also provide additional real estate for commercial development in the downtown area. The URA has a co-funding scheme to incentivize building developers to build underground linkages.[7]

- Air-conditioning – In the underground infrastructure initiative above, air-conditioning is used as a complementary measure to mitigate weather considerations, i.e. underground tunnel entrances/exits to MRT stations. Already, most of Singapore's transit network is air-conditioned, except for elevated MRT stations, most bus terminals and some buses. Aside from underground infrastructure connecting to MRT stations, there are other pedestrian underpasses between buildings that are air-conditioned, but usually limited to the heavily trafficked downtown areas only; other underpasses are at best only mechanically ventilated. Open-air walking facilities like POBs, sheltered walkways, etc. are not cost-effective to be air-conditioned.

- Barrier-Free Accessibility – This is similar to the American with Disabilities Act in US. The LTA have embarked on a multi-million project over 3-5 years to upgrade the road furniture to cater to the mobility-impaired. This includes covering drain grates, having curb-cut ramps, tactile guidance, etc. Unfortunately not all aspects of the road facilities can be upgraded. In Singapore, there are many pedestrian overhead bridges (POBs) which are overpasses across roads for pedestrians to cross streets in place of an at-grade crossing (refer to the third picture in Fig 2.1 for an example of a POB), and these are installed to accord priority to heavy traffic. The POBs have stairs and only a few of them can be fitted with long ramps to achieve barrier-free accessibility. Therefore even though some POBs may be sheltered, those on wheelchairs or pushing strollers will have to detour to use at-grade crossings and be exposed to the weather. Besides the road facilities, the MRT system is fully accessible, and the buses are gradually being replaced as they age to newer wheelchair accessible ones.

[7] URA. Urban Design Guidelines for Downtown Core.
http://www.ura.gov.sg/cudd/ud_handbook/ud_handbook_Downtown.html

General Trends of Work-Related Trips (Commuting Walks & Downtown Walkability)

Based on the Household Interview Survey 2004 conducted by the LTA,[8] around 43% of all daily motorized trips by trip purposes are work trips. This underlies the significance of commuting trips in our consideration for walking. The LTA did not provide non-motorized trips in their analysis of trip purposes, but we know from the General Household Survey 2005 conducted by the Singapore Department of Statistics (Singstat)[9] - only 6% of work trips are by walking alone. Majority of commuting trips in Singapore therefore involve a need to travel on motorized modes, with walking integral to the transportation system.

In general, a commuting trip in Singapore has several possibilities, but how much walking is required is mainly dependent on two factors – car usage and home type. A car user will drive to work from home, and the walking part only involves him getting to his car-park from his home, and then from his office building car-park to his office, which in both cases are minimal distances to walk. A public transit user has the same simplistic relationship – getting to the transit system from his home, and from there, exit to get to his place of work. However the public transit user has his/her trip complicated by the experience within the transit system itself which by its nature create more opportunities for walking. From Fig 2.2 below, slightly more than 50% of all work commuters are using public transit.

Besides car usage, the other distinguishing difference between Singaporean pedestrians lies in whether if they stay in public housing (predominantly those provided by the Housing & Development Board - HDB) or private housing. As of March 2007, HDB residents form 81% of the population in Singapore.[10] Due to the large proportion of public housing residents, land use and transportation planning is normally geared towards providing for this higher density group, which is also equitable because public housing residents are often those who have the least choice of travel mode and public transportation is necessary to support their travel demand.[11] Referring to Fig 2.2 below, we can see a strong reliance of public housing residents on public transit in Singapore.

[8] LTA. (2005a). '2004 Household Interview Survey' Presented at the *LTA Planning and Policy Seminar, September 2005*. Singapore.
[9] Derived from Singapore Department of Statistics (Singstat). (2005) .*General Household Survey 2005 Statistical Release 2 Transport, Overseas Travel, Households and Housing Characteristics*. Retrieved 24 March 2008 from http://www.singstat.gov.sg/pubn/ghs.html.
[10] HDB (2007). *Annual Report 2006/2007.* Singapore: HDB, pp 79.
[11] May, A. D. (2004). Singapore: The Development of a World Class Transport System. *Transport Reviews 24*(1): 79-101.

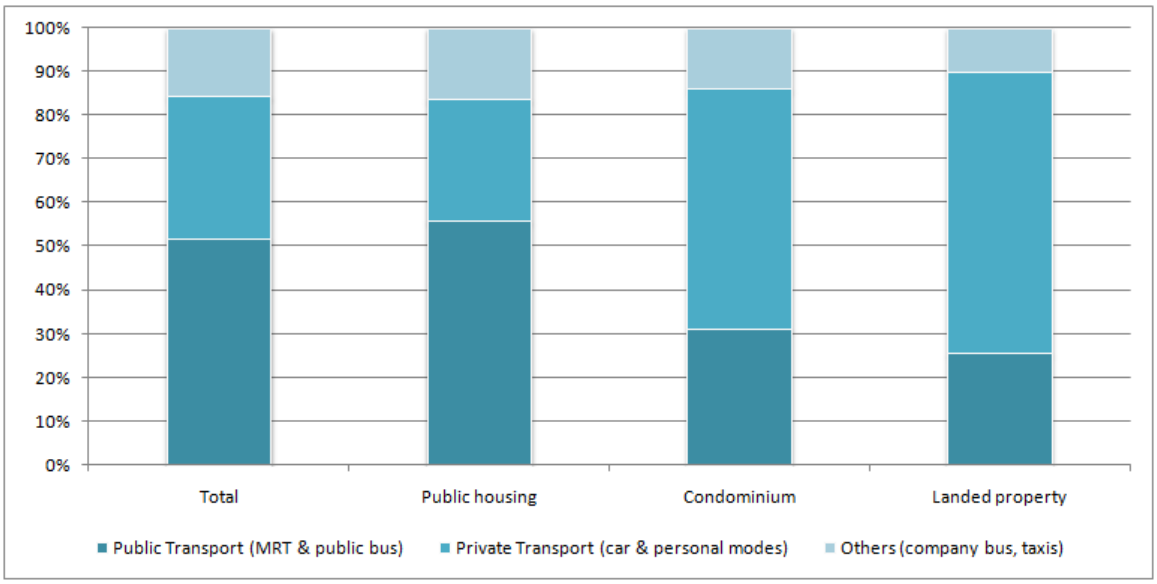


Fig 2.2 Motorized modes of commuting to work by housing type (Source: derived from Singstat (2005))

Our focus in tracing the walking experience is on public housing dwellers who take public transit (47% of all work commuters[12]). Now, the commuting trip that is the worst-off in terms of walking is actually that of a private landed housing resident who takes public transit. It is arguable if they are disadvantaged by land use policies or if they self-select their own homes knowing that they will not be near public transport and they can afford to drive. Nevertheless this group is a minority (1.5% of all work commuters), and chances are this 1.5% are already staying in the occasional private estates that are accessible to public transit. For condominiums dwellers who take public transit which form 3.0% of all work commuters, the situation is generally less severe for them because condominiums are located in public housing estates or along main roads where public transit is available. We will discuss the needs of private housing residents briefly in Chapter 4 for potential future studies.

From LTA (2005a), we know that the number of people heading into the central area of Singapore is about 19%[13] of all travel during the AM peak hour. Given the CBD's small size compared to the rest of the island, this area experiences the most intense travel demand and is rightly so since this is the CBD of Singapore. This explains our initial assumption that a typical economically-active pedestrian commutes from public housing to the CBD and then spends his day walking within the CBD before he returns home in the evening.

[12] Derived from Singstat (2005).
[13] LTA (2005a)

How do commuters generally feel about walking?

In the WEXiS survey, when asked if the walking experience in their daily commutes would cause them to switch from public transit to other private modes, 50% said yes. This is a pretty alarming figure.

When commuters are queried about what they liked about their current walking experience, 57% of them treat it as a form of exercise and 63% of them opined that it is a short distance to walk so the experience is bearable. Other likes about the walk are that commuters can buy things along the way, some walks are pleasant and shady, etc. Note that these figures do not assert that commuters prefer exercise to buying things along the walk as a stronger liking; it could just be that many commuters do not have the chance to buy things along the way right now. This line of questioning is more to understand what commuters like about their individual walking experience currently.

Commuters' main complaint about their walk experience is that it gets very inconvenient when it rains (76% of respondents), and the second most common reason is that the weather will cause them to perspire by the time they reach office (46% of respondents). The rest of the respondents who did not list these two factors as issues with their walking probably are already enjoying a better walking experience which allows them to be protected from the rain or that they walk in cool air-conditioned comfort, or it could just be that they really do not mind rain and the physical exertion. Nevertheless, from the general response we have observed above, there is definitely room to improve the walking experience for the commuters. Other dislikes that commuters felt are the walks while transferring between public transport modes, the squeeze with the rush hour crowd and the distance that they have to walk from the public transport node to and from their homes or offices.

What walking criteria matter to the commuters?

From the WEXiS survey, we have the results of how commuters choose their walking routes based on the criteria below.

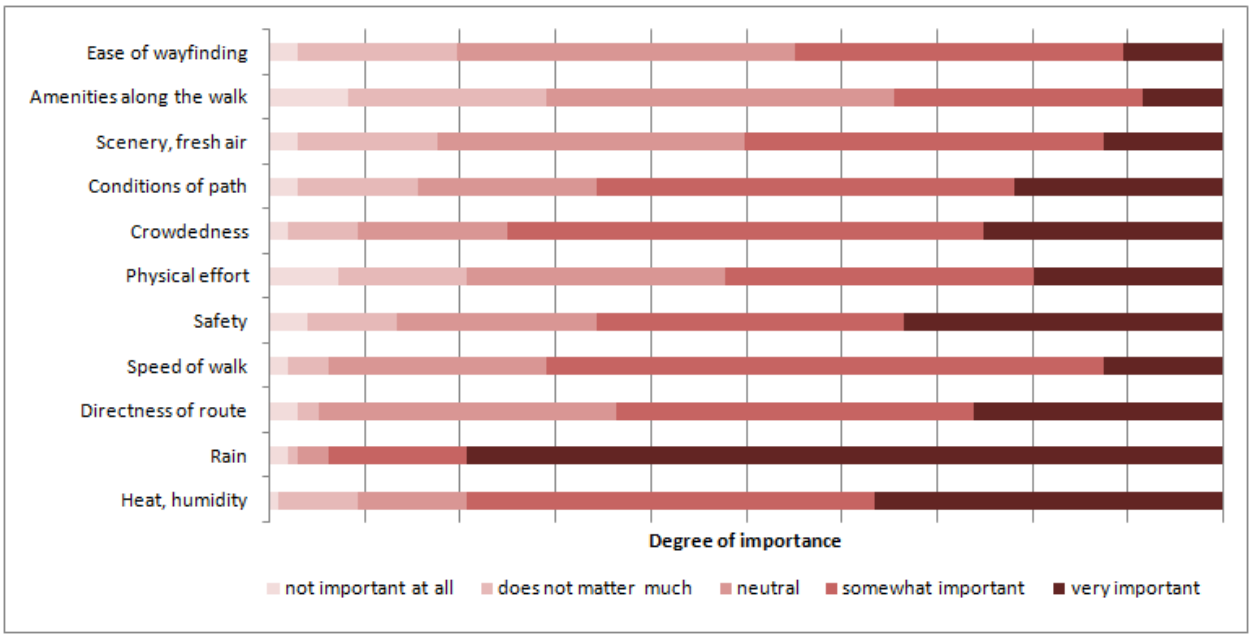


Fig 2.3 Results of WEXiS survey on commuters path choice criteria (Source: WEXiS survey)

Overwhelmingly, weather considerations are the most important for commuters when it comes to choosing their paths, especially rain. Crowdedness came up as the third most important factor (addition of "somewhat important" and "very important"), and it is likely the bad experience of peak hour commuting traffic that has resulted in this. These findings are consistent with our earlier assessment of the top dislikes about commuters' current walking experiences. In relation to the hierarchy of walking needs, they allude to the fact that enjoyment factors are lacking or at least trailing the third tier accessibility factors. The general observation is that while Singapore might have developed an efficient and accessible transportation infrastructure, commuters in Singapore have elevated their tastes to the level where they demand an enjoyable walking experience in their everyday commuting.

So that said, should Singapore provide air-conditioning comfort in all pedestrian walkways across the island to beat the weather? What was observed from the results above are that almost 80% of commuters rank rain as a "very important" consideration which will influence them to choose their walking routes. Comparatively, less than 40% rank hot and humid weather as "very important". This suggests that rain is much more of an issue than heat and humidity. Another question on the WEXiS survey asked commuters to choose their ideal walking environment on a typical sunny workday between: (A) an air-conditioned indoor space (42% chose this), (B) a sheltered walkway (27%) that is still partially exposed to the outdoor environment, and (C) a totally open walkway with some tree-shading (31%). The sample images are shown below in Fig 2.4. Interestingly, the respondents were split between the three. Our expectations, given the hot and humid Singapore weather and the earlier response was that majority would choose (A), but

42% is not that much of a majority. This is likely because the heat in the morning is not that unbearable yet, and the commuters value other factors like crowdedness, speed, etc which would likely be worse in an indoor environments. Most of the survey respondents are white-collar workers who work in an air-conditioned environment, and knowing they will be staying in such an environment for the entire day, a walk out in the open may be their idea of comfort and enjoyment in the early morning.

With these in context, let us start to trace the public transport commuter from his home to his workplace in the downtown area and review if current infrastructure provisions are adequate.

Fig 2.4 Ideal walking environments that WEXiS survey respondents were asked to choose

Commuting by Public Transport in Singapore – Hub & Spoke concept

Singapore's transit system is based on a hub and spoke concept where feeder services in residential estates bring commuters to a transportation hub where Mass Rapid Transit (MRT) trains or trunk bus services then bring them to other hubs in downtown where they either walk or transfer to another bus to get to their destinations. The MRT system in Singapore is planned to be the backbone of the public transit system, and it performs the main spoke functions in this case as opposed to long distance trunk bus services.

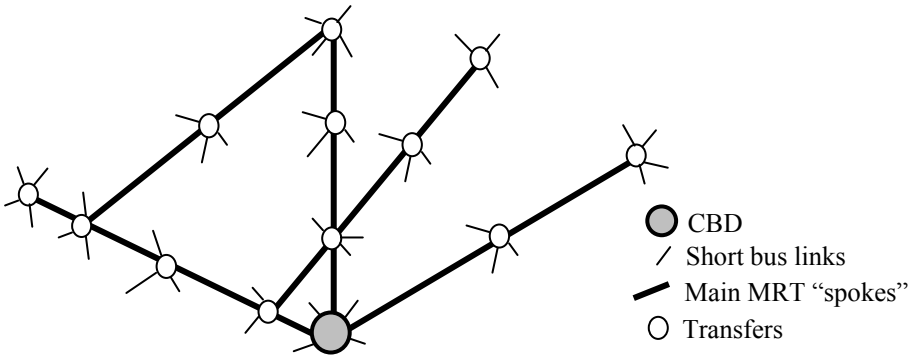


Fig 2.5 Schematic illustration of Singapore's hub and spoke transportation system and the transfer opportunities which are inherent to such a system

The characteristic of a hub and spoke system is transfers within the system itself. A resident which stays near to an outlying residential MRT station can just walk to the station and eliminate one transfer, but this resident is a lucky minority (see Fig 2.6). Due to the spatial distribution of HDB estates, most residents will need to hop on to a feeder bus or bicycle to get to the MRT station and make that first transfer.

Beyond the first possible transfer at the MRT station that is in the residential estate, there are still plenty of other chances for walking depending on the need to transfer to another MRT line or if the ultimate destination involves another bus transfer, etc. If we refer to the matrix in Table 2.1 below, we can see that there are many possibilities for commuters to walk indeed. Given that our analysis assumes a typical trip from a residential neighborhood to the downtown area, the likely transit combinations are "W-B-W-M-W" and "W-B-W-M-W-M-W", i.e. there would be one or two transfers involved. With this in mind, let us look at the walking experience first from home to the MRT station.

Table 2.1 Matrix showing typical transfer combinations where walking is needed

	Access (home to transit node)	All Bus	MRT as main mode[1]			Egress (transit node to work)
No transfer	**W-**	B	M [2]			**-W**
One transfer		B-**W**-B [3]	B-**W**-M	M-**W**-B	M-**W**-M [4]	
Two transfers		B-**W**-B-**W**-B	B-**W**-M-**W**-B	B-**W**-M-**W**-M	M-**W**-M-**W**-B	
Three transfers		B-**W**-B-**W**-B-**W**-B	B-**W**-M-**W**-M-**W**-B			

B - Bus; M - MRT; **W - Walk**

Note: 3 residential estates have LRT systems, which function as a higher-end feeder system (as opposed to the bus). For simplicity, LRT is ignored here and considered under buses.

[1] With the MRT as the main mode, it is unlikely that people will need or want to transfer from one bus to another, hence there are no B-W-B combinations
[2] If you stay in the same MRT line throughout and we also consider seamless cross platform transfers as "no walking" transfers
[3] Most bus to bus transfers are at the same bus-stop which will not require much walking, so this is more for transfers involving different bus-stops
[4] Since we excluded cross-platform transfers, these involve transfers between stations of intersecting MRT lines which can be a walk of up to 200m.

The commuting experience - From home to the MRT station

Fig 2.6 below shows plans of Pasir Ris, an estate in Singapore which has about 28,000 HDB dwelling units (or 108,000 population) as of Mar 2007.[14] Assuming a walking catchment radius 800m for the estate's MRT station,[15] and a conservative 200m for bus-stops, we see that almost all residents are comfortably within the catchment of a transit node. This is a characteristic of the town and transportation planning integration that Singapore practices.[16] However as mentioned earlier, for residents who have to take the feeder bus to get to the MRT station, they would have made their first transfer of their commuting trip.

Fig 2.6 Map of Pasir Ris, with MRT 800m (left) and bus 200m (right) catchments (Base image source: Singapore Land Authority (SLA) – www.map.gov.sg, markups: Author)

If we zoom in closer, we can see how Singapore facilitates walking to the nearest transit node. Knowing the weather considerations, the key strategy that has been adopted is to create an inter-connected network of covered walkways so that you can walk from home to the transit node without getting wet from rain or be exposed to the sun. Fig 2.7 below shows an aerial photo of Woodlands, another residential estate with 58,000 dwelling units (or 219,000 population) as of March 2007.[17] In between the high-rise public housing on the right, we can see the buildings are interconnected with a series of sheltered walkways which leads them to a bus stop along the main road cutting across the middle from top to bottom. Beyond that, the shelter crosses the road via a pedestrian overhead bridge (POB), and the shelter continues, dissecting a field[18] to reach Woodlands MRT station.

[14] HDB (2007)
[15] From LTA (2005a), 68% of commuters are walking a distance of 400m-800m to an MRT station. This reflects their willingness to walk as opposed to taking a bus. This is consistent with the findings from Wibowo (2005) which reported that 790m is the upper limit that commuters are willing to walk to an MRT station.
[16] Lam, SH & Toan TD (2006) Land Transport Policy & Public Transport in Singapore. *Transportation 33*: 171-188.
[17] HDB (2007)
[18] The shelter that is cutting across the field is an interim one until the plot of land is developed, then the continuous shelter would most likely be provided along the periphery of the development.

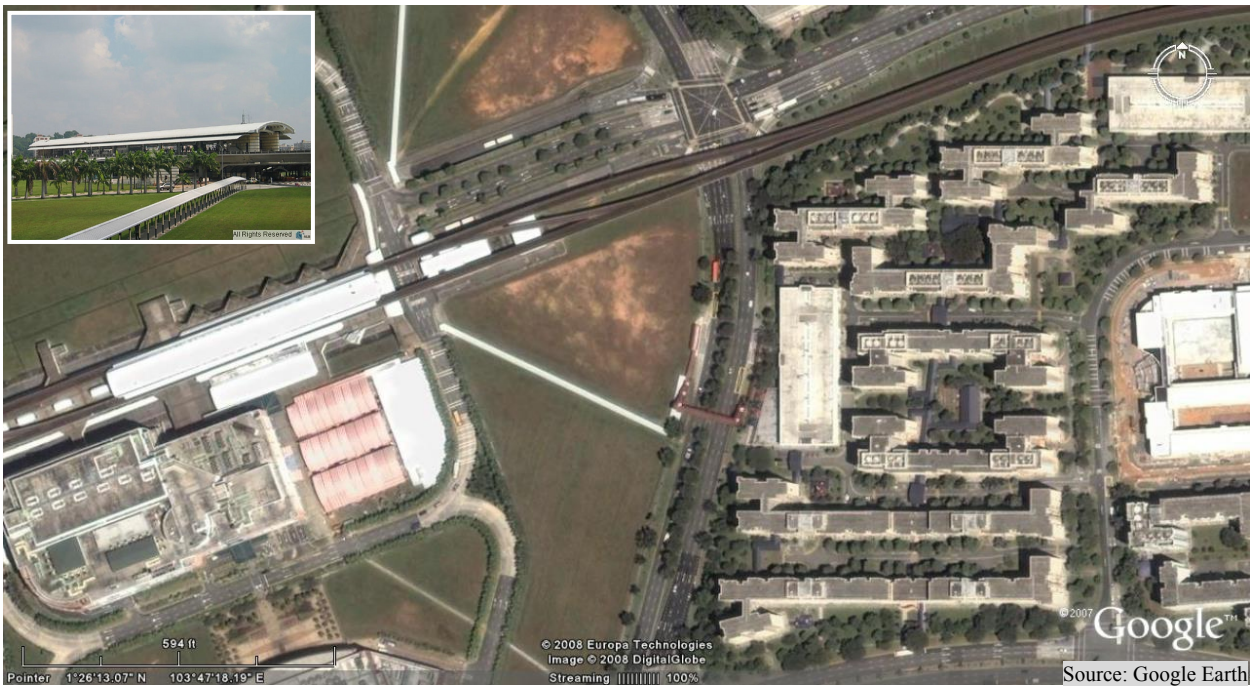


Fig 2.7 Sheltered walkways and their connections to bus-stops and a MRT station. Inset: View of sheltered walkway leading to MRT station from POB (Source: National Library Board retrieved from SNAP on Flickr)

While the concept of sheltered walkways is sound, it is inevitable that tracing a continuous sheltered path would not be the most direct of routes as we can gauge from the clusters of buildings on the right. When it comes to the crossing of roads, either the continuous shelter is achieved via POBs which involves climbing stairs (non-barrier free) or there will be a break in continuous shelter across at-grade crossings (there is a gap close to the MRT station above). It is also arguable how aesthetic the network of sheltered walkway may be because it can overwhelm the streetscape. Nevertheless, even though the sheltered walkway may not be perfect, it is an ideal solution in residential areas to connect pedestrians to transit nodes.

As it is probably not cost-effective to fully cover all pedestrian footpaths with shelter, particularly along all sidewalks (not to mention the visual impact!), we can rely on shade that are provided by trees. Nevertheless, unlike some older estates which has older trees with bigger canopies, new towns such as Pasir Ris and Woodlands generally do not have that much tree canopy coverage, and it is a constraint that we have to live with for now. However, it would be fair to say that new towns are less walkable because of the lack of shady footpaths.

Fig 2.8 Left: trees coverage in Bedok, a mature estate in Singapore, and right: in a newer town Pasir Ris shown in the same scale.

Commuter perceptions about the walking experience around their homes

From the WEXiS survey and in follow-up interviews with selected respondents, it was understood that most commuters are satisfied with the walking accessibility part of their public transit experience around their homes. Complaints were directed mainly at the frequency of buses and its service quality rather than their walking experiences. This is an indication that the integrated town and transportation planning is effective to reduce the need for commuters to walk much.

About half of the WEXiS survey respondents felt that more sheltered walkways should be provided around their homes. From follow-up interviews with selected respondents, it is understood that most people do not use the sheltered walkway network in their journey to work if it involves walking a detour, therefore they would appreciate more direct sheltered walkways to be made available. For people who need to cross roads to get to a transit node, they would also rather do so at at-grade pedestrian crossings than to trace a continuous sheltered path which would mean they have to climb POBs which takes more physical effort. Therefore it is clear that in the absence of a more accessible sheltered system, commuters' preference is for directness and speed when it comes to their walking experience around their homes. Given that the public transit system provides air-conditioned comfort, the "sacrifice" for some short term exposure to the weather is perhaps bearable just before the commuter enters the transit system (third tier of hierarchy of walking needs displaces enjoyment).

However, consistent with our WEXiS survey findings, the situation is very different when it is raining, and Singapore's torrential rain is normally too strong for even umbrellas to shield completely. Even though sheltered walkways are not 100% weatherproof, they are still better than umbrellas, and these follow-up interviews with selected survey respondents revealed that they will follow the circuitous covered walkway route when it rains. This alludes to the fact that the sheltered walkways for commuting are more for rainy day use.

From the urban design standpoint, while sheltered walkways may be desired by commuters to be more extensive, but too much of it will overwhelm the streetscape.[19] From a cost-effective point of view, it is also impossible to provide shelters everywhere. The function of sheltered walkways as a rainy day use should remain; however, given that commuters are sacrificing comfort by using other more direct routes, it is hence important to note that sidewalks and walking routes which are more direct should not be neglected. Shelter should be provide where necessary and tree planting is a natural solution to these problems, and more thought by the planning agencies could be given to ensure better shady trees coverage along major thoroughfares to transit nodes, even for newer residential estates.

Transportation hubs – the main gateway into the public transit system

The MRT stations within residential estates are seen as transportation hubs since most residents are fed into it from the feeder bus services that serve the estate. One of the key land use and transportation integration strategies is to make this transfer from feeder services as seamless as possible to the MRT transportation hub. Newer centers have their bus terminals better integrated with the MRT stations such as Woodlands and Sengkang - one of the newest residential estates in Singapore. Current design of such transportation hubs are aimed towards vertical integration of modes and transfers in air-conditioned comfort. Besides transportation, these hubs are also combined with commercial and retail centers to maximize convenience for commuters when they head in and out of work.

The older estates may not have their bus terminals as closely integrated to the MRT station, but they do have retail centers as well and the transport operators are continually upgrading walkways between bus terminals and MRT stations with wider, sheltered paths with more retail and amenities, etc. For example, as of March 2008, one of the two public transport operators, SMRT Corporation has 120 food and beverage outlets on its MRT stations' premises, a tenfold increase compared to about 10 such stores just four years ago.[20]

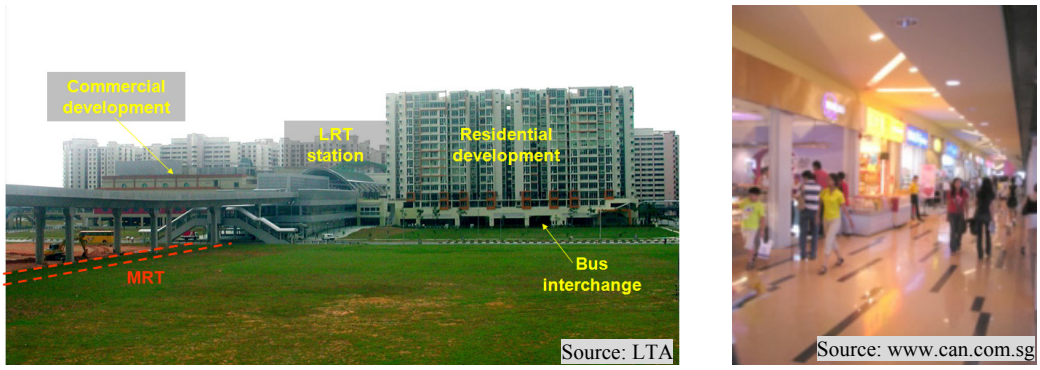


Fig 2.9 Left: Sengkang transportation hub with integrated residential and commercial developments. Right: new retail pedestrian mall between Tampines MRT station and its bus interchange.

[19] Tong (2004)
[20] Koh, L. (2008, March 1). Next Stop: Makan! *Today*. Retrieved from http://www.todayonline.com

Analysis about integrated transportation hubs

From the commuters' perspective, given their strong preference for all-weather protection, transportation hubs are a boon and a right direction for Singapore to continue pursuing. Where it is possible to achieve vertical integration whereby walking distance is minimized, this is an even better outcome for commuters. Introducing retail element into transportation hub is also an interesting possibility. From the WEXiS survey (Fig 2.3 above), 33% of commuters felt that it is important to have retail amenities along their walking path. However, follow-up interviews with selected individuals revealed that they felt the retail amenities are a good bonus to have. In the morning rush hour, when most shops are not opened anyway except for breakfast eateries, the retail integration does not play an important role. However, in the evening peak when commuters return home, all follow-up interviewees appreciate the retail integration very much because there is more time for them to shop or they can grab dinner on the way home, etc.

What this implies from the transportation standpoint is that if the transportation hub is designed successfully, the trip to the hub can be considered not a transfer at all. Instead, the transportation hub is part of a chained trip as commuters go there with a purpose and then head to work or home. Walking in this case is barely an issue as commuters experience a convenience. Otherwise they may have to make additional walking trips when they get home in the absence of any retail integration around the transportation hubs. This is important because in a Stated Preference Survey done in 2004 regarding commuters' perception towards transfers, the results found that transfers between MRT and buses had the worst transfer penalty (as opposed to bus-bus and MRT-MRT).[21] This could be because of the extended distance to walk for some and the grade separation too. Therefore Singapore is moving in the right direction by introducing integrated transportation hubs to mitigate the negativity of bus to MRT/MRT to bus transfers.

MRT Transfers within the Public Transit System

For many years, transportation planners have undertaken the task of estimating the transfer penalty which is the perception that commuters have towards transfer trips. This has an important role to play in transit planning, design and operation. The independent variables that affect the transfer penalty include walking time, waiting time, transit cost, number of transfers, number of seats, etc.[22] However, due to the very subjective nature of transfers, there is no affirmative study yet on how to best assess the transfer penalty. It is beyond the scope of this thesis to assess the transfer penalty, but what we will try to do is to improve the walking part of the transfer penalty through a design approach. Existing literature gauge walking distance as an independent variable in determining transfer penalties, but could the walking experience be a factor as well? Guo and Wilson (2004) did a study in Boston to assess the transfer penalty

[21] LTA. (2005b). '2004 Stated Preference Survey' Presented at the *LTA Planning and Policy Seminar*, September 2005, Singapore.
[22] Guo, Z. and Wilson, N. (2004). Assessment of the Transfer Penalty for Transit Trips: A GIS-based Disaggregate Modeling Approach. *Transportation Research Record 1872*: 10-18.

through a GIS-based disaggregate approach. Amongst the independent variables that they tested across a variety of models, walking shows up consistently to be three to seven times more critical than wait times in influencing transfer penalties. Of course pure transfer penalties exist, i.e. once a commuter is made to step out of a vehicle, he already perceived a residual transfer penalty, but could this again be an intrinsic penalty given that he knows he has to walk that long boring tunnel again? Can the penalty be reduced by having a transfer experience that he can look forward to? In an interview with Guo,[23] he agreed with the possibility of my assertions above, but concluded that the realm of using design to improve the transfer experience is rather new, but theoretically it may work although it is uncertain how impactful it might be. Earlier, we understood from WEXiS survey respondents that the "pain" of the transfer was not felt that severely when they made the evening peak return trip from work to the retail-integrated transportation hub. This implies that if we design the transfer correctly, the transfer penalty can be ameliorated.

Singapore is in the midst of improving the transfer experiences in her transit system, in particular the uncertainty and time wasted in waiting. In a comprehensive public transport review done recently, the Transport Minister, Mr. Raymond Lim acknowledged that transfers can be frustrating to the public transport user and he outlined several initiatives to make the hub and spoke system more seamless.[24] These initiatives include shorter frequencies of buses, greater bus priority measures, travel information display, distanced-based "through fares" regardless of mode or number of transfers, etc. With these improvements, this would mean that commuters would be able to better plan their transit trips. Long walking distances may be eliminated in future because commuters can hop on to buses which arrive punctually and transfers as many times as necessary with a constant fare to reach his destination effectively. While seemingly more transfers may be introduced, but if the transfers are seamless and if there is certainty in travel time with an improvement in walking distances, commuters will ultimately benefit. One other initiative that was also pointed out is that there would be more integrated transportation hubs to increase convenience for commuters which is again another positive move. However, despite all these, we may need to tackle a walking issue that does not seem to be addressed by these new initiatives, and that is MRT to MRT transfers.

Singapore has envisaged that the MRT is the backbone of her public transport system which is essentially the main "spoke" of the hub and spoke system. Given the nature of MRT systems, it is not unusual to find that one may have to transfer between different lines to get to their destination, even for downtown destinations. Unlike bus to bus transfers which normally takes place at the same bus-stop, MRT transfers may require commuters to walk through walkways/tunnels which link two interchanging stations. Currently cross-platform transfers only exist at the first generation MRT lines built in the 1980s. With the completion of the North East

[23] Guo, Z., personal communication, 2 April 2008.
[24] Lim, R. (2008b, January 18). Putting the Commuter at the Centre. Speech at the launch of the Land Transport Gallery. Transcript retrieved 1 March 2008 from http://www.mot.gov.sg

Line (NEL) in 2003, commuters for the first time had to use transfer tunnels and the general perception is that the distance is too far (approximately 200m when measured on plan). This is despite the fact that these transfer tunnels are air-conditioned with lifts, escalators, travellators, etc. Although this could be a matter of commuters accustoming themselves to such transfers gradually over time, but given that Singapore is aggressively expanding her rail network (see Fig 2.10 below), all future intersecting MRT lines may most likely result in similar transfers which require commuters to walk an extended distance. Is there scope for Singapore to improve the walking experience in such MRT transfer situations in future?

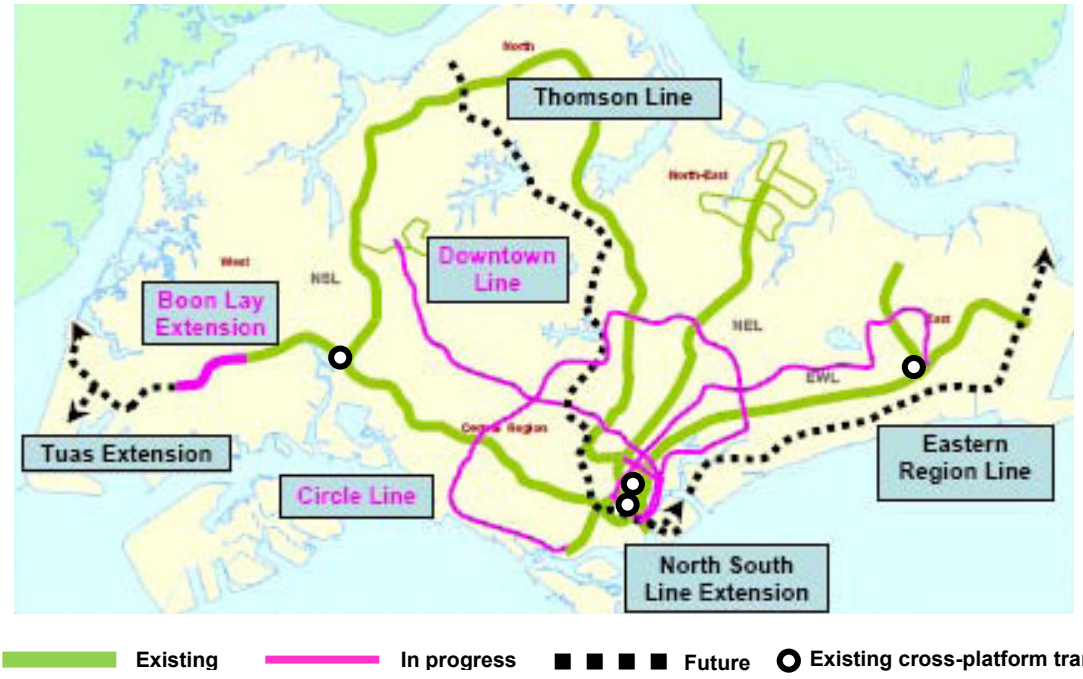


Fig 2.10 Singapore's 2020 rail network (Source: LTA through Straits Times (2008, January 20) "2 New MRT Lines & 2 Extensions by 2020" Accessed 15 March 2008 at http://www.straitstimes.com. [Existing cross-platform transfers are author's own additions]

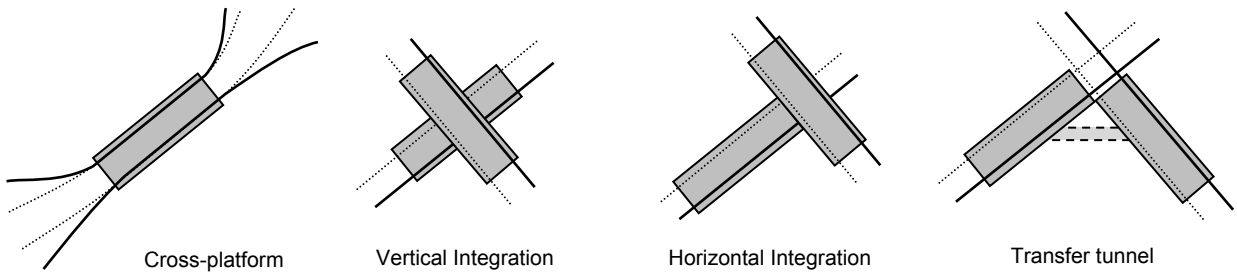


Fig 2.11 Left to right: MRT stations transfer situations in decreasing idealness (Source: Author)

Fig 2.12 The two transfer tunnels of the North East Line – Outram Park and Dhoby Ghaut MRT stations

Analysis of the walking experience in MRT transfers

On the face of things, it appears the design of MRT transfers are being done right by providing for air-conditioned comfort and all-weather protection. However, to commuters, this is not exactly the case. The MRT transfer is being perceived as an additional walk that they should not be expected to do. Unlike the transfer to the transportation hub which we mentioned earlier that commuters can derive utility from shopping, getting food, etc., this one has no utility at all. The air-conditioned transfer tunnels are the bare minimum that commuters expect for the

inconvenience that they are put through for the transfer, according to follow-up interviews with survey respondents. Imagine getting commuters to step out into the streets, be exposed to the weather and transfer between MRT lines in the middle of their trip – that will have been unthinkable in the commuters' point of view.

According to the 2004 Stated Preference Survey conducted by LTA, commuters perceived the second transfer as two to three times worse than the transfer penalty from the first one.[25] If majority of commuters have already made the first transfer from the residential estate feeder system into the transportation hub, then any transfer within the MRT system is therefore a second one and a worse experience.

From our WEXiS survey results, 62% stated that the MRT transfers at the NEL stated above (see Fig 2.12) are too far to walk, this is despite the fact that the system has been in place for more than 4 years, so it is not a matter of getting accustomed to such transfers. Interestingly, when asked to compare the walking experience between the two transfers which the NEL has, 48% of commuters prefer the Dhoby Ghaut transfer over the Outram Park one, while 40% are indifferent to the two. According to this 48% who prefer the Dhoby Ghaut transfer, an overwhelming 98% of them felt that it was because the Dhoby Ghaut transfer is more airy, spacious and brighter – basically more visually aesthetic. In comparison, the Outram Park transfer is narrower and more confined, and most of the respondents who thought that Dhoby Ghaut was better, felt that improving the aesthetic conditions of Outram Park would make it more walkable too. Therefore perhaps there is room for us to improve the design aspects of transfer tunnels to ameliorate the commuting walking experience. Of course, nothing would still beat the elimination or minimizing of such transfer distances through good transportation planning and engineering (see Fig 2.11 above), but given land and engineering constraints we will have to do our best with whatever transfer situations that may result. As Singapore now moves into tightening the transit hub and spoke system, the MRT transfers could end up to be the weakest link of the public transit system left to deal with.

The final step – Leaving the transit system and getting to the downtown workplace

Fig 2.13 shows a map of the existing Singapore CBD which should also be read together with Fig 1.2. Public transit accessibility is best into the CBD when compared to the rest of Singapore, and due to the much higher urban density, all MRT stations are underground and there is also very close integration with adjacent buildings through underground tunnel links at some stations. While the stations have their usual entrances/exits on the surface, these underground tunnel links go a step by directly linking to adjacent buildings and commuters can go from transit node to office in a completely air-conditioned environment. Fig 2.13 shows Raffles Place and Tanjong Pagar MRT stations with their tunnels spreading like fingers to office buildings around it. Such

[25] LTA (2005b)

level of integration is ideal in a dense urban environment due to high land prices and heavy volume of pedestrian traffic.

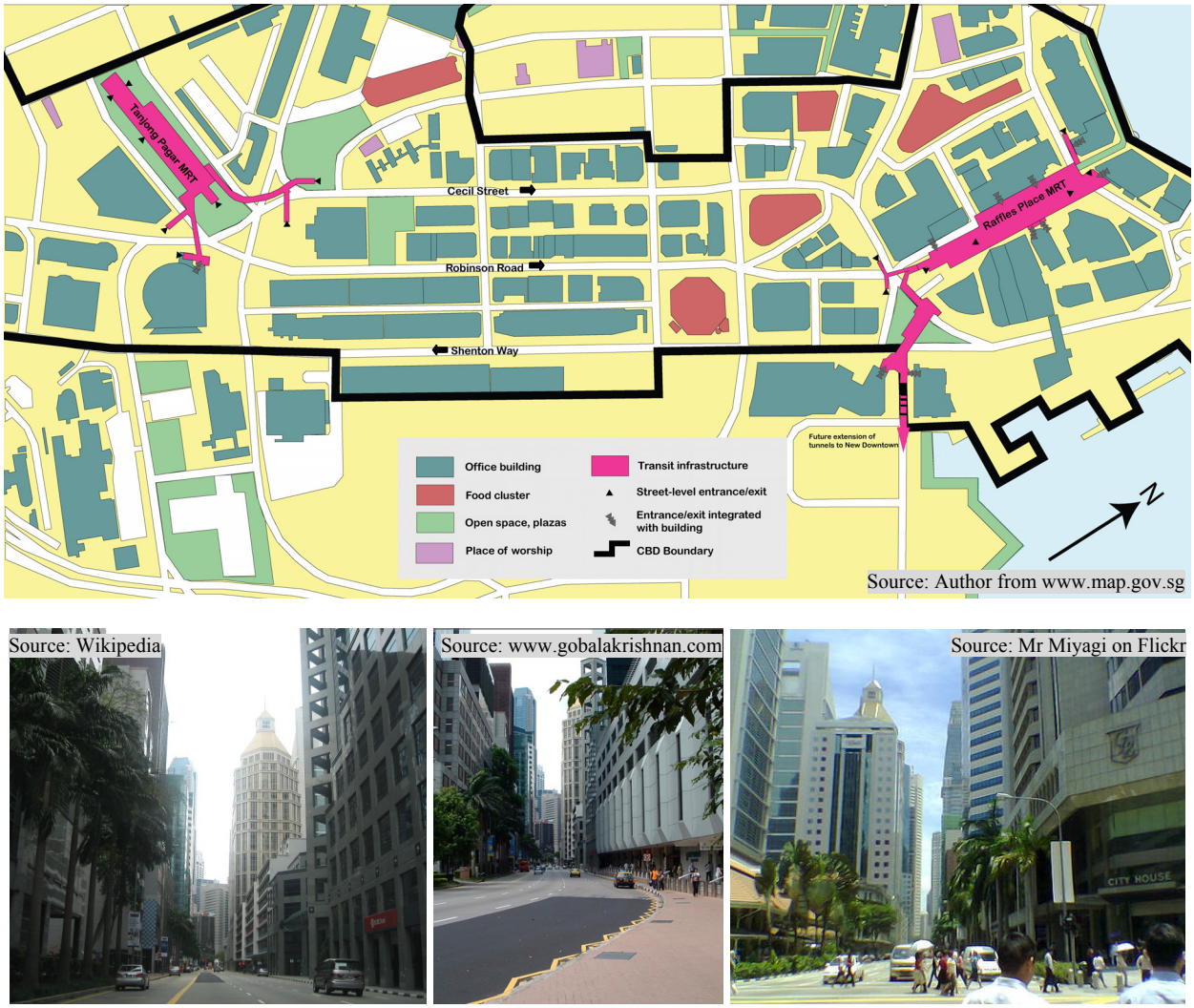


Fig 2.13 Top: Singapore's CBD which is essentially the area between the two MRT stations with three distinct corridors along Cecil Street, Robinson Road and Shenton Way. Bottom: various views along Robinson Road, arguably the spine of the Singapore CBD

The covered linkway network that is abundant in residential estates is not prevalent in the downtown area, most likely because of space constraints and perhaps an intentional aim not to overwhelm the streetscape (see images in Fig 2.13). Most buildings however have a sheltered corridor along their frontage either historically (there are some colonial buildings) or as required by URA for the newer buildings, but there is generally no continuous cover when there is a break in buildings or across roads. Therefore, unless you work in an office building that is lucky enough to be linked into the MRT system, most likely you will be at the mercy of the weather because of a lack of continuous shelter in the CBD. Comparatively, one can easily stay sheltered

all the way from your home to the MRT system, but it will more difficult to do so from the MRT system to the workplace if you do not enjoy the benefit of underground integration.

Even without such high-level integration like the Raffles Place MRT concept, MRT stations in the downtown area should at least have extended entrances/exits to better connect commuters to their destinations. If we look at an MTR station in Hong Kong's downtown shopping district versus a similar MRT station in Singapore (see Fig 2.14 below), the difference is rather obvious, and 45% of WEXiS respondents also felt that Singapore can do better in the scope of extending the reach of the MRT station entrances/exits. The advantages they cite are that the extended entrances/exits would offer than all-weather protection sooner and prevent the need for them to cross at-grade roads.

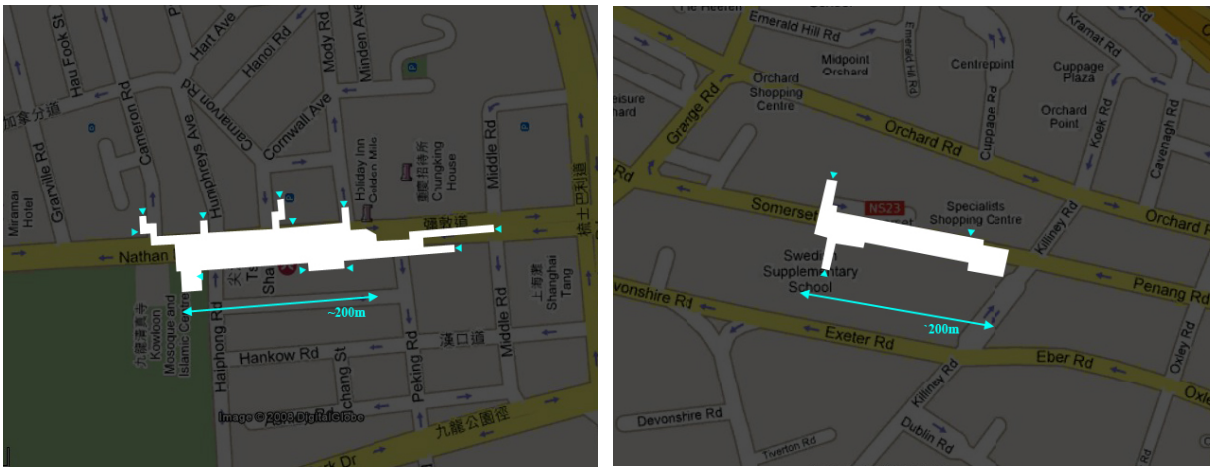


Fig 2.14 Hong Kong's Tsim Sha Tsui Station and Singapore's Somerset Station shown in the same scale. While the Hong Kong MTR is an 8-car system, we can see that that station box size is similar to Singapore's 6-car MRT system, likely because of back-of-house station layouts. Regardless that Tsim Tsa Tsui station's many entrances may be partly due to the street network, Somerset station is definitely lacking in entrances' connectivity. (Source: Base from Google maps. Station outlines traced from www.mtr.com.hk and www.map.gov.sg respectively.)

Analysis about the last segment – walking from the transit system to the downtown office

From the WEXiS survey, commuters are generally appreciative of the underground pedestrian connections to their offices if available. However, due to overcrowding during the morning rush hour, many prefer to actually walk outside in the open where it is more spacious. During rainy days, the underground links are a boon although the wet and crowded conditions do not make the walking experience within them that enjoyable.

For commuters who are going somewhere in the CBD which is not connected via any underground integration, they do not mind the walks to the office that much. The MRT stations in the CBD are reasonably close enough to most office buildings; hence they need not have to walk too much before they get into the cool air-conditioned comfort of their office. When it is

raining, however, this group of commuters laments the lack of continuous shelter. They will have to exit via the nearest MRT station egress which is not that far-reaching in the first place and then flit from shelter to shelter.

To conclude, the existing high level of integration in the downtown MRT stations are a boon, though peak hour pedestrian traffic can be overwhelming and commuters appreciate the option to walk outside if the weather is fair. However, rainy days are the times where commuters desire all weather protection the most, and there may be scope for the MRT stations to have more integration with office buildings or at least extend the reach of their station entrances/exits.

Walkability within the Downtown Area

Our assessment about walkability within the daily commutes to the downtown area is that it is still reasonable. Weather in the morning is not that unbearable yet, and commuters only need to take a short walk before they reach their offices where they can cool down. Underground links to office buildings are appreciated most during rainy days, but about two thirds of them prefer to use other alternatives like sheltered walkways or out in the open if given a choice during fair weather. While such underground links in the morning commuting traffic serve more as a function of egress from the transit system, they play a pretty major role for downtown walkability too during other times of a typical workday.

First of all, why is it important to have good walkability in the downtown area? The CBD has perhaps the highest concentration of people who are moving about during office hours, and it peaks during lunch time. Due to the compactness of Singapore's CBD or any city's CBD for that matter, walking is the most natural mode to use as opposed to taking public transport and driving. The one-way streets and frequency of transit restrict the accessibility of public buses and parking costs are a further deterrent to driving. Another important fact about walking within the downtown is that most trips are very purposeful – i.e. getting lunch during lunch break or running to the bank to run an errand, so given that the walk is only the derived demand for them to achieve the final purpose, it will be good if we can improve that experience as much as possible so that it does not discourage these trips.

We first compare the Singapore CBD street-blocks with that of London and Boston's CBDs. All three are rather similar, with the Singapore blocks perhaps slightly bigger, but not that significantly. Walkability in terms of street density is reasonable in Singapore since a higher street density creates more intersections with corresponding at-grade pedestrian crossings that helps to facilitate walking. Rarely will you find a pedestrian overhead bridge (POB) in Singapore's city centre. There are a few examples on the south side of the CBD (Shenton Way) and in Chinatown, but other than these, land constraints and visual impact do not favor the provision of POBs which is actually a boon to downtown walkability.

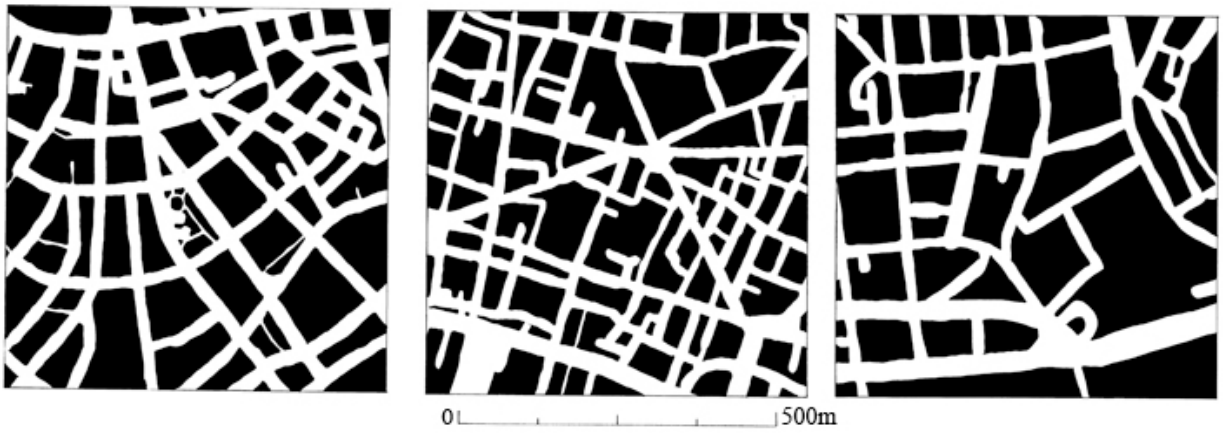


Fig 2.15 CBD street density comparison (L to R: Boston, London and Singapore). (Source: Author)

Where land use is concerned, the Singapore CBD also has a good mix of retail and services in the midst of the high office density. There are plenty of good food options concentrated in the CBD (see Fig 2.13) which many Singaporeans can attest to. While all factors and planning seem to point towards a walkable downtown, but the most important considerations for pedestrians in choosing their walking paths is not addressed – weather considerations. As mentioned in the commuting section, continuous shelter is lacking in the CBD, and while weather considerations are acceptable in the early morning, but in other times of the day, the Singaporean hot and humid weather is relentless. From the WEXiS survey, 79% of respondents said that they have given up on leaving office during lunch hour when the weather is too hot and they do not have a comfortable walking option, instead they lunch-in or order take-out. Not all office workers are in the same shoes though, over at Raffles Place MRT station, the extensive underground pedestrian network which links the transit node to adjacent buildings allows the direction of pedestrian flow to reverse during lunchtime towards the MRT station. This is because in the concourse of the MRT station, there is a popular 2,000m^2 commercial area where there are restaurants, cafes, boutiques to draw customers and its success is due to its excellent accessibility from surrounding developments in air-conditioned comfort.

Therefore a natural enhancement to the walkability of downtown would be to further extend the underground pedestrian tunnel system with commercial integration. However, despite its apparent usefulness, subterranean infrastructure is very expensive to construct, and Singapore, be it the LTA or the URA, in most cases have to entice private developers to build or co-fund such links. From the pedestrians' viewpoint, underground pedestrian tunnels have their limitations too. Where they completely replace at-grade street crossings, pedestrians on the surface will be inconvenienced by having to use these grade-separated passageways. Such walking experience is worse when there are no escalators (i.e. stair-climbing) or if it is not wheel-chair accessible. An example of this is shown in Fig 2.16 below, at the junction of Esplanade Drive and Stamford Road where Singapore's premier performance theatre is (Esplanade – Theatres on the Bay), right

at the edge of the CBD. The intersection is completely impassable by at-grade pedestrians, but yet the 4-way underpass system does not have barrier-free accessibility. In this case, it is clearly a matter of vehicular traffic taking priority over pedestrian accessibility. As this issue of the lack of pedestrian accessibility is not widespread in the Singapore downtown, we will not address it specifically; however, the aim is to highlight that even with greater underground integration, Singapore planning agencies should note that at-grade pedestrian accessibility should never be neglected, especially where barrier-free needs are concerned.

Fig 2.16 An example of an intersection in Singapore which restricts walkability

Preliminary Conclusions about Work-Related Walking Experience

The nature of the hub and spoke system of getting commuters to work in Singapore has resulted in the fact that transfers are inevitable, and this hub and spoke system is still reiterated by the Transport Minister as the most efficient means to be retained in Singapore.[26]

From my analysis, the walking experience while commuting to work is relatively seamless. The extensive infrastructure provided by Singapore has given commuters a choice to use them, and while it may not be possible to site them to please everybody, most commuters appreciate their presence when they are needed. When they are not needed, commuters seek walking choices that suit their own walking needs, particularly the third tier – accessibility, in terms of the effort, directness and speed of getting somewhere. These choices are also due to the fact that the walking is reasonably short enough for most to sacrifice the short term discomfort of the heat and humidity, knowing they can cool down soon once they get into the transit system or to their office. For Singapore planners, it is important to note that it is not enough to just achieve connectivity via a continuous network of sheltered walkways; care should be taken into the planning to make sure that they fulfill the third tier walking needs of directness and accessibility.

[26] Lim (2008b)

Where it is not possible to do both, alternatives should be left for commuters to choose their most direct route, and other forms of comfort like shady trees should not be neglected.

Problems that were observed about the public transit experience are mainly inherent in the transfer experience itself. This could be resolved as Singapore undertakes a slew of initiatives to tighten the hub and spoke system and make transfers more seamless and efficient. The only problem related to the transit system that surfaced from the analysis is that more and more MRT transfers will be necessary in future. For certain trips, the MRT transfer distance can be substantial, and for some commuters, that MRT transfer distance is the farthest they have to walk amongst all the walking segments of their entire commute. As the MRT system expands and more of such extended transfer tunnels are needed between intersecting MRT lines, this is definitely an aspect of walking that we should seek to enhance.

Where walkability of the downtown area is concerned, the spatial planning and design of the land use in the CBD supports a walkable environment, but the biggest issue that pedestrians currently face is the uncomfortable tropical weather. There could be room to further extend the underground pedestrian network to provide pedestrians a cool walking environment or possibly some other interventions to improve downtown walkability. However, the extension of the underground pedestrian network should not be at the expense of at-grade pedestrian accessibility, particularly for the needs of those who are mobility-impaired.

Chapter 3 Enhancing Walking in Work-Related Trips

From our earlier chapter, we noted two main issues to address in terms of enhancing the walking experience in Singapore in work-related trips. First, the expanding MRT network will result in more MRT transfers of extended distances which create additional but unwelcome walking opportunities in the public transit system. The other issue is the inadequate walkability in the downtown area for pedestrians due to the lack of continuous shelter, which is compounded by the uncomfortable Singapore weather when they are making intra-downtown trips. In this chapter, we will explore possible solutions for both issues, supported by case studies and best practices in other cities where appropriate.

Enhancing the Walks in MRT Transfers

As mentioned in chapter 2, there is existing research on the physiological and psychological effects on transfers in the field of environmental science to understand commuter behavior at work/home, and there are also extensive studies by transportation planners to model and understand transfer penalties to improve transit. However, as far as my research uncovered, none of these studies focused specifically on the walking transfer between mass transit modes as a possible area to improve. Granted that walking transfers between mass transit modes may be a small piece of the entire commuting "juggernaut", but for an extensive MRT network, it becomes important if transfers are prevalent especially when there involve more than one transfer. In Singapore, a commuting trip from the terminal MRT stations to the city center takes around 30 mins. Assuming a 1.5m/s walking speed for a 200m transfer distance, this would mean the transfer walking adds 8% and 16% to the MRT trip time for one and two transfers respectively. For other MRT stations in between the terminus and the city center, the weightage of transfers is even greater in proportion to the overall commuting time. Also our earlier claim in Chapter 2 asserts that the MRT transfer in Singapore's context is typically the second transfer in the public transit commuting chain, it is therefore even more important to enhance the transfer penalty.

There are bigger solutions of improving the transfer experience, such as having more point to point services or building the interchange MRT stations to be more closely integrated. However given the constraint of not being able to do so, what then can we do to improve the transfer experience? Technological and operational improvements can enhance the waiting experience, but what about the walking part?

Gehl (1987) suggests that if the walks are necessary (as in the case of commuting trips), then the built environment matters little to influence the walks. However, he comes from the perspective that the built environment does not affect the frequency of necessary walking activities (which I

agree should not and would not) and the impact is more for the frequency of leisure walks. There is still a realm of possibility the experience of these necessary walks can be enhanced by actions of design. Current research of pedestrians' behavioral science in different environments had not been directed at the context of MRT transfer tunnels, but Zacharias (2001) revealed that there are established correlations between pedestrian behavior and the environment, such as climate, visual, tactile, auditory perceptions, etc.[1] Transportation planners have also studied the walkability of transit access/egress which influence the choice of access mode to the main transit mode.[2,3] Therefore, we can infer that improving the walkability of transfer walkways should at least improve that segment of the commuting experience, if not the entire commute itself. Also, to reiterate the finding from the WEXiS survey, 48% of respondents perceived a positive difference in their walking experience when they compared one transfer tunnel over another in Singapore's MRT system.

Current design of MRT transfer walkways

The MRT system in Singapore is designed in accordance with the American National Standard NFPA 130[4] as a base design guide.[5] This is adapted into the Standard for Fire Safety in Rapid Transit Systems (SFSRTS) sanctioned by the Singapore Civil Defence Force (SCDF). The standards guide the safety design of MRT stations in order to facilitate the escape of commuters in the event of a fire, and it assumes a worst-case situation with the greater of AM/PM peak traffic, surge factors, simultaneous detraining, etc.[6] Given that people can escape in a quick manner in the event of a disaster, the normal operational capacity of a transfer walkway is expected to be satisfactory. In addition to this, for pedestrian congestion and flow considerations, the LTA requires design consultants/contractors to further substantiate their design with pedestrian simulation models.[7] Walkway design constraints are more apparent in a transfer tunnel situation between two underground stations, as opposed to a transfer between an elevated station and an underground one because the former is done in a more confined space. Therefore our focus is more on transfer tunnels. As more of Singapore's MRT lines go underground, transfer tunnels are also more likely to occur in future.

[1] Zacharias, J. (2001). Pedestrian Behavior and Perception in Urban Walking Environments. *Journal of Planning Literature. 16*: 3-18.
[2] Cervero, R. (2001). Walk-and-Ride: Factors Influence Pedestrian Access to Transit. *Journal of Public Transport. 7*: 1-23.
[3] Wibowo (2005)
[4] NFPA 130 was first issued in May 1983 by the National Fire Protection Association Inc. USA and it is specially prepared to cover fire protection and life safety from fire in fixed guideway transit systems. The latest edition is published in 2007.
[5] Siew, Y. C. (2004). Fire Safety Design for Rapid Transit Systems. Conference proceedings of *Fire India* held in 2004. Accessed 20 March 2008 from http://www.nfpa.org/assets/files/PDF/NFPA%20Journal/FireIndia.pdf
[6] Singapore Civil Defence Force (SCDF). (2005). *Standard for Fire Safety in Rapid Transit Systems 2005.* Accessed 20 March 2008 from http://www.scdf.gov.sg/downloads/FS_Publication/SFSRTS_2005_Edition_Rev21092005.pdf
[7] LTA. (2006). *Architectural Design Criteria for Road and Rail Transit Systems*. Singapore: LTA. pp 6/26.

In Hong Kong's MTR system, the MTRC have developed their own design standards in the 1970s[8] which is generally more conservative than the NFPA130.[9] Hong Kong has also made use of pedestrian simulation software like Pedroute[10] to substantiate their pedestrian flow design.[11] A quick comparison of the different standards for pedestrian tunnels in mass transit systems are shown in Table 3.1. The design guidelines from the Transit Capacity and Quality of Service Manual (2nd Edition) [12] are also listed for comparison. From these figures, we can calculate the walkway width that is needed to achieve the design flow rate.

Table 3.1 Design Flow Rate of Transit Passageways from Various Sources (Ordered in decreasing stringency L to R)

	Passengers/m/min	**Based on:**
Standard of Fire Safety for Rapid Transit Systems (SCDF, 2005)	80	Walking speed of 60m/min (or 1m/s)
Transit Capacity and Quality of Service Manual (TRB, 2003)	82	Level of Service E or 0.5-0.9m^2 space per passenger
Hong Kong Mass Transit Railway Corporate guidelines (Lau, 1994)	89	-
National Fire Protection Association Code 130 (TRB, 2003)	89.3	Walking speed of 61m/min

The purpose of showing these design capacity figures of differing standards is not to critique their basis or practicality, but more to assert the point that they are very engineering-based. The design standards are intended to move passengers efficiently and safely. Certain aspects of commuter comfort are incorporated, such as crowding and walking speed (third tier of walking needs), however, other aspects like visual and other sensory aesthetics are not.

Naturally transit facilities are designed for functional reasons, so it is arguable if aesthetical objectives even need consideration in the first place. However, the commuting experience can be a very stressful one psychologically.[13] In the worst case, this could lead to transit commuters switching to cars, or if commuters have no choice but to stick to transit, then the prolonged exposure to the stressful commuting experience may influence performance at work or

[8] Black, R. and Pierce, R. C. (1993). Construction of Metros towards the 21st Century. In North, BH (Ed) *Modern Railway Transportation: Proceedings of the International Conference Railways.* London: Institution of Civil Engineers (Great Britain).
[9] Lau, E. C. S. (1994). *A Study of Evaluation Methodology for Passenger Handling Facilities in Subway Stations (University of Hong Kong)*. Retrieved from http://sunzi.lib.hku.hk/hkuto/record/B31950632.
[10] Pedroute is a software developed by Halcrow Group Limited. Description is available: http://www.halcrow.com/html/our_projects/projects/pedroute_paxport.htm
[11] Lee, J. Y. S., Lam, W. H. K. and Wong, S. C. (2001). Pedestrian Simulation Model for Hong Kong Underground Stations. *Proceedings of the 2001 IEEE Intelligent Transportation Systems Conference, Oakland (CA), USA*. 554-558.
[12] Transportation Research Board (TRB). (2003). *TCRP Report 100: Transit Capacity and Quality of Service Manual 2nd Edition.* Washington, D.C.: TRB.
[13] Schaefer, A. (2005, September 21). Commuting Takes its Toll. *Scientific American Mind.* Retrieved from http://www.sciam.com

relationships with family as what many psychological studies discover.[14] Commuting frustration is primarily caused by predictability in their travel times.[15] While car drivers are equally susceptible to such stresses, at times worse than transit riders, Singapore's well-managed road system is generally smooth-flowing and greatly reduces the frustration of car driving. Besides, commuting stress is also greatly correlated with behavioral control.[16] In transit, commuters are at mercy to the system and they cannot wield any form of control except to leave the system. Drivers however, for better or for worse, can drive faster or choose another route.

Studies have shown that transit commuting stress is often due to transfers because they expose commuters to greater risks of travel delays. Much can be done to improve the perception of waiting by synchronizing train arrivals, having shorter frequencies, or having greater predictability, etc. In fact for peak hour travel, Guo (2004) asserts in one of his models that train frequencies are so often that it should not have a big effect on transfer penalties. Waiting enhancements are also aplenty, such as seating in the platform area, mobile TV screens, station aesthetics, travel information displays, etc. Walking during transfers is a new area to improve on, and it has few research devoted to it so far. In a Swedish example, a study acknowledged that long transfer tunnels create a monotonous and static environment, and it recommended decomposing the spatial monotony with acoustics - as one walk down the tunnel, the echoes are different and this can be accompanied by synchronized lighting difference too (see below).[17]

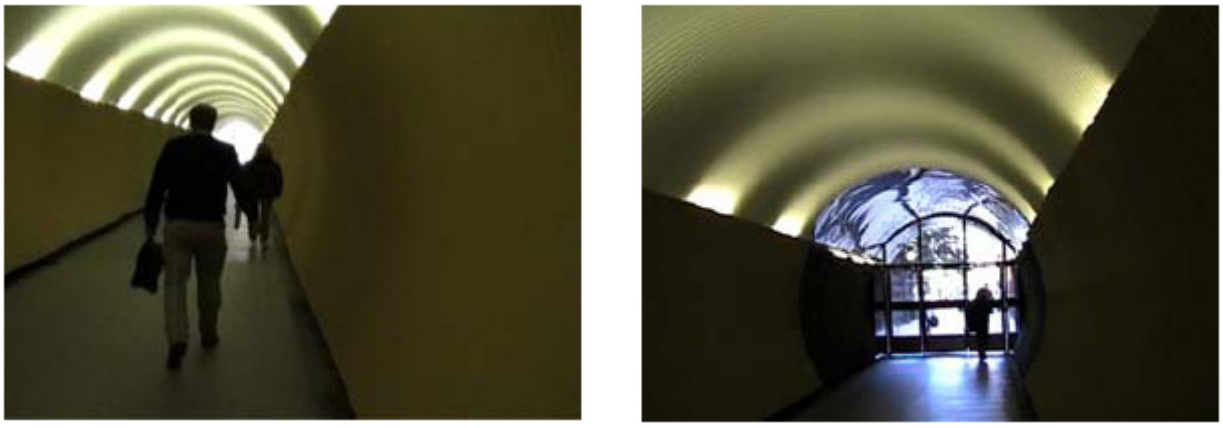


Fig 3.1 Breaking the monotony of passageways using lighting synchronized with acoustics. (Source: Rydén, 2005)

[14] Wener, RE. and Evans GW. (2004). *The Impact of Mode and Mode Transfer on Commuter Stress, The Montclair Connection.* Final Report retrieved from New Jersey Department of Transportation.
[15] Ibid
[16] Wener, R., Evans GW. and Lutin, J. (2006). Leave the Driving to Them: Comparing Stress of Car and Train Commuters. From *Investing Today for a Brighter Tomorrow. Proceedings of the 2006 Rail Conference*. (American Public Transportation Association)
[17] Rydén, L. (2005). Application of Acoustic and Architectural Design of Two Railway Stations in Stockholm. Presented at *Twelfth International Congress on Sound and Vibration (Lisbon)*.

Often the designs of transfer tunnels are constrained by engineering considerations, e.g. transfer tunnels have to avoid rail tunnels or other subterranean structures. Also the costs of constructing subterranean structures are very high. Both these concerns may restrict designers and builders to just construct the transfer tunnels to the minimum specifications required by the standards and/or pedestrian simulation models. As the standards optimize pedestrian walking speed and flow, it probably does not make economic sense to subscribe to ultra-wide passageways or high ceilings just to make the transfer walkway more aesthetic-looking. Instead, we should enhance our walkways with these "engineering" dimensions as a given, and as far as possible, do so within reasonable economic means.

Design Improvements

In the design of indoor environments, many architectural and environmental science studies can be found, but these are usually related to indoor office or retail shopping experiences. Basically, ambient, design and social factors such as lighting, temperature, colors, materials, sound, presence of other people, etc.[18] can influence how people work or shop. In the realm of rail transit, such studies are fewer and are almost entirely devoted to station design only.[19] However, if we go along the same approach, it is therefore possible that the design of transfer tunnels can also be improved. Looking back at the pictures in Fig 2.12 of the two existing transfer tunnels in the Singapore MRT system, we can see that they are brightly lit, clean and I would supplement that they are also in cool air-conditioned comfort. Dhoby Ghaut has travellators while Outram Park does not, but the provision of travellators is also related to the width of the passageway – there is really not much room to fit in travellators in the Outram Park transfer, and it is important to note that WEXiS respondents generally do not feel that the better Dhoby Ghaut walking experience is attributable to the travellator provision. Going by the full list of factors described by Baker (1986), I picked out lighting, sounds, colors and scent to elaborate below, and I also add to that list – information display, interactivity and renewability.

In our design consideration, we should bear in mind not to deviate from the function of transfer tunnels because people are there to walk and to travel; the enhancements are just there to sidetrack them and make the walking experience better. Another design constraint is that SFSRTS standards would require materials and design enhancements to be generally non-combustible and non-toxic,[20] but there should be safe materials or other mitigations available to work around this.

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[18] Baker, J. (1986). *The Role of the Environment in Marketing Services: The Consumer Perspective.* In: Czepiel J, et al. (Eds.) The Services Challenge: Integrating for Competitive Advantage. Chicago: American Marketing Association. Pp 79-84.

[19] Kido, EM. (2005). Aesthetic Aspects of Railway Stations in Japan and Europe, as a Part of "Context Sensitive Design for Railways". *Journal of the Eastern Asia Society for Transportation Studies. 6*: 4381-4396.

[20] SCDF (2005)

Information display

Based on anecdotal evidence, the reason why walking during transfers could be stressful is because one is trying to make the connecting train. Some commuters are laidback and walk slowly, but many others walk briskly, wanting to catch the next train and not just miss it by a whisker which means additional wait time. This can be seen as people wanting to possess behavioral control again – "I can control my punctuality by how fast I walk" (see paragraph referenced by footnote 16). In the two Singapore MRT transfer tunnels, it is starkly obvious that there is no train arrival information along them despite its prevalence everywhere else in the system, and it could be that it is an intentional aim to prevent mass frantic running. But is this really the best solution? I postulate that if commuters know when the train is coming, particularly the next two, then they can manage their walks better and be less stressed. If such messages are displayed, it could also take a more sensitive form like "Next train: 90s – Slow walk", "Next trains: 60s & 2mins", or something to this effect.

Fig 3.2 Rendering of train display information idea

Lighting

Holgate (1992) described the importance of lighting excellently by virtue of the use of the adjectives "bright" and "gloomy" to depict people's moods.[21] While sunlight is the most ideal lighting type, it is unavoidable that artificial lighting is used in most cases. The color temperature,

[21] Holgate, A. (1992). *Aesthetics of Built Form.* New York: Oxford University Press.

luminance and other attributes of indoor lighting has a direct relationship with mood and behavior with variations between gender, age, lighting purpose,[22] etc. It will be good to conduct a study to find out the right combination of lighting in the Singapore MRT system which commuters will react most positively towards. From WEXiS, we have preliminary evidence from commuters who find the Dhoby Ghaut walking experience better because of the lighting conditions there.

Sound

The use of music to enhance people's mood is a common "tactic" in retail and restaurants, but is there a realm of possibility for it to be employed in transit? It is important to note that audible official notices take priority in the transit environment,[23] so the use of music will have to be limited to the breaks in between announcements. Hellström (2005) presented that many European cities like Stockholm, London, Brussels, etc. use classical music in train stations to deter crime and it had been successful because most delinquents do not find classical music "cool", hence they avoid the train station.[24] This shows an interesting correlation between music and behavior, although Hellström does not agree with such use because of the irresponsibility to just relocate crime and not eradicate it. However, while there is a realm of possibility to use music to improve transit users' mood, the appreciation of music is a subjective and private matter, and Rydén (2005) made the point that it should not be force fed to transit users indiscriminately. For the improvement of waiting in rail stations, he proposed that virtual sonic spaces are created where music is only audible within them and transit users self-select to be immersed in music. We can explore the possibility of creating similar sonic zones in transfer tunnels, but given the relatively short walking time as opposed to waiting, the stimulating effect towards the audible senses may not be that great. An alternative would be to use more neutral sounds like water flowing and sounds of nature which may appeal to all users across the board. Another variation of using sound is to allow a live music performer within the transfer tunnel, though there needs to be careful planning in order for the performer not to obstruct traffic or become a nuisance instead.

[22] Knez, I. (1995). Effects of Indoor Lighting on Mood and Cognition. *Journal of Environmental Psychology. 15*:39-51

[23] Rubin, B. (1998). Audible Information Design in the New York City Subway System: A Case Study. Presented at *International Conference on Auditory Display (University of Glasgow, UK).*

[24] Hellström, B. (2005). Theories and Methods Adaptable to Acoustic and Architectural Design of Railway Stations. Presented at *Twelfth International Congress on Sound and Vibration (Lisbon)*.

Fig 3.3 Rendering of possible sonic zones along transfer tunnels and photo of a well-known busker along an underpass in Singapore's premier shopping street - Orchard Road.

Colors and Scents

The use of colors and scents are other established variables of environmental design. However, their application for this thesis may be limited. For colors, there is definitely scope to leverage on them to create visual interest for commuters, however I was not able to uncover adequate research to give a specific recommendation. Colors like sound is also subjective, and it may not be possible to appeal to all tastes with a particular color scheme, but we can use colors in other context like advertising which is renewable and less permanent. In the WEXiS survey, commuters were shown photos of an underground passageway which were colorfully decked out in advertisements, and their reaction to it is positive. We will further examine this under the items of advertisements and renewability below. For scents, a recent example in San Francisco had cookie smells accompanying a "Got Milk" advertisement at a bus-stop which resulted in several public complaints about possible allergies or other negativities about the scents.[25] The targeting of olfactory senses in advertising is common in magazines (e.g. perfumes) but perhaps it may not be suitable for the general public in transit applications.

Interactivity

If transit users can interact with the environment that they walk in, it may help to take their minds off the actual walking. This may not be limited to just tactile applications, but there could also be more virtual experiences. Also it is important not to slow commuters down with this enhancement (and commuters probably will not bother to slow down too), so the interactivity experience needs to be in pace with the walking. An interesting application may be touch-screen video walls along the travellator or along the sides of the wall. As commuters walk along the

[25] Gordon, R. (2006, December 6). Aromatic Ads Pulled from City Bus Shelters. *San Francisco Chronicle.* Retrieved from http://www.sfgate.com

video wall, they can view ticker-tape news or select other information along it which follows them as they walk. Or it could be other simpler applications of lights following their footsteps, water parting as their hands move through them – elements of interactive urban design developed by the Massachusetts Institute of Technology.[26] While these feel exciting, such interactivity is probably too "space-age" for transit use and cost-prohibitive. However, its use may be more justifiable under other leisure walking circumstances, as we will discuss in Chapter 4. A less high-tech interactive option may be just static displays which are thought provoking. An example would be something that was observed in Hong Kong's MTR system. Display information along a stairway actually tells commuters how much calories they burned with the number of steps they climbed (see Fig 3.4 below).

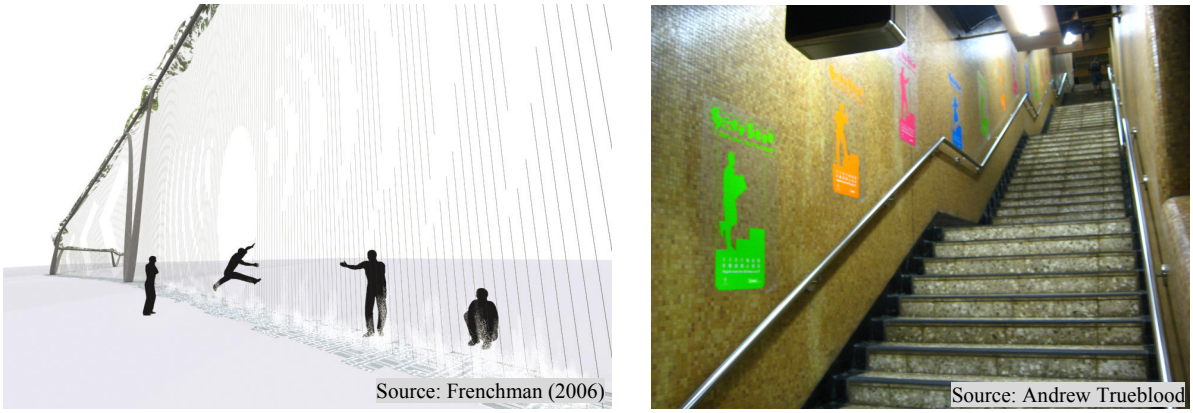

Fig 3.4 (Left) Digital water fountain which parts as users interact with it. (Right) More down-to-earth interactivity at a Hong Kong MTR station.

Greenery and landscaping

It has been established that greenery and landscaping in urban streets gives people the perception that the living environment and quality of life is better. This is on top of their more obvious functional use of shading, cooling and aesthetic enhancements. Greenery also have a natural scent, and there would be fragrance too if flowers are used. Landscaping can also include water features like fountains and others which further enhance the pleasantness of the environment experience. The use of landscaping in indoor environments such as shopping malls, airports, etc. is common, but it has its associated maintenance costs like watering, waterproofing, lighting, etc. Additional widths in the transfer tunnel would also need to be catered for these landscaping features, which add to the implementation costs. Still, the use of landscaping in transfer tunnels offer a genuine visual interest which may provide stress relief for commuters, and it also gives out oxygen and humidity to improve air quality for indoor environments too.

[26] Frenchman, D. and Rojas, F. (2006). Zaragoza's Digital Mile: Place-Making in a New Public Realm. *Places*, 18-2

Fig 3.5 "Green wall" enhances air quality and provide visual interest in indoor environments. Right picture shows the use of landscaping in a transfer tunnel between Hong Kong's Central and Hong Kong MTR stations

Advertisements

Advertisements when done in small panels along the wall offer little to serve as visual interests to commuters. Most commuters may even be oblivious to them. However, for large-scale advertisements that are pervasive and in-your-face, they attract greater attention, and many times, the colors and information that are presented on it can serve as a beneficial distraction for walking commuters. From WEXiS, commuters perception of such large-scale advertisements are very positive (68% of respondents think their use will improve their walking experience). However, such ads need to be done tastefully and not overwhelm the built environment.[27]

Fig 3.6 Colorful advertisements to enhance transfer walkways

[27] Kido, EM. (2006). Railway Landscape Design and Relationship with Form, Function and Aesthetic. *Japan Railway & Transport Review.45*:22-30

Showcases

Just like advertisements, these 3-dimensional showcases will provide more visual impact than a similar-sized advertising panel. The showcases can be used for advertising purposes or to display works of art and other public information. Golany (1996) related the evolution of underground passageways in Japanese cities in his book. What started off as a pedestrian-use only tunnel became advertising walls as show windows were drilled 1m deep into the walls. Gradually display racks were set up beside the show windows and salesmen stood next to them to sell their products. Eventually this evolved into the underground commercial phenomenon that is prevalent in Japanese subway systems.[28]

Renewability

Even if the design of the transfer tunnels can include all the suggestions above, the novelty of the enhancements will have a specific shelf-life since commuters would be seeing them practically every day. We can overcome this if we can inject a certain element of renewability in the enhancement design. Therefore if we were to consider the showcasing of art, it can be periodically updated with new displays, this is currently being done at the walkway leading to the Esplanade – Singapore's premiere arts performance centre. With renewability, there is more scope to incite interest and discussion amongst transit users. For this reason, simple but permanent enhancements like painting bright colors along the wall of a transit may not be an effective tool. In fact users may perceive it negatively over time as they grow tired of the color scheme.

Special note – airport design:

When it comes to walking in transportation, people probably walk the longest in air travel – moving between terminals and gates, and transiting from gate to gate in airports. Most world-class airports take their walkway designs very seriously, espousing many of the principles that I laid out above such as lighting, music, landscaping, advertising, etc. Often you will also find retail along long walking corridors, but this does not really work in transfer tunnels because it demands substantial width and it may also disrupt the flow of commuters. Incidentally 72.5% of respondents in WEXiS think that having retail along transfer walkways can improve their walking experience, but I still would not recommend this.

Two interesting airport walkway designs I would like to point out are the Chicago O'Hare and Detroit Metro airports in the United States. Bright neon lights in "psychedelic" colors light up the walkway, and in the case of Detroit, the lights are dynamic which move with synchronized music. Such concepts are truly interesting instead, but as much as I was impressed, they probably may not work in mass transit transfer tunnels. The lighting generally needs to be dimmed to

[28] Golany, G. S. and Ojima, T. (1996). *Geospace Design*. New York: John Wiley & Sons.

enhance the effects of the psychedelic lighting, and the lighting itself may even trigger adverse medical reactions.

Fig 3.7 Bright and psychedelic walkways in US airports - Left: Detroit Metro airport; Right: Chicago O'Hare airport

Ending note on MRT transfer walking design enhancements

Personally, I do not espouse any particular solution although the landscaping idea comes across as most appealing to me. However, in terms of practicality and cost-effectiveness, the large scale use of advertisements would be the most logical. This is because by its nature, advertisements are refreshed regularly meaning they can provide renewed visual interest. For transit operators, they can also enjoy a greater advertising revenue stream from the use of advertisements. Out of all these proposed enhancements, the next steps would be for the LTA and the transit operators to assess the technical feasibility and then to communicate with the public to obtain their feedback to ascertain the need and type of enhancement measures that are most desired.

Enhance Downtown Walkability

For a commuting trip from home to office, the tail end of the trip from the transit node to the office is a very important factor of consideration too. Typically, based on the density of development and MRT transit stations catchment, the tail end of the commuting trip in terms of distance from transit node to office should be lesser than the first leg from home to the transit node. However, the nature of downtown's one-way pair road systems, congestion, etc. means less convenience for taking a feeder bus to get to your office. The lack of continuous shelter which is more apparent in the downtown area may also result in a less comfortable walk than a residential estate too, especially when it rains. Currently, the Singaporean government is reviewing the bus system to provide better transfer connectivity at this tail end of the commuting trip. As for walking, the general push is to go for increased integration between office developments and transit nodes. Fig 3.8 shows the development of an underground network of pedestrian tunnels in Singapore's new downtown area first introduced in Chapter 1. This

underground network is actually an extension from the Raffles Place MRT underground pedestrian network (see Fig 2.13 in addition). While the government planners are moving in the right direction, they seem to have neglected the existing CBD area, can we do something for the numerous offices and employment that are already there? Also what can we do for other parts of the downtown area that are outside the CBD, where the relatively lower density may not be able to justify the construction of expensive subterranean structures?

Fig 3.8 Underground pedestrian network visualized for new downtown area which will be well integrated with transit nodes. (Source: URA's presentation at the ULI International Waterfront Development Conference 2005, retrieved from http://www.uli.org)

Increased subterranean connectivity between transit and office buildings in the existing CBD

The construction of underground infrastructure is very expensive. Even though the LTA recognizes the desirability of connecting offices to transit nodes directly, their strategy is to adopt a co-sharing strategy with the private developers who will stand to benefit from such a connection. A paper presented by the LTA revealed a case study of the difficulty of such negotiations with private developers at the construction of the Circle Line Esplanade Station,[29] see Fig 3.9 below.

[29] Goh, S. & Mead, A. (2004). Circle Line MRT – Convention Centre Station: Connecting the City Underground. Proceedings of the *3rd Great Asian Streets Symposium.* Singapore: National University of Singapore.

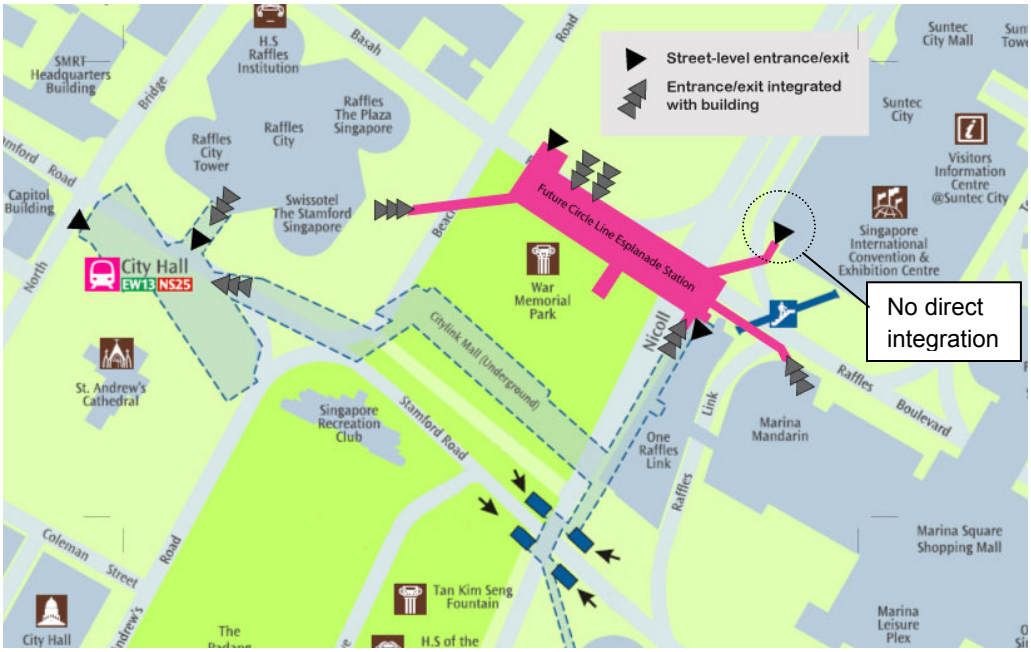

Fig 3.9 The integration of CCL Esplanade Station with surrounding developments (Source: Base from LTA; Annotations based on information from Goh (2004): Author)

For the case of the Esplanade Station, all developers around it have been eager to integrate with the new underground station because of the belief that it will increase their real estate values, which undoubtedly has many research to support that fact. However, one of the developers (Suntec City) did not wish for such integration and despite lengthy negotiations, there was no deal and the final design of the station only has an entrance at the edge of its development and no direct integration. While the LTA designs for the eventual possibility of such a direct connection one day through the use of knockout panels, this case study illustrates the difficulty of negotiating with private developers to achieve a social benefit.

Coming back to the existing CBD area, Fig 2.13 shows the extent of the underground connections from the two major transit nodes to the surrounding buildings. As illustrated previously, the lack of underground connections is compensated with covered "arcades" along the frontage of the buildings but there is a limitation to the continuity of those shelters too. The amount of people ending up at the CBD during the morning peak would perhaps justify the need for the government to do more to provide a more integrated walking experience.

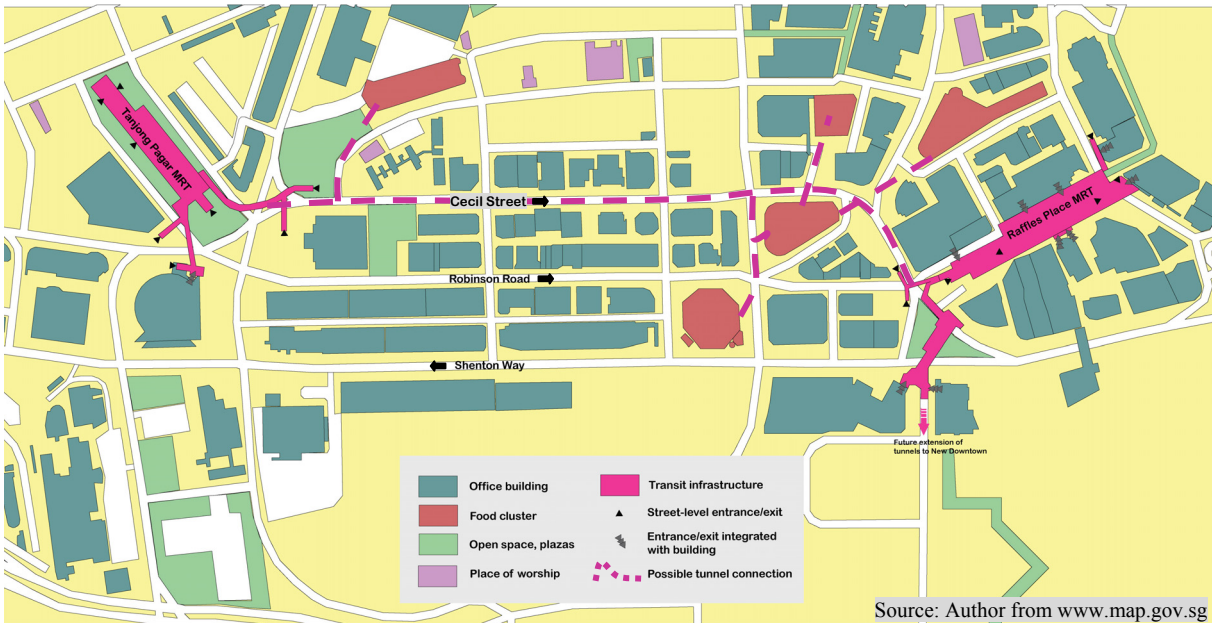

Fig 3.10 Schematic underground tunnel network with building integration in the CBD

The solution to provide a better walking experience is to extend the underground network as shown in Fig 3.10 above. Due to the exising railway tunnels that run along Robinson Road between Raffles Place and Tanjong Pagar MRT stations, it would be difficult to extend the underground pedestrian network along Robinson Road, hence we went by the Cecil Street corridor instead. The additional objective of building an underground pedestrian network like this is to enhance the walkability of the downtown area which we will discuss in the next section – justification for an extended underground network will be much more apparent then.

Due to the costs of building such a major subterranean project, this is not an effort that the LTA can undertake alone. While the LTA can be the developer of such an underground network, it will require the support of other agencies like the URA or the Ministry of Finance. Currently, the URA have guidelines and even cash subsidies which encourage developers to build more underground links[30], but the initiatives are not being taken up in a big way at all. There is a need for greater "carrots" to entice private developers to co-share this project, such as tax breaks or density bonuses for redevelopment. Ultimately, with enhanced land value through integration with the transit network, the government will likely recoup its initial monetary investment through higher property taxes from increased land values for properties which integrate with the new underground system. The building of such a long underground network is a perfect opportunity to introduce retail along it which is another revenue generator to offset the investment costs too. In fact, if the sums work out right, the private sector may even be keen to

[30] URA. Urban Design for Downtown Core. Retrieved from http://www.ura.gov.sg/cudd/ud_handbook/ud_handbook_Downtown.html

develop this underground pedestrian network in lieu of the government. Many examples around the world such as the underground system in Japan and Toronto integrate directly with their transit system and they have been huge commercial successes, raising land values and enhancing convenience for commuters. In Singapore, there are only instances of this in Raffles Place MRT station within the CBD and Citylink Mall in the vicinity of City Hall MRT station, which is the first underground retail mall in Singapore (see Fig 3.9 and 3.11).

Fig 3.11 Underground retail malls extending from transit stations. Left: Citylink extending from Singapore's City Hall MRT station; Right: One of the many underground links with retail at Shinjuku Station, Japan's busiest station

Enhancing walkability for intra-downtown trips

After the daily commute to work, there is a huge concentration of pedestrians in the CBD during office hours - this human traffic would be out and about for the entire working period which peaks during lunchtime. Due to the agglomeration of businesses and density of mixed-use services/retail, coupled with the disincentives to drive, short dispersed trips in the CBD can only be fulfilled by walking. Downtown origin-destination surveys show that in most cities, 90% of intra-CBD trips are made on foot.[31] Surely this underlies the importance of having downtown walkability?

Earlier in Chapter 2, we have established that the problem with downtown walkability is mainly Singapore's tropical weather, and to a certain extent as well, traffic priority over pedestrian accessibility. Most block lengths in the CBD are of reasonable walking distances - having mid-block crossings may still help, but from anecdotal evidence, people already jaywalk today at mid-block locations since the traffic during off-peak hours is not that heavy. However, there will still be significant benefits of reducing noise and air pollution if we can better segregate car and

[31] Fruin, J. J. (1971). *Pedestrian Planning and Design*. New York: Metropolitan Association of Urban Designers and Environmental Planners, Inc.

pedestrians.[32] The issue that is more critically in need of addressing is the weather which stifles downtown walkability in Singapore.

Most current literature that I have researched recommend that the solution to enhance pedestrian walking in the CBD is to pedestrianize the busy streets. Indeed, if we look at the images of many big cities' pedestrianization efforts, their popularity with pedestrians is very dramatic. Such is the intensity of the pedestrian concentration in the downtown area which easily justifies the pedestrianization schemes. While most pedestrianization schemes are for shopping streets, the business office district can also benefit from pedestrianization due to the high volume of people who makes short trips.[33] It is important to note that with enhanced walkability like these pedestrianization initiatives, additional pedestrian traffic will be induced, and this is an important consideration when assessing the cost benefit analysis of pedestrianization schemes viz a viz the negativities on vehicular traffic. However, enhancement initiatives like pedestrianization in the typical context of Western cities do not address the basic fundamental issue of the hot and humid weather in Singapore which makes walking unbearable, especially for CBD pedestrians dressed in office-wear. During rainy days which are often in Singapore, the need for enhanced walkability further increases – we need something more than just traditional pedestrianization.

Fig 3.12 Same popular examples of pedestrianization, Ströget, Copenhagen (left) and Ginza, Tokyo (right)

Suggestion 1 – Underground Pedestrian Network

Several cities face severe weather considerations too, such as Toronto, Montreal, Minneapolis, Calgary, Tokyo, etc, and instead of pedestrianization, they proliferated the use of underground pedestrian networks or skywalks for the case of Minneapolis and Calgary. For most of these cities, it is perhaps more of their harsh winters that provided the impetus to create these enclosed

[32] Richards, B. (1974). Approaches and Techniques. In Organisation for Economic Co-operation and Development (Ed.) *Streets for People.* pp 7-27. Paris, France: OECD.
[33] Thompson, J. M. (1974). Strategies and Policies. In Organisation for Economic Co-operation and Development (Ed.) *Streets for People.* pp 29-39. Paris, France: OECD.

networks, and in turn these networks can double up as cooling relief during summers too. Regardless of their underlying objectives, the aim of accommodating the pedestrian in all-weather comfort is the same for all these cities. In Japan, commuters' top satisfaction with the underground network is the rain protection that it provides,[34] and this is not unlike what we would like to achieve for Singapore too.

Fig 3.13 Skywalks in Minneapolis (left) and Calgary (right)

As a natural extension of the idea to provide better integration of transit nodes with office developments in the CBD, we can leverage on the same underground network to improve downtown walkability. This is the main reason why I do not think a skywalk network would be that suitable in Singapore's context. Besides the missed opportunity to integrate with transit, the skywalks will also most likely mar the streetscape of the CBD area which is the usual case for skywalk systems in North America with a few exceptions.[35,36] However, given our earlier considerations that such underground networks are expensive to construct, just how much more justifiable would the element of enhancing downtown walkability make the case for such a huge investment? For this, I point to the case study of Houston.

[34] Golany (1996)
[35] Robertson, K. A. (1994). *Pedestrian Malls and Skywalks*. Vermont, USA: Avebury.
[36] Bednar, M. J. (1989). *Interior Pedestrian Places.* New York: Whitney Library of Design.

Case Study: Houston, Texas Pedestrian Tunnel Network [37,38,39]

Despite a lack of an underground subway system (or any mass transit system at all until the completion of a new surface LRT line recently), Houston has developed the most extensive underground pedestrian network in North America. Another interesting fact about Houston is that the bulk of the network was developed without any coordinated planning effort by the city government. Houston's network was first inspired by Rockefeller Center in New York City's Manhattan, but Rockefeller Center had reasons to go underground which was to better integrate with the subway system. While Houston may not have a subway system, they do have hot and humid weather during some periods of the year and the fourth largest city in United States is known for its reliance on air-conditioning (not unlike Singapore).

It is arguably the land ownership and planning policies of the city that first sparked the creation of tunnel network. Houston's developments own land to the center of the road, hence private developers have much say as to where they want to build underground links. The first tunnel was built by an oil tycoon between two of his buildings in the 1930s during the Great Depression, and he was inspired by Rockefeller Center. Soon after, other private developers follow suit, and what resulted is a labyrinth of underground tunnels which are mostly privately owned. The tunnels became a tool for increasing property value, particularly in the oil bust of the 1980s, and that concept has remained till today. It is extremely difficult for an office building not connected to the tunnel network to be considered a Class A office building which commands close to 20% more rental than a Class B one. This property value enhancement is what thrived Houston's underground pedestrian network despite the high costs of construction – typically 3 times higher than skyways. Today, the network tunnel is 11km long and it connects 77 buildings with more than 100 eateries plus a host of other service providers within. See Appendix 3 for Houston's underground pedestrian network.

Despite the success of Houston's underground network and it being a place of interest (tours are conducted there), the underground network has its drawbacks. First of all, navigation is extremely tedious, and even the 'tunnel lady' tour guide who has years of experience can get lost in it. Secondly, the private ownership of the tunnels means that public access is limited to the building owners' whim and fancy – usually during office hours only, i.e. no access at nights and weekends. Some parts of the network, like those belonging to the former Enron buildings, but now leased by Chevron, are totally closed off to the public. Lastly, the tunnels dilute street life which is a major factor of concern. However, even with these shortcomings, the tunnels are very well-used and liked by Houstonians, and some even walk the corridors for exercise.

[37] Ibid
[38] Brown, M. (2007, September 20). Houstonians Go Underground to Escape Summer Heat. *Voice of America News.* Retrieved from http://www.voanews.com
[39] Blumenthal, R. (2007, August 21). It's Lonesome in this Old Town, Until You Go Underground. *The New York Times.* Retrieved from http://www.nytimes.com

Naturally, the Houston underground network is a huge enhancement to the walkability of downtown since pedestrians can now walk freely regardless of weather. The rationale of citing the Houston case study is to show the immense potential that CBD pedestrian traffic can have to be able to justify an extensive underground pedestrian network through real estate enhancement. This is apparent in Houston and it is attained even without considering any benefits that integration with transit might have. For Singapore's case, the dual objective of integrating transit and enhancing downtown walkability should reap even greater benefits. The earlier proposal to better integrate transit with CBD buildings in Fig 3.10 above can be expanded to make it a network for intra-CBD connectivity too.

Solution 2: Enhanced Pedestrianization Scheme

As impressed as I was with the potential of underground pedestrian tunnels in Singapore's context, I am also concerned with its associated disbenefits too. First of all, wayfinding in these tunnels are usually difficult, as in the experience of Houston,[40] but this can probably be mitigated with good design, clear signage, etc. The lack of sunlight was found to be the biggest dissatisfaction that pedestrians in Japan have with underground walkways,[41] but again this can be mitigated with daylighting design.

To me, the most dissuading factor of having an underground pedestrian network would be the loss of street-life when everybody is contented to stay underground. Houston's street life is virtually non-existent in the areas above the underground network.[42] This is generally true for other grade separation pedestrian networks like the skyway systems. In cities like Minneapolis, the popularity of skywalks removed substantial pedestrian traffic from the streets and real estate prices on the street-level have plummeted, perpetuating the street-level abandonment. Only Calgary seemed to have balanced the vitality of retaining street life through its efforts of encouraging street activity and its seamless vertical integration between the streets and the skywalks, etc.,[43] but even then a former Calgary planning commissioner, James McKellar remarked, "the skywalk system kills and sterilizes ground-level activity".[44] Notable urban designer Jan Gehl stated that "he knows of no city in the world (outside of ultra-crowded Japan) that succeeds on two levels" and he denounced the skywalk system in Minneapolis.[45] The importance of retaining street life will be covered in Chapter 4, but as an alternative proposal to

[40] Ibid
[41] Golany (1996)
[42] Brown (2007)
[43] Robertson (1994)
[44] Andersen, K. (1988, August 1). Fast Life Along the Skywalks. *Time.* Retrieved from http://www.time.com.
[45] Berg, S. (2007, November 15). Urban Designers Critique Minneapolis and offer this idea: Tear down all those horrible skyways. *Minnpost*. Retrieved from http://www.minnpost.com/stories/2007/11/15/103/urban_designers_minneapolis_should_d

the underground pedestrian network scheme, perhaps we can do an enhanced modified version of the traditional pedestrianization concept.

Essentially this scheme is similar to other pedestrianization schemes around the world, but we do more to ameliorate the climatic considerations that Singapore has. Like other pedestrianized schemes, there first needs to be careful traffic impact assessment and effective communication to the public and stakeholders. For most cases around the world, such as the well-publicized one in Ströget, Copenhagen, Denmark, often the initial worries about traffic and reduced retail performance are unfounded,[46] but I would not generalize the case for Singapore. Without going into the technical feasibility of the pedestrianization, we shall approach the idea purely from the design standpoint. Our aim is to allow pedestrians to walk freely on the streets of the CBD, with shelter above to block the rain, and some form of cooling underneath to offset the heat. This idea is partly inspired by the concept of Clarke Quay, a popular food and entertainment area in Singapore.

Case Study: Clarke Quay, Singapore [47,48]

Clarke Quay is a 30ha area along the Singapore River which is conserved for its historic significance. In conjunction with the Singapore River cleanup from 1977 to 1987, Clarke Quay was restored and redeveloped as a mixed-use residential, commercial and entertainment precinct. The Clarke Quay Festival Village was opened in 1993, but it was an unsuccessful conventional gentrification of the heritage site. In 2002, the developer saw a new opportunity to increase the potential of Clarke Quay with a better tenant mix (and perhaps to coincide with the opening of an MRT station nearby), and they invested S$88m to revamp Clarke Quay. An English architectural firm, SMC Alsop was appointed to rejuvenate Clarke Quay, and their brief was to develop an attractive redesign of the streetscape and also to address the perennial climate problem – temperature and rainfall.

In my opinion, the breakthrough in their design was the creation of full weather-protected zones along the streets of Clarke Quay. They did this through giant futuristic umbrella structures which allow sunlight to pass through but absorb heat from it. While it is debatable how artistic-looking or out-of-place these giant umbrellas are, once you are underneath them, the pleasant walking experience is undeniable, and the presence of retail, fountains, food outlets and nightspots all contribute towards a fantastic human-scale atmosphere, something that I would not imagine as possible in Singapore in an open-air environment. The interior of the umbrellas are also

[46] Richards (1974)
[47] Development Bank of Japan (2000). *The Success of Singapore's Waterfront Revitalization*. Retrieved from http://www.dbj.go.jp/singapore/english/file/publishing/s_3_e.htm
[48] Additional web references retrieved 1 April 2008
from http://www.smcalsop.com/, http://www.arcspace.com/architects/alsop/cq/cq.html and http://en.wikipedia.org/wiki/Clarke_Quay

artificially cooled by giant "whale-tail" mechanical fans, and these play an important role in making the walking experience in Clarke Quay a cooling and non-humid one.

From WEXiS, more than 90% of respondents who have been to Clarke Quay before and after the revamp agreed that the new Clarke Quay is more successful than the original one. Close to 70% of them attributed this success to the "climate-controlled" environment that is underneath those giant umbrella shelters.

Fig 3.14 Clarke Quay before and after the revamp.

Fig 3.15 Clarke Quay with its giant umbrellas, inviting interior and whale-tail fans (Source: SMC Alsop)

The key to achieving a similar pedestrianization in the CBD is to first of all, provide shelter from both the sun and the rain. The heat however would require more intervention than just a roof, and due to operating cost considerations, we may be restricted to just mechanical fans like the Clarke Quay ones. The use of solar energy should be explored to power the fans and lighting within the covered pedestrian mall to be more environmentally sustainable. Currently some retail stores already line the sides of the CBD arterials. With pedestrianization and given that the roads can be up to 5-lanes wide, we would also need to introduce more human scale interventions along it, like food/retail kiosks, cafes, landscaping, performers, etc.

Fig 3.16 The future of Robinson Road (left) can potentially be a cross between Clarke Quay (top right) and Las Ramblas, Barcelona (bottom right)

The main objective of suggesting this pedestrianization scheme is to retain a vibrant street-life during the day while enhancing the walkability of the CBD. Indirectly, the advantage of this scheme is also that it is a much more easily implementable scheme as opposed to the high costs of constructing an underground pedestrian network, granted of course we address the associated costs of pedestrianization like traffic impact, higher maintenance, etc. Other advantages of the pedestrianization are that it can be 24-hour accessible unlike the underground pedestrian network

which would have regular closing hours. There could be problems of crime and undesirable loitering on the pedestrianized streets, but given Singapore's low crime rates, and if the scheme is successful enough to attract street life, this is a non-issue.

American cities in the 1970s use a host of measures like pedestrianization, skywalks, and pedestrian tunnels to revitalize the downtown. Today, cities value a more vibrant urban street life which arguably, amongst the 3 measures, is only achievable by pedestrianization.[49] The Singapore CBD which is "dead after dusk" can definitely be injected with a new lease of life; therefore pedestrianization could be leveraged to extend the vibrancy during office hours till other times of the nights and weekends. Currently, this CBD part of Singapore's downtown is desolate after the exodus of the office crowd. The uniqueness and potential vitality of pedestrianization in the heart of the CBD would serve as a big draw to attract street life to the area at night. URA has identified increased city residential use as one of their strategies in Singapore's long range planning – Concept Plan 2001,[50] and if we look at Fig 3.17, many new residential developments are already being constructed within and around the core of the existing CBD which is defined by the area between the two MRT stations. The creation of a vibrant street for day and night use will increase the livability of the area and attract greater residential use to be mixed with commercial functions. At present, there is a very small-scale pedestrianization scheme along Boon Tat Street which is an extension of the Lau Pa Sat Food Centre next to the street (refer to Fig 3.23). At night, the street is pedestrianized and seating is set up for people to get good street food. Other pedestrianizations are show as green dashes below and these are permanent road closures, but rather distant from the core CBD area.

Fig 3.17 Upcoming high-rise residential developments and pedestrianization in the CBD area

[49] Berg (2007)
[50] URA, *Concept Plan 2001*, retrieved from http://www.ura.gov.sg/student/creative_land_use.htm

Possible implementation plan

Without going too much into the technical details, I outline a possible implementation plan to achieve the part pedestrianization of the CBD. Robinson Road is the most ideal corridor because it runs right along the center of the core of the CBD.

First, traffic studies would need to be done to determine the capacity of the road system – it appears that the redundancy of Cecil Street can allow Robinson Road to be freed up for the pedestrianization. In terms of delivery access, currently the service vehicles are using minor roads parallel to Robinson Road so there should be minimum service access worries too.

It may be good to start things small by staging the implementation, with the first phase of pedestrianization possibly just a street block length or temporarily closed during off-peak hours only, but we should be mindful of the negative impact that such small scale implementation may have to the eventual long term benefits. First of all, it is important to note that unless a permanent change comes about, many of the advantages of pedestrianization will not materialize since there is no certainty of the initiative to catalyze any significant change.[51] Also if the pedestrianization is temporary, limited infrastructure can be constructed to effect any significant enhancement. E.g. without any shelter or cooling, people would not use the streets even with pedestrianization and the scheme will fall flat on its face. Also Robinson Road is a wide 5 lane road, hence there needs to be more human scale intervention along its pedestrianization to make it inviting to users, e.g. food kiosks, performers, café tables and seats, etc. Without permanence, such enhancements cannot take place on a large basis and a wide but bare Robinson Road would not be attractive to draw pedestrians to use it.

With these in mind, next, government planners would need to think through the entire plan with enough certainty to render it in drawings and impressions. This is naturally done in conjunction with building developers that are along Robinson Rd. Next, a mock up of the pedestrianization is set up in order to gauge public response. A block length of Robinson Road can be closed for 2 weeks or so, and an outdoor canopy is then set up which provides shelter and cooling underneath it. The canopy design should allow adequate day-lighting to simulate the potential actual design of the pedestrianization. During the street closure, exhibition of the pedestrianization schemes can be displayed within the sheltered area, and feedback is solicited from the CBD pedestrians. Cafes, retail kiosks would line the sides of the covered areas just like how it might feel with full-scale pedestrianization.

Ending Note on Enhancing Downtown Walkability

In this chapter, we discussed and analyzed four possible areas of walking in the Singaporean context to improve on. While we approach them based on findings from the WEXiS survey, extensive literature review and anecdotal evidence, more work will need to be done to further

[51] Richards (1974)

establish their need and effectiveness to enhance the walking experience in the downtown area. Walkability surveys can be conducted on a larger scale which can also incorporate visual preference surveys of the proposed enhancements using similar renderings shown above. Selective enhancements can also be tested out in a smaller scale to test out their feasibility where it is cost-effective to do so.

It is important to note that while we recommend measures to enhance the experience of walking as a means of travelling, we should be mindful of the implications that it may have to affect walking as a form of leisure. When I suggested the enhancement of underground tunnels, I was alluding to this possibility because of the street-life that it may take out. We will discuss this briefly in the next chapter.

Chapter 4 Note on Non-Work-Related Walkability Issues

As much as I was keen to deal with all aspects of walkability in Singapore, the extensive scope of walking in work-related trips in the previous two chapters made it impossible to fully cover them all. However I will briefly discuss two rather important issues in this chapter for completeness and to also set the stage for possible follow-up research. The two issues are walkability in residential estates and the consideration of walking as a form of leisure.

Issues of Walkability within Residential Estates

While Singapore's focus on economic success has motivated the planning and facilitation of an efficient commuting system to bring people to their work, how would the walkability within residential neighborhoods fare against such a framework?

In Fig 4.1 below, we have street network density diagrams of a neighborhood in Pasir Ris – the Singapore residential estate we have seen earlier in Chapter 2 (Fig 2.6), and a same scale comparison of Cambridgeport – a neighborhood in Cambridge, Massachusetts. Based on the figure/ground comparison, it is easy to say that pedestrian accessibility is better in Cambridgeport, because smaller street blocks allow pedestrians to walk shorter distances around blocks relative to "as the crow flies" distance. However, the nature of public housing in Singapore is that they are high-rise buildings, and the ground floor is designated as public space with pathways well-connected to the street sidewalks, therefore the Pasir Ris "superblock" is actually more porous once we overlay these additional permeable layers.

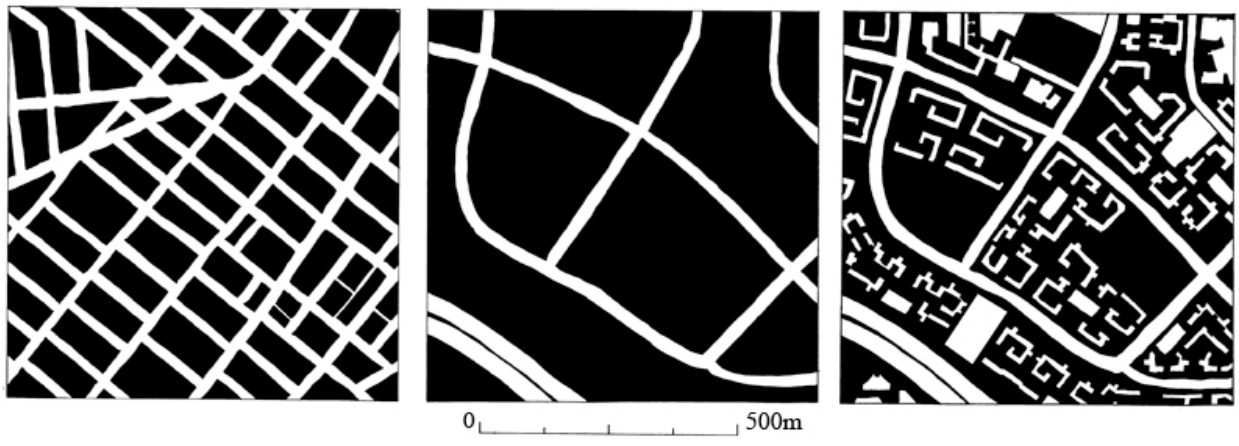

Fig 4.1 Street density of Cambridgeport (left) compared with a Pasir Ris neighborhood of the same scale and with additional permeability from the public housing buildings (Source: Author)

The nature of public housing design in Singapore is one which is high-density with complementary commercial use. A typical centre like the one that is serving the Pasir Ris neighborhood above (shown in Fig 4.2 below) has food courts, banks, dentists, clinics, post office, hair dressers, etc. On the scale of the entire Pasir Ris estate (Fig 4.3), we can see that the retail concentration is evenly distributed on the map, and their 400m/800m catchment radii[1] are overlapping and serving the entire estate.

Fig 4.2 Neighborhood centre in Pasir Ris, typical of Singapore's public housing estate (Source: Author)

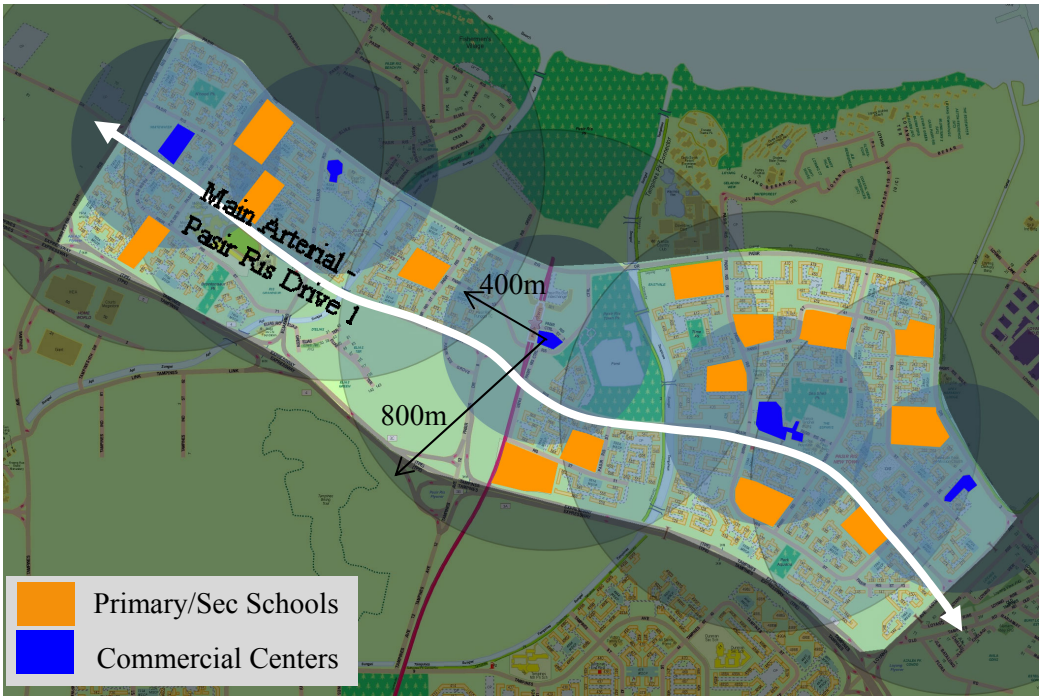

Fig 4.3 Distribution of commercial centers and schools around Pasir Ris (Source: Map – SLA; Markups: Author)

[1] Common guideline of a comfortable walking distance is typically ½ a mile or 800m or a 10-20min walk - (Southworth, 2006; Oslzewski et al, 2005). Though considering that Singapore's weather can be overbearing, we additionally check the catchment of the commercial centers with a 400m (or 5min) radius.

Schools are also a very important part of a residential neighborhood. If we look at how students go to school in Fig 4.4 below, we can see a large proportion of pre-primary and primary school children walk to school. These two groups of students make up almost half of the entire school-going population in Singapore.[2] This large inclination towards walking is not unexpected because the target student mix of such schools is from the neighborhood, i.e. within walking distance. There is a generally a good distribution of schools around residential estates, like Pasir Ris shown in Fig 4.3 above.

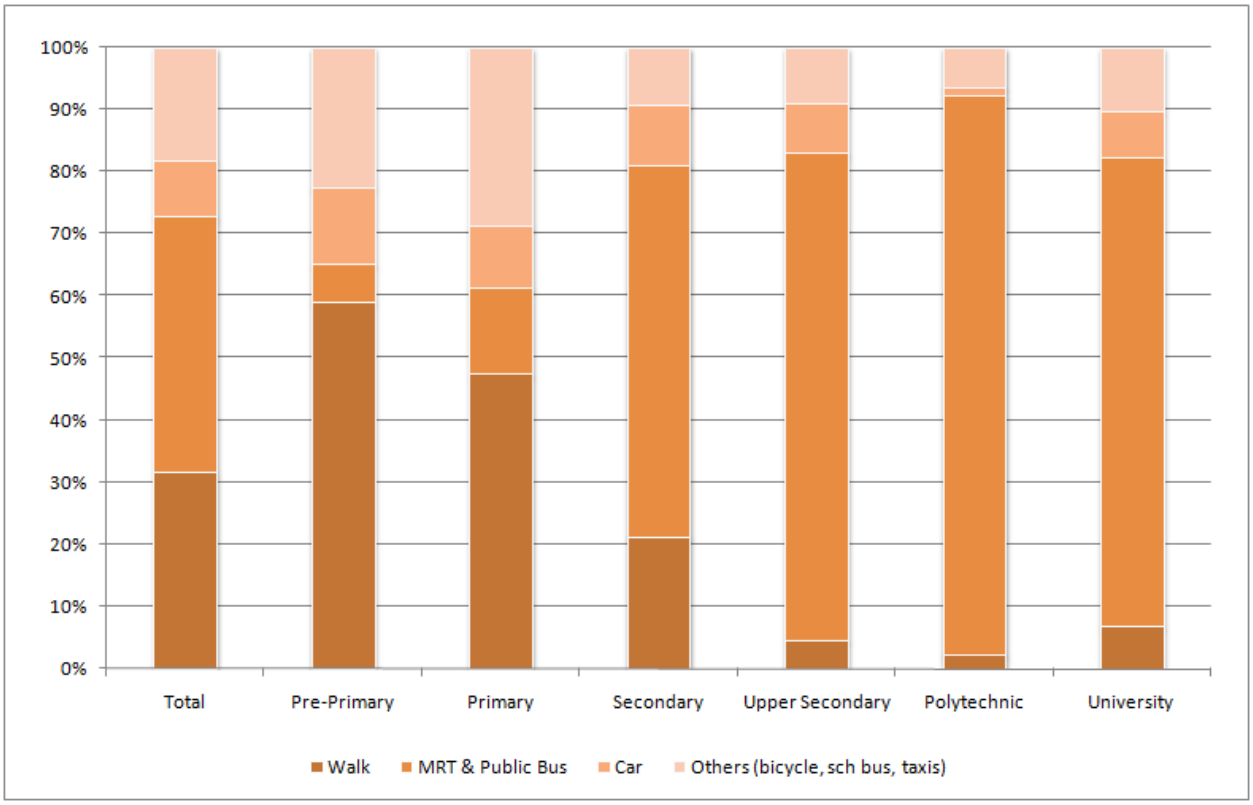

Fig 4.4 Main transportation modes that students use to get to school [Derived from Singstat (2005)]

Traffic priority versus residential walkability

Generally, all factors point towards the fact that Pasir Ris and most estates like it in Singapore are rather walkable for school trips and non-work trips to the supermarket, banks, post office, etc. However, the emphasis of an efficient transportation system may have a conflict with intra-neighborhood walkability. Take for example the neighborhood in Pasir Ris which we have been citing so far. We mentioned earlier that the Pasir Ris "superblock" is actually very porous, but that is only assuming that we can do mid-block crossings, and for this example we cannot do so easily. An arterial road, Pasir Ris Drive 1 (see Fig 4.3 and 4.5), runs along the entire length of the

[2] Singstat (2005)

estate and divides it. At the section of Pasir Ris Drive 1 in Fig 4.5, midblock at-grade crossings are not allowed and pedestrians have to cross via pedestrian overhead bridges (POBs). This is a result of segregating pedestrians from motorized traffic, with priority given to cars which inconveniences pedestrians as a result. The street-blocks widths range from 260m to 360m, this means a resident who stays in the middle of a street-block but does not wish or cannot use the POB will have to detour that same amount of distance just to get to the opposite side of a 25m wide road, more than 10 times worse-off.

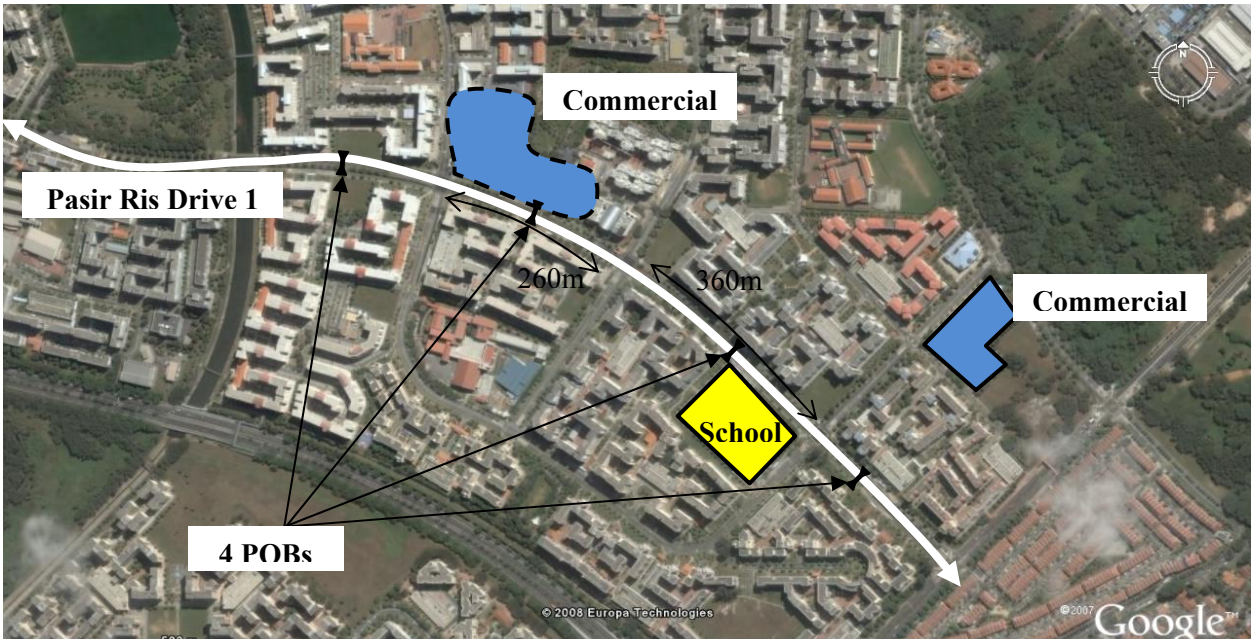

Fig 4.5 Four POBs along part of Pasir Ris Drive 1 (Source: Base map - Google Earth; Annotations/markups: Author)

Fig 4.6 Traffic priority over pedestrian walkability as seen in the photos above (Source: Author)

It is arguable how much traffic priority we should accord to cars in residential districts. Of course given the much high density of Singapore's townships, transportation efficiency is no doubt a big consideration too. Some pedestrian segregation is also justifiable for pedestrian safety too, such as the POB connecting to the school in Fig 4.5 above. It ensures primary school children can cross the road in a safer manner. However, for the residential street block that is just opposite the commercial center edged with dotted lines, given the likely high pedestrian traffic between the two, is there room to consider better pedestrian priority? Imagine a homemaker who has to buy groceries from the supermarket with her grocery cart from the other side of the POB, he/she has to climb the POB twice in the space of 1-2hrs, with the load of the grocery cart too.

Another issue that is associated with POBs is that they are usually not barrier-free. For the mobility-impaired or parents pushing strollers, they will have huge difficulties using these POBs or they would just give up totally and make a detour. A mother lamented to me after she completed the WEXiS survey, "Singapore is too pram-unfriendly in many places!", and I would have to agree with her. She is a car-user, and even without the experience (frustration) of the public transit system, she finds walking with her baby a huge chore, so much so that she drives to most places now even though they are within walking distance.

Not many cities can claim to be fully accessible, but many of them are also centuries old, and it takes time to gradually evolve and replace infrastructure with accessible ones. However, Singapore is still growing, and she should definitely set the record straight now and implement accessible measures where necessary. The government acknowledges the need for universal accessibility too.[3] The inaccessibility of POBs is noted, and the LTA is looking into providing more at-grade crossings but traffic considerations will need to be balanced.

Singapore's main transportation planning impetus may be getting people to work efficiently, and it is justifiable because of the economic benefits of time savings. However when the peak periods are over, the permanent road infrastructure that favors traffic flow usually pose as a disincentive to walkability within a residential estate despite the overarching land use policy that encourages a compact and walkable one. Certain roads may be continually busy during the day, but the question is outside commuting hours, how important are motorists' time viz a viz the priority to be accorded to residential pedestrians? Can traffic demand also be high twenty four hours constantly? It does seem kind of foolish and unfair to demand pedestrians to climb a POB late in the night when there are very few cars on the road.

[3] Lim, H. H. (2008, March 6). Speech on Land Transport (Part 3) at the Committee of Supply Debate. Transcript retrieved 25 March 2008 from http://www.mot.gov.sg

The most amicable solution would be to reroute all major traffic out of areas with high pedestrian movements, but in land-scarce Singapore, that may not be the easiest solution. Ultimately, transportation planners have to balance the priority of traffic versus pedestrians. (Fruin, 1971) gave the interesting analogy about how it is a source of frustration and humiliation to the pedestrian who is forced to wait in the rain (and hot sun in Singapore's context) while the car-driver in his air-condition compartment enjoys traffic priority; the pedestrian also gets honked or splashed with rainwater runoff if he does not react quickly.

Fig 4.7 Lack of pedestrian priority is sorely felt during rainy days

Studies in the US show a positive correlation between traffic domination in residential neighborhoods with the stress and social characteristics that the neighborhood endures.[4] Naturally the typical US residential area is distinctly dissimilar to that of a Singapore Housing & Development Board (HDB) housing, which designs of road setbacks have at least tried to keep traffic at bay from residential living. However, the issue of inconveniencing pedestrians is still unresolved and the problem is compounded by the fact that the demographics which remain in a residential neighborhood during off-peak hours constitute retirees, children, home-makers, etc. Their main mode of transportation is likely walking and they are usually not that mobile too. Even if they have the means to drive a personal car, should we even be encouraging them to drive when they can walk?

While Cervero (2001) and Wibowo (2005) asserted that walking is the most natural and important mode to access transit, Cervero (1995 and 1997) also revealed that walkability affects non-walk trips more than commuting trips, i.e. poor walkability for non-work trips will result in people changing modes, destinations or forfeit the trip totally. For commuting trips, poor walkability affects the access mode for commuters to get to their main transit mode (i.e. use other alternatives like cycle, feeder bus, kiss and ride, etc.), but the main mode itself is less elastic to the walkability characteristic[5,6] This means that the pedestrian design within residential estates matter more for intra-neighborhood non-work trips than commuting trips. Many work trips may start off with a feeder bus journey at the residential end, and this can be an argument for traffic priority during peak hours, but not during off peak.

Besides inconveniencing pedestrians, giving motorists too much priority in residential estates can also be potentially dangerous. Motorists who are used to speeding along arterial roads in housing

[4] Fruin (1971)
[5] Cervero, R. and Radisch, C. (1995). *Travel Choices in Pedestrian Versus Automobile Oriented Neighborhoods Working Paper*. California: University of California Transportation Center
[6] Cervero, R. and Kockelman, K. (1997). Travel Demand and The 3Ds: Density, Diversity, and Design. *Transportation Research Part D. 2*(3):199-219.

estates may pose a risk to pedestrians on foot when they turn into the smaller collector roads. This is despite extensive traffic calming measures like raised crossings, colored pavement texture, warning signals, etc. (see Fig 4.8 below). While traffic accidents in Singapore is reasonably low - the fatality rate is 4.68 per 100,000 population in 2007[7] compared to the 14.24 per 100,000 population in the US in 2006,[8] the occurrences of traffic accidents involving school children in residential areas, no matter how low, is still a cause of concern.

Fig 4.8 Typical traffic calming measures in the residential estates. Left- red texture pavement in school zones; right- raised pedestrian crossings (Source: LTA)

Traffic priority in residential areas has been enhanced around the world as early as the 1960s.[9] In the US, extensive traffic calming has been the feature of neighborhood design in recent years. The Dutch have their *Woonerven*, Swedes have their "Vision Zero" and the Germans also have their *Verkehrsberuhigung*. All these practices are just different ways of traffic calming where pedestrians are active, particularly in residential areas. Motorists are expected to slow to a speed safe enough where pedestrians will not be severely injured in the event of an accident. That allowable speed ranges from 5km/h to 30km/h. Different ways to achieve this traffic calming effect include physical methods like speed bumps, or the psychological means of the shared street concept of the *Woonerven* (see Fig 4.9 below) or utilizing street-side parking to slow traffic down. Regardless of the differences in method and means, their main objectives are all the same – to accord priority to pedestrians where they rightfully belong. Singapore's traffic calming is primarily of the physical methods type, but because of the presence of arterial roads running through residential estates where vehicles travel at 50km/h (higher if motorists disobey the posted speed limit); the calmed local collectors may have limited effectiveness.

[7] Singapore Police Force (2007). *Road Accident Situation 2007.* Retrieved 25 March 2008 from http://www.spf.gov.sg/stats/traf2007_overview.htm
[8] USDOT Fatality Analysis Reporting System (2006), *FARS Encyclopedia.* Retrieved 25 March 2008 from http://www-fars.nhtsa.dot.gov/Main/index.aspx
[9] Richards (1974)

Fig 4.9 Shared streets where the pavement is flush with the sidewalk and with special paving material give motorists the perception that they do not own the streets, but it is shared with the pedestrian realm.

Walkability in Private Residential Estates

Aside from public housing estates, I will take this opportunity to include a short note on the walkability issues in private residential estates. While it is true that private residents are a minority in Singapore, but from anecdotal evidence and the WEXiS survey, it is noted that streets in landed property are very pedestrian-unfriendly. First of all, land use is almost strictly residential and relatively low-density which pretty much limits residents to travel a long distance if they need to get anything done. The sidewalks are narrow with occasional tree roots cracking up the sidewalk or with some other obstructions along them like potted plants, trash bins, etc.

Most private landed property estates are also highly inaccessible to any form of transit because they can be very far from the major roads where buses ply, making it practically impossible to have access to public transit on foot. Fair enough, landed properties are out of the economic reach of most Singaporeans unless one is a high income earner, but does this mean that we should assume the residents within such an estate will always drive, and not cater to their walkability or transit needs at all? Such thinking becomes a self-fulfilling prophecy as people who want to upgrade to better housing have no choice but to buy a car even though they prefer to walk or take transit. The design of private residential estates can definitely be better planned to encourage walkability. However, to improve on the existing estates may be more challenging as the streets are already very narrow, and with expensive private residential land at stake, there is a limit to what government planners can do.

Fig 4.10 The street conditions along certain private estates can restrict walkability

Fig 4.11 Map of a private residential estate in Bukit Timah, Singapore. This diagram shows how far private estate residents have to walk in order to get to their nearest transit stop along Dunearn Road. The measures indicate straight-line distances from Dunearn Road, but in reality, residents have to walk much more due to the street layout and exact bus-stop location (Source: Google Earth; Annotations: Author)

Walking as a Form of Leisure

For the last section of this chapter, we will put forth the issues of walking as a form of leisure. Earlier in Chapter 1, we have explained that walking as a form of leisure is different from walking as a means of travelling. Walking for leisure has many different forms, ranging from a stroll in a park, to walking down the waterfront, to window-shopping within an indoor shopping mall. Regardless of the type, walking for leisure distinguishes itself from walking as a means of travelling in that people are not in a hurry for time and they value enjoyment of aesthetics, comfort and experience more than the need for accessibility (enjoyment displaces third tier of walking needs). The perception of enjoyment varies between individuals, which is why they derive different experiences out of the same leisure walking activity.

From the WEXiS survey, respondents were asked to choose what form of leisure environment they prefer most, and also what they seek most from these leisure destinations, and the results are shown in Fig 4.12 below.

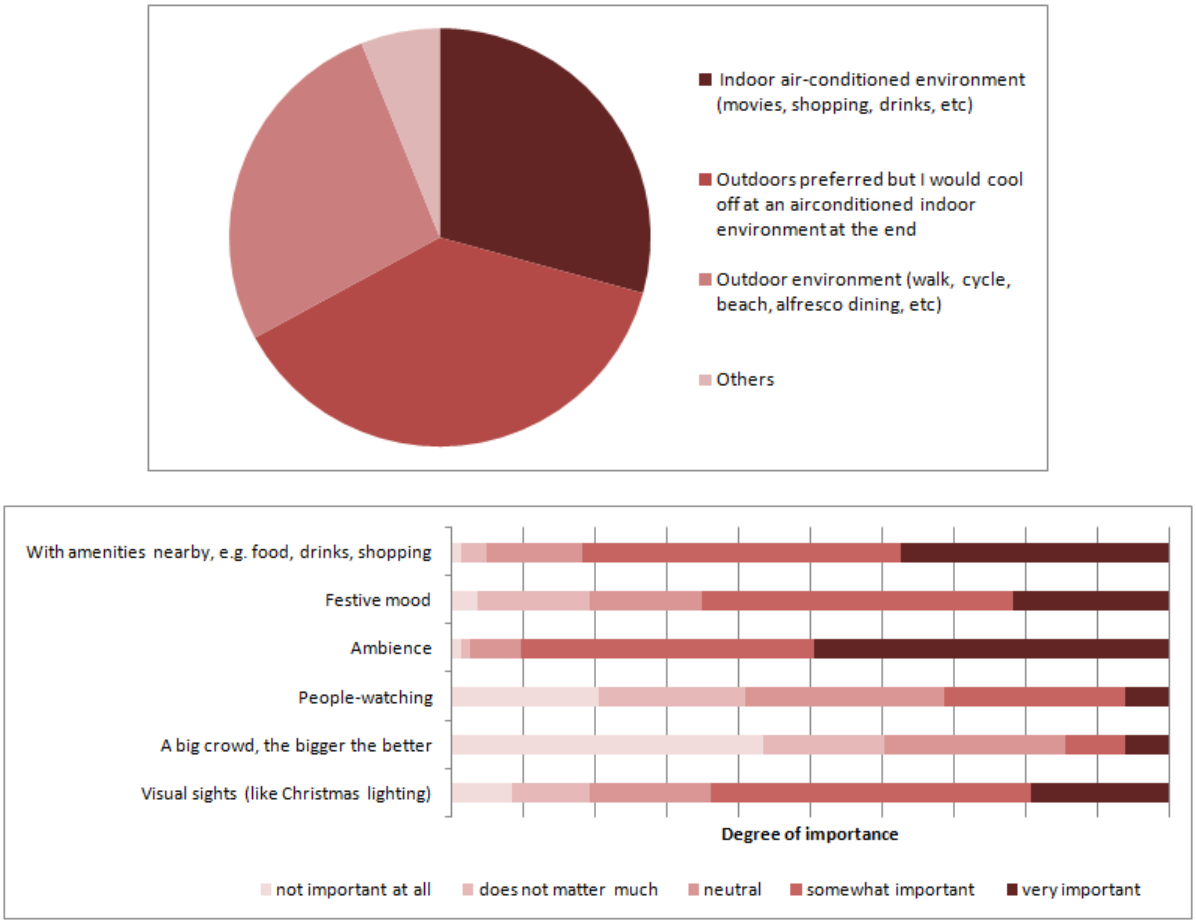

Fig 4.12 Where Singaporeans prefer to be for leisure activities; and what they desire from these leisure destinations

Generally, amongst survey respondents, it is noted that there is an almost equal split between preference for the outdoor environment (27%) and that of the indoor leisure experience (29%). Another 38% is willing to enjoy the outdoor environment but only if they have somewhere indoors to cool off after the hot and humid outdoors. As a Singaporean myself, I do appreciate the outdoors when it comes to specific activities like jogging, cycling, inline-skating, etc. i.e. activities that require me to sweat it out anyway. However when it comes to a leisurely stroll, I will still prefer to be in air-conditioned comfort. After all, if one is dressed nicely for the weekend, the last thing he or she would want is to be all hot and sweaty underneath those clothes. My consideration for leisure walks would be different if there is enough drawing power to offset the discomfort of walking. From WEXiS above, the most important factors to the respondents are ambience, amenities, festive mood and visual sights.

The main argument that I wish to make about walking for leisure is that an indoor walking environment does not constitute an ideal leisure walking environment. In an interview with Professor Yung Ho Chang, Head of the Architecture Department at the Massachusetts Institute of Technology[10], Professor Chang agreed with my thinking that the quality of life in a city is reflective of the experience one derives from the street life in the city. If a city's idea of leisure is limited to that of an indoor shopping mall experience, it makes no difference if you are walking in Dubai, Kuala Lumpur or Singapore because the indoor experience is indistinguishable between the three. Singapore's outdoor streetscape and greenery are unique and they definitely deserve much more attention than those provided by indoor shopping environments. From the WEXiS survey, it is heartening to see that there is still a fair amount of people who value the outdoor environment, but there is also an equally high number of people who prefers to stay indoors too. The proportion may slowly lean towards greater indoor use if Singapore does not arrest the trend. As a city grows affluent and air-conditioning becomes ubiquitous, it is only natural that people will seek all-weather comfort wherever they go. Professor Chang cited his own experience of the "Three Furnaces of China", namely Wuhan, Nanjing and Chongqing, which are known for their hot summer weather. He noted how lifestyles there had progressed from living with the heat when the cities were poorer to the current trend of luxuriating in air-conditioned comfort which moves seamlessly from one's home, to the car and to the office when the people can now better afford it. This is similar to Singapore too.

In tropical Singapore where the weather is the pedestrian's biggest enemy, it is hard to sustain an interest in the outdoors when a prolonged exposure would cause one to break out in perspiration – not exactly the ideal outcome anybody would want to seek from a leisure outing. So what options do we have? Is there any way to ameliorate the weather considerations to keep people outdoors in Singapore?

In Chapter 3, one of the suggestions for overcoming the weather and to improve the downtown walkability in the CBD is to put people underground via the use of pedestrian tunnels. My

[10] Chang, Y. H., personal communication, 12 March 2008.

argument for such a suggestion is that for walking as a means of travelling, it is acceptable and in fact most appropriate to put people in all-weather comfort such as underground pedestrian tunnels. The key is being able to separate the pedestrians who are walking as a means of travelling and that of leisure walking. In the CBD where few trips are leisured-based, it is not that difficult to go for the pedestrian tunnel option. However, my recommendation for the CBD is still more of the enhanced pedestrianization option with shelter and cooling which could catalyze more leisure trips to the CBD instead.

Singapore is heading towards the direction of greater use of subterranean spaces, particularly in her new downtown area (see Fig 4.13 which is reproduced from Fig 3.8). The effect of this underground city would most likely cannibalize the street life aboveground, as in the case of many cities which have grade-separated pedestrian facilities like Houston, Minneapolis, Calgary, etc. Quoting Jan Gehl again, only Japan has managed to succeed at both the at-grade and underground levels of pedestrian activity due to her sheer density of pedestrians.

Fig 4.13 The underground pedestrian network in Singapore's new downtown

In the new downtown, Singapore is equally keen to develop the streetscape to one which is befitting of a world class city. The vision of the Landscape Master Plan for the new downtown is for it to be a "City-in-a-Garden".[11] Different color schemes from planting different species of flora would distinguish the various districts of the new downtown. Quoting Goh (2006), the aim of the landscaping is to create a multi-level visual experience, i.e. one can appreciate unique aspects of the landscaping beauty when you view it from three different levels, namely the city, a car driver's perspective and the pedestrian point of view. Specific landscaping strategies are also intended for Marina Boulevard, one of the key arterials of the new downtown, for it to create a sense of space and provide for street-based activities such as 'al fresco dining' and kiosks.

Fig 4.14 Features of the new downtown's Landscape Master Plan. Left: different flora coloring schemes for different areas; Right: Artist impression of Marina Boulevard. (Source: URA)

In Fig 4.13, the underground pedestrian city is planned to run underneath Marina Boulevard too. Given that the vision of street-based activities such as "al fresco dining" is in direct competition with the underground city, which one will win out, or is there room for both? For this case, Marina Boulevard happens to have the strong draw of having the Marina Bay waterfront on one of its side, so it has a strong case of retaining a substantial amount of street life. However, in other situations, Singapore needs to be mindful of the implications that facilitating people to move underground may be at the expense of street life. In the example of Citylink Mall, which we have seen earlier in Fig 3.9 and 3.11, its huge success cannibalized the use of an otherwise fantastic open space above it – the War Memorial Park. Of course, other issues like traffic priority helped to contribute to the reason why the open space is under-utilized.

[11] Goh, KC. (2006). Creating a Multi-Sensory Environment at Marina Bay. *Skyline May/June 2006 (URA's bi-monthly magazine)*. Retrieved from http://www.ura.gov.sg/skyline/skyline06/skyline06-03/text/pg4.html

Fig 4.15 Left: pedestrian traffic in Citylink Shopping Mall; Right: directly aboveground is the underutilized War Memorial Park (See Fig 3.9 and 3.11 in addition)

Where leisure walking is concerned, city planners need to create an ambience and leisure environment so inviting that pedestrians would be naturally drawn to it, even with the presence of an underground pedestrian mall right underneath it. The key principles of achieving this are similar to the walkability considerations that were covered in Chapters 2 and 3, with more to be done on enhancing the enjoyment tier of the hierarchy of walking needs. However, regardless of how strong the enjoyment factor of a walking experience can be, the weather consideration will eventually set in to turn away the hardiest of pedestrians. Right now, many of the leisure walking attractions in Singapore are only possible in the evening, which can still be rather humid to stay out for an extended time and naturally they will still be susceptible to rain too. Looking to the future, can Singapore do more to extend the leisure walking environment to apply for bright sunny days and to provide for all-weather comfort for extended use too?

A peek into a possible future?

The concept of the revamped Clarke Quay in Singapore, seen earlier in Fig 3.15, is a viable model to create an inviting venue for leisure activities. However, the overwhelming views of the giant umbrellas are probably not the best idea to be applied on the waterfront or along a shopping street, like that of Orchard Road - Singapore's top shopping destination. However, the same idea of cooling and shelter could be explored in less conspicuous forms. The investment of cooling technology specifically for leisure walking use is likely to be justifiable for a high pedestrian volume area, like that of Orchard Road. It goes beyond just creating comfort for both local pedestrians and tourists, because of the potential to enhance the city image for Singapore.

Fig 4.16 Orchard Road – Singapore's premier shopping street with wide sidewalks and fantastic tree-scapes, but subject to the mercy of the weather. Right: cooling technology being used along Orchard Road

New cooling technology which is supposedly environmentally sustainable has been proposed for a 30km bicycle lane in Doha, Qatar. Cooled water runs through pipes which can lower the ambient temperatures from 50°C to 32°C by convective heat transfer.[12] Another futuristic-looking project in Toronto seeks to achieve similar climate-control effect too.[13] While both projects' statuses are unknown, they do indicate that some form of cost-effective cooling technology may be eventually available for Singapore to create an enjoyable outdoor environment in future. Right now, we can only peer into the future and hope that Singaporeans do not have to wait too long for that day to come.

Fig 4.17 Bicycle lane projects in Doha, Qatar (left) and Toronto, Canada (right)

[12] Retrieved from http://www.velomondial.net/page_display.asp?pid=32 and http://www.qatarliving.com/node/97773
[13] Retrieved from http://www.velo-city.ca

Chapter 5 Recommendations and Conclusions

By tracing a typical work trip and examining the commuting patterns and downtown walkability for work-related travel, I have managed to pick out 2 areas that can be enhanced with regards to the walking experience that pedestrians in Singapore currently have.

Enhance MRT transfer walks

Firstly, the trend of increased walking opportunities within the MRT system due to transfers will potentially become more significant as Singapore's MRT system expands aggressively in the next decade or so. Even as the government planners are going through the process of tightening the city-state's transportation hub and spoke system by revamping the bus planning, minimizing transfers, increasing transit predictability, etc., they have not addressed the issue of increased transfer walking between MRT lines. Even though this transfer is being done in air-conditioned comfort, the authorities should not assume that commuters would be happy with this transfer experience. With every transfer, commuters grow wearier of the public transit system and even though they may not necessarily switch to private transport because they do not have any other choice, this weariness may pose other social costs like increased absenteeism, strained family relations, etc. While it is most desirable that the planning and design of the MRT system eliminate the need for long transfer walks totally, but it will not be possible to achieve this every time. Given this constraint, Singapore should attempt to enhance the walking experience that commuters have during their transfers by using simple cost-effective means. Measures like greening the transfer tunnels add amazing aesthetics and improve air quality at the slight expense of higher maintenance costs. Large scale advertising could also be another option which provides visual interest while providing transit operators an additional revenue stream too.

Follow-up work

To better establish that there is a desire amongst commuters to improve the walking experience within transfer tunnels, the authorities can conduct a large-scale survey to understand the exact needs of the commuters. This can be in a form of consultative exercise to garner ideas and suggestions which can evolve into a community participation effort to engage MRT commuters in enhancing their own walking experience.

Enhance Downtown Walkability

In Chapter 3, we proposed two possible solutions to enhance downtown walkability through the underground pedestrian network option and that of the enhanced pedestrianization scheme with shelter and artificial cooling. In general, the underground pedestrian network provides better integration with transit but at much higher implementation costs and possible cannibalization of street pedestrian traffic too. For this case, my preference is more inclined towards the enhanced pedestrianization scheme. The scheme can still fit into the integration with transit, albeit with some vertical separation. However, such vertical separation may actually be welcomed by pedestrians because it allows them an avenue to exit the underground tunnels in all-weather protection so as to avoid the crowded tunnels which are worst during peak periods. This scheme also has the potential to create buzz in the existing CBD which can be a tool to create life in the CBD even after office hours. The only seemingly downside to the pedestrianization scheme would be the impact on traffic and possible technical difficulty of implementing such large-scale sheltering and cooling.

Unless the underground pedestrian network scheme comes about very strongly as cost-effective and feasible, my opinion is that the case is definitely stronger for the enhanced pedestrianization scheme to be pursued further by the Singapore government.

Follow-up work

As detailed clearly in Chapter 3, there needs to careful study and assessment by the government planners with close consultation with the stakeholders in the CBD too. If deemed feasible, an area of the CBD should be identified and closed for short term pilot-testing. During this period, the area is sheltered and simulated as the prototype scheme for the actual pedestrianization. The objective of doing this is to hold a public consultation exercise on the pedestrianization concept and to let CBD pedestrians have a sneak preview on the proposed enhancements and gauge their response.

Other Recommendations for Singapore Planning Agencies

It is encouraging that the recent transportation review done by LTA has identified the need to make the land transportation system more people-centric. However, it is not enough to solely focus on getting people to work efficiently and quickly via motorized means, the finer aspects of walkability within the transportation system are equally important too. Aside from the two specific enhancement initiatives recommended above, it is suggested that the Singapore government adopt walkability as an official people-centric initiative with collaboration across the different planning agencies, namely URA, LTA, HDB, Singapore Tourism Board (STB) and the National Parks Board (NParks). All agencies are currently involved one way or another when it

comes to providing for the pedestrian realm, and they can definitely achieve more by coming up with a synergistic plan that cuts across all their areas of responsibility.

Future Study

This thesis strategized several enhancement measures that the Singaporean government can pursue further with respect to work-related walking. Chapter 4 also lays down the groundwork for subsequent research into other aspects of improving Singapore's walkability, with respect to improving residential walkability for both public and private housing estates, and also to improve walking as a form of leisure. Regarding walking for leisure, it is important to note that if we go ahead with the initiatives to enhance walking for work-related trips, we should bear in mind that we do not do so at the expense of walking for leisure. Planners need to be aware that certain walking enhancements like moving pedestrians underground may cannibalize pedestrian street activity, which in turn may stifle the leisure walking environment that Singaporeans currently enjoy. This thesis sets the stage for much work to be followed up with the Singapore planning agencies and also for subsequent research. It is my personal desire to see through this future work when I practice in Singapore subsequently in order for a chance to realize what I envision for Singapore in having an enhanced pedestrian experience.

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Statistics of Selected Cities **Appendix A**

(Source: CIA World Factbook 2007)

	Singapore	Hong Kong	Japan	Malaysia	Indonesia	United States	Canada	Germany	Switzerland	Denmark
2006 estimates										
GDP - per capita (purchasing power parity)	$31,400	$37,300	$33,100	$12,800	$3,900	$43,800	$35,700	$31,900	$34,000	43,094
Unemployment rate	3.1%	4.9%	4.1%	3.5%	12.5%	4.8%	6.4%	7.1%	3.3%	3.8%
2007 estimates										
Population (millions)	4.55	6.98	127.4	24.82	234.69	301.14	33.39	82.40	7.55	5.47
Land Area (sqkm)	693	1092	377,835	329,750	1,919,440	9,826,630	9,984,670	357,021	41,290	43,094
Population density (ppl/sqkm)	6600	6400	300	100	100	0	0	200	200	100
Sex Ratio (male/female)	0.954	0.956	0.953	1.012	1.001	0.967	0.977	0.966	0.969	0.977
Age structure										
0-14 years	15.2%	13%	13.8%	32.2%	28.7%	20.2%	17.3%	13.9%	16.1%	18.6%
15-64 years	76.3%	74%	65.2%	62.9%	65.6%	67.2%	69.2%	66.3%	68.2%	66.0%
65 years and over	8.5%	12.90%	21.0%	4.8%	5.7%	12.6%	13.5%	19.8%	15.8%	15.4%
Median Age (years)	37.8	41.2	43.5	24.4	26.9	36.6	39.1	43	40.4	40.1
Average Life expectancy (years)	81.8	81.68	82.02	72.76	70.16	78	80.34	78.95	80.62	77.96
Climate (as described by CIA Worldbook and not according to the Koppen-Geiger climate classification system)	tropical; hot, humid, rainy	subtropical monsoon	varies from tropical in south to cool temperate in north	tropical; annual southwest (April to October) and northeast (October to February) monsoons	tropical; hot, humid; more moderate in highlands	mostly temperate	varies from temperate in south to subarctic and arctic in north	temperate and marine; cool, cloudy, wet winters and summers;	temperate, but varies with altitude	temperate; humid and overcast
2005 estimates										
Roadways (km)	3234	1955	1,183,000	98,721	368,360	6,430,366	1,042,300	231,581	71,297	72,257
roadways length / million pop	711	280	9286	3977	1570	21353	31216	2810	9437	13214

Page 1. Walking Experience in Singapore

Page 2. Walking Experience in Singapore (Progress: 0%)

Page 3. Part A - Walking as a means of travel (Progress: 5%)

What type of housing do you reside in?

	% of Respondents	Number of Respondents
HDB housing	75.73%	78
Private home in a HDB estate (i.e. near to public amenities)	8.74%	9
Private home elsewhere	14.56%	15
Other (Specify)	0.97%	1

Details

Number of respondents 103

Number or respondents who skipped this question 29

Please indicate the main mode of transportation you use mostly to get from home to work/school.

	% of Respondents	Number of Respondents
Bus/MRT	60.19%	62
Taxi	1.94%	2
Private vehicle (self-drive, passenger, motorcycle)	33.01%	34
Bicycle	0.97%	1
Walk	2.91%	3
Other (Specify)	0.97%	1

Details

Number of respondents 103

Number or respondents who skipped this question 29

On average, how long is your daily commute to and from work/school? (in minutes).

Details

Number of Respondents 103

Number or respondents who skipped this question 29

Roughly, how much time is spent walking? Include bus/mrt walk transfers for public transport users, but exclude waiting time. (in minutes)

Details

Number of Respondents 103

Number or respondents who skipped this question 29

Here is a list of reasons why you may LIKE the walks that form part of your daily routine of getting to work/school, please check those that apply.

	% of Respondents	Number of Respondents
It's a form of exercise	31.32%	57
I only walk a short distance, so it doesn't matter	34.62%	63
The walk is pleasant because it is sheltered	10.44%	19
The walk is pleasant because it is air-conditioned	4.40%	8
I do stuff along the way; i.e. buy breakfast, newspapers, etc	13.74%	25
Details Other (Specify)	5.49%	10
Number of respondents		***100***
Number or respondents who skipped this question		***32***

Here is a list of reasons why you may DISLIKE the walks that form part of your daily routine of getting to work/school, please check those that apply.

	% of Respondents	Number of Respondents
I have to transfers between buses and/or MRT which are not convenient	11.16%	24
The carpark/bus-stop/MRT station is a long distance from home/school/office	13.49%	29
I perspire by the time I get to my office/school	21.40%	46
It is very squeezy to walk with rush hour crowd	14.88%	32
I hate it when it rains	35.35%	76
Details Other (Specify)	3.72%	8
Number of respondents		***100***
Number or respondents who skipped this question		***32***

If you are a public transport user or were a previous public transport user, is the walking part one of the key factors making you feel like switching to non-public transport choices like taxis or cars?

	% of Respondents	Number of Respondents
Yes	50.49%	52
No	49.51%	51
Number of respondents		***103***
Number or respondents who skipped this question		***29***

Page 5. Walking as a means of travel - What matters to you? (Progress: 15%)

Assume it is a typical sunny weekday in Singapore and you are getting to work/school in the morning under normal circumstances. If let's say you are given 3 choices of pedestrian environments which you can use solely to walk to your destination (refer to pictures below), which one would you prefer?

	% of Respondents	Number of Respondents
A) Air-conditioned indoor walkways (indoors or underground). Often these walkways may be indirect, requiring you to follow a circuitous route in order to trace a continuous sheltered path, and also they may be crowded and confined.	41.67%	40
B) Sheltered walkways (along the fronts of buildings, five-foot ways, covered linkways, etc.). Often, these options will still be partially exposed to weather in terms of humidity. These routes are also narrow and indirect - often requiring you to use pedestrian underpasses or covered overhead bridges to trace a continuous sheltered path.	27.08%	26
C) Open-air footpaths (ocassionally with tree-shading).		

These would be fully subject to weather and may involve crossing roads. However these options are good in that you get fresh air and greenery. Also they are usually the most direct and fastest routes.	31.25%	30

Number of respondents	*96*
Number or respondents who skipped this question	*36*

Considering your choice above, please rate the factors below on how they influence which route you prefer to walk. E.g. if you prefer to cut across a big grassfield to get to work quickly in a hot sunny day but not when it rains, you will rank directness and rain highly and lesser on heat/humidity. (1- not important at all; 2- does not matter much; 3- neutral; 4- somewhat important; 5- very important).

	1	2	3	4	5	Number of Respondents
Heat, humidity	1% (1)	8% (8)	11% (11)	42% (41)	36% (35)	96
Rain	2% (2)	1% (1)	3% (3)	14% (14)	79% (76)	96
Directness of route (e.g. cutting across a field instead of walking around it; not using covered walkways which are usually circuitous)	3% (3)	2% (2)	31% (30)	37% (36)	26% (25)	96
How fast you can walk (you may be slowed by obstructions, traffic crossings, slippery floors, potholes, etc EVEN if route is direct)	2% (2)	4% (4)	22% (22)	58% (56)	12% (12)	96
Safety (e.g. how deserted it is, crossing roads, chances of falling/slipping and hurting yourself)	4% (4)	9% (9)	20% (20)	32% (31)	33% (32)	96
Physical effort of walk (e.g. climb stairs, long distance)	7% (7)	13% (13)	27% (26)	32% (31)	19% (19)	96
Crowdiness (e.g. shoulder to shoulder squeezing, even if you may be able to move fast)	2% (2)	7% (7)	15% (15)	50% (48)	25% (24)	96
Conditions of the path (bad conditions would be water-ponding, broken tiles, drain-grates which trap your heels, etc)	3% (3)	12% (12)	18% (18)	43% (42)	21% (21)	96
Scenery, fresh air	3% (3)	14% (14)	32% (31)	37% (36)	12% (12)	96
Amenities along the walk (e.g. shops, food)	8% (8)	20% (20)	36% (35)	26% (25)	8% (8)	96
Ease of finding your way around (usually not so good if you are using underground tunnels)	3% (3)	16% (16)	35% (34)	34% (33)	10% (10)	96

Number of Respondents	*96*
Number or respondents who skipped this question	*36*

Reflecting on your actual personal experience now at your workplace, school, etc. Say you are going for lunch (or other flexible trips), are you influenced by the weather and the walking options that you have? e.g. if it's too hot and you don't have a covered path, you may skip lunch or eat-in; or you will go eat at a place where you can get to the quickest or most comfortably away from the weather?

	% of Respondents	Number of Respondents
Yes	79.17%	76
No	20.83%	20

Number of respondents	*96*
Number or respondents who skipped this question	*36*

Page 10. Walking as a means of travel - Current status of pedestrian facilities (Progress: 25%)

We would like to understand the availability of pedestrian facilities in downtown city centre and around your home. Please indicate whether you feel if they are adequate.

	Not enough	Just right	Over-provided	Number of Respondents
Are there enough indoor/underground				

pedestrian links in downtown?	47% (43)	52% (48)	0% (0)	91
Are there enough tree-shaded footpaths in downtown?	42% (39)	53% (49)	3% (3)	91
Are there enough sheltered walkways around your home?	48% (44)	47% (43)	4% (4)	91
Are there enough tree-shaded footpaths around your home?	45% (41)	52% (48)	2% (2)	91
	0%(0)	0%(0)	0%(0)	0
			Number of Respondents	*91*
			Number or respondents who skipped this question	*41*

In general, do you feel that sheltered walkways (see image below) are asethetically pleasing, even though you may like to use them for a functional reason?

	% of Respondents	Number of Respondents
Yes	40.66%	37
No	16.48%	15
Thera are only some cases of badly designed ones	42.86%	39
Number of respondents		*91*
Number or respondents who skipped this question		*41*

Page 11. Walking as a means of travel - Design of Singapore's MRT system (Progress: 30%)

Page 12. Walking as a means of travel - MRT Entrances/Exits (Progress: 30%)

In your opinion, do you feel that an MRT station should have an extensive network of entrances/exits to better connect commuters to the MRT system?

	% of Respondents	Number of Respondents
Yes	94.32%	83
No	3.41%	3
I don't know	2.27%	2
Number of respondents		*88*
Number or respondents who skipped this question		*44*

Page 13. MRT Entrances/Exits - The Need to be more Extensive (Progress: 35%)

Why do you feel that MRT entrances/exits should be more extensive? (check all that apply)

	% of Respondents	Number of Respondents
Feels like I get into the MRT system faster; i.e. the perception that the MRT station is nearer	25.95%	48
Offers me weather protection sooner	35.68%	66
Eliminates the need for me to cross many roads to get into the station	36.76%	68
Details Other (Specify)	1.62%	3
Number of respondents		*83*
Number or respondents who skipped this question		*49*

In your opinion, do you feel that Singapore's current MRT design in terms of the extensiveness of station entrances is adequate?

	% of Respondents	Number of Respondents
Yes	44.58%	37
No, Singapore can do better	55.42%	46
Number of respondents		*83*

Number or respondents who skipped this question *49*

Page 14. MRT Entrances/Exits - Why they need not be too Extensive (Progress: 35%)

Why do you think that MRT entrances/exits should not be made too extensive? (check all that apply)	% of Respondents	Number of Respondents
Too confusing even for me who uses it everyday	33.33%	2
Too narrow, gets crowded during rush hour, unlike they can be built wider to accommodate more pedestrians	33.33%	2
I don't like to walk too long in an underground tunnel	0.00%	0
Waste of money for the government	33.33%	2
Number of respondents		*3*
Number or respondents who skipped this question		*129*

Page 15. Walking as a means of travel - MRT Transfers (Progress: 40%)

There have been comments that the MRT transfers between the North East Line at Dhoby Ghaut (North South Line) and Outram Park (East West Line) stations are long distances to walk, do you feel this is valid?	% of Respondents	Number of Respondents
Yes	62.07%	54
No	35.63%	31
I don't know	2.30%	2
Number of respondents		*87*
Number or respondents who skipped this question		*45*

In your personal experience, which MRT transfer is a more pleasant walking experience?	% of Respondents	Number of Respondents
Dhoby Ghaut	48.28%	42
Outram Park	3.45%	3
Indifferent (both just as good or bad)	40.23%	35
I don't know	8.05%	7
Number of respondents		*87*
Number or respondents who skipped this question		*45*

Page 16. MRT Transfers - Why Dhoby Ghaut Station? (Progress: 45%)

Why Dhoby Ghaut? (check all that apply)	% of Respondents	Number of Respondents
Very spacious, airy (sensory attribute)	28.83%	32
Brighter (sensory attribute)	25.23%	28
Colourful advertisements (sensory attribute)	19.82%	22
Travellators	23.42%	26
Details Other (Specify)	2.70%	3
Number of respondents		*40*

Number or respondents who skipped this question *92*

Do you feel that the sensory attributes like brighter lights, spaciousness, colourful advertisements contribute to a perception that the Dhoby Ghaut transfer is more “walkable”?

	% of Respondents	Number of Respondents
Yes	97.50%	39
No	2.50%	1
No, it is purely the travellator	0.00%	0

Number of respondents *40*

Number or respondents who skipped this question *92*

If the Outram transfer is spruced up aesthetically (no travellators and without making it bigger), do you think that will help in making the walk more enjoyable?

	% of Respondents	Number of Respondents
Yes	75.00%	30
No	12.50%	5
Don't know	12.50%	5

Number of respondents *40*

Number or respondents who skipped this question *92*

Below are some examples of how an indoor walking environment can be enhanced, please select all which you think can help make your routine walking experience a more interesting one. (refer to image below for some of them)

	% of Respondents	Number of Respondents
Colourful static advertisements	21.77%	27
Video advertising	13.71%	17
Interactive displays which engages you to touch them	5.65%	7
Moving light shows	8.87%	11
Music	17.74%	22
Performers/bustlers	5.65%	7
Retail activity	23.39%	29
Nothing above works	0.81%	1
Other (Specify)	2.42%	3

Details

Number of respondents *40*

Number or respondents who skipped this question *92*

Page 17. MRT Transfers - Why Outram Park Station? (Progress: 45%)

Why Outram? (check all that apply)

	% of Respondents	Number of Respondents
Distance feels shorter, horizontally	66.67%	2
Distance feels shorter, vertically	33.33%	1

Number of respondents *3*

Number or respondents who skipped this question *129*

Page 18. Walking as a means of travel - End of Part A (Progress: 50%)

Page 19. Part B - Walking for Leisure (Progress: 55%)

Suppose you have time and desire to go out for a leisurely weekend, which option below would you choose most naturally?

	% of Respondents	Number of Respondents
Indoor air-conditioned environment (movies, shopping, drinks, etc)	29.27%	24
Outdoor environment (walk, cycle, beach, alfresco dining, etc)	26.83%	22
Outdoors preferred but I would cool off at an air-conditioned indoor environment at the end	37.80%	31
Other (Specify)	6.10%	5

Details

Number of respondents ***82***

Number or respondents who skipped this question ***50***

Which are the areas below that you would consider walking around for leisure, be it indoors or outdoors. Please check all that apply.

	% of Respondents	Number of Respondents
Orchard Rd	14.01%	50
Suntec / Marina Centre / Raffles City area	14.85%	53
Chinatown	4.76%	17
Little India	1.12%	4
Shenton Way/Robinson Rd	0.84%	3
Esplanade / One Fullerton / Merlion Park	13.17%	47
Singapore River (Boat Quay/Clarke Quay/Robertson Quay)	12.04%	43
Beaches/Parks	18.21%	65
Shopping centres (downtown or neighbhourhood ones)	13.45%	48
Around your home (void decks, playground, along the canal, etc)	6.44%	23
I don't walk (or enjoy walking) for leisure	0.28%	1
Other (Specify)	0.84%	3

Details

Number of respondents ***83***

Number or respondents who skipped this question ***49***

Most of the destinations above for walking as leisure are in the open, which is natural given that the sights and sounds that make the walk enjoyable cannot be contained indoors. However, given Singapore's hot and humid weather, the walk may not be as enjoyable. What are your thoughts on Singapore's climate on your leisure walking experience?

	% of Respondents	Number of Respondents
I don't mind the weather at all	16.87%	14
I MIND the weather, but I have no choice since I like these leisure activities	33.73%	28
I can't stand the weather, therefore I try to do these activities occasionally or at night when it is cooler	36.14%	30
I hate the weather, that's why I don't do outdoors but prefer an indoor cooling environment	4.82%	4
I don't like to walk for leisure at all	2.41%	2
Other (Specify)	6.02%	5

Details

Number of respondents ***83***

Number or respondents who skipped this question ***49***

Suppose you are going to choose a destination for a leisure walk outdoors, please rate the factors determining the quality of the destination which will influence your choice (i.e. ignore weather considerations). (1- not important at all; 2- does not matter much; 3- neutral; 4- somewhat important; 5- very important)

	1	2	3	4	5	Number of Respondents
Visual sights (like Christmas lighting)	8% (7)	10% (9)	16% (14)	44% (37)	19% (16)	83
A big crowd, the bigger the better	43% (36)	16% (14)	25% (21)	8% (7)	6% (5)	83
People-watching	20% (17)	20% (17)	27% (23)	25% (21)	6% (5)	83
Ambience (waterfront or quieter, cosier walks)	1% (1)	1% (1)	7% (6)	40% (34)	49% (41)	83
Festive mood	3% (3)	15% (13)	15% (13)	43% (36)	21% (18)	83
With amenities nearby, e.g. food, drinks, shopping	1% (1)	3% (3)	13% (11)	44% (37)	37% (31)	83
	0%(0)	0%(0)	0%(0)	0%(0)	0%(0)	0
	0%(0)	0%(0)	0%(0)	0%(0)	0%(0)	0
					Number of Respondents	*83*
					Number or respondents who skipped this question	*49*

Page 20. Walking for Leisure - Clarke Quay (Progress: 65%)

Have you been to this area of the revamped Clarke Quay?

	% of Respondents	Number of Respondents
Yes	81.48%	66
No	18.52%	15
Number of respondents		*81*
Number or respondents who skipped this question		*51*

Have you been there BEFORE the revamp, i.e. when they were still outdoors?

	% of Respondents	Number of Respondents
Yes	93.83%	76
No	6.17%	5
Number of respondents		*81*
Number or respondents who skipped this question		*51*

Page 21. Clarke Quay - What do you think? (Progress: 70%)

What do you think is good about this revamped Clarke Quay?

	% of Respondents	Number of Respondents
Cooling and non-humid	17.53%	54
Shelter from rain	21.75%	67
Good restaurants	12.99%	40
Good drinking options	12.66%	39
Lively crowd	14.61%	45
Fountain	7.79%	24
Live entertainment occasionally	11.04%	34
Nothing is good	0.65%	2

Details	Other (Specify)	0.97%	3
		Number of respondents	***81***
		Number or respondents who skipped this question	***51***

What would you say is bad about this revamped Clarke Quay? (check all that apply)		**% of Respondents**	**Number of Respondents**
	Giant umbrellas look out of the place	23.08%	21
	Giant umbrellas are ugly	15.38%	14
	There should be air-conditioning under the umbrellas!	7.69%	7
	The use of the giant fans are not environmentally sustainable	14.29%	13
	Nothing is bad at all!	34.07%	31
Details	Other (Specify)	5.49%	5
		Number of respondents	***81***
		Number or respondents who skipped this question	***51***

If you think that the revamped indoor streets of Clarke Quay is an overall success compared to its previous design, would you say that it is largely attributable to the "climate-controlled" design factor of the giant umbrella and huge blower fans?		**% of Respondents**	**Number of Respondents**
	Yes	53.09%	43
	No	23.46%	19
	I don't know / I don't think the revamped Clarke Quay is a success	23.46%	19
		Number of respondents	***81***
		Number or respondents who skipped this question	***51***

Page 22. Walking for Leisure - Orchard Rd (Progress: 75%)

For what purpose do you go Orchard for leisure?		**% of Respondents**	**Number of Respondents**
	Shopping	34.55%	76
	Dining / Cafes	30.45%	67
	Nightspots	4.09%	9
	Sights like festive decorations	17.27%	38
	People-watch	5.91%	13
	Just walk around with no specific purpose	5.91%	13
Details	Other (Specify)	1.82%	4
		Number of respondents	***81***
		Number or respondents who skipped this question	***51***

If you like to walk around Orchard Rd, please indicate if you like to do so indoors or outdoors, say on a typical weekend/holiday. You may select more than one option. (p.s. remember it is walking for leisure, i.e. you are not in a hurry for time and possibly no definite destination too)		**% of Respondents**	**Number of Respondents**
	Indoors (air-conditioned shopping centres)	46.15%	60
	Outdoors (tree-shaded pedestrian sidewalks)	25.38%	33
	Outdoors, but mainly at night only	23.08%	30

None of these, I don't like to walk around Orchard Rd		5.38%	7
	Number of respondents		***81***
	Number or respondents who skipped this question		***51***

Page 23. Orchard Rd - What is Good about Indoors? (Progress: 80%)

Please indicate what you like about walking indoors (check all that apply)		**% of Respondents**	**Number of Respondents**
Air-conditioned		31.03%	36
Shops to browse around as and when I like it		30.17%	35
Better to people-watch		2.59%	3
Easier to access (I can come out from the MRT or carpark and be indoors immediately!)		16.38%	19
Everything that I do is located indoors, like cinemas, shops, restaurants, etc.		18.10%	21
Details	Other (Specify)	1.72%	2
	Number of respondents		***41***
	Number or respondents who skipped this question		***91***

What do you not like about walking outdoors in Orchard Rd		**% of Respondents**	**Number of Respondents**
Weather (hot/humid/rain)		31.91%	30
Lots of traffic along the road		23.40%	22
Many road crossings		15.96%	15
Streets can be overcrowded		26.60%	25
Details	Other (Specify)	2.13%	2
	Number of respondents		***41***
	Number or respondents who skipped this question		***91***

What do you think can be improved about the experience of walking outdoors?		**% of Respondents**	**Number of Respondents**
Maybe some form of artificial cooling but nicely blended in with the environment		20.72%	23
More space for pedestrians to walk		23.42%	26
Less traffic		17.12%	19
More outdoor cafes/refreshment areas		13.51%	15
More performers, live acts, etc		9.01%	10
More visual displays like billboards, giant TV screens (some examples already at Orchard Emerald, Isetan Scotts)		11.71%	13
Details	Other (Specify)	4.50%	5
	Number of respondents		***41***
	Number or respondents who skipped this question		***91***

Page 24. Orchard Rd - What is so good about walking around? (Progress: 80%)

Please indicate what you like about walking indoors (check all that apply)

	% of Respondents	Number of Respondents
Air-conditioned	28.16%	29
Shops to browse around as and when I like it	31.07%	32
Better to people-watch	3.88%	4
Easier to access (I can come out from the MRT or carpark and be indoors immediately!)	21.36%	22
Everything that I do is indoors, like cinemas, shops, restaurants, etc.	14.56%	15
Other (Specify)	0.97%	1

Details

Number of respondents ***33***

Number or respondents who skipped this question ***99***

Please indicate what you like about walking outdoors. (Please check all that apply)

	% of Respondents	Number of Respondents
Great atmosphere / ambiance	15.75%	23
Nice buildings to look at (lighting or decor)	13.70%	20
Moving displays on buildings like billboards, giant TV screens (see picture below)	8.22%	12
Great to people-watch	10.27%	15
Ice-cream vendors	7.53%	11
Live acts / performers	9.59%	14
Nicely shaded sidewalks	15.75%	23
Wide enough sidewalks to stroll comfortably	17.81%	26
Other (Specify)	1.37%	2

Details

Number of respondents ***33***

Number or respondents who skipped this question ***99***

Page 25. Orchard Rd - Your Reactions to Possible Outdoor Walking Enhancements (Progress: 85%)

Bright billboards, lights (e.g. Times Sq in New York, Ginza in Tokyo - see below)

	% of Respondents	Number of Respondents
Will work	46.84%	37
Will not work	12.66%	10
Maybe	40.51%	32

Number of respondents ***79***

Number or respondents who skipped this question ***53***

Pedestrianization, i.e. taking traffic away from Orchard R and opening it to pedestrians exclusively. (see pictures below)

	% of Respondents	Number of Respondents
Will work	50.63%	40
Will not work	15.19%	12
Maybe	34.18%	27

Number of respondents	*79*
Number or respondents who skipped this question	*53*

Performances, interactive displays, activities (see image below)

	% of Respondents	Number of Respondents
Will work	56.96%	45
Will not work	8.86%	7
Maybe	34.18%	27
Number of respondents		*79*
Number or respondents who skipped this question		*53*

Music along Orchard Rd (see image below)

	% of Respondents	Number of Respondents
Will work	40.51%	32
Will not work	12.66%	10
Maybe	46.84%	37
Number of respondents		*79*
Number or respondents who skipped this question		*53*

Page 26. Orchard Rd - An Underground / Indoor City? (Progress: 95%)

Would you like to see such a reality happen? I.e. the possibility of an inter-connected underground mall at Orchard Rd?

	% of Respondents	Number of Respondents
Yes	92.41%	73
No	7.59%	6
Number of respondents		*79*
Number or respondents who skipped this question		*53*

If this underground indoor city happen, would you still consider using the outdoor streets above?

	% of Respondents	Number of Respondents
Yes, I will still come out to the open	74.68%	59
No, there is no need to come out at all!	25.32%	20
Number of respondents		*79*
Number or respondents who skipped this question		*53*

Do you think that if the underground city does get built, will it cause the outdoor street life along Orchard Rd to dwindle and become not as lively as what it is today?

	% of Respondents	Number of Respondents
Yes	20.25%	16
No	44.30%	35
Maybe	35.44%	28
Number of respondents		*79*
Number or respondents who skipped this question		*53*

Page 27. End of Survey (Progress: 100%)

Gender

	% of Respondents	Number of Respondents
Male	41.77%	33
Female	58.23%	46
Number of respondents		*79*
Number or respondents who skipped this question		*53*

Age

	% of Respondents	Number of Respondents
<19	1.27%	1
20-24	1.27%	1
25-29	30.38%	24
30-34	59.49%	47
35-39	5.06%	4
40-49	2.53%	2
50-59	0.00%	0
60+	0.00%	0
Number of respondents		*79*
Number or respondents who skipped this question		*53*

Educational Level

	% of Respondents	Number of Respondents
No qualification	0.00%	0
Primary	0.00%	0
Secondary	6.33%	5
Higher Secondary/JC	0.00%	0
Polytechnic	10.13%	8
University (Bachelor degree)	68.35%	54
Masters or PhD	15.19%	12
Number of respondents		*79*
Number or respondents who skipped this question		*53*

Marital status

	% of Respondents	Number of Respondents
Single	56.58%	43
Married	43.42%	33
Number of respondents		*76*
Number or respondents who skipped this question		*56*

Your email address for us to possibly contact you in future (optional)

Details

Number of Respondents 32

Number or respondents who skipped this question 100

Any additional comments that you may wish to provide regarding your walking experience? (optional)

Details

Number of Respondents **13**

Number or respondents who skipped this question **119**

Survey related resources

Houston Tunnel Network Map

Appendix C

(Source: http://www.housotonwdowntown.com)