2008

Bachelor of Planning Thesis

Vi Ong

University of New South Wales

[An Integrated Public Transport System for Sydney]

The sustainability of transport systems in the developed world's cities is under threat from climate change and peak oil. The planning and management of cities such as Sydney assume continued motor vehicle use, resulting in high levels of emissions and oil dependence. It is a major undertaking to change urban form to adapt to the realities of peak oil and climate change, yet to do so does not necessarily guarantee more sustainable transport use. There is a need to consider more achievable alternatives to unsustainable private motor vehicle dependence which remains pervasive in the developed world. Better integration and planning to improve existing public transport is one such alternative. However, little is known about what integration actually involves and how it can best attract new users. This thesis examines measures that could make public transport more integrated and palatable in Sydney. Comparisons are made with comparable low-density new world cities to provide complementary perspectives on how better integration and thus sustainability can be achieved. Issues addressed include the organisational structure of public transport planning, network coverage, route and network planning, ticketing and fare systems, frequency and operating extent of service, speed and capacity of public transport, public information and marketing.

Table of Contents

List of Tables

List of Figures

Acknowledgements

Thanks to my friends and family for putting up with me and my rants on urban planning transport and helping me get through university and life.

Sam and James, thanks for being there to bounce ideas about transport planning at 3AM over MSN and many other occasions at more sane hours of the day.

Matt, thanks for playing tour guide whilst I was in Toronto when we spent those two days travelling all over the GTA by car, TTC and GO Transit, checking out interesting sites for planners like us, as well as Pacific Mall. In the near future, I intend to return the favour, with Cabramatta as a must see!

Thanks to the Sandy Tsirlis and the Toronto Transit Commission for the photography permit, day pass, and all the souvenirs.

At uni, thanks to Phil Brogan for being my thesis advisor – I'm sorry I wasn't a more diligent student. And all the staff I've met over the five years at UNSW, thank you for your help in broadening my horizons.

Thank you to the University of Toronto for allowing me free access to the 2006 TTS Database. I've certainly spent a lot of time using their statistics in Excel to produce the insightful and exclusive statistics used in thesis.

I would also like to thank the following people for their expertise, experience and anecdotes in the history of Sydney's transport system whilst I worked at RailCorp (in alphabetical order to avoid any favouritism):

- John Bryan
- Scott De Martino
- Frank Golotta
- Rex Gunton
- Gary McGregor (who also set up the scholarship which helped subsidise my visit to Toronto and first trip overseas)

Thanks to the Network Development team for making work that extra bit of fun. And Market Development and Research for the Compendium – #2 on the Sydney urban transport planner's best sellers list, after the TDC's Household Travel Survey Report.

I've had some wonderful times with the UNSW Bachelor of Planning Class of 2009, which have also had to deal with my penchant for all things transportation.

1 Introduction

1.1 Foreword

Technically, this thesis was prepared for the purpose of fulfilling the dissertation requirements of the Bachelor of Planning Program, at the University of New South Wales' Faculty of Built Environment. The topic was selected by me, with guidance from my thesis advisors.

Upon embarking this thesis, I was indecisive when it came to selecting a thesis topic – the chosen topic certainly reflects the prolonged indecision. The topic area, that being transport planning, was always obvious to my colleagues. Currently, I am reluctant to further pursue researching transport planning issues and topics as I prefer to seek the sense of accomplishment that practical application of transport planning theory can bring. During the topic selection process, I was reluctant to narrow my holistic perspective of transport planning down to a narrowly defined topic, particularly being aware that this could very well be my last opportunity to conduct official academic research.

The theme of this thesis – 'integrated transport' – is a cliché amongst the planning fraternity without having defined what it entails. To my advantage, this topic allows me some flexibility to write as a generalist in this specialised niche. To my disadvantage, due to the breadth of the topic juxtaposed with the finite word length (20,000), the limited time with which to research, and the limited resources, has forced this dissertation to become less like a research report with its extensive and conclusive primary research, and more like a discussion paper which relies heavily on secondary sources of information. It whets the appetite, rather than cures the hunger.

To compensate for such shortcomings, I have attempted to utilise primary sources of information where possible. For example, past and recent conversations with those amongst the transport planning fraternity, comparative case studies, and site visits to these case studies. However, I must stress this is my first attempt at a research paper of such length and breadth, and thus it is likely to be far from perfect. I would also like to declare that the terms 'transit', 'public transport', 'public transportation', 'public transit' and 'mass transit' may be used interchangeably throughout this thesis, although the definition is identical. It is with such caveats, that I introduce my thesis – 'An Integrated Public Transport System for Sydney'.

P.S. The abrupt conclusion is acknowledged by the author and is largely the result of time constraints and the restrictive word limit.

1.2 Hypothesis

The concept of 'integrated public transport' (IPT) can be interpreted in the following ways:

1. Public transport that is coordinated in such as way so as to maximise utility whilst minimising resources used – wasteful duplication is minimised
2. Public transport that presents or markets itself as a seamless system regardless of mode
3. Public transport that can be used as a seamless system regardless of mode

It is hypothesised that an integrated multi-modal public transport system will produce socially, economically and environmentally sustainable outcomes in low-density Australian cities and provide a practical alternative to the private motor car with relatively low capital cost and lead time. The discussion in thesis validates the prudency of implementing centralised planning of all conventional mass transit modes (bus, tram, train, ferry) in order for it to better compete on cost, coverage, and convenience with private motor vehicles. Such justification is needed for the significant government intervention that is expected, in order for the Australian state and federal governments to stray from the neoliberal stance that they have espoused as of late.

1.3 Aim

The aim of this thesis project **is to discuss** Sydney's potential in creating an integrated multi-modal public transport network through the improved management of transport operations primarily with existing infrastructure, rather than the planning of new infrastructure. This includes discussing past and current strategies, organisational structures and the interface between the provider and the user. Following the discussion and the use of a comparative case study, the thesis will suggest potential new measures that can be applied to Sydney based on the results of the comparison.

1.4 Disclaimer

This thesis is not intended to recommend exactly what actions the government should take in improving public transport, as the author does not purport to claim that he has the expertise to make such recommendations, nor does he purport to claim that he has the resources to thoroughly evaluate each recommendation to ensure that it can be applied without any funding or operational problems. This thesis is a review of transport planning theory, a reflection of current practices, and a comparison of a like-minded city elsewhere in the world that is facing similar problems and has demonstrated different techniques in achieving an integrated transport network.

1.5 Research Methodology

1.5.1 Literature Review

A literature review was undertaken to provide theoretical context and background information in order to:

- Explain the importance of sustainability
- Explain transport's role in sustainability
- Argue the importance and relevancy of public transport in meeting sustainability objectives and why the public transport planning approach was adopted in this thesis
- Explore theoretical concepts and principles involved in public transport planning
- Determine which concepts the base case and case studies will be evaluated against
- Review Sydney's past transport policies and practices
- Review case study's past transport policies and practices

The results of this review are interspersed throughout this thesis.

1.5.2 Case Studies

A comparative case study will look at another New Western World city in a similar circumstance to the base case, Sydney. The case study allows for detail and context. This comparison will be made with Toronto, Ontario, Canada. The selection and finalisation of the case study was based on several criteria:

- Availability of primary and secondary sources of information, particularly the use of the Internet and telecommunications in order to obtain data
- Having similarities with Sydney in urban form and planning policies as well as differences in terms of transport and planning policy
- The constraints on the length of the thesis, affecting the number of case studies or detail of analysis of each case study
- The author's familiarity with the case study city

Travel to Toronto was undertaken to conduct research for the literature reviews, conduct face-to-face interviews, and conduct field work observations and photography. A study trip was undertaken by the author to Toronto in order to physically experience the city's public transport offerings.

2 Background

2.1 Introduction to Sustainability

The concept of Ecologically Sustainable Development (ESD) or Sustainability is pervasive in planning theory and practice in the 21st century (e.g. Ward 2002, Freestone 2000, Hamnett 2000). However, the term "retains its novelty because people are still reluctant to embrace it" (Williams, 2007, p. 122).

The principles of sustainable development had its origins in the 1970s. However, the term 'sustainable development' was not coined until 1987, by the UN-established World Commission on Environment and Development (WCED), which had published *Our Common Future,* more commonly known as the Brundtland Report (Williams, 2007, p. 123). The WCED defined sustainable development as 'development that meets the need of the present without compromising the ability of future generations to meet their own needs' (WCED 1990, 87; cited by Williams, 2007, p. 123).

The Commonwealth of Australia later prefixed 'Ecologically' to Sustainable Development in its policies (Hamnett, 2000); cited by Williams, 2007, p. 124). Principles of ESD are to:

- Integrate environmental and economic goals in policies and activities
- Ensure that environmental assets are appropriately valued
- Provide for social equity within and between generations
- Recognise the global dimension
- Deal cautiously with resilience and irreversibility (Commonwealth of Australia 1990, 3-10; Williams 2007, 124).

Whilst the Commonwealth Government appears to have latched onto the ecological aspect of sustainability, the social and economic implications are just as integral. The need for sustainable development is the main motivation for this thesis.

2.2 The relationship between Sustainability and Transport

2.2.1 Social and Economic Sustainability

2.2.1.1 Transport as a Human Right

The following excerpt from the Universal Declaration of Human Rights (United Nations, 1948) that has the strongest relevance in the context of this topic:

> *Article 13.*
>
> *Everyone has the right to freedom of movement and residence within the borders of each state….*

Lucas (2004, p. 9) cited Bruton (1993, p. 13) who provided this summary of the role of transport in our society:

> *It influences the location and range of productive and leisure activities; it affects the location of residence; it influences the range and provision of goods and services available for consumption. It inevitable influences the quality of life.*

Lucas (2004) mused that from such a perspective, transport and mobility should therefore be seen as a stimulant for society. In its simplest terms, transport is needed for survival.

2.2.1.2 Transport Disadvantage

A major argument for public transport is its ability to improve social and economic sustainability by reducing transport disadvantage. A transport system that is sustainable must satisfactorily accommodate the needs of most if not all societal groups. For example, a city oriented towards private motor vehicle use clearly discriminates against those who cannot afford to drive as well as those physically unable to drive. Such societal groups therefore must rely on other modes, such as walking, cycling or public transport.

It is naive to suggest that inequality does not exist in our society – transport is no exception where there is a disparity amongst those within our society, thus resulting in social exclusion. The issue of social exclusion is widely covered by numerous academics including Lucas (2004), Dodson et al. (2006), Donaghy et al. (2005). Pickup and Giuliano (2005, p. 35) succinctly outlined three factors of social exclusion that could be influenced by transport planning:

- Poor access to services…
- Lack of hope: excluded people feel little hope for the future especially if barriers such as disability or health problems, lack of transport…limit the opportunities to work or participate in society…

- Polarised and fragmented communities…

This paper does not attempt to discuss the history, the issues or the concepts relating to social exclusion – nevertheless it is recognised that the need to overcome the problems of social exclusion in order to fulfil the aim of social sustainability.

Whilst the degree of transport disadvantage can be mapped spatially, there are several societal groups that are more likely to experience social exclusion or transport disadvantage (Dodson et al. 2006, 442; citing Denmark 1998, Wu & Hine 2003). These include (Dodson et al. 2006, p. 443; Pickup and Giuliano, 2006, pp. 44-45):

- Low-income earners – who may have difficulty in obtaining finance to own and maintain a car for transport
- Beneficiaries and/or unemployed – people dependent on social welfare or seeking work have limited social or employment opportunities due to poor accessibility stemming from poor public transport services, or not owning or being able to afford a car
- Children and youth – too young to drive and thus reliant on public transport services or adult drivers to seek social opportunities
- Women – more likely to be low-income or welfare-dependent or in casual/part-time employment and thus are more likely to travel outside peak commuting times when public transport may be minimal or non-existent
- Elderly – who may be unable to drive, living off a pension, or have limited physical mobility and are dependent on door-to-door motorised transport
- Disabled or physically ill – physical mobility is inherently limited, and exacerbated as they may be unable to drive, and transport services may not physically accommodate their needs (e.g. wheelchair-bound)
- Outer urban dwellers – those who live in areas that may be spatially isolated, have such low densities that transport planners see any transport service in such areas as 'not economically viable'
- Ethnic minorities – may have difficulty in obtaining information about transport choices or using public transport services due to language difficulties

Transport disadvantage can also appear be more subtly, rather than through specific societal groups. For instance, public transport in New Western World cities concentrates on meeting the intense demand during the commuter peak periods. During off-peak periods, service levels taper off or are negligible. This discriminates those who require transport during the off-peak,

nights and weekends, such as shift-workers, casual or part-time workers (who are already on low-income), students, children, and women (half the population).

2.2.2 Economic Development

As mentioned in 2.2.1.2, individual accessibility and mobility can be a significant determinant in improving quality of life. However, transport's relationship on economic sustainability can also be observed on a macro scale.

Banister (2002, p. 3) is one among many that have observed the close relationship between economic growth and transport demand. Technological improvements, particularly since 'Britain's railway revolution of 1830 to 1850' (Gilbert & Perl, 2008), have resulted in mobility revolutions, and economy repercussions. Conventional economic theory advocates investment in transport and technological advancements in transport as a means of increasing competition, arguing that "Transport negates the effect of space and enlarges the competing population of firms and households by bringing more people and products within reach of one another" (Low, 2003, p. 6). Under this theory, competition should result is more efficient use of limited resources and thus sustainability.

In more recent times, academics have questioned the overall sustainability of this relationship. As Low later explains (Low, 2003, p. 8), "overcoming space by technology is today stretching the capacity of the environment to absorb the wastes thereby produced" – i.e. the increased transport demand resulting from economic growth can itself be unsustainable once other factors are considered. 'Transport intensity' has been promoted as a means to measure this, as it uses the relationship between GDP and transport demand to ascertain the amount of economic growth achieved from each freight or passenger kilometre (Banister & Stead, 2002).

In order to work towards economic sustainability, the transport network must not just be supportive of economic growth, but such growth must also be able to use transport efficiently.

2.2.3 Environmental Sustainability

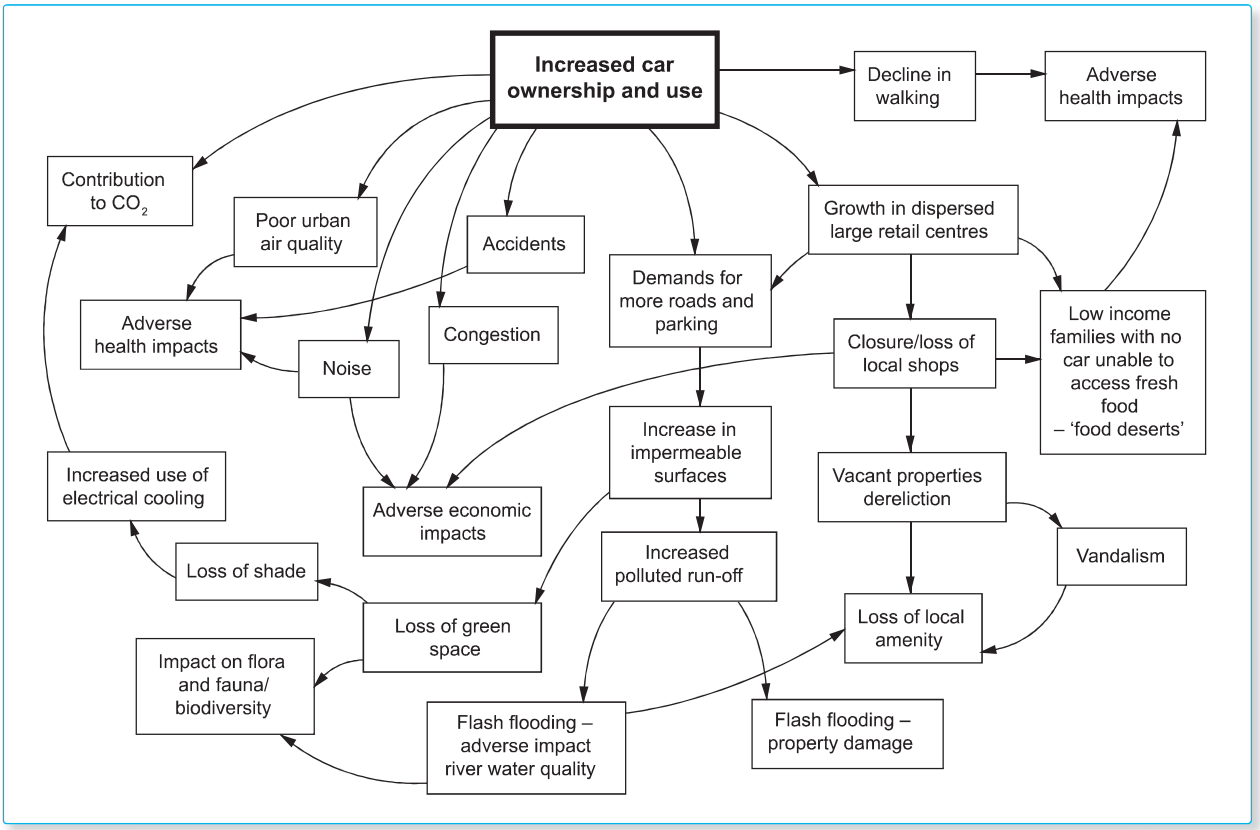
Environmental impacts of transport can be observed either on a local scale, or global scale (Low, 2003, pp. 12-15). Table 1 outlines how the environmental impacts of transport can effect sustainable development, whilst Figure 1 reflects the innumerable relationships between aspects of sustainability and transport. This thesis does not attempt to intensively explore the environmental impacts of different transport use, but it recognises that such impact must be minimised.

Table 1: Examples of Environmental Impacts of Transport

Scale	Impact	Consequences
Local	Noise Pollution	Poorer quality of life
Local	Air Pollution	Respiratory problems in humans and animals
Local	Water Pollution	Contamination of water supply, wildlife loss
Local	Urban form	Reliance on motorised transport, results in less walking and thus obesity
Local	Land Use	Destruction of wildlife habitats
Global	Energy Consumption	Dependence on finite sources of energy can result in major problems when temporary or permanent shortages arise
Global	Greenhouse Gas Emissions	Climate Change

(Low, 2003) (Gilbert & Perl, 2008) (Banister, 2002)

Figure 1: An example of the web of interconnectedness and sustainability's sensitivity to transport policy



(Royal Commission on Environmental Pollution, 2007) cited by (Gilbert & Perl, 2008)

2.3 Approaches to Planning for Sustainable Transport: ITLUP and ITP

The aim of this thesis does not specifically imply the need to evaluate the minutiae of transport planning, such as transport planning models, which also verge on transport engineering. The priority of this thesis is the importance of the people that we plan for and the behaviour of those people.

2.3.1 Integrated Transport and Land Use Planning (ITLUP)

ITLUP can be considered to be the more proactive, demand-led approach to planning for sustainable transport. The consensus amongst professionals appears to be that there is a strong relationship between urban form and sustainable transport practices does exist in cities worldwide. Under this approach, managing urban form is the main tool for planners to encourage demand for sustainable transport; various aspects are outlined below.

2.3.1.1 Land Use Planning and Urban Density

2.3.1.1.1 Description

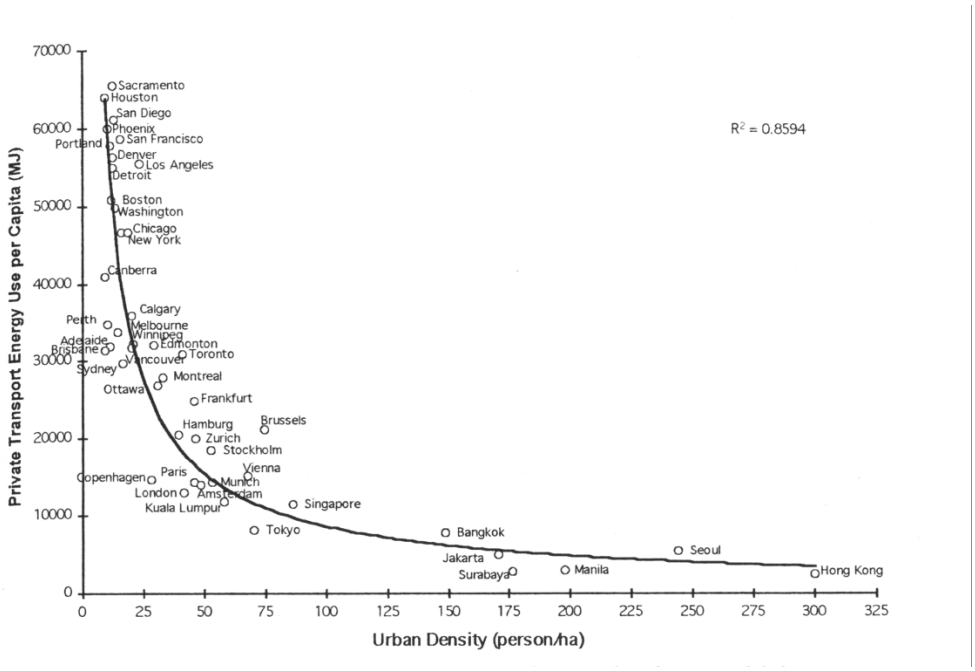
Newman and Kenworthy (1996, 1999) are considered pioneers in identifying trends between urban form and travel choices that can be identified based on aggregated data. Having collected data from several dozen cities from around the world, they were able to identify that lower urban density equated to high automobile use and that the pattern grew exponentially, as shown in Figure 2. This trend has not gone unnoticed by other academics. Giuliano and Dargay (2006) published results of their comparative study of land use and travel in the United States compared to the United Kingdom. Their research showed a similar trend trends: that higher urban density in the UK resulted in shorter travel distances and lower car ownership than the US.

Theoretically, dispersed land uses can also equate to lower densities, as 'dispersed' implies low intensity and scattered land use activity. However, in Australian cities, while suburban development may be of low density, the land uses are not necessarily dispersed. The urban morphology of Sydney reveals that it has gradually grown in concentric rings away from the CBD. This differs from US cities where lax planning controls have led to not just lower densities, but more scattered urbanisation separated by informal agricultural green belts, supported by a web of freeways.

Generally, dispersed land uses refer to the decentralisation of employment as well housing, making it more difficult to provide high quality public transit viably. As shown in Figure 1,

amongst three New Western World countries, Canadian Cities has greater centralisation of population and jobs in the inner city, and the lowest car use and highest public transport use.

Figure 2: Energy use per capita in private passenger travel versus urban density in global cities 1990



(Newman & Kenworthy, Sustainability and Cities: Overcoming Automobile Dependence, 1999, p. 101)

Table 2: Land Use Distribution and Travel Demand 1991

	Land Use Distribution by Distance from CBD								**Travel Demand**	
	Central City		*Inner Area*		*Outer Area*					
	Pop/ha	Jobs/ha	Pop/ha	Jobs/ha	Pop/ha	Jobs/ha	*% of pop in CBD*	*% of jobs in CBD*	*Car Use (pass. kms) per Capita*	*Public Transport Trips per Capita*
Australian cities average	14.0	363.7	21.7	26.2	11.6	3.6	0.2	14.5	10797	92
US cities average	50.0	429.9	27.2	27.2	11.8	6.2	0.8	10.5	16045	63
Canadian cities average	37.9	354.6	43.6	44.6	25.9	9.6	1.4	19.7	9290	161

(Newman, Kenworthy, & Bachels, 2001, pp. 46, 54-55)

2.3.1.1.2 Weakness

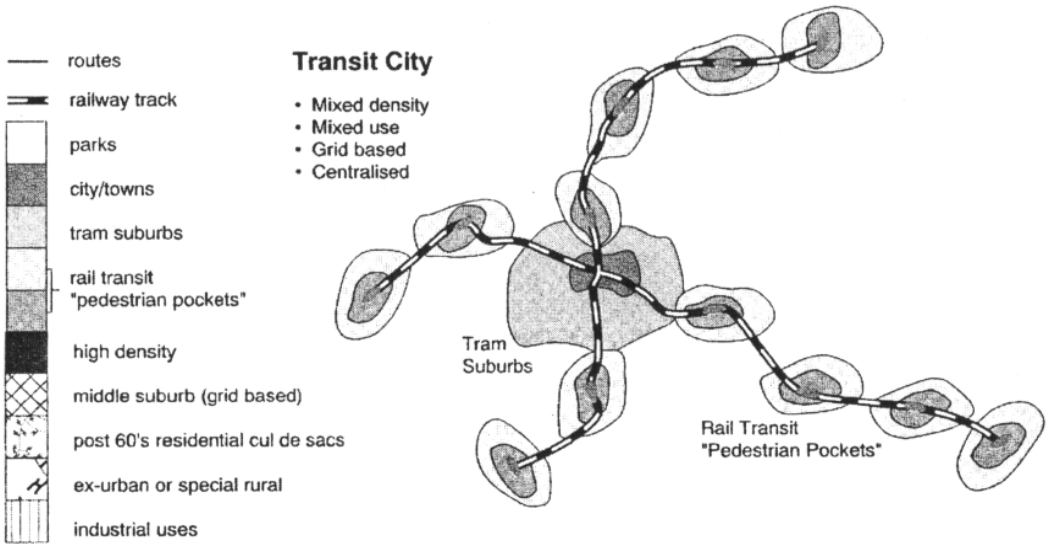
Pund (2001) has criticised some of Newman and Kenworthy's conclusions in regards to the urban form and travel choice debate (although not their efforts). Pund (2001, p. 75) supports Kirwan (1992) who stated that "they [Newman and Kenworthy] have relied heavily on basic correlations and avoided multivariate analysis." According to Kirwan (1992, as cited by Pund, 2001, p. 75), Newman and Kenworthy had contradicted 'two fundamental principles of strategic analysis': firstly, that they include 'a robust model' to avoid 'spurious conclusions' and secondly, "the impossibility of deducing complex patterns of interaction from simple correlations."

2.3.1.2 Neighbourhood Design

2.3.1.2.1 Description

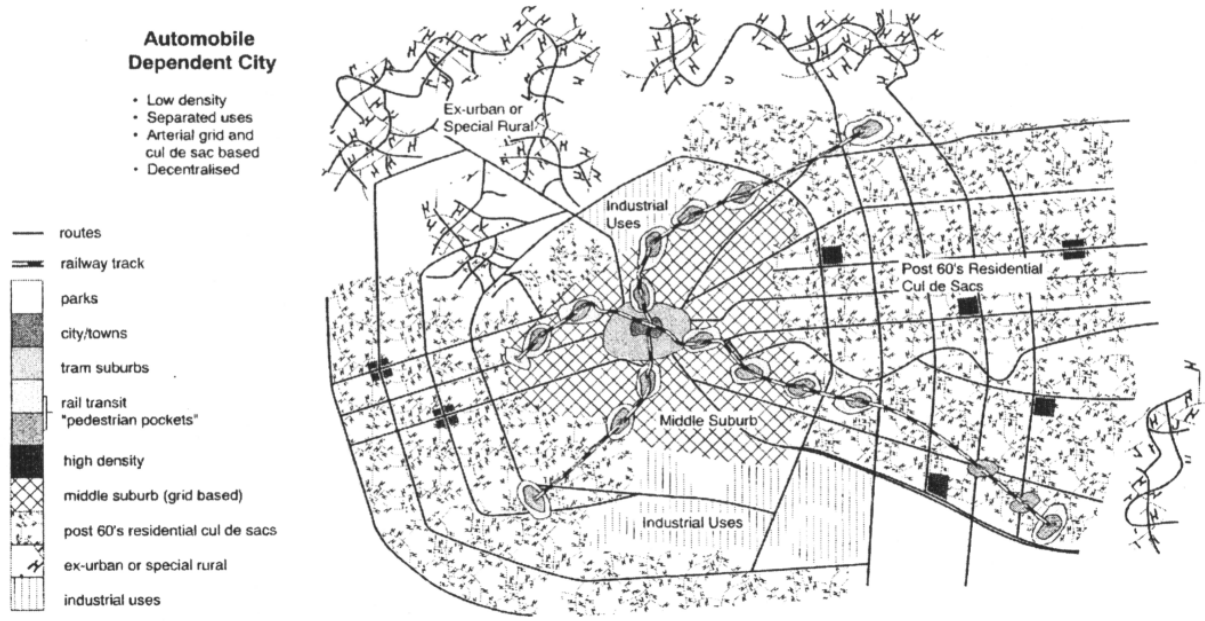
Early suburbs have two distinguishing features compared to post-war suburbs: firstly, they are centred on a public transport node such as a railway station or an at-grade transit route; secondly, priority is given to access of such node. This is reflected in Newman and Kenworthy's (1999, p. 29) 'Transit City' scenario (Figure 3) or Muller's 'Electric Streetcar Era' (2004, p. 62). The traditional transit suburb (see Figure 4) was forgotten for the latter half of the twentieth century as private automobiles and detached housing became more affordable.

Figure 3: The Transit City



(Newman & Kenworthy, 1999, p. 29)

Figure 4: The Automobile Dependent City



(Newman & Kenworthy, 1999, p. 31)

The early 21st century has seen a revival of traditional neighbourhood design (TND) under the banner of 'new urbanism'. Crane (1996, p. 51) summarised the aim of the new urbanism movement as "establishing the sense of community that is often missing in newly developed neighbourhoods, to be accomplished largely by mixing land uses and getting people out of their cars and onto the street".

2.3.1.2.2 Weakness

Robert Cervero, of the University of California in Berkeley, is a frequent commentator amongst many on the impact of neighbourhood design and location upon travel choices. For example, he has featured San Francisco Bay Area for the purposes of comparing pre-war and post-war suburbs (or at least urban form based on such eras). Cervero and Radisch (1996, p. 141) remarked that only "having nice sidewalks, attractive landscaping, and other pedestrian amenities in a low-density, residential-only neighborhood is unlikely to prompt many residents to walk to shops and stores"; a fully integrated approach was required – "density, diversity and design". Later, Cervero and Duncan's (2003) results (p. 1482) showed that that "although well-connected streets, small city blocks, mixed land uses, and close proximity to retail activities were shown to induce nonmotorized transport, various exogenous factors, such as topography, darkness and rainfall has far stronger influences."

In Crane's (1996, p. 62) analysis of new urbanism, his first concern was of the potential for such design to generate more trips across all modes including car trips. His concern lay in the overestimation of urban design's ability to reduce automobile dependence (p. 62). Furthermore, the affect of Neo-traditional neighbourhoods is likely to be severely hindered by the ad-hoc implementation over a metropolitan area, where destinations or access to them may still be favourable to cars. Greenwald (2003, p. 52) has confirmed using statistical analysis, some of Crane's concerns, commenting that "New Urbanist philosophies should not be considered a panacea for all transportation ills" and that "transit substitution for automobile usage is not strong" although walking substitution is.

Planners and developers attempting to implement TND on brownfields sites or in existing suburbs, may also encounter resistance from nearby residents, who "fear greater traffic congestion, shortages of on-street parking, greater noise and air pollution, lower property values of nearby single-family homes, overloading of public facilities such as parks and schools, and the introduction of "undesirable people"" (Downs, 2004, p. 224). Furthermore, the property market is only gradually seeing TND as a desirable attribute (see Figure 5). The following quote in Albany's (NY) Times Union (Vielkind, Nearing, & Churchill, 2008) reflects the mood across much of the New World: "Development patterns may not change quickly, if at all... The appeal of the suburbs remains powerful, offering the American Dream trifecta: a single-family home with good schools and low crime."

Figure 5: New Urbanism at Ellenbrook, on the urban fringe of Perth, Western Australia; features single-storey detached dwellings and with ample on-street parking (with off-street parking accessible from the rear of properties) to satisfy the tastes of the Perth property market

Ong, V. 2008.

2.3.2 Integrated Transport Planning

ITPO is a more reactionary approach involving adapting the supply of transport capacity across any mode, in order to meet the transport task (demand).

Since the 1950s, the transport planning model (TPM) "has been the bedrock upon which analysis has taken place. Its value has been its ability to examine the city and region at the aggregate level and to establish relationships between a given land-use pattern and travel." (Banister, 2002, p. 131). However, the TPM also had significant limitations; most of the following outlined by Hutchinson (1981, cited by Banister 2002, 137):

- The TPM was biased in the expansion of road supply, and did not consider that such expansion encouraged further use of cars and encouraged longer trips
- Public transport demand is not only constrained by car ownership, but also employment concentration near public transport, parking capacity and parking costs.
- Dimensions of transport demand are "dictated by factors external to the transport sector such as the housing market, household structure and income, and employment location decisions".
- "There is a great uncertainty in the social, economic and technical environment of transport systems, and transport plans must be sufficiently robust and adaptable to changes..."
- "... making plans on the basis of extrapolated trends it not planning. It is a set of activities that encourages present trends regardless of the direction in which they lead. Such planning can therefore lead in undesirable or infeasible directions" (Vuchic, 2005, p. 475)

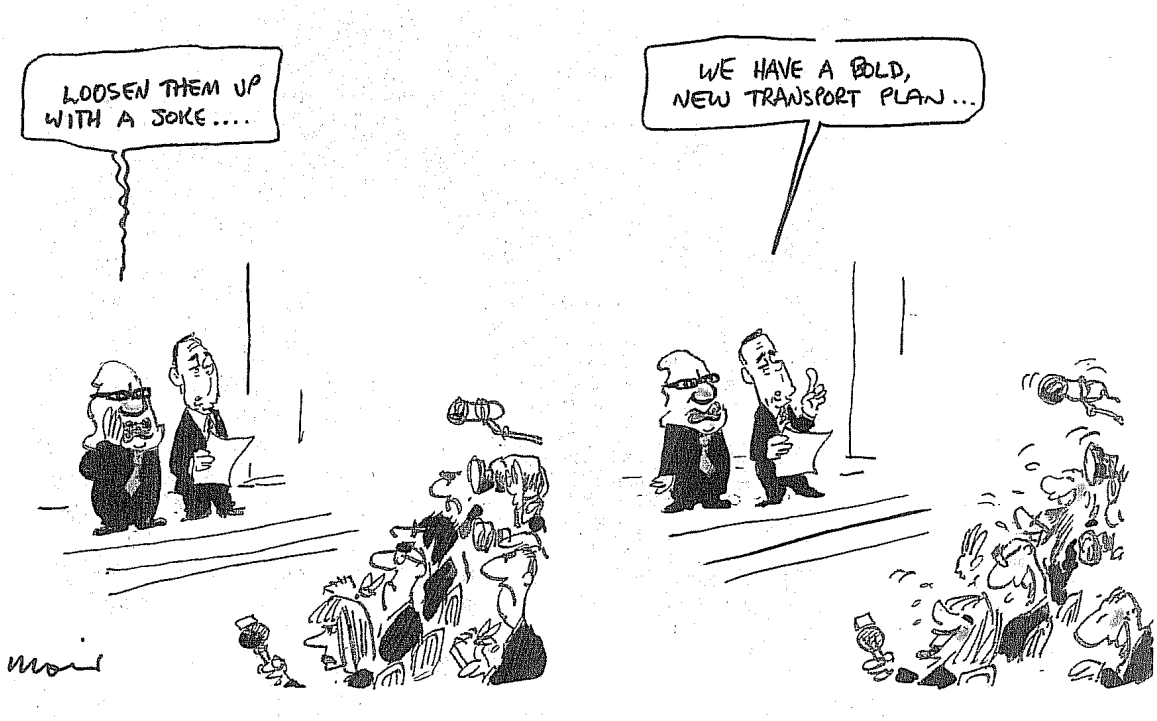
The rise of the sustainability as a policy objective has clouded the effectiveness of the TPM and its successors. According to Banister, there are three arguments for a 'renaissance' in transport planning:

- Stability in decision-making remains essential, so that "decisions can be made with some certainty" (Banister, 2002, p. 161). Therefore, transport planning remains a necessity.
- Increasing road supply to meet forecast increases in traffic is futile due to induced demand and inability to dramatically increase supply; thus demand management will take centre stage (Goodwin et al. 1991, p. 111), cited by (Banister, 2002, p. 161).
- "As affluence increases, other factors related to quality [of life] and environmental responsibility become more important... the imperative to predict the growth in demand

and the overriding importance of economic factors in assessment now becomes less dominant." (Banister, 2002, p. 162).

The renaissance has been accepted by other commentators in the field as the pursuit of sustainability gains traction – e.g. (Whitelegg & Low, 2003).

Figure 6: Transport Planning remains a subject of ridicule



Sydney Morning Herald, 2008, May 5.

2.4 Why focus on Integrated Public Transport Planning and Operations (IPTPO)?

Comparing cities in the developed world, those in the New Western World (North America and Australasia) have much lower public transport use by mode share of trips and distance travelled (see Table 3 below). Whilst it can be seen that land use characteristics vary immensely between each grouping and suggests that it can determine public transport use, Section 2.3.1 revealed that better land use planning is not a panacea for encouraging sustainable transport use.

Table 3: Land Use and Mode Share by Location of Groupings of Cities, 1995

	Australia and New Zealand	***USA***	***Canada***	***Western Europe***	***High Income Asian Countries***
Land Use					
Urban Density (persons/ha)	15.0	14.9	26.2	54.9	134.4
Proportion of Jobs in the CBD	15.1%	9.2%	15.7%	18.7%	20.1%
Mode split of all trips					
Non-motorised modes	15.8%	8.1%	10.4%	31.3%	29.1%
Motorised private modes	79.1%	88.5%	80.5%	49.7%	38.6%
Motorised public modes	8.1%	3.4%	9.1%	19.0%	32.3%
Proportion of total motorised pass-km on public transport	7.5%	2.9%	9.8%	19.0%	50.3%

(Kenworthy and Laube 2001), cited by (Barter, Kenworthy, & Laube, 2003)

Integrated Public Transport Planning and Operations (IPTPO), as implied by this thesis, involve strategies that attempt to utilise public transport both from a strategic planning and everyday operations perspective. Therefore, IPTPO should be considered as part of the transport planning renaissance (see 2.3.2) for the following reasons:

- The ability to plan and manage public transport provides greater certainty in planning outcomes than increasing road supply.
- Public transport use is more sustainable than private motor vehicle use.
- Whilst increasing public transport supply is neither sustainable nor logical as a demand management tool, public transport can be used to absorb the spill over demand for road space and attempt to better utilise existing transport infrastructure.

The following sections and describe two recent sustainability issues where IPTPO can provide a response within a short time-frame.

2.4.1 Greenhouse Gas Emissions and Climate Change

Climate Change refers to the change in the earth's climate as a result of the "enhanced greenhouse effect" (UNFCCC, 2008b). According to the United Nations Framework Convention on Climate Change, "The average temperature of the earth's surface has risen by 0.74 degrees C since the late 1800s. It is expected to increase by another 1.8° C to 4° C by the year 2100 - a rapid and profound change - should the necessary action not be taken. Even if the minimum predicted increase takes place, it will be larger than any century-long trend in the last 10,000 years (UNFCCC, 2008a). Current evidence of Climate Change, as well as future effects are outlined in Table 4.

Table 4: Impacts of Climate Change, based on UNFCCC website (italicised points are direct quotes

Current Evidence	Future Effects
➢ Heavy rainfall events occurring with increasing frequency, resulting in flooding ➢ Longer droughts and increasing desertification ➢ *Average Arctic temperatures increased at almost twice the global rate in the past 100 years* ➢ *Snow cover has declined by some 10 per cent in the mid- and high latitudes of the Northern Hemisphere since the late 1960s.* ➢ *The average global sea level rose at an average rate of 1.8 mm per year between 1961 and 2003, but between 1993 and 2003 it rose by 3.1 mm per year.* ➢ *Almost all mountain glaciers in non-polar regions retreated during the 20th century.* ➢ *Scientists have observed climate-induced changes in at least 420 physical processes and biological species or communities.*	➢ Changes in climate ➢ *A future of more severe storms and floods along the world's increasingly crowded coastlines is likely, and will be a bad combination even under the minimum scenarios forecast.* ➢ Salt water intrusion will reduce quality and quantity of fresh groundwater supplies ➢ Snow cover contraction and glacier retraction ➢ Food supply disruptions due to changed precipitation distribution ➢ *Most of the world's endangered species may become extinct - some 25 per cent of mammals and 12 per cent of birds* ➢ Expansion in range of some dangerous "vector-borne" diseases that currently only exist in tropical regions ➢ *Nature will be more vulnerable than previously to changes in climate* due to human-induced environmental damage. ➢ *Similarly, the world's vast human population, much of it poor, is vulnerable to climate stress. Millions live in dangerous places -- on floodplains or in shantytowns on exposed hillsides around the enormous cities of the developing world.*

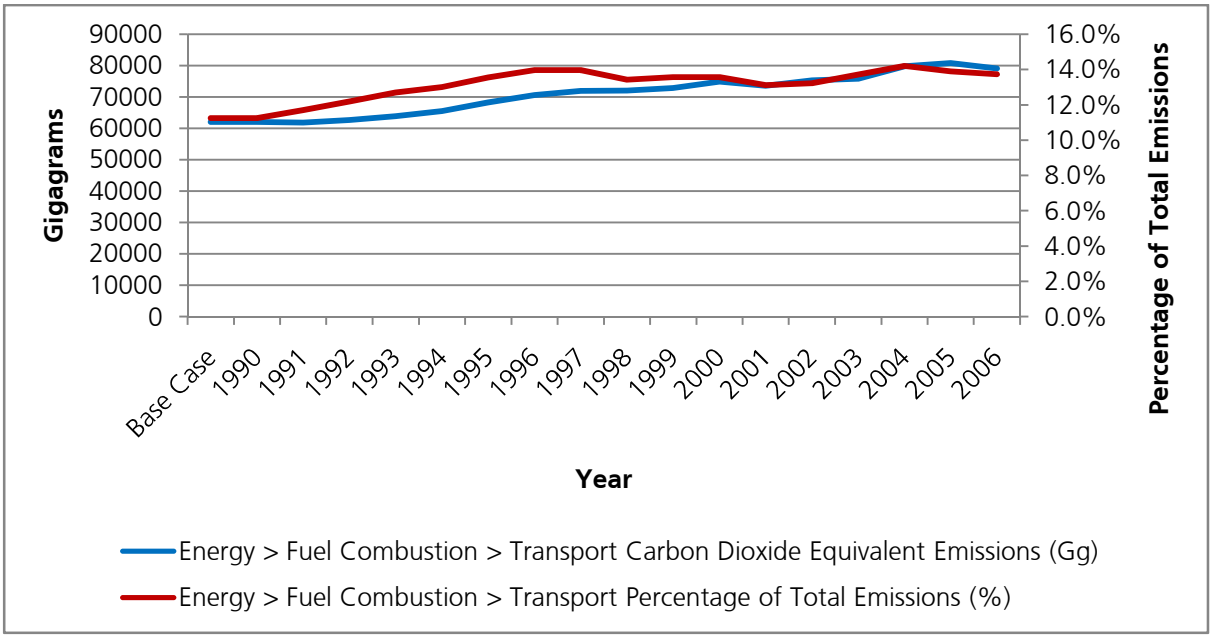
(UNFCCC, 2008c) (UNFCCC, 2008d)

The Intergovernmental Panel on Climate Change (IPCC) was established by in 1988 by the World Meteorological Organization (WMO) and by the United Nations Environment Programme (UNEP) as "to provide independent scientific advice on the complex and important issue of climate change" (IPCC, 2004, p. Foreword). The IPCC's first report, released in 1990 concluded that the IPCC was certain that "emissions from human activities are substantially increasing the atmospheric concentrations of greenhouse gases and that this will enhance the greenhouse effect and result in an additional warming of the Earth's surface" (IPCC, 2004, p. 3).

The significance of human-induced climate change has only recently gained acceptance amongst the majority of the Australians. As recently as April 2007, former Prime Minister John Howard believed that "to say that climate change is the overwhelming moral challenge for this generation of Australians is misguided at best and misleading at worst" (AAP, 2007). It was only after a change in government in November 2007 that the Department of Climate Change was established (Department of Climate Change, 2008b).

The absolute amount of greenhouse gas emissions resulting from energy consumption by civil transport in Australia has grown by 27% from 1990 to 2006; similarly, transport's share of total emissions has also increased by 22% over the same time period. Meanwhile, total greenhouse emissions from all Australian sources grew by only 4% (see Figure 7 for absolute values).

Figure 7: Australian Greenhouse Gas Emissions Resulting from Transport



(Department of Climate Change, 2008a, pp. 30-31)

Most studies have found that transit creates fewer emissions on a per-passenger kilometre basis (Pucher, 2004, p. 211; Legacy, Glover, & Low, 2007). Lenzen (1999) attempted to consider all direct and indirect requirements resulting in greenhouse gas emissions, including 'fuel production (coal, oil and gas extraction, oil refining, gas distribution, electricity generation), from operating and capital expenditure of transport industries and private households (purchase of vehicles, maintenance, administration labour, etc), and expenditure of the general government on the transport system (construction of roads, railways, airports, seaports, etc)' (pp. 271-272). His results in Table 5 also take into account average loading of each vehicle, not the maximum theoretical loading. This is important assumption as "transit's relative environmental advantage is greatest on heavily used routes... buses with one or two passengers... are more polluting than most cars" (Pucher, 2004, p. 211).

Table 5: Greenhouse Gas Intensity by Urban Transport Mode for Direct and Indirect Requirements, based on Australian data

	Greenhouse Gas Intensity (kg of Carbon Dioxide-equivalent per passenger km)		
	Fuel (direct and indirect fuel requirements)	**Operating requirements** (operator's and common)	**Total**
Urban			
Light rail, public	0.13	0.07	0.20
Bus, public	0.15	0.07	0.22
Ferry, public	0.32	0.12	0.44
Bicycle (low use estimate)	0.10	0.05	0.15
Bicycle (high use estimate)	0.10	0.03	0.13
Heavy rail, public	0.17	0.10	0.27
Average, urban	*0.16*	*0.07*	*0.23*
Urban + Non-urban			
Private car, petrol	0.21	0.14	0.35
Private car, diesel	0.24	0.14	0.38
Private car, LPG	0.22	0.14	0.36
Average, private car	*0.22*	*0.14*	*0.36*
Bus and coach, private	0.09	0.05	0.14
Average, urban+non-urban	*0.19*	*0.12*	*0.31*

(Lenzen, 1999, pp. 276-277)

Interestingly, modelling of the impact of different policy responses in Sydney in one case so far suggests that doubling bus frequencies or halving transit fares result in very modest reductions in emissions (.016 and 0.42% respectively), compared to 25% improvement in fuel efficiency reducing emissions by 21.26%; however the latter comes at a cost of 4.8% increased passenger vehicle (car) kilometres car, resulting in the undesirable side effect of increased traffic congestion (Hensher, 2008).

2.4.2 Energy Consumption and Peak Oil

"Some 95% of the fuel used for transport is... made from crude oil."

"The oil used for transport represented about 58% of all end uses of oil products in 2004."

"Transport comprised a higher share of oil use in North America (71 per cent) and in Europe (61 per cent) and a lower share in almost all of the rest of the world."

(Gilbert & Perl, 2008, pp. 120-122).

Table 6 below demonstrates the amount of energy used on a per capita basis based on approximately 40 global cities and illustrates the dependence on oil-based fuels for transportation, particularly in the New World (North America and Australasia).

Table 6: Transportation Energy Use per Capita in Global Cities, 1990

Country/Continent	Private Transportation			Public Transportation			Total Transportation Energy (MJ)
	Gasoline (MJ)	*Diesel (MJ)*	*% Private of total*	*Diesel (MJ)*	*Electricity (MJ)*	*% Public of Total*	
American Average	*55807*	*7764*	*99*	*650*	*129*	*1*	*64351*
Australian Average	*33562*	*4970*	*98*	*764*	*159*	*2*	*39456*
Sydney	29491	4481	97	776	326	3	35074
Canadian Average	*30893*	*6538*	*97*	*1057*	*163*	*3*	*39173*
Toronto	30746	1058	95	1286	523	5	33613
European Average	17218	7216	95	604	653	5	25692
Asian Average	6311	5202	89	1202	148	11	12862

(Newman & Kenworthy, 1999, pp. 70-71)

A major concern with respect to the worldwide production of oil is the concept of 'peak oil', when the global production or extraction of oil has peaked. Debate is vigorous on when the peak will take place as well as the severity of the peak. The Bureau of Transport and Regional Economics (2005, p. 31) summarised both sides thusly:

"In essence, depletionists maintain that oil prices will rise dramatically after the 'low hanging fruit' has been exhausted and hence governments should embark on preparatory action. The antidepletionists do not deny the existence of diminishing returns, as the industry moves from larger to smaller deposits and from better to poorer quality oil. However, they point to the fact that, to date, this has been offset by improved knowledge and advances in science and technology generally."

Assuming the 'depletionists' are correct, the peaking of oil production will occur within the next 5 years if not already; however the peak is unlikely to be obvious until well after the peak takes place (Greene, 2004). Documentaries such as 'The End of Suburbia' (Greene, 2004) and 'A Crude Awakening' (Gelpke, McCormack, & Caduff, 2006) have also revealed severe

consequences of oil dependence for agriculture. As supply declines, demand for transport fuels could become subordinate to demand for oil-based pesticides and fertilisers (Potts, 2008). Furthermore, the depletionists point out that five years is not enough time to develop new technologies or alternative fuels to maintain current levels of oil dependence and energy consumption (Kunstler, Heinberg, Ruppert, recorded by Greene, 2004). The following quotes on the two most popular alternative fuels have been transcribed from 'The End of Suburbia' (Greene, 2004).

The Hydrogen Myth

"Hydrogen is a joke. It is a myth. We will not have a hydrogen economy. Hydrogen is not a form of energy; it is a form of energy storage. And all hydrogen now is produced from some other substance which requires the input of energy... You also have to look at infrastructure requirements. 600 million internal-combustion engines on the planet... Who's going to build the hydrogen cars? Somewhere around 90 barrels of oil goes into the energy to make one car..." – Michael C. Ruppert, From the Wilderness Publications

"It's fabulous because you only have to have electricity and water. Well, to have electricity you have to have some other form of energy. The single easiest way to create hydrogen is methane. Methane is just a scientific term for natural gas. So in a world that we're [also] short of natural gas, the last thing we need is a brand new user." – Matthew Simmons, Energy Investment Banker.

The Cost of Ethanol

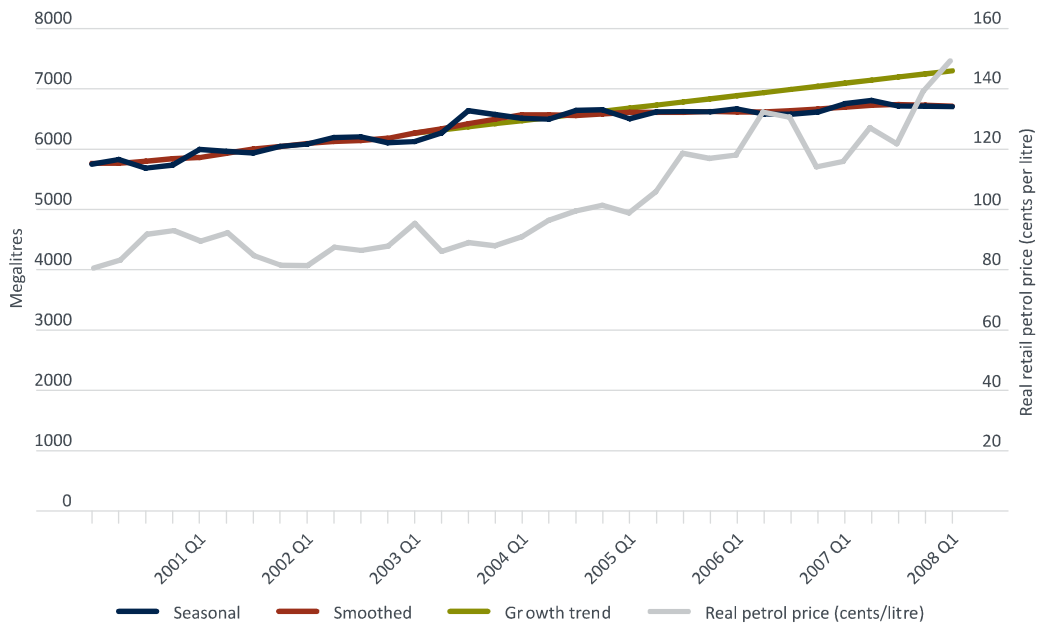
"Ethanol is a net energy loser. It takes more gasoline to create and fertilise the corn and convert it to alcohol than you'd get from burning it." – Michael C. Ruppert

Regarding, plant-based ethanol as an alternative to oil: *"It's mathematically and agriculturally impossible. There isn't enough land to do it. Even if we were to become happy, as we unfortunately are, to turn it entirely to corn ethanol, we probably then wouldn't have much, possibly no land left for growing our food."* – Julian Darley, author 'High Noon for Natural Gas'

Irrespective of peak oil, the New World is extremely economically and politically sensitive to fluctuations in oil supplies and prices. Governments remain in tight-lipped about their willingness to counter petrol price increases: as Economics writer Ross Gittins (2008) remarked, "There's little the politicians could or should do to reduce prices, but you simply can't get them to admit it... small cuts in petrol taxes would cost a fortune... and with prices changing so often, the relief they offered motorists would be forgotten within days".

In July 2004, the Australian retail price of transport fuels first broke the psychological barrier of $1 per litre in the third quarter of 2004 and has not fallen below this price since (Australian Bureau of Statistics, 2004) (Bureau of Infrastructure, Transport and Regional Economics, 2008). Since April 2008, the price of petrol in Sydney plateaued at ~$1.40 per litre (Caltex Australia Petroleum, 2008). As seen in Figure 8, record high fuel prices have partly resulted in a decline in consumption; the United States has also experienced a similar decline (Bureau of Infrastructure, Transport and Regional Economics, 2008).

Figure 8: Australian petrol/LPG/car-diesel fuel use and retail petrol price



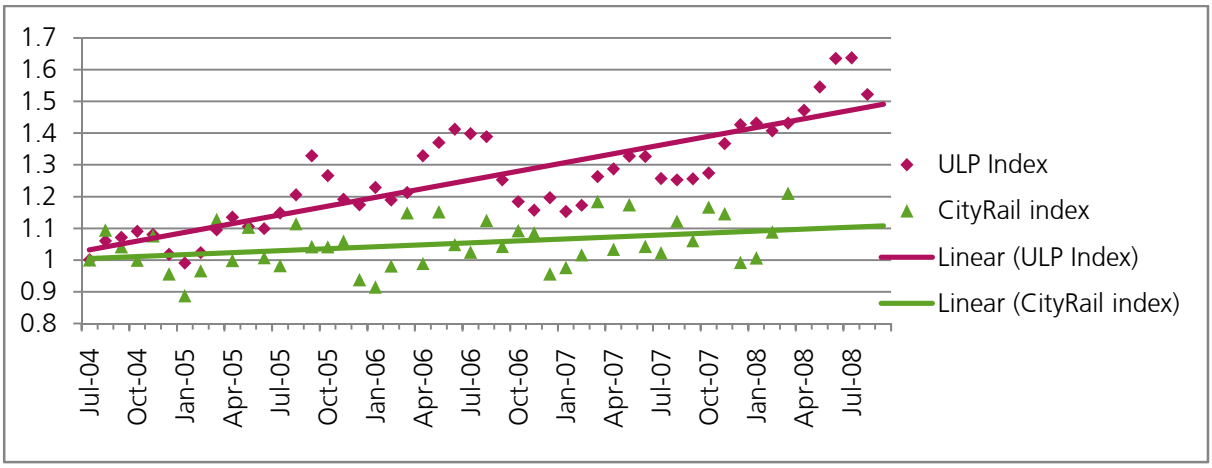
Source: ABARE Mineral Statistics (various quarters).

(Bureau of Infrastructure, Transport and Regional Economics, 2008, p. 6)

Commuters in the US have also responded to increasing fuel prices by choosing to use public transport, with the American Public Transportation Association reporting that public transit patronage increased by 5.2% in the second quarter of 2008 compared to the same quarter in 2007, and that 2007 saw the highest number of transit trips in 50 years (American Public Transportation Association, 2008b). This has resulted in congestion as "six out of ten (63 percent) are experiencing capacity problems during the peak period" and that "almost all agencies responding (91 percent) report they are facing limitations in their ability to add service to meet increased ridership demands." (American Public Transportation Association, 2008c). The Australian media have also reported record patronage on public transport systems over the last year (Besser & Burke, 2008; Sexton, 2008). Figure 9 reflects growth in the average monthly

retail price of unleaded petrol in Sydney leading the growth in monthly patronage on Sydney's suburban rail network (CityRail).

Figure 9: The Relationship between growth in Retail Unleaded Petrol Price in Sydney and CityRail Monthly Patronage. Index values and trend lines shown. June 2004 = 1



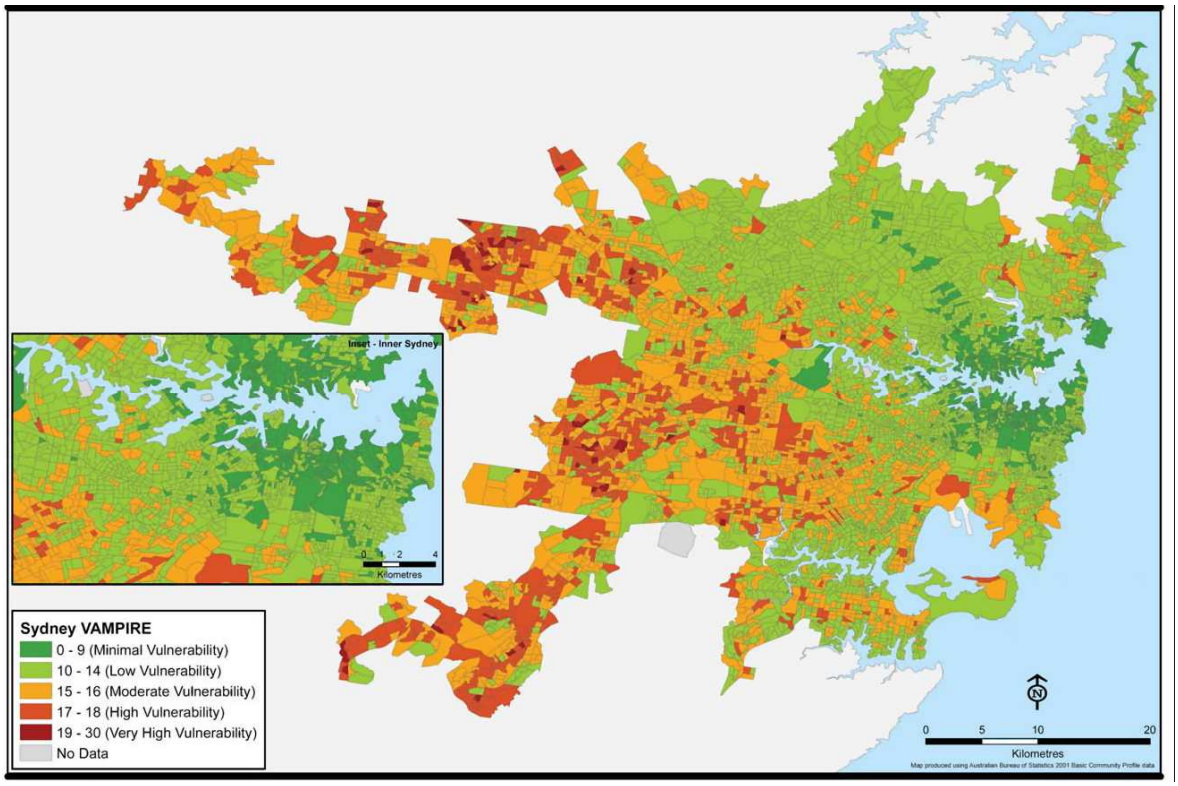
(Caltex Australia Petroleum, 2008) (Rail Corporation New South Wales, 2008)

As of October 2008, the price of crude oil fell from a record of US$147 in July 2008 to US$72 per barrel (Bloomberg, 2008). The decline in the crude oil price has coincided with falls in the value of the Australian dollar (Davies, 2008). Whilst the possibility of lower prices in the future cannot be precluded, expectations that the Australian dollar will remain below 75 US cents to the end of 2009, from a peak of 98.5 cents in July 2008 (Bloomberg News, 2008), suggested that the retail price of fuel in Australia falling dramatically is unlikely in the next year or two. The possibility of oil production cuts (Bloomberg, 2008) and lingering threat of force majeure events such as natural disasters, only serve to undermine any stability in the price of transport fuel. Furthermore, in the US where the retail price of fuel has dropped by approximately 70 US cents per gallon (18.5 US cents per litre), "the sour economy is prompting them to stick to their new fuel-efficient ways" and at these prices it still "isn't low enough to return to their old ways" (Campoy, 2008). Adding to fuel price concerns is the looming financial crisis, dubbed by Australian Prime Minister Kevin Rudd on 14 October 2008 "as the worst financial crisis in our lifetime... the economic equivalent of a national security crisis." (Rudd, 2008). Pessimism due to the financial crisis has driven retail fuel prices to the $1 per litre range as of December 2008; however this drop is likely to be a short-term phenomenon.

Academics Dodson and Sipe (2008) created the 'Vulnerability Assessment for Mortgage, Petrol and Inflation Risks and Expenditure' or VAMPIRE index which "combines information on car dependence, mortgages and incomes at the Collection District (CD) level" to understand and map such vulnerability (Dodson & Sipe, 2008, p. 12). Results for Sydney's suggest that "41

percent [of CDs] saw their oil and mortgage vulnerability worsen during between 2001-2006" (Dodson & Sipe, 2008, p. 28). The slower economic growth and higher unemployment (Rudd, 2008) and mortgage repossessions (Dodson & Sipe, 2008) will only cause the situation for the vulnerable to deteriorate. It is worth noting that the most vulnerable areas of the Sydney metro are those located in working class areas, far from the Sydney CBD, and away from fixed mass transit. Lastly, as shown in the Table 7 below, public transport modes remain more energy efficient than private transport modes.

Figure 10: Sydney VAMPIRE Map



(Dodson & Sipe, 2008, p. 16)

Table 7: Comparisons of Energy Use per Passenger-Kilometre for Different Transport Modes (in Megajoules)

	USA		Australia	Western Europe
Transport mode	**ORNL (2001)**	**Kenworthy (2002)**	**Lenzen (1999)**	**Kenworthy (2002)**
Car	3.8	3.3	4.4	2.5
Personal truck	4.8	NA	NA	NA
Transit bus	5.1	2.9	2.8	1.2
Light-rail transit	3.3	0.7	2.1	0.7
Metro (heavy rail)	3.3	1.7	NA	0.5
Suburban rail	3.1	1.4	2.8	1.0

Based on (Pucher, 2004, p. 210)

2.4.3 Conclusion on Peak Oil and Climate Change

A survey of the National Association of Home Builders (of the USA) revealed that 51% of builders had no plans to change where and how they would build houses in response to high fuel prices. Furthermore change in urban form would take time: "There are 80 million single-family-homes in the country... People are not going to abandon them or convert them into two-family homes..." (El Nasser, 2008). Similarly, the Toronto Star declared that the 'sea change' in planning principles "after more than 50 years of unparalleled suburban growth... doesn't come easy" (Gombi, 2008).

Dodson and Sipe (2008) have encouraged investing in public transport to overcome areas of oil vulnerability that have been revealed through VAMPIRE. Citing Dodson (2008), Dodson and Sipe (2008, p. 40) argue that "development timeframes are too slow and unresponsive to provide rapid and comprehensive re-development of outer suburban areas" and due to higher land values, developers will always remain attracted to building higher-density development in higher value, inner-urban areas. Therefore, "a more effective response to suburban oil vulnerability than current planning approaches would be to improve public transport services to match the quality found in inner and middle suburban areas" (Dodson & Sipe, 2008, p. 40).

In the United States alone, the relatively low transit mode share (Table 3) still saves almost 160 billion litres of petrol and 37 million tonnes in carbon dioxide emissions annually (American Public Transportation Association, 2008a). Therefore, considering social, economic and environmental sustainability (Section 2.2), and the need for an immediate response to climate change and peak oil concerns, improving existing public transport provides an ideal and politically-expedient alternative with a relatively short lead time.

3 Case Study Profiles

3.1 Selection of Case Studies

3.1.1 Why was Sydney, Australia, selected as the base case?

Firstly, Sydney was selected as the base case as it is the home town of the author who already possesses an understanding of transport in the city and is familiar with the data resources available to examine Sydney in detail.

Secondly, this thesis has been prepared to fulfil the requirements of the Bachelor of Planning degree at the University of New South Wales, which is located in the Sydney metropolitan area. The audience is likely to be academics or professionals that are familiar with and reside in Sydney, Australia. Thus it is anticipated reader is likely find professional or personal relevancy in a Sydney base case.

3.1.2 Why was Toronto, Canada selected for comparison?

Toronto has numerous planning-related, historical, cultural and economic similarities to Sydney, making it an ideal candidate for comparison to Sydney:

- Both Australia and Canada are both first world, high-income economies (The World Bank Group, 2008);
- Both Sydney and Toronto are the most populated cities in their respective countries (Australian Bureau of Statistics, 2008c; Statistics Canada, 2007d);
- Both Sydney's and Toronto's European heritage is a result of British colonisation and thus urban development in both countries reflect the British heritage (Aplin, 2000; Hayes, 2008);
- Like Australia, Canada occupies the middle ground amongst developed countries between the two extremes: of the high car dependence of the United States, and high public transport use of Western Europe (Table 3).

Of academic interest, is the high regard in which Toronto is held for its planning and transportation policies, relative to the New Western World (Mees, 2000; Newman & Kenworthy, 1999; Cervero, 1998). Mees (2000) in particular argued that Toronto's transit practices were superior to Melbourne and could indeed be applicable to Melbourne. The selection of Toronto for this thesis is partly inspired by Mees' research.

3.2 Demographics and Urban Density

3.2.1 Sydney

In the 2006 Census, the Sydney metropolitan area has a population of approximately 4.1 million, based on the Australian Bureau of Statistics' (ABS) definition of 'Statistical Division' (Australian Bureau of Statistics, 2008a). This assumption is used by the ABS in its attempt to define the Sydney metro area (Australian Bureau of Statistics, 2008c). The classification 'Urban Centre' is generally defined as areas with a population density greater than 200 per square kilometres (sq km) (Pink, Australian Standard Geographical Classification, 2007). Based on this benchmark, the Sydney urban centre or urban area has an approximate population of 3.6 million over an area of 1788 square kilometres (Australian Bureau of Statistics, 2008b), resulting in a population density of approximately 2037 per sq km or 20.4 per hectare, based on author's own calculations. Two-thirds of dwellings in the Sydney SD are separate detached dwellings. Table 8 and Table 9 allow side-by-side comparison with Toronto.

3.2.2 Toronto

In the 2006 Census, the Toronto metropolitan area had a population of approximately 5.1 million, based on Statistics Canada's (Statcan) definition of 'Census Metropolitan Area' (Statistics Canada, 2007a). This assumption is used by Statcan in its attempt to define the Toronto metro area (Statistics Canada, 2007f). The classification 'Urban Area' is generally defined as areas with a population density greater than 400 per square kilometres (sq km) (Statistics Canada, 2007e). Based on this benchmark, the Toronto Urban Area has an approximate population of 4.1 million over an area of 1749 square kilometres (Statistics Canada, 2007b) resulting in a population density of approximately 2718 per sq km or 27.2 per hectare, based on author's own calculations. Thus, the population density of Toronto's urban area is roughly one-third greater than that of Sydney's. 41.7% of dwellings in the Toronto CMA are separate detached dwellings (Statistics Canada, 2007a), validating the higher population density compared to Sydney. Table 8 and Table 9 allow side-by-side comparison with Sydney.

Admittedly there is some difference in the definitions of the ABS' 'Urban Centre' and Statcan's 'Urban Area' classifications with respect to the density threshold. However, due to the similar size in urban area, and similar ratio between the UC/UA and SD/CMA population, this makes the population density calculations somewhat comparable (Table 8), at least for the purpose of identifying public transport use trends. See Figure 11 and Figure 12 maps at approximately the same scale to compare the two cities.

Table 8: Land Area, Population and Population Density, 2006 and 2001

	Sydney		Toronto	
	Urban Centre (UC)	Statistical Division (SD)	Urban Area (UA)	Census Metropolitan Area (CMA)
Area (km²)				
2006	1788.1	12428.4	1748.6	5903.6
2001	1687.4	12144.6	-	5902.74
Population				
2006	3,641,421	4,119,191	4,753,120	5,113,149
2001	3,502,301	3,997,321	4,366,508	4,682,897
2001-2006 Growth	4.0%	3.0%	8.9%	9.2%
2006 Population of UC/UA as % of SD/CMA	88.4%		93.0%	
Population Density				
Per km²				
2006	2036.5	331.4	2718.3	866.1
2001	2075.6	329.1	-	793.3
Per hectare				
2006	20.4	3.3	27.2	8.7
2001	20.8	3.3	-	7.9

(Australian Bureau of Statistics, 2007) (Australian Bureau of Statistics, 2008a) (Australian Bureau of Statistics, 2008b) (Statistics Canada, 2007c) (Statistics Canada, 2007b).

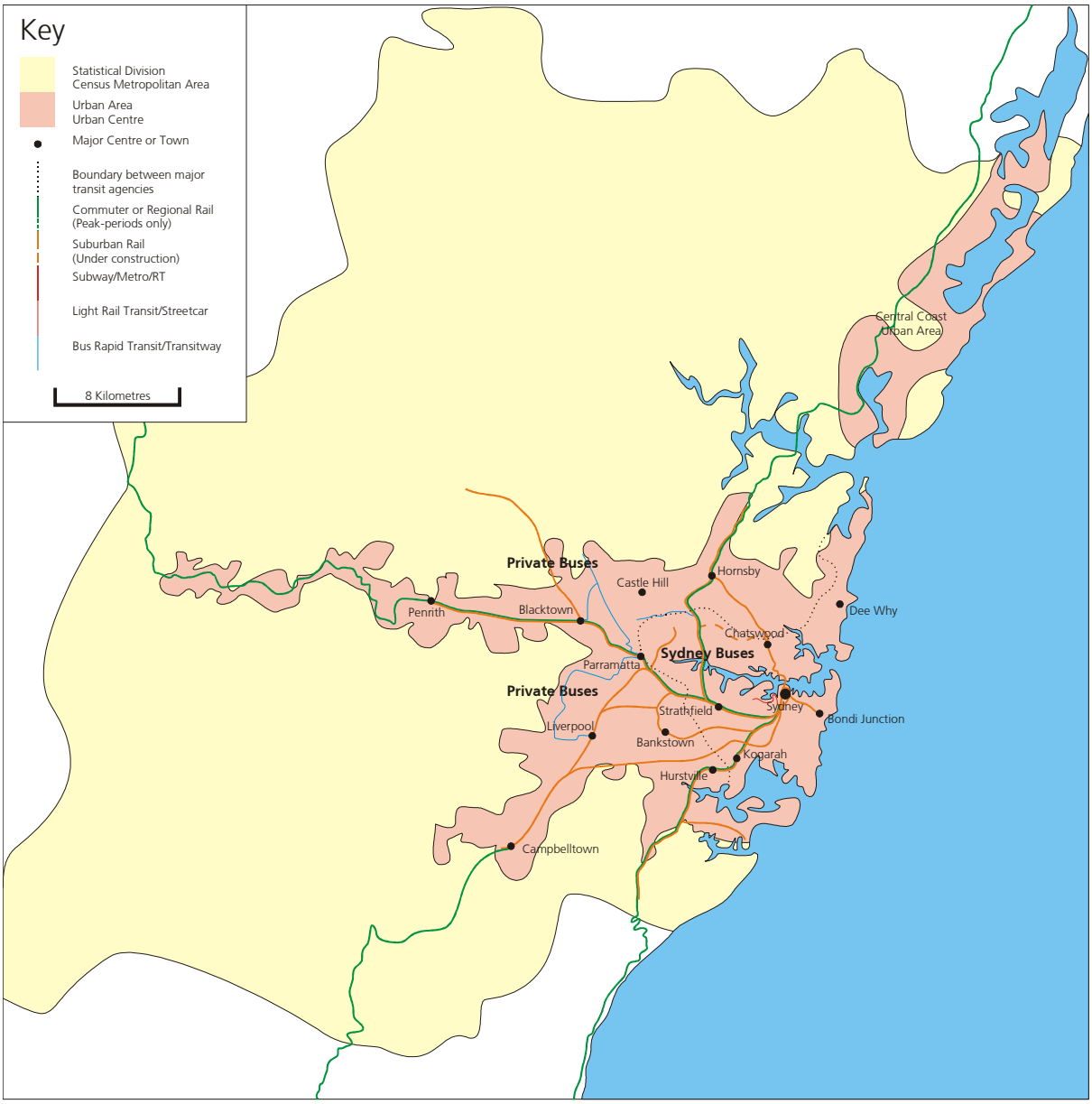
Table 9: Dwelling structure as percentage of total dwellings in each city

	Separate, single-detached house	Semi-detached houses, row or terrace house, townhouse, duplex, etc.	Flat, unit, or apartments (excluding duplexes)	Other
Sydney SD	63.7%	11.8%	23.9%	0.6%
Toronto CMA	41.7%	20.3%	37.7%	0.1%
'Other' includes dwellings being rented through a Residential park (includes caravan parks and marinas), Employer-government (includes Defence Housing Authority), Employer-other employer-provided, other single attached houses and movable dwellings such as mobile homes and other movable dwellings such as houseboats and railroad cars.				

(Australian Bureau of Statistics, 2008a) (Statistics Canada, 2007a)

Henceforth, 'metro area' will refer to either the urban centre or urban area of each city. This thesis will focus on the metropolitan areas or urban areas of each respective city, although comparisons will be made with the SD and CMA when statistics are not available at the Urban Area scale.

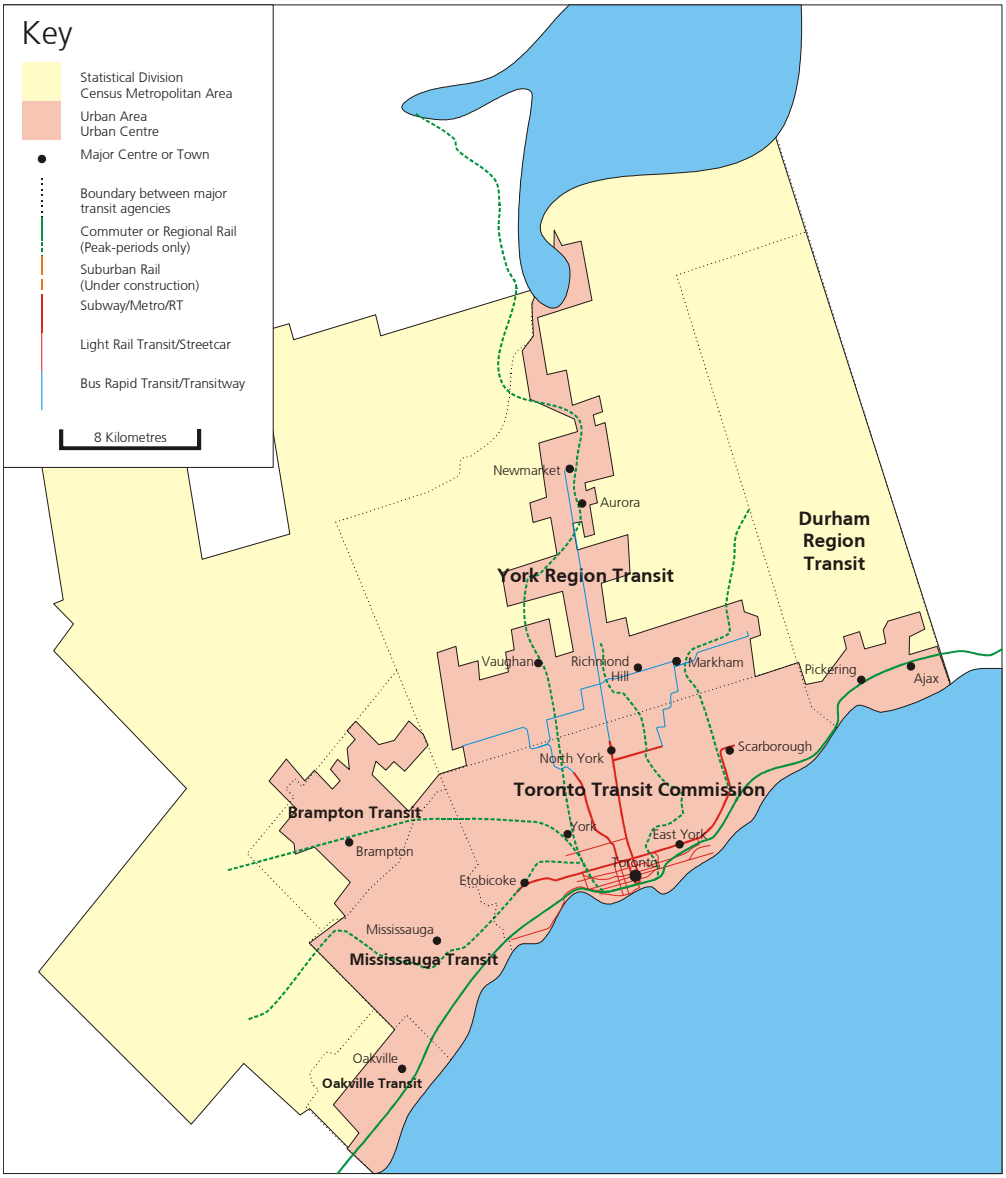
Figure 11: Map of Sydney Metropolitan Area and Fixed Public Transportation Infrastructure



Maps drawn by author based on numerous sources. Approximately to scale, however alignments and exact boundaries have been simplified.

(Microsoft, 2008; Farrell, 2006, pp. 26-27; Pink, 2008, p. 149)

Figure 12: Map of Toronto Metropolitan Area and Fixed Public Transport Infrastructure



Maps drawn by author based on numerous sources. Approximately to scale, however alignments and exact boundaries have been simplified.

(Microsoft, 2008; Statistics Canada, 2007)

NB. Whilst urban growth appears to be more sharply defined in Toronto compared to Sydney, this is due to the difference in size of statistical collection districts of each respective statistics bureau to determine the size and boundary of each urban centre or area. These maps do not imply that Sydney's urban growth is necessarily more organic than Toronto's.

3.3 The Public Transport Network

This section describes the conventional mass transit modes currently available in each case study. This section will only describe the main transit operators so far as to explain the transit mode that they may operate. Further explanation about the relationships between different transit operators, their catchments, and modes will be covered throughout Chapter 4. Figure 11 and Figure 12 are maps of each respective case study and depict scale of public transport within each city.

3.3.1 Sydney

3.3.1.1 Heavy Rail

All suburban, intercity, and regional heavy rail public transport passenger services within New South Wales are operated by Rail Corporation New South Wales. The 150th anniversary of NSW Railways occurred in 2005 (RailCorp, 2005). Suburban and regional rail (dubbed 'Intercity) services are operated under the CityRail brand (Market Development and Research, Product Development, RailCorp, 2008, p. 9). The CityRail network comprises of 304 stations, with intercity services extending out of the Sydney metro area to nearby regional areas including the neighbouring metropolitan areas of Newcastle, Wollongong and the Central Coast. The suburban network covers 315 of the total 1,030 route kilometres (Market Development and Research, Product Development, RailCorp, 2008, p. 12). The Central Coast is served by CityRail's Intercity services (it is included in the north-eastern sector of the Sydney SD but is a distinct urban area from Sydney). The main hub is Central Station located at the southern end of the Sydney CBD. Gaps between stations average 3.4 km across the whole CityRail network, and 1.9 km on the suburban network.

CityRail services operate all day and evening services on most lines, seven days per week (CityRail, 2008e). Each weekday, RailCorp operates 1,916 suburban train trips over 67,524 train kilometres in addition to 502 intercity train trips (Market Development and Research, Product Development, RailCorp, 2008, p. 13). The average speed of all CityRail services is 41-42 km/h. (Market Development and Research, Product Development, RailCorp, 2008, p. 14). During the morning peak hour, service headways are as low as 3 minutes (or conversely train frequencies are as high as 20 trains per hour) on some sections of the network. (Market Development and Research, Product Development, RailCorp, 2008, p. 17).

Total number of journeys annually was 281.5 million as of 2006/07 (Market Development and Research, Product Development, RailCorp, 2008, p. 11). This is the highest annual patronage figure ever achieved on the CityRail network (except in 2000/01 during the Olympic Games) (Market Development and Research, Product Development, RailCorp, 2008, pp. 22-23).

All suburban rail services and most intercity services are powered by 1500 volt DC supplied through overhead wiring. Double-deck Electric Multiple Units (such as in Figure 13) make up 1,558 carriages (97%) of the 1,600 carriage CityRail fleet (Market Development and Research, Product Development, RailCorp, 2008, p. 16).

Figure 13: The upper deck of a CityRail 'Millennium' Train, used for suburban services.

Ong, V. 2006.

3.3.1.2 Tram, Streetcar, and Light Rail

In 1940, Sydney's tram network had a track length of 190.4 kilometres (Departmental Annual Reports of various years) cited by (Gibbons, 1983, p. 167). At its peak in 1945, patronage on the tram network almost reached 400 million (NSWYB, 191-45) cited by (Spearritt, 2000, p. 141), or 405 million (Gibbons, 1983, p. 170) depending upon the source. However by 1961, the tram system completely ceased operations (Gibbons, 1983, p. 174).

Public opinion at the time of cessation believed that trams were to blame for traffic congestion. By 1937, there was one tram every 19 seconds in afternoon peak on Elizabeth Street (Gibbons, 1983, p. 169). According to Spearritt (Spearritt, 2000, p. 141), a "subtle coalition of the NRMA and British engineering experts" conspired to shut down the tram network. Gibbons (1983, 174) recounted that a consultant's report at the time "recommended the acquisition of double-decked buses to maintain capacity, but as these would be faster than trams, 15% fewer vehicles would be needed", suggested buses were faster and more flexible because they could disperse across many routes and convey passengers more directly.

In 1997, light rail (LR) was brought back to Sydney as a mass transit mode. The network remains in an embryonic state, catering to **3.5 million passengers per year** (Metro Transport Sydney, 2008), with 14 stops over a route length of 7.2 km, and services operating at 8 to 10 minute headways (Metro Transport Sydney, 2006). The line operates from Central Railway Station to the inner western suburb of Lilyfield. Due to the small modal share of LR in Sydney (Figure 23), it will not be explicitly mentioned in the following analysis to maintain brevity.

3.3.1.3 Bus

Sydney's public transport bus services can be broken up into two distinct groupings colloquially referred to as 'public buses' and 'private buses'. The **estimated annual patronage** of all public transport bus services (i.e. both 'public' and 'private') is in the range of **276 million passengers**, based on the Transport Data Centre's estimate of 922,000 bus trips on an average weekday (2008, p. 29) for the Sydney SD, multiplied by an annualisation factor of 300 (Market Development and Research, Product Development, RailCorp, 2008, p. 77). **However, the annual patronage** of all public transport bus services **recorded by the Ministry of Transport (MoT) was 194 million for the 2007/08 financial year** (Ministry of Transport, 2008, p. 25) for the Sydney metro area. It should be noted that Region 6 (Inner Western Sydney, served by Sydney Buses) was excluded from MoT's estimate due to data integrity issues (Ministry of Transport, 2008d, p. 26), and that the Transport Data Centre-based estimate includes Central Coast bus use whilst the MoT figure does not. Thus the true figure could be close to an average of the two: i.e. ~235 million.

Inner Western Sydney, the lower Northern suburbs, the lower North Shore, the Eastern Suburbs and Northern Beaches (Figure 14) are served by the State Transit Authority (STA) under the Sydney Buses brand, or known colloquially as 'public buses'. STA is a government-owned authority that operates government bus services in Sydney and Newcastle Buses and Ferries (State Transit Authority of NSW, 2008). STA's bus fleet (Sydney Buses and Newcastle Buses)

totalled 1,978 buses (State Transit Authority of NSW, 2007, p. 3). Sydney Buses' network includes some 300 routes, accommodating 99,000 services per week, resulting in 78.3 million bus kilometres annually (State Transit Authority of NSW, 2007, p. 152). Patronage for Sydney Buses almost reached 187 million trips in 2006/07, exceeding the previous year's patronage by 1 million (State Transit Authority of NSW, 2007, p. 16). Approximately 63% of all bus trips on the typical weekday are taken on Sydney Buses, based on the 2006 Household Travel Survey (Transport Data Centre, 2008, p. 29).

Figure 14: Sydney Buses' bus at Wynyard to the Northern Beaches

Ong, V. 2008

Public bus services in the outer suburbs of Sydney and Central Coast are provided by private companies, hence the misnomer 'private buses'. These are public services operated by private operators that have been contracted by the NSW Government. Contractors were traditionally contracted to plan and operate services only within their individual contract area, without consideration for land uses, trip generators, or destinations outside their contract niche. This has resulted in a bus network planned based on operators' constraints, thus often detrimental to Sydney-wide patronage. The disparities between State Transit and Private Bus areas were and

remain the subject of some discussion, particularly in the Unsworth Review (NSW Government, 2004). Approximately 37% of all bus trips on the typical weekday are taken on private buses, based on the 2006 Household Travel Survey (Transport Data Centre, 2008, p. 29), falling to 20% on weekends (Transport Data Centre, 2002, p. 2).

The implementation of the recommendations of the Unsworth Review has been generally referred to as 'Bus Reform' (Ministry of Transport, 2007c). Since the review, a new bus contracting regime was established, including the creation of large contract regions throughout Sydney and NSW to allow Ministry of Transport to effectively manage bus planning and operations and to allow effective transport and land use integration. There are currently 15 contract regions in Metropolitan Sydney (Ministry of Transport, 2007c) replacing the previous 'patchwork' of 87 bus contract areas and routes (NSW Government, 2004). Four regions in Sydney have since undergone major integrated network reviews. As part of the overall 'Bus Reform', the task of planning bus routes is now undertaken jointly by Ministry of Transport and the Bus contractor (including State Transit).

In the outer suburbs of Sydney are several bus-only roadways or bus lanes referred to as Transitways or T-ways. These were built to provide bus priority along major corridors in low-density suburbs to major suburban centres and bus-rail interchanges.

The 36 station, 31km long Liverpool to Parramatta T-Way (LPT) accommodates one trunk route (Currie, 2006) that is currently operated by a STA subsidiary known as Western Sydney Buses (State Transit Authority of NSW, 2007, p. 3). The transitway feeds into Liverpool and Parramatta Transport Interchanges and connects to outlying trip generators such as Prairiewood Town Centre, the industrial suburbs of Smithfield and Wetherill Park, and large educational institutions. Patronage on the LPT reached 2.28 million trips in 2006/07 (State Transit Authority of NSW, 2007, p. 16). In the morning peak, headways on Parramatta-bound services can be as little as 5 minutes (Western Sydney Buses, 2008).

The North-West Tway (NWT) includes 30 stations spread along two corridors totalling 27.5 km in length (NSW Government, 2007a). Unlike the LPT, the bus network is fully integrated into the NWT. The NWT accommodates a range of transit services ranging from local, line-haul, feeder, cross-suburban and express bus routes operated by contractors Hillsbus or Busways (NSW Government, 2007b). The NWT is located in the outer north-western suburbs of Sydney, connecting the outlying Rouse Hill Town Centre with both Parramatta and Blacktown Transport Interchanges.

3.3.1.4 Ferry

Public ferry services in Sydney Harbour are currently operated by Sydney Ferries. At the time of writing, Sydney Ferries is being 'decorporatised' in preparation for future privatisation or outsourcing of ferry operations (AAP, 2008). The ferry system plays a relatively small role within the Sydney metropolitan area; however it remains a convenient transit service for those living within reach of the harbour. Sydney Ferries operates over 178,000 services per year, (Sydney Ferries, 2007, p. 20), carrying **14.1 million passengers** (Sydney Ferries, 2007, p. 9) across eight routes (Sydney Ferries, 2007, p. 5). The fleet of 37 ferries travel approximately 1.3 million kilometres annually (Sydney Ferries, 2007). Sydney Ferries' hub is located at Circular Quay on the northern end of the Sydney CBD, where it is an interchange for CityRail and Sydney Buses services. Other major interchanges served include Manly, Parramatta and Balmain. Due to the small modal share of ferries (see Figure 23), explicit referencing of ferries will be excluded to maintain brevity.

Figure 15: Circular Quay Ferry Wharves

Ong, V. 2008.

3.3.2 Toronto

3.3.2.1 Heavy Rail

3.3.2.1.1 GO Transit Commuter Rail

There are three heavy-medium rail systems operating in the Toronto metro area. The largest (by coverage) is the GO Transit commuter rail system, which covers 390 route kilometres and includes 59 stations spread across seven lines, averaging 6.6 km spacing between stations (Greater Toronto Transit Authority, 2008c). GO Transit was established in 1967 as a provincial government authority to provide commuter rail services along "an initial 90 mile corridor" (~145 km) (Solomon, 2007, p. 66). The catchment of GO Train extends outside the Toronto metro area, well into the Greater Toronto Area (GTA) to nearby cities such as Hamilton and Oshawa.

Only the Lakeshore lines are served by GO Trains all day, seven days a week. The five remaining lines only operate during weekday peak periods. During the off peak periods and weekends, these lines are served by GO 'Train-bus' (bus replacement of trains). 181 weekday train trips are made by GO Trains (Greater Toronto Transit Authority, 2008c). The 58 diesel locomotive and 435 carriage GO Train fleet is operated and maintained by the private sector (Greater Toronto Transit Authority, 2007, p. 7). Furthermore, approximately two-thirds of the trackage used by GO Transit is privately owned and controlled (Greater Toronto Transit Authority, 2007, p. 7), thus GO is required to rely on external parties to ensure GO Trains can operate punctually and reliably. All passenger carriages are double-decker carriages, offering 2x2 transverse seating. The GO Train hub is located at Union Station (Figure 16), at the southern end of downtown Toronto. Here, passengers can transfer to and from the TTC's Union Station (Figure 17), or the GO Bus Terminal (Figure 22).

Weekday patronage on the GO Train network is 170,000, which includes GO Buses that either feed directly into the GO Train network, and the 'train-bus' (Greater Toronto Transit Authority, 2008c); **annualised, GO Train patronage is 49.2 million** (as of 2006) (Greater Toronto Transit Authority, 2007).

3.3.2.1.2 Toronto Transit Commission (TTC) Subway and Scarborough Rapid Transit

Within the inner portion of the Toronto metro area is the City of Toronto. The City of Toronto's heavy rail services are provided not only by GO Transit, but also the Toronto Transit Commission's (TTC) rapid transit network. Unlike GO, the TTC maintains all of its everyday operations in-house (Lee, 2008). The largest component of this network is a conventional subway or metro network. The first portion of the subway network opened in 1954 – extending

7.4 km underneath Yonge Street (Filey, 1996, p. 87). Today, there are three lines, totalling 69 stations along 61.9 route kilometres (Toronto Transit Commission, 2008d). Using its fleet of 678 subway cars, the TTC achieved 74.5 million operating kilometres in 2007.

Figure 16: GO Train to Lakeshore East at Union Station

Figure 17: Entrance to TTC Union Station

Ong, V. 2008.

The Scarborough Rapid Transit (RT) Line is a 6.4 kilometre long 'Intermediate Capacity Transit System' (ICTS) owned and operated by the TTC (Toronto Transit Commission, 2008d) since 1985. The RT extends from the eastern terminus of the Bloor-Danforth Line, Kennedy Station (Figure 39), to McCowan Station, just east of the suburban Scarborough City Centre. ICTS is a proprietary system developed by the UTDC (a former province-owned corporation) and features 12.7 metre cars ('mini-subway') that are permanently coupled in pairs, linear induction engines, steerable-axles, and automatic train control (Filey, 1996, p. 141). The original intention was for the corridor to be served by coupled streetcars on dedicated right-of-way, until the provincial government offered to fully fund the construction of an elevated ICTS line to promote the technology (Filey, 1996, p. 137). Today, the 28 RT cars are manually operated by TTC staff over 3.7 million kilometres annually (as of 2007) (Toronto Transit Commission, 2008d).

The average weekday patronage of the combined subway and RT network totals 945,000 passengers. Excluding passengers transferring from other TTC services, (fares collected) patronage is 844,000 (Toronto Transit Commission, 2008d). When considering that daily patronage across all TTC services including transfers (i.e. unlinked trips) is 2,397,000 (Toronto Transit Commission, 2008d), it seems that 39% of all unlinked TTC trips involve using the subway on at least one occasion. **Annual patronage for the entire TTC system,** including streetcar, bus, subway and RT, **reached 459.8 million in 2007** (Toronto Transit Commission, 2008d).

3.3.2.2 Tram/Streetcar and Light Rail

Unlike Sydney, Toronto made the decision to retain its streetcar network in 1972 (Filey, 1996, p. 125), resulting in streetcar route kilometre length (one-way, not round trip) of 152.15 today (Toronto Transit Commission, 2008d). In 1990, a sixty-two year drought in new streetcar lines was broken by the 509 Harbourfront line, which feeds into Union Station (Figure 18) (Filey, 1996, p. 148). This line was extended and connected into the 510 Spadina LRT (Light Rail Transit) line (Figure 19) in 1997 (Toronto Transit Commission, 2008e). The 509 and 510 corridor is the second busiest streetcar line on the TTC system - a remarkable feat considering the line reopened eleven years ago (it replaces the original Spadina streetcar tracks that were abandoned in 1966) (Bow, 2006b).

Using a fleet of 248 light rail vehicles, the TTC achieved 11,850 operating kilometres in 2007 (Toronto Transit Commission, 2008d). The streetcar system carries approximately 330,000 passengers daily (Metrolinx, 2008b).

Figure 18: Streetcar stop underneath Union Station, within the TTC Union Station's 'Paid Area'

Figure 19: Spadina LRT

Ong, V. 2008.

3.3.2.3 Bus

Buses across the Toronto metro area are operated by a patchwork of operators based on local government areas.

Within the City of Toronto, local bus services are provided primarily by the TTC. The TTC maintains a fleet of 1,545 40-foot buses, 1,122 of which are accessible as of 2007 (Toronto Transit Commission, 2008d). These buses provide service across 138 routes totalling 3564.85 km in route length, resulting in 107.6 million kilometres operated last year (Toronto Transit Commission, 2008d). Trolleybuses (known locally as trolley coaches) have been used by the TTC in the past, however these were phased out in 1993 due to lack of funds to renew the fleet (Filey, 1996, p. 153).

GO Transit operates GO Buses to complement GO Train. GO Buses provides long-distance cross-regional bus services throughout the GTA over an 8,000 sq km catchment (Greater Toronto Transit Authority, 2008c), in addition to substituting or extending the catchment of GO Train services. Some routes operate primarily along freeway corridors, servicing park and ride lots, GO Bus Terminals (Figure 22) or interchanges with local transit networks. The GO Bus fleet includes 363 buses that are operated and maintained in-house (Greater Toronto Transit Authority, 2007), which serve 2,501 route kilometres. On an average weekday, 2,050 bus trips are made, including GO 'Train-bus' trips (Greater Toronto Transit Authority, 2008c). Excluding GO Train-bus patronage, **GO Bus patronage in 2006 was 7.07 million** (Greater Toronto Transit Authority, 2007).

The larger networks outside of the City of Toronto (such as one featured in Figure 20) but still within the Toronto CMA are listed in (Table 10). All of these networks are designed to complement GO Transit services.

Of interest is VIVA, a service managed by York Region Transit but operated by multinational corporation Veolia Transportation. VIVA is a series of bus rapid transit (BRT) routes in the York Region (north of the city of Toronto), offering a high frequency service using on-road bus priority or dedicated busways, and dedicated bus shelters equipped with real-time passenger information displays and ticket vending machines (Figure 21) (York Region Rapid Transit Corporation, 2004a). VIVA currently achieves "35,000 boardings each weekday and 29,000 boardings on weekends" (York Region Rapid Transit Corporation, 2008). Mississauga is also currently hoping to emulate VIVA's success with its own BRT project due for completion by 2012 (City of Mississauga, 2008b).

Figure 20: York Region Transit bus at Finch GO Bus Terminal, opposite Finch TTC Subway Station (behind photographer). The TTC station is accessed via a pedestrian subway.

Figure 21: VIVA facilities at Finch GO Bus Terminal. The Finch TTC Bus interchange and subway station is in background.

Ong, V. 2008.

Table 10: Major Bus Agencies and Patronage within the Toronto CMA, excluding TTC and GO Transit

Agency	*Mississauga Transit*	*York Region Transit*	*Brampton Transit*	*Durham Region Transit**	*Oakville Transit*	*Milton*	**Total**
Patronage (2006)	29,022,000	17,108,000	10,139,000	6,942,000	2,415,000	86,000	65,712,000

*Not all DRT services fall within the Toronto CMA.

(Metrolinx, 2007b, p. 13)

Figure 22: GO Bus Terminal, opposite Union Station

Ong, V. 2008.

3.3.2.4 Ferry

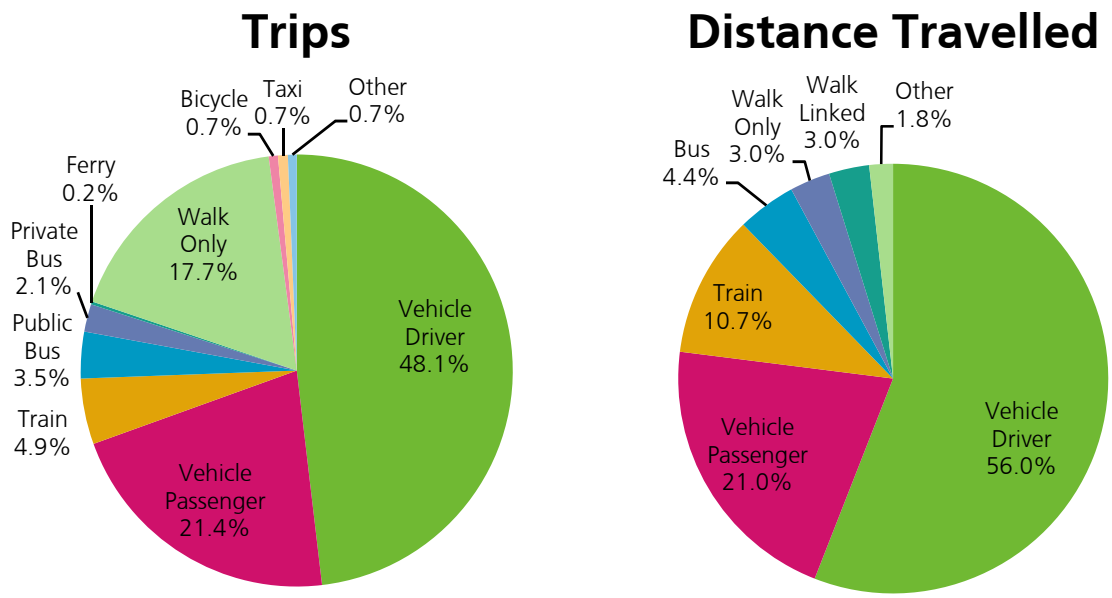
Toronto's public ferry service is primarily a tourist service, operating from the Toronto harbour front to the Toronto Islands, most of which is parkland (City of Toronto, 2008). Therefore, for the purposes of this thesis, ferries will not be considered part of Toronto's public mass transit system.

3.4 Transport Patterns and Trends

3.4.1 Sydney

The following data is sourced from the 2006 Household Travel Survey (HTS), which is an annual survey of travel behaviour of people residing in the Sydney SD (Transport Data Centre, 2008). On an average weekday (Transport Data Centre, 2008, p. 4), the average Sydneysider spends 79 minutes per day to undertake 3.77 *unlinked* trips, covering 35.6 kilometres, with each trip with an average length of 9.4 km. Of the 35.6 kilometres, 19.9 km is by private motor vehicle (VKT per capita) (Transport Data Centre, 2008, p. 4). On weekdays, the average commute takes 34 minutes each way, whilst the average non-work trip takes 18 minutes each way (Transport Data Centre, 2008, p. 4). On weekdays, 22% of commutes and 27% of *linked* trips for education/child care are by public transport, compared to just 1% to serve passenger and 6% for social and recreation opportunities (Transport Data Centre, 2008, p. 11). 21.4% of all *linked* weekday trips occur during the AM peak arriving at the destination between 6:31 and 9:30 AM (Transport Data Centre, 2008, p. 37); 15% of AM peak trips are by public transport (Transport Data Centre, 2008, p. 39). See Figure 24 for explanation of *linked* and *unlinked* trips.

Figure 23: Sydney SD Mode Share on Average Weekday based on Unlinked Trips, 2006



"'Walk-only' trips are those where the main mode is walking and excludes walking trips to access other forms of transport. 'Walk-linked' trips are walking trips to access other forms of transport eg. walk trip to the station to ride the train. The current methodology of estimating distance tends to overestimate short trips, especially walk trips."

(Transport Data Centre, 2008, p. 29)

Mass transit (i.e. public transport excluding taxi) received a weekday **mode share of ~9.3% of *linked* trips** (author's own calculations from 2006 HTS) **or 10.7% of *unlinked* trips** (see Figure 23). **This equates to Sydneysiders making approximately 0.41 *unlinked* transit trips per capita per weekday.** When counting **distance travelled mode share** of unlinked trips increases to approximately **15.1%.** The average distance for a train trip is 19.8 km, which is significantly greater than the 7.2 km average for a bus trip, 10.5 km for vehicle driver and 8.9 km for vehicle passenger (Transport Data Centre, 2008, p. 16).

3.4.2 Toronto

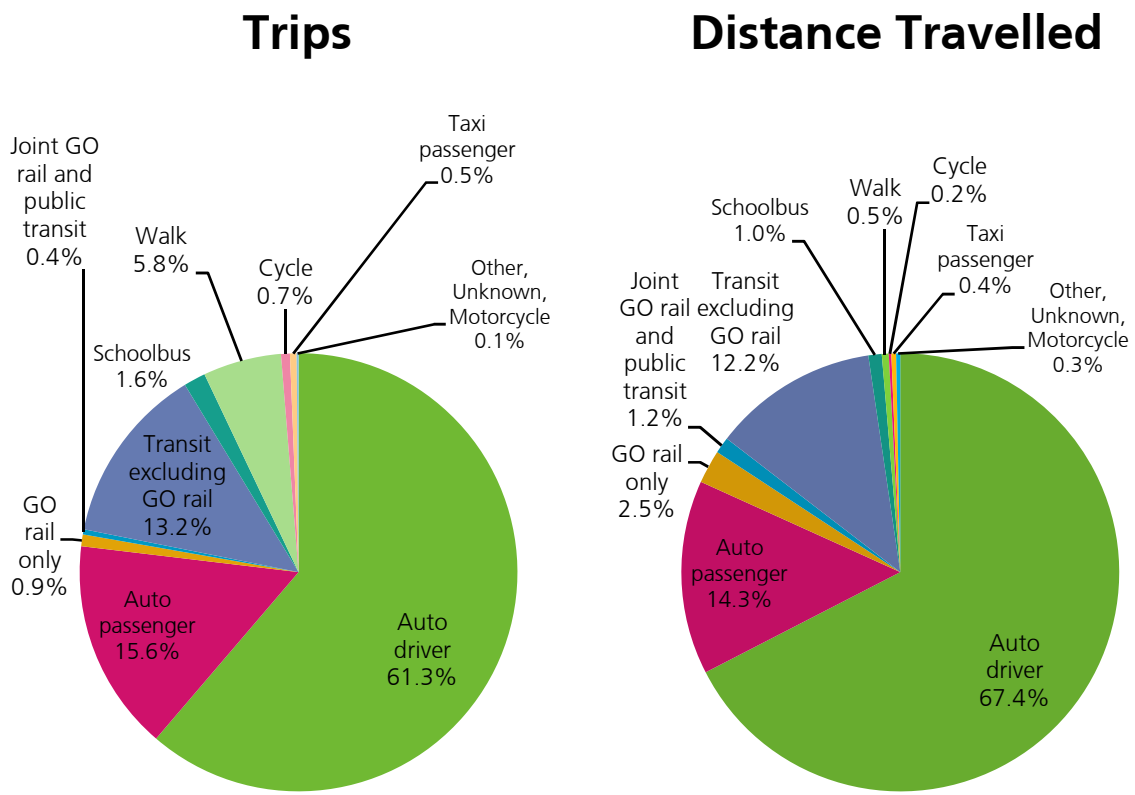
All the following statistics about Toronto travel behaviour have been based on that retrieved on 24-25 October 2008, from the 2006 Transportation Tomorrow Survey (2006 TTS) Database, managed by the Data Management Group, of the Urban Transportation Research and Advancement Centre, Department of Civil Engineering, University of Toronto (Data Management Group, 2008a). The TTS "is a comprehensive travel survey conducted in the Greater Toronto and Hamilton Area (GTHA) once every five years" (Data Management Group, University of Toronto, 2008b). The similar scope makes this survey comparable to Sydney's Household Travel Survey (HTS) (Transport Data Centre, 2008). Most of these statistics are a preliminary version that have not been published before, particularly as the author limited the results to only the Toronto CMA, and have been calculated by the author based on queries submitted to the database. As declared on a popup when selecting the 2006 TTS database, "At this time, only preliminary results are available...Information is released at this time to facilitate planning studies that are not sensitive to small changes in the estimates. Estimated values presented in Version 0.1 will change with the release of a Version 1." (Data Management Group, 2008a). Furthermore, due to different methodologies in the TTS and HTS, the data may not be directly comparable, despite the author's best efforts; thus, interpretations should considered indicative, not definitive.

On an average weekday the average Torontonian living in the Toronto CMA undertakes 2.05 *linked* trips, travelling 20.2 kilometres, with each trip an average of 9.8 km. On weekdays, 24.9% of commutes and 16.7% of *linked* trips for education/child care are primarily by mass transit, compared to just 0.4% to serve/facilitate passenger and 4.2% for shopping. 24.2% of all *linked* weekday trips occur during the AM peak (starting at the origin between 6:00 and 8:59 AM); 20.7% of AM peak trips are primarily by mass transit.

Figure 24 shows mode share for all *linked* trips conducted by residents in the Toronto CMA. **Mass transit** (i.e. public transport excluding taxi) received a **primary mode share of 14.4% of**

***linked* trips,** although when counting **distance travelled this increases to approximately 15.9%,** thus suggesting mass transit use in Toronto CMA is far higher than Sydney SD (Figure 23) (see note below Figure 24 for elaboration on such interpretation). **In terms of *unlinked* trips, Toronto makes approximately 0.64 *unlinked* transit trips per capita per weekday** (based on author's calculations)**, higher than Sydney's 0.41 (see 3.4.1)**. The average distance for a GO train trip is 27.7 km, 31.2 km for joint GO rail and transit trip, which is greater than the 9.1 km average for a local transit trip, 10.8 km for vehicle driver and 9 km for vehicle passenger. These results are similar to Sydney, although GO rail is higher due to its regional rail task compared to CityRail's suburban rail task (see station spacing in 3.3.1.1 for comparison).

Figure 24: Toronto CMA Mode Share on Average Weekday, based on Linked trips, 2006



Mode share used in Toronto's TTS counts trips is based on the primary mode of an individual *'linked'* trip to one destination, whereas Sydney's HTS does not count primary mode to report mode share, but rather all modes of an individual trip to a final destination as separate *'unlinked'* trips. Therefore, the mode share of public transport and walk-linked trips from Sydney's HTS is exaggerated compared to Toronto's HTS due to the tendency for such trips to be multi-modal or *linked* in practice.

From authors own calculations based on data retrieved from TTS 2006 Database (Data Management Group, 2008a).

4 IPTPO Criteria and Case Study Evaluation

4.1 Outline

There are five criterion related to Integrated Transport Planning and Operations that will be discussed in this chapter. The comparison between and analysis of the case studies has been categorised by criterion rather than case study. This is to allow comparisons and analysis to be made more easily between each case study when discussing common criteria, themes or objectives.

Each criterion in this chapter is divided into three parts as follows.

4.1.1 Theory

Theory explains the theoretical context of each criterion and how the criterion can improve the integration in public transport from the transport planners' and transport users' perspective. Examples may be included to illustrate where the criterion has been satisfied in locations other than the two main case studies.

4.1.2 Sydney

This will explain Sydney's compliance with the theory by explaining the current situation and recent history in each case study with respect to the criterion. Planned strategies or initiatives intended to meet the criterion will also be explained, should they exist.

4.1.3 Toronto

Similarly, Toronto's compliance with the theory will be evaluated following the Sydney discussion. Under this part, further analysis is undertaken to examine Sydney's performance, not only against theoretical concepts, but with practice in the Toronto case study.

4.2 Fares and Ticketing

4.2.1 Theory

The complete elimination of fares on public transit systems has been trialled in the past; however this is usually seen as financially unsustainable (Transport Cooperative Research Program, 2004). Furthermore, the relationship between fare levels and patronage/ridership, remains weaker than that between service levels and patronage/ridership (Currie & Walliss, 2008; Litman, 2008; Shepherd, Zhang, Emberger, Hudson, May, & Paulley, 2006; Paulley, et al., 2006). Admittedly, free transit services do appear in some limited applications (Vuchic, 2005, p. 398). Nonetheless, it is generally accepted that transit fares are necessary. On the matter of public transit fares, there are generally three areas of interest:

- Fare collection, "the locations of and methods of collecting fares and control of payments by passengers" (Vuchic, 2005, p. 376);
- Fare structures, "the relationship between fare amount and distance travelled on a transit line" (Vuchic, 2005, p. 384); and
- Level of fares and special fares, the amount charged and variations to address particular demand or social issues (Vuchic, 2005, pp. 389, 394).

For the purposes of this thesis, the theory and analysis will attempt to focus on the integration and planning-related aspects of fare policies and away from the specific engineering aspects of fares such as fare collection. The primary integration issue in relation to fares is the ability to accommodate transfers between different transit routes, operators, or modes within a metropolitan area. The issue of transfers (see also 4.4.1) is important in transit as "There will always be a need for transfers in public transit as long as... (Transportation Research Board, 1996)

- "Single point-to-point transit service is not available to all locations required by ridership;
- "Different modes of transit are required to go from the point of origin to the destination."

There are three means of integration in relation to fares:

- Transfer fares
- Integrated fare collection or Integrated ticketing
- Integrated fare structure

Transfer fares are separate fares that are sold to allow riders to transfer between lines/routes, modes, or agencies. Whilst Vuchic (2005, p. 388) has stated that transit fares can double the

amount paid, to avoid confusion henceforth, 'transfer fares or tickets' only refer to ticket products that allow transfers at a discounted rate compared to the full fare payable.

Integrated fare collection or integrated ticketing refers to methods of fare collection that can be used between different lines/routes, modes, or agencies. Transfers may not be discounted when using integrated ticketing. From the user's perspective, integrated ticketing can allow for fare payment to be prepaid into a convenient form rather than relying on cash; examples include as multiple ride tickets where the remaining number of rides is deducted as each ride is undertaken, stored value or charge magnetic strip-based or 'smart' cards (Vuchic, 2005, pp. 379-380). Prepaid tickets can also increase the speed of boarding, a benefit to both the boarding passengers and those already on the vehicle. 'Integrated ticketing' is differentiated from 'integrated fares' as the former is a means of integrating or streamlining the *method* of payment, not *amount or level* of payment.

An integrated fare structure is a pricing structure that is consistent across multiple lines/routes, modes, and agencies, where transfers do not incur a financial penalty and are covered in the original fare paid to enter the system. Flat fare is the simplest structure that can accommodate integrated fares, and remains common amongst many transit systems and "is constant regardless of distance (Vuchic, 2005, p. 385). Graduated fare structures, either zonal (based on number of predetermined zones) or sectional (based on number of equidistant sections) charge fares roughly on the distance travelled (Vuchic, 2005, pp. 386-387). Automated fare collection (AFC), which relies on electronic technology to calculate and collect fares, has facilitated in the prevalence or entrenchment of graduated fare structures (Vuchic, 2005, pp. 383-384). Tradeoffs between different fare structures are shown in Table 11.

Table 11: Tradeoffs between different fare structures

	Flat	***Zonal***	***Section***
Important Characteristics			
Equity	Poor	Good	Very good
Passenger attraction	Good	Very Good	Very good
Revenue collected	Variable	Good	Very good
Simplicity of collection	Excellent	Fair-good	Poor
Simplicity of control	Excellent	Fair	Poor
Simplicity for passengers	Excellent	Fair-good	Poor
Desired conditions			
Line length	Short (<5km)	Medium	Long
Network type	Ubiquitous	Divisible in zones	Long lines
Travel distance	Short	Variable	Variable

(Vuchic, 2005, p. 388)

The importance of fare integration, either upon patronage or transit operator revenue appears to still be a matter for some debate. The implementation of fare integration in a pre-existing transit system is likely to result in a decrease in costs for users that make transfers. However, in the attempt to synchronise fare structures and eliminate transfer costs, the absolute fare for users that don't transfer may increase. When Brisbane, Queesnland implemented its new integrated fare structure in August 2004, it was reported that train fares had increased (Transit Australia, 2004). Evidence of the relationship between fare integration and patronage increases could be circumstantial and be detrimental to the viability of transit agencies by limiting their ability to respond to changes in the market place (Hensher, 2007, p. 60). Nonetheless, evidence of increases in patronage that have been attributed to the implementation of an integrated fare structure appears overwhelming, and includes London (White, 2002; Hensher, 2007), New York (Shaller, 1998; Hensher, 2007), Paris, Zurich, Los Angeles (Hensher, 2007, pp. 62-63) citing (Booz Allen Hamilton, 2002), Madrid (Matas, 2004), and Brisbane (Queensland Transport, 2007). In Brisbane's case, "patronage on TransLink services has increased by over 30%" in the three years following the integrated fare system and other service improvements (Queensland Transport, 2007, p. 66); the implementation of an integrated ticketing scheme based on smart card technology was completed on 25 February 2008 (Transit Australia, 2008, p. 141).

4.2.2 Sydney

Sydney does not offer a fully integrated fare structure for its public transport services. As of 2008, all bus and rail public transport fares are based on a combination of an inherent boarding fee or 'flag fall', and a sectional structure, resulting in a rate that falls as distance increases (IPART, 2008; IPART, 2007b). Each agency maintains its own structure.

CityRail fares accommodate free transfers between railway lines, as fares are calculated based on the distance between the origin and intended destination (plus flag fall). However, one-way 'single' and round-trip or 'return' are restrictive as they do not allow breaks in journey (except for transfers) or change of destination after purchase (CityRail, 2008c). Single and return fares are discounted by at least 30% if purchased after the AM peak (IPART, 2008, p. 64). The CityRail network is a hybrid of Automated Fare Collection (AFC) and Self Service Fare Collection (SSFC) – fares are checked at major stations by AFC, and through roving patrols by Transit Officers (CityRail, 2008b). There are no prepaid CityRail-only ticket products available for everyday use, other than periodicals that start from day of purchase.

On bus services, the first fare must be paid upon boarding, and includes the flag fall and sectional fare to the intended transfer point; the flag fall must be paid for each transfer made,

as well as the sectional component. The fare structure for both public and private buses was standardised in 2005 (Ministry of Transport, 2007a). Sydney Buses also offers prepaid multi-ride tickets ('TravelTens') that are sold on a sectional structure with 20% discount off cash fares (IPART, 2007b, p. 44), with tickets validated by AFC readers upon boarding and no free transfers. Western Sydney Buses (LPT) has its own sectional fare structure (IPART, 2007b).

There is partial fare integration among selected tickets sold on or on behalf of the government transport operators, i.e. Sydney Buses, Sydney Ferries, and CityRail. The TravelPass range includes a range of periodical tickets (weekly, quarterly, yearly) that offer multi-modal multi-transfer, or single-mode multi-transfer tickets based on a zone structure of concentric rings radiating from the Sydney CBD (CityRail, 2008f). These can be purchased from State Transit ticket agents as prepaid tickets or from CityRail stations (Figure 25) for immediate use. The price is a premium compared to the equivalent single-mode single or return ticket covering the same distance. However, as a periodical multi-modal ticket, they offer a significant discount over separate periodical or multi-trip tickets for each mode. The DayTripper (CityRail, 2008) is akin to a one-day version of the most expensive and extensive TravelPass – however it is also 28% the cost for 14% of the duration.

None of the TravelPasses include travel on the 'Private Bus' networks prevalent in the outer suburbs, where 40% of bus travel takes place (see Figure 23). The exception to this is the Pensioner Excursion Ticket (PET) (CityRail, 2008d), valid to all pensioners, at 87.5% less than the cost of the DayTripper, yet the latter does not allow private bus use. Meanwhile, the typical concession discount for all fares including TravelPass is only 50%. Periodical tickets have only been made available across 'selected' private bus services since 1 October 2008 in the form of weeklies with 20% discount compared to cash fare (Ministry of Transport, 2008e). However, these are still based on the flag fall + sectional fare structure, with no free transfers.

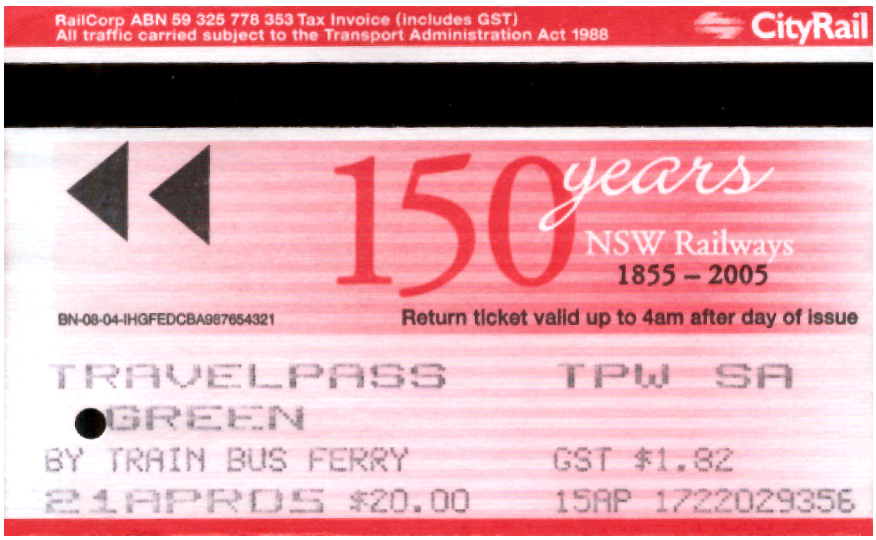
The AFC systems used by CityRail and Sydney Buses are rapidly ageing, reflected in 2008 media reports of: thousands of CityRail customers per day forced to pay for their fare at their destination (if at all) due to failing ticket vending machines (TVM) and long queues at ticket windows, costing $20 million per year in lost revenue (Besser, 2008d); and Sydney Buses having to buy obsolete, second-hand fare validators from Translink (Queensland's transit authority) to replace local stockpiles (Besser, 2008a). These failures have been exacerbated by the delay in implementing the integrated ticketing system known as TCard, first announced in 1993 (Besser & Sexton, 2007). The media blamed the delay on a disinterested Transport Minister (Smith, 2008a), and an uncooperative transport bureaucracy, which "were never contractually required" to co-operate with the contractor in the implementation of TCard (Besser, 2008e).

Following the front-page headline "Why Iemma [the NSW Premier at the time] has made Sydney a global joke" (Creagh & Besser, 2008), it was reported that "Sydney's disastrous six-year foray into integrated transport ticketing, which has deteriorated into a $200 million legal stoush between the Government and the Tcard contractor, ERG, has earned the city worldwide notoriety".

There were other problems; TCard was reportedly meant merely to duplicate existing fare structures and ticket types, totalling 500 fare variants. Melbourne's already integrated fare system means results in only 54 variants (Besser & Sexton, 2007). However, numerous calls from transport industry groups, lobby groups, and ERG itself had highlighted the underlying need for an integrated fare structure prior to the implementation of an integrated ticketing system (Baker, 2007; Mason, 2008; Smith, 2008b).

As of July 2008, it was reported new contractors would be sought, to implement a new Tcard (Besser, 2008g) that operated "alongside the existing ticketing system, with little interaction required", based on a "common fare structure for all buses, trains and ferries" to be developed by IPART (Besser, 2008h). " [The] project would be delivered by 2012. But even this could be interpreted as optimistic" (Besser, 2008k, p. 2).

Figure 25: TravelPass sold by CityRail



Ong, V. 2005.

4.2.3 Toronto

Toronto does not have an integrated fare system across the entire metropolitan network as fare structures and ticket products can vary depending upon agency. In 1921, when the TTC was established, it implemented a five-zone fare structure; this was gradually simplified to a flat fare by 1973 (Solomon, 2007, p. 15). Today, most local transit agencies within the Toronto metro area (Brampton Transit, 2008; Durham Region Transit, 2008; Town of Milton, 2007; City of Mississauga, 2008a; Oakville Transit, 2008; Toronto Transit Commission, 2008c) offer:

- flat cash fare with free transfers (CDN$2.50-$2.75 as of October 2008);
- prepaid discounted multi-ride ticket products including free transfers; and
- Monthly and/or annual periodical passes allowing unlimited use with the specified period

The free transfer system has allowed the TTC to construct multi-modal interchanges where passengers can change modes without exiting the 'paid area' of the station (e.g. Figure 18, Figure 27, Figure 28), minimising physical effort required to transfer between modes. In York Region Transit (YRT) is an exception in regards to fare structure, as both the cash and prepaid fares are based on a combined flag fall and zone fare, although transfers within the same zone as the origin remain free (York Region Transit, 2008a). Prepaid discounted multi-ride and periodical tickets are available. VIVA is included in YRT's fare structure.

There are few attempts at fare integration between local transit agencies. For example free transfers can be made between Mississauga and Brampton Transit services (City of Mississauga, 2008c); however most agencies' tickets are incompatible between different agencies. There are several TTC bus routes that run well into YRT's territory; but to use these services to cross from Toronto to York Region (or vice versa), the user must pay the flat fare of both agencies.

There is one multi-agency ticket product: the Greater Toronto Area (GTA) Weekly Pass (Toronto Transit Commission, 2008h). It includes all services provided by TTC, Mississauga, Brampton and YRT. This product is priced at a premium and due to its periodical nature, may only be of value for full time workers.

GO Transit's fare structure is similar to CityRail as the fare level is based on the shortest possible distance via GO services between the origin and destination – there is a flag fall and a sectional component to the fare (Greater Toronto Transit Authority, 2008a). Transfers between modes and routes are permitted. The route taken does not necessarily need to be the shortest (Greater Toronto Transit Authority, 2008d) - this provision is needed as some lines may only operate at particular times or certain days of the week. Some fares have been known to fall in price as a

result of new GO routes being established that shorten the travel distance between relevant stations (Girard, 2008). Round trip, prepaid discounted multi-trip and periodical tickets are also sold, but these limit travel to stations between two specified 'fare zones' at time of purchase (Greater Toronto Transit Authority, 2008f).

Where GO Transit differs significantly from CityRail is with respect to the "GO Transit Fare Integration (Co-Fare) Program" (Greater Toronto Transit Authority, 2008e). This program allows valid GO Transit ticket holders to purchase discounted fare (usually 50-65c) or a discounted periodical pass from most GTA local transit agencies in order to travel to and from their local GO station. Whilst this encourages patronage on GO, "[the] primary purpose of this program is to reduce the need for parking at our train stations." (Greater Toronto Transit Authority, 2008e). Under this program, GO transit subsidises the local transit trip that the passenger is making to access or egress the station (Charles River Associates, 1997, p. 104).

Integrated ticketing trials using GO Transit's Presto smartcard were completed at the end of September 2008 (Kalinowski, Smartcard faces bumpy ride, 2008e). The trial used the existing flat-fare + transfer fare structures of Mississauga, GO Transit and TTC. It would appear that in future, a new GTA-wide fare structure based on distance travelled would be desirable, as would discounts for frequent users or time-of-day discounts (Metrolinx, 2008a). Whilst Presto is welcomed by agencies, questions remain in regards to installation and operating costs, funding sources for costs, as well as fine-tuning of transfer policies (Kalinowski, Smartcard faces bumpy ride, 2008e).

Figure 26: Presto Card Readers at Union Station

Ong, V. 2008.

Figure 27: Subway Platform Level at Main Street Station, on Bloor-Danforth line

Figure 28: Above-ground Bus and Streetcar Interchange, directly above Subway Platforms (accessed in the concourse and waiting area in the left) at Main Street Station

Ong, Vi. 2008

4.3 Frequency and Operating Extent

4.3.1 Theory

Frequency in public transport operations refers to how often a transit service operates or passes a particular location. Headway is the amount of time between services. By default transit users desire short headways between services or high frequency of service to minimise waiting time (Vuchic, 2005, pp. 7-8). The problem is that most transit agencies prefer long headways and low frequencies, particularly during the off-peak when demand is low and agencies wish to minimise use of resources. Usually, a compromise is made between passenger convenience and cost of operation (Vuchic, 2005, p. 10). It is this compromise which is of significant interest with respect to ITPO.

Many case studies and modelling exercises conducted by academics, professionals and transit agencies have proven that increased transit frequencies will increase patronage (Currie & Walliss, 2008; Litman, 2008; Shepherd, Zhang, Emberger, Hudson, May, & Paulley, 2006; Paulley, et al., 2006; Espino, Ortuzar, & Roman, 2007; Taylor, Miller, Iseki, & Fink, 2008; Wall & McDonald, 2007). Shorter headways and thus wait times can also improve the flexibility and convenience of transit services to provide an acceptable alternative to car use (Davidson & Knowles, 2006; Carr, 2008), and reduce the inherent transfer penalty incurred when having to transfer between routes or modes. Service frequency is also a common indicator for assessing the level of service quality and accessibility (Victoria Transport Policy Institute, 2008d). Whilst there are other indicators of level of service, frequency has been included due to the importance of its relationship with IPTPO (see also 4.4). The ideal convenient maximum headway of transit service appears to be 10 minutes (Vuchic, 2005, p. 216; Reinhold, 2008).

The concept of elasticity is used to quantify the relationship between variables that may affect patronage and the level of patronage itself. For example, an elasticity of 0.5 that for every 1% increase in the variable, patronage will increase by 0.5%. Litman (2008, p. 46) summarised the elasticity of transit ridership and transit service as 0.5-0.7 in the short term, increasing to 0.7 to 1.1 in the long term. However, as Litman (2008, p. 46) adds that these elasticities and can be affected by numerous factors:

- "Transit price elasticities are lower for existing (transit dependent) riders than for new (discretionary) riders, and lower in urban areas than for suburban commuters.
- "Elasticities are about twice as high for off-peak and leisure travel as for peak-period and commute travel.
- "Discretionary ridership is often more responsive to service quality (speed, frequency and comfort) than fares."

Therefore, during off-peak periods including evenings and weekends, increased service frequencies should result in increased patronage, a result buoyed by the high elasticity expected in off-peak periods. The elasticity of 0.39 (Litman, 2008, p. 30) citing (TRACE, 1999) between car travel times and public transport use can also be advantageous for public transport mode share when headways are reduced, thus waiting times and journey times for transit are reduced. It is also more cost-effective for transit agencies to encourage travel during off-peak periods when there is existing capacity in relation to infrastructure, fleet, and labour remaining from the morning or afternoon peak (Toronto Transit Commission, 2003, p. 9). Thus, the marginal capital and operating cost of increasing frequency during the off-peak is far less than if frequency was to be increased during the peak.

Increased frequencies during the inter-peak, evening and weekends can also result in qualitative improvements for transit users and increasing patronage. Anxiety about personal safety is major a deterrent for potential transit users (Hine, Wardman, & Stradling, 2003), particularly at night (Stradling, Carreno, Rye, & Noble, 2007). Increasing service frequencies can reduce waiting time, thus reducing a major to using transit during quieter times of the day and replace the need for costlier solutions such as Guaranteed Ride Home programs (Victoria Transport Policy Institute, 2008b).

4.3.2 Sydney

The CityRail network's task is focused around the weekday commuter peaks. This can be illustrated based on the number of trains that enter the CBD in any given 1 hour period. During the 1 Hour AM Peak (i.e. arriving at Central station from 7:30 to 8:30 or 8:00 to 9:00 depending on individual line), approximately 95 suburban or outer suburban services and 15 Intercity services enter the Sydney CBD (Market Development and Research, Product Development, RailCorp, 2008, p. 40). As shown in Table 12, the total service frequency drops by over half after the peak hour during the weekday. The minimum headway found at most suburban station in Sydney is 30 minutes. However, such a generalisation assumes all services stop at all stations, which is not the case, as there is a mix of zonal and express/local operation. Therefore, main suburban interchange stations will see headways shorter than 30 minutes, as well as suburban stations served by intercity services.

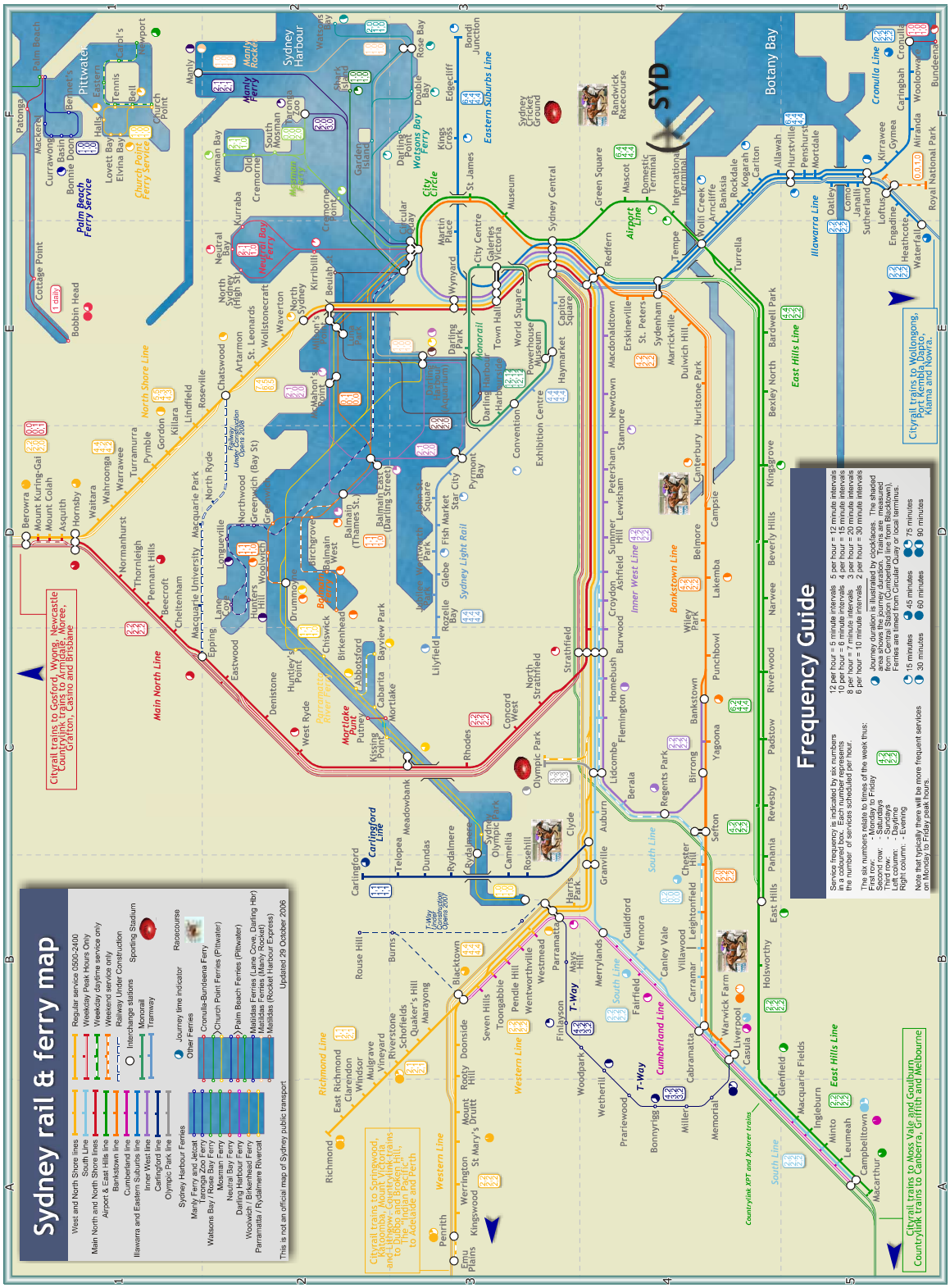
Table 12: CityRail Train Frequencies on Suburban Lines by Time of Day and Day of the Week, 2006-2008.

Line	***1 Hour AM Peak***	***Weekday Inter-peak***	***Weekday Evening***	***Weekend Daytime***	***Weekend Evening***
Illawarra	14	6	4	4	4
Eastern Suburbs	15	6	4	4	4
East Hills	12	6	4	4	4
Bankstown	6	4	2	2	2
South	8	2	4	2	2
Inner West	4	4	2	2	2
West	15	6	6	6	6
Northern	8	2	2	2	2
North Shore	13	7	4	6	5
Total Suburban and Outer-Suburban	**95**	**43**	**32**	**32**	**31**

(Market Development and Research, Product Development, RailCorp, 2008, p. 40; Australian Rail Maps, 2006)

There appears to be only one benchmark specifically related to service frequency, however it ignores the problem of low frequencies outside of the peak – "Deliver peak service frequencies of at least one train every 15 minutes for any station used by more than 1,000 passengers per hour in the peak" (State Rail, 2001). Furthermore, RailCorp's ability to increase capacity remains constrained by lack of track capacity, conflicting freight services, maintenance works and other general operating constraints such as conflicting movements at junctions, low speed limits and need to terminate or turn back trains (State Rail, 2001, p. 16). A survey of CityRail customers found that frequency was the highest priority for 51% of respondents (ITSRR, 2008), compared to journey time and punctuality.

Figure 29: Unofficial Map of CityRail and Sydney Ferries Network, depicting simplified stopping patterns and frequencies as of 2006



(Australian Rail Maps, 2006)

A cursory glance at bus services suggests a similar reduction in frequency outside of peak periods. Frequencies and service hours can vary immensely depending upon the route, the operator, and the market which the route serves. Generally speaking, private bus networks offer an inferior level service compared to Sydney Buses, however obviously demographic, land use and urban density are also significant factors in determining patronage demand and transit service supply.

An extreme example of commuter bias can be seen in Figure 30, a guide for a bus interchange on a major radial arterial approximately 10 km from the Sydney CBD by road. Of interest is the 20 weekday-only (and probably peak periods only) routes compared to 16 Monday-Sunday routes and five Monday-Saturday routes. In particular, Hillsbus clearly reflects a bias in serving the commuter market with 18 weekday routes compared four daily routes, although Sydney Buses is not immune to such bias either.

A more typical example of bias towards the commuter market can be seen at Parramatta Transport Interchange (PTI) in Figure 31. Unlike Lane Cove Interchange, which is located on a major commuter route to the Sydney CBD, PTI is:

- Located in the heart of the Parramatta CBD, the location of 39,000 jobs (Department of Planning, 2006);
- Serves as the terminus for Sydney's two T-way corridors (Ministry of Transport, 2007b);
- Connected to CityRail's fourth-busiest station (Market Development and Research, Product Development, RailCorp, 2008, p. 48); and
- Adjacent an enclosed shopping centre boasting 115,278 m^2 of retail floor space and 396 specialty stores (Ministry of Transport, 2008a).

Parramatta is served by a larger variety of bus operators. Nonetheless, there are seven weekday-only routes, compared to 40 Monday-Saturday or Monday-Sunday routes.

As there are fewer infrastructure constraints with respect to timetable planning for bus services, frequency benchmarks can be complied with provided resources are available to meet the minimum frequency. The NSW Ministry of Transport have published service planning guidelines that apply to all bus contractors. Under the Metropolitan Bus System Contract (MBSC), if a contract area has already implemented an integrated network plan (four regions have completed this), they are required to review their service plans annually, including seeking public comment. Minimum frequencies are determined by route types used to develop network plans. These are summarised in Table 13.

Figure 30: Extract from Lane Cove Interchange Guide

Bus services at Lane Cove Transport Interchange

Bus departure information

Please use this listing to find your bus number, route destination and bus stand. Refer to the interchange map overleaf to find the bus stand location.

Stand	Route Number	Bus Route Destination	Bus Operator	Service Operates
C	140	Epping via Epping Rd direct, Macquarie Centre, Macquarie University (Limited Stops)	Sydney Buses	Monday to Friday
B	140	Manly via Pacific Hwy, St Leonards, Crows Nest, Falcon St, Neutral Bay, The Spit, Balgowlah (Limited Stops)	Sydney Buses	Monday to Friday
C	251	Lane Cove West via Epping Rd, Sam Johnston Way, Mars Rd	Sydney Buses	Monday to Friday
A	251	City - QVB via Freeway	Sydney Buses	Monday to Friday
C	252	Lane Cove West via Burns Bay Rd	Sydney Buses	Monday to Saturday
B	252	City - QVB via Pacific Hwy, St Leonards, Crows Nest, North Sydney	Sydney Buses	Monday to Saturday
C	253	Lane Cove West via Longueville Rd, Riverview loop, River Rd	Sydney Buses	Monday to Saturday
B	253	City - QVB via Pacific Hwy, St Leonards, Crows Nest, North Sydney	Sydney Buses	Monday to Saturday
C	254	Drummoyne via Longueville Rd, River Rd, Riverview, Burns Bay Rd, Lane Cove West, Huntleys Point, Victoria Rd	Sydney Buses	Monday to Sunday
B	254	City - QVB via Pacific Hwy, St Leonards, Crows Nest, North Sydney	Sydney Buses	Monday to Sunday
C	261	City - QVB via Northwood, Longueville, Crows Nest, North Sydney	Sydney Buses	Monday to Saturday
B	261	Chatswood via Pacific Hwy	Sydney Buses	Monday to Friday
C	286	Denistone East via Epping Rd, North Ryde, Coxs Rd, Macquarie Hospital, Herring Rd	Sydney Buses	Monday to Friday
B	286	Milsons Point via Pacific Hwy, St Leonards, Crows Nest, North Sydney	Sydney Buses	Monday to Friday
C	287	Ryde (Bus Depot) via Epping Rd, Coxs Rd, Macquarie Hospital, North Ryde, Lane Cove Rd, Ryde, Victoria Rd	Sydney Buses	Monday to Friday
B	287	Milsons Point via Pacific Hwy, St Leonards, Crows Nest, North Sydney	Sydney Buses	Monday to Friday
C	288	Epping via Epping Rd, North Ryde, Coxs Rd, Macquarie Hospital, Macquarie Centre, Macquarie University	Sydney Buses	Monday to Sunday
A	288	City - QVB via Freeway	Sydney Buses	Monday to Sunday
C	289	Epping via Epping Rd, Cox Rd, North Ryde, Macquarie Hospital, Macquarie Centre, Macquarie University	Sydney Buses	Monday to Sunday
B	289	City - QVB via Pacific Hwy, St Leonards, Crows Nest, North Sydney	Sydney Buses	Monday to Sunday
C	290	Epping via Epping Rd direct, Macquarie Centre, Macquarie University	Sydney Buses	Monday to Sunday
B	290	City - QVB via Pacific Hwy, St Leonards, Crows Nest, North Sydney	Sydney Buses	Monday to Sunday
C	291	Epping via Epping Rd direct - does not go via Macquarie Centre or University	Sydney Buses	Monday to Sunday
A	291	City - QVB via Freeway	Sydney Buses	Monday to Sunday
C	292	Marsfield via Epping Rd, Macquarie Park, Fontenoy Rd, Macquarie Centre, Macquarie University, Vimiera Rd	Sydney Buses	Monday to Sunday
A	292	City - QVB via Freeway	Sydney Buses	Monday to Sunday
C	293	Marsfield via Epping Rd direct, Vimiera Rd	Sydney Buses	Monday to Friday
A	293	City - QVB via Freeway	Sydney Buses	Monday to Friday
C	294	Epping via Epping Rd, Macquarie Park, Talavera Rd, Macquarie Centre, Macquarie University	Sydney Buses	Monday to Friday
B	294	City - QVB via Pacific Hwy, St Leonards, Crows Nest, North Sydney	Sydney Buses	Monday to Friday
B	536	Chatswood via Pacific Highway	Sydney Buses	Monday to Sunday
C	536	Gladesville via Burns Bay Rd, Lane Cove West, Hunters Hill, Pittwater Rd	Sydney Buses	Monday to Sunday
C	610	Rouse Hill Town Centre via M2 Motorway, Baulkham Hills, Castle Hill, Kellyville, Beaumont Hills	Hillsbus	Monday to Sunday
A	610	City - Railway Square via Freeway	Hillsbus	Monday to Sunday
C	612	Riley T-way Station via M2 Motorway, Baulkham Hills, Castle Hill, Kellyville	Hillsbus	Monday to Friday
B	612	Milsons Point via Pacific Hwy, St Leonards, Crows Nest, North Sydney	Hillsbus	Monday to Friday
C	613	Bella Vista via M2 Motorway	Hillsbus	Monday to Friday
A	613	City - Railway Square via Freeway	Hillsbus	Monday to Friday
C	614	Crestwood via M2 Motorway, Northmead, Winston Hills, Merindah Rd, Baulkham Hills	Hillsbus	Monday to Friday
A	614	City - Railway Square via Freeway	Hillsbus	Monday to Friday
C	615	Riley T-way Station via M2 Motorway, Baulkham Hills, Kellyville	Hillsbus	Monday to Friday
A	615	City - Railway Square via Freeway	Hillsbus	Monday to Friday
C	616	Rouse Hill Town Centre via via M2 Motorway, North West T-way, Glenwood, Parklea, Stanhope Gardens, Kellyville Ridge	Hillsbus	Monday to Friday
A	616	City - Railway Square via Freeway	Hillsbus	Monday to Friday
C	619	Castle Hill via Macquarie Centre, M2 Motorway, Baulkham Hills	Hillsbus	Monday to Sunday
A	619	City - Railway Square via Freeway	Hillsbus	Monday to Sunday
C	620	Dural via M2 Motorway, Thompsons Corner, Cherrybrook, Glenhaven	Hillsbus	Monday to Friday
A	620	City - QVB via Freeway	Hillsbus	Monday to Friday
C	642	Round Corner via Pennant Hills Rd, Thompsons Corner, Glenhaven, Dural	Hillsbus	Monday to Friday
A	642	City - QVB via Freeway	Hillsbus	Monday to Friday
C	650	West Pennant Hills Valley via M2 Motorway, Pennant Hills, West Pennant Hills, Castle Hill Rd	Hillsbus	Monday to Friday
A	650	City - QVB via Freeway	Hillsbus	Monday to Friday
C	654	Round Corner via M2 Motorway, West Pennant Hills, Glenhaven, Dural	Hillsbus	Monday to Friday
A	654	City - QVB via Freeway	Hillsbus	Monday to Friday

For timetables, fares and route planning, please contact the Transport Infoline on 131 500 or visit www.131500.info

(Ministry of Transport, 2008c)

Service or revenue kilometres for bus services under the MBSC regime have increased by 3% between 2006/07 and 2007/08 (Ministry of Transport, 2008d), suggesting that either frequencies are increasing, service hours of routes being extended, or that the number and length of routes have increased. Conversely, it is interesting to note that the Ministry of Transport's own service planning guidelines do not declare maximum headways for evening services at the district level. Yet, there is strong local evidence from the NSW 2006 Household Survey (Transport Data Centre, 2008, p. 13) that also suggests that increased service frequencies and extended service hours can reduce the unattractiveness of public transport. The response rates for particular reasons, as well as how increased frequencies can address such reasons are shown in Table 14.

Figure 31: Extract from Parramatta Interchange Guide

Bus services at Parramatta Transport Interchange

Bus departure information

Please use this listing to find your bus number, route destination and bus stand. Refer to the interchange map overlead to find the bus stand location.

Stand	Route Number	Bus Route Destination	Bus Operator	Service Operates	
A2	520	City-Circular Quay via UWS Rydalmere, Ermington, West Ryde, Ryde, Gladesville and Drummoyne	Sydney Buses	Monday to Sunday	
A2	L20	City-Circular Quay via UWS Rydalmere, Ermington, West Ryde, Ryde, Gladesville and Drummoyne Limited Stops	Sydney Buses	Monday to Saturday	
A2	521	Eastwood via UWS Rydalmere, Park Road Rydalmere and Mobbs Lane	Sydney Buses	Monday to Saturday	
A2	523	West Ryde via UWS Rydalmere, Ermington Shops and Cowells Lane Ermington	Sydney Buses	Monday to Saturday	
A2	524	West Ryde via UWS Rydalmere, South Street Ermington, Ermington Shops and Melrose Pk	Sydney Buses	Monday to Sunday	
A2	525	Burwood via UWS Rydalmere, Newington, Olympic Park and Strathfield	Sydney Buses	Monday to Sunday	
A2	545	Chatswood via Dundas Valley, Eastwood, Macquarie Park and North Ryde	Sydney Buses	Monday to Sunday	
A2	547	Macarthur Street Loop - Limited Service	Sydney Buses	Monday to Saturday	
A2	550	Chatswood via Eastwood, Macquarie Park and North Ryde - Limited Service	Sydney Buses	Monday to Friday	
A2	N60	Nightride - City Town Hall via Granville, Strathfield and Leichhardt	Punchbowl Bus Company	Monday to Sunday Early Mornings	
A2	N70	Nightride - City Town Hall via Strathfield and Leichhardt	Punchbowl Bus Company	Monday to Sunday Early Mornings	
A3	546	Oatlands via Bettington Road	Sydney Buses	Monday to Sunday	
A3	623	Beecroft via North Parramatta and Carlingford	Sydney Buses	Monday to Sunday	
A3	624	Epping via North Parramatta and Carlingford	Sydney Buses	Monday to Sunday	
A3	625	Pennant Hills via Carlingford and Thompsons Corner	Hillsbus	Monday to Sunday	
A3	627	Cherrybrook via North Parramatta and Carlingford	Hillsbus	Monday to Friday	
A3	609	Northmead via Lake Parramatta	Hillsbus	Monday to Sunday	
A4	600	Rogans Hill via Northmead, Baulkham Hills and Castle Hill	Hillsbus	Monday to Sunday	
A4	601	Kellyville via Northmead, Baulkham Hills and Kellyville Plaza	Hillsbus	Monday to Sunday	
A4	603	Knightsbridge via Northmead, Baulkham Hills East and Castle Hill	Hillsbus	Monday to Saturday	
A4	604	Castle Hill via Model Farms and Baulkham Hills Pool	Hillsbus	Monday to Saturday	
A4	606	Castle Hill via Northmead, Winston Hills, West Baulkham Hills and Crestwood	Hillsbus	Monday to Sunday	
B1	906	Fairfield via Harris Park, Granville, Excelsior Street South Granville and Old Guildford	Veolia	Monday to Saturday	
B1	907	Bankstown via Granville, Blaxcell Street South Granville, Chester Hill and Yagoona	Veolia	Monday to Sunday	
B1	909	Bankstown via Harris Park, Parramatta Rd, Auburn Station, Regents Park and Potts Hill	Veolia	Monday to Sunday	
B1	910	Bankstown via Granville, Blaxcell Street South Granville, Chester Hill and Yagoona	Veolia	Monday to Sunday	
B2	800	Liverpool via Smithfield, Wetherill Park, Stockland Mall and Wakeley	Westbus	Monday to Saturday	
B2	802	Guildford via Merrylands	Hopkinsons	Monday to Sunday	
B2	803	Guildford via Merrylands and Chetwynd Road	Hopkinsons	Monday to Sunday	
B2	804	Fairfield via Merrylands and Guildford	Hopkinsons	Monday to Sunday	
B2	808	Woodpark via Merrylands, Guildford and Guildford West	Hopkinsons	Monday to Friday	
B2	809	Guildford West via Merrylands and Guildford	Hopkinsons	Monday to Sunday	
B2	810	Merrylands via South Wentworthville - Limted Service	Westbus	Monday to Friday	
B2	811	Merrylands via Mays Hill, Old Prospect Rd, Pemulwuy and Whalans Rd Greystanes	Westbus	Monday to Saturday	
B2	813	Merrylands via Mays Hill, Old Prospect Rd, Pemulwuy and Gardenia Pde Greystanes	Westbus	Monday to Friday	
B2	815	Merrylands via Mays Hill, Old Prospect Rd, Pemulwuy and Macquarie Rd Greystanes	Westbus	Monday to Sunday	
B2	T80	Liverpool via Transitway	Western Sydney Buses	Monday to Sunday	
B2	N60	Nightride - Fairfield via Merrylands	Punchbowl Bus Company	Monday to Sunday Early Mornings	
B2	N70	Nightride - Penrith via Blacktown and Mount Druitt	Punchbowl Bus Company	Monday to Sunday Early Mornings	
B4	609	Childrens Hospital at Westmead	Hillsbus	Monday to Friday	
B4	700	Blacktown via Mays Hill, Pendle Hill and Prospect	Hillsbus	Monday to Sunday	
B4	705	Toongabbie via Wentworthville, Pendle Hill and Girraween	Hillsbus	Monday to Sunday	
B4	708	Pendle Hill and Toongabbie Retirement Bus	Hillsbus	Monday to Friday	
B4	711	Blacktown via Westmead Hospitals, Wentworthville, Toongabbie, Seven Hills and Lalor Park	Hillsbus	Monday to Sunday	
B4	T61	Blacktown via Westmead, NW T-Way, Kings Langley and Sunnyholt Rd	Hillsbus	Monday to Sunday	**T series services**
B4	T62	North Kellyville via Westmead, NW T-Way, Bella Vista, Norwest and Kellyville Plaza	Hillsbus	Monday to Sunday	**operating on the**
B4	T63	Kellyville Ridge via Westmead, NW T-Way, Glenwood, and Stanhope Gardens	Hillsbus	Monday to Friday	**North-West T-way**
B4	T64	Rouse Hill via Westmead, NW T-Way, and Beaumont Hills	Hillsbus	Monday to Sunday	**commence**
B4	T65	Rouse Hill Town Centre via Westmead, NW T-Way	Hillsbus	Monday to Sunday	**11 March 2007**

For timetables, fares and route planning, please contact the Transport Infoline on 131 500 or visit www.131500.info

(Ministry of Transport, 2007b)

Table 13: Maximum scheduled headways between services by bus route type, quoted from Ministry of Transport's Service Planning Guidelines

Type	*Description*	*Time of day*	*Maximum headway*
Regional	• link residential areas to the nearest regional centre • integrate with other regional routes to form high frequency services • pass through major trip generators • are direct and frequent • allow interchange with other transport modes • serve multiple trip purposes • includes MoT designated 'strategic transport corridors'	Early morning Peak Inter Peak (Weekday Daytime) Night time Saturday Daytime Sunday Daytime	30 minutes 20 minutes 30 minutes 60 minutes 30 minutes 30 minutes
District	• link residential areas to either: • the nearest district centre and a strategic transport corridor operating to the nearest regional centre; or • the nearest district centre and other mode operating to the nearest regional centre (eg train station or ferry wharf); or • the nearest regional centre, where it is closer than the nearest district centre; and • can operate on part of a strategic transport corridor	Peak Inter Peak Saturday Daytime Sunday Daytime	60 minutes 60 minutes 60 minutes 60 minutes
Local	• Inter Peak fixed route; or • Flexible transport service including dial a ride, roam zones, community transport, taxi, etc.	Inter Peak To be negotiated with MoT	120 minutes

(Ministry of Transport, 2006, pp. 24-29)

Table 14: Reasons for using car to travel to work from 2006 HTS, and how increased public transport frequencies or shorter headways can react counteract such reasons

Reason	*Response Rate*	*Resolution*
Vehicle faster	49%	Shorter headways can result in shorter waiting times, reducing the total door-to-door journey time
Bus train unavailable inaccessible	33%	Extended service hours for public transport makes it available for those who need it outside daytime hours.
Can make trip whenever I like	19%	People do not wish to be restricted by poor frequencies or restricted service hours when making trips. High frequencies for up to 18 hours daily can cater to a greater variety of trip purposes and work shifts
No timetable waiting time constraints	19%	Travelling by car does not require the driver to consult a timetable to determine the appropriate time to travel. Therefore, to compete with the convenience and flexibility of the car, public transport must provide 'turn up and go' headways of 10 minutes or less, so that consulting a timetable to avoid a long wait is no longer necessary.

Reason and response rate sourced from (Transport Data Centre, 2008, p. 13). Resolutions from author.

4.3.3 Toronto

GO Transit's commuter rail task is strongly in reflected in the frequency of its operations and the service hours of its operation (see Table 15 for summary of on GO Train, GO Bus and GO Train-bus). A generalisation of service frequency is difficult due to the mixed stopping patterns and short-working (where service starts or ends short of the typical terminating or end location on the line, route or service sector) evident on all lines during peak commuting periods (Greater Toronto Transit Authority, 2008b). Such practices are also evident on the GO Train-bus that substitutes most of the train lines during the off-peak periods. Furthermore, most trains terminate at Union Station, with only a minority of trains through-routed to serve those travelling in the reverse-peak direction. For example, in the morning peak, headways on the Lakeshore West line in the East and Inbound/Peak direction can be as small as five minutes (including short worked trains). Of the eight trains arriving at Union Station between 7:31 and 8:30 AM on a weekday, only two continue onto the Lakeshore East line in the Outbound/Reverse-peak direction. On GO Bus routes, peak and off-peak frequency appears to be dictated by demand and thus headways can vary significantly, assuming the service operates at all outside the peak, particularly during the evening and on weekends. The service intensity of GO Transit (and therefore frequency and operating extent) based on the number of weekday trips per route kilometre is significantly lower than that of CityRail, even when including CityRail Intercity services (Table 15).

Included in Table 15 are statistics for the TTC's service intensity. The comparison of service intensity of local Toronto transit operators other than TTC is difficult due to the scarcity of published data of either service kilometres or trips. In comparing TTC with Sydney, it should be noted that the TTC operates services predominantly in the City of Toronto, which has a higher population density and would be considered comparable to Sydney Buses' catchment.

The TTC Subway and RT operate at a high frequency throughout the week, at a maximum headway of 6 minutes of all lines for over 19 hours per day on Monday to Saturday, and over 16 hours on Sundays (Toronto Transit Commission, 2008g). This result is a service intensity that is 9 to 18 times that of CityRail's suburban services (Table 15), Most TTC streetcar lines operate from 5 AM to 1:30 AM on weekdays (Toronto Transit Commission, 2008g). The least used route, 502 Downtowner, has a maximum headway of 20 minutes during weekdays. The most used route, 504 King, maintains an average headway of 10 minutes or less for at least 13 hours per weekday, and at least 10 hours per day on Sundays. The service intensity of TTC streetcars is almost 1.3 times that of Sydney Buses (Table 15).

Figure 32: Schedule at a Spadina LRT stop.

Note the 'FS' designation for frequent service, and the extent of operating hours it applies to.

Ong, V. 2008

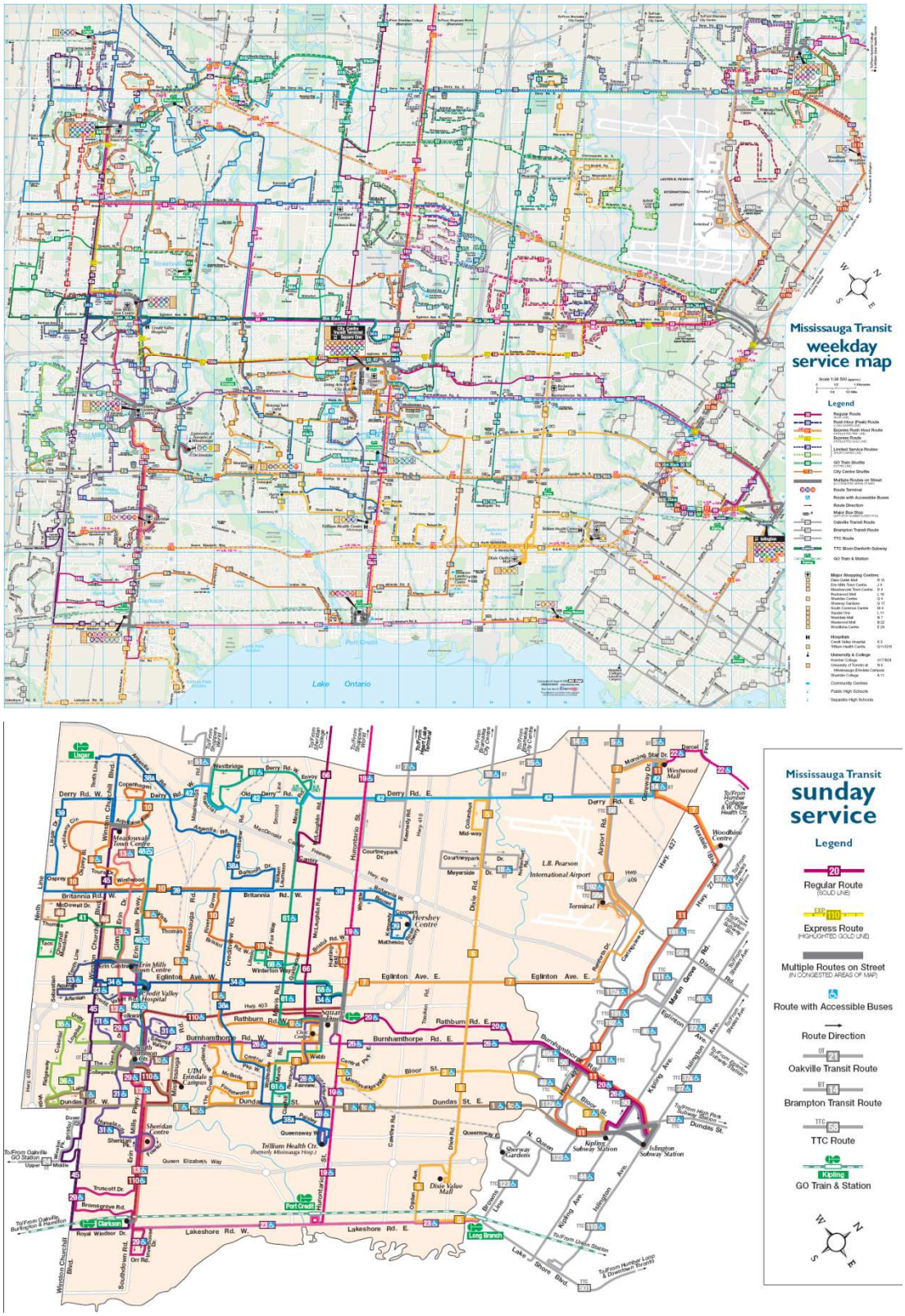
The service intensity of TTC buses appears to be half that of Sydney Buses (Table 15). Nonetheless, TTC's bus route length and the absolute number of service kilometres exceed that of Sydney Buses, suggesting that the scale of TTCs bus operations is greater. Although the TTC's service intensity is slightly lower than that of Sydney Buses, it is also more than twice of all bus services across the Sydney metro area.

Interestingly, the annualisation factor for TTC patronage is 312, higher than CityRail's 300, based on dividing annual patronage by weekday patronage (Toronto Transit Commission, 2008d; Market Development and Research, Product Development, RailCorp, 2008). This suggests that the higher service intensity offered by the TTC all year round, can result increased patronage on weekends as weekend patronage on TTC has a stronger impact on annual patronage than CityRail.

For transit operators other than the TTC, it is likely that service intensities in the outer suburbs are lower, since this can be seen in Sydney's bus service intensity where privately operated bus regions are included. With respect to service hours, the difference in network coverage between a weekday and weekend is significant (see Figure 33 for a comparison of Mississauga's). Like Sydney, there also exceptions where service frequency can match modes or routes found in the inner suburbs. For instance, three out of five of YRT's VIVA routes have a maximum scheduled headway of 15 minutes, 18 hours per day, 7 days per week (York Region Rapid Transit Corporation, 2004b).

Like RailCorp, timetable planning for GO trains is constrained by similar rail-related operating constraints (Greater Toronto Transit Authority, 2007), which are exacerbated by lack of track kilometres under GO ownership (see 3.3.2.1.1 GO Transit Commuter Rail). Increases in GO bus service are led by increased patronage. Nevertheless, a significant constraints is the need for provincial government subsidies, as usually only 85% of GO's operating costs are recovered through fare revenue (Greater Toronto Transit Authority, 2007; Kyonka, 2008).

Figure 33: Comparison of Mississauga's Weekday and Sunday Route Network



(Mississauga Transit, 2008)

Table 15: Service Intensity in Toronto and Sydney

City	Sydney				Toronto							
Managing Agency (Brand)	MoT Metropolitan Bus Contracts		RailCorp (CityRail)		GO Transit			Toronto Transit Commission				
Mode or Type	Public (Sydney Buses)	Public + Private	Suburban Services	Suburban + Intercity	Train	Bus (incl. Train-bus)	GO Total (incl. Train-bus)	Subway	Scarborough RT	Bus	Streetcar	Total
Route km	1300*	5300*	315	1030	390	2501	2891	62	6.4	3565	152	3785
Service km (000,000's)	78.29	103.90	20.26	32.67	-	-	-	74.51	3.73	107.61	11.85	197.71
Weekday Number of Operated Trips (000's)	16.27 ^	25.00 ^	1.92	2.42	0.18	2.05	2.23	-	-	-	-	-
Service km/Route km (000's)	60.22	19.60	64.31	31.72	-	-	-	1203.75	583.44	30.19	77.88	52.23
Weekday Trips/Route km	12.52	4.72	6.08	2.35	0.46	0.82	0.77	-	-	-	-	-

Service intensity figures should be treated as estimates as they have been calculated by the author based on where data has been made publicly available, and subject to integrity issues due to different accounting methods of each agency.
*Route km for Sydney bus network is based on 2000 network and thus may not be up to date, and may be an overestimate as new integrated network plans are implemented (Transport Data Centre, 2002). State Transit has also expanded its contract area since 2000.
^Weekday trips of MoT buses assume average weekday is equivalent to one-three hundredth (Market Development and Research, Product Development, RailCorp, 2008, p. 77) of the Annual Number of Trips (State Transit Authority of NSW, 2007; Ministry of Transport, 2008d)

(Greater Toronto Transit Authority, 2007; Greater Toronto Transit Authority, 2008c; Market Development and Research, Product Development, RailCorp, 2008; Ministry of Transport, 2008d; State Transit Authority of NSW, 2007; Toronto Transit Commission, 2008d; Transport Data Centre, 2002)

In 2003, the TTC evaluated a range of service improvements that would increase ridership in its Ridership Growth Strategy (Toronto Transit Commission, 2003). As illustrated in Table 16 and the strategy, off-peak service improvements including the maximum 20 minute headway and 'full service' well into the evening can be implemented within six to twelve months (Toronto Transit Commission, 2003, p. 53) and result in relatively cost-effective increases to patronage, as well as benefit tens of millions of existing users (Toronto Transit Commission, 2003, p. 28).

As of 2008, the maximum headway for bus and streetcar is at 30 minutes, although the intention is to reduce this to 20 minutes in 2009 (Toronto Transit Commission, 2008a, p. 7); the subways and RT have maximum 5 minute headway. After many years of deferrals, a blog from a respected Toronto transit activist suggests that most of the service improvements and others recommended by the Ridership Growth Strategy will be implemented from November 23, 2008 (Munro, 2008).

Table 16: Proposed Service Improvements, annualised benefits and costs, as recommended in TTC Ridership Strategy

	Existing riders who benefit (million)	New ridership (million)	Operating Costs ($ millions)			Extra Peak Vehicles Required	Capital cost ($ millions)	New Ridership to Subsidy + Capital Ratio
			Costs	Revenue	Subsidy			
Improve peak period service on major routes:								
2% increase in peak service	17.4	0.44	1.4	0.7	0.7	16	9.4	4%
6% Increase in peak service	45.1	1.73	4.5	2.7	1.9	53	31.9	5%
10% increase in peak service	74.3	2.84	9.2	4.4	4.7	100	60	4%
Improve off peak service on major routes	44.73	2.28	12	3.5	8.4			27%
Full service on all routes from 6 AM to 1 AM	8.73	2.88	20.1	4.5	15.6			18%
Maximum of 20 minute service on all routes	18.22	2.73	19.1	4.2	14.8			18%

Ratio column added by author. (Toronto Transit Commission, 2003, p. 28)

4.4 Network Geometry, Mode Selection and Transferability

4.4.1 Theory

Vuchic (2005, pp. 186-187) lists several "network design features that affect transit service quality and thereby influence passenger attraction":

- Area coverage or catchment – to maximise transit's mode share
- Operating speed
- Travel desire lines – networks must reflect high passenger demand to particular destinations
- Directness of travel – the ratio between distance travelled and straight-line distance should ideally remain low
- Simplicity, connectivity and easy transfers – needed for passenger convenience.

There is a significant volume of literature dedicated to the principles of network planning. In this thesis, only the key concepts that are required to evaluate each case study will be discussed, as the literature already covers much of the detail in network types and planning.

A transit line or route must be able to meet one of two basic tasks: "collection of passengers and their transport (haul) over a distance" (Vuchic, 2005, p. 195). The former function requires that the route must maximise area coverage in order to attract passengers, whereas the latter requires higher speed and higher capacity service where a great volume of transit desire lines are expected to converge. Circuitous routing can be used to expand coverage with one route, however it should not done mid-route as this increases delays for through passengers (Vuchic, 2005, p. 195). Each line can only be designed as a compromise where one of the two functions dominates; therefore a network of lines or routes is required to fulfil both functions.

With respect to line geometry, there are several types that can be classified based on direction of travel in relation to the metropolitan area's CBD:

- **Radial and diametrical lines –** lines that originate from the suburbs and converge on the CBD (Vuchic, 2005, p. 201). Diametrical lines are those that are through routed through the city centre, like the diameter of a circle.
- **Tangential, circumferential, circle and loop lines –** for non-CBD oriented trips (Vuchic, 2005, pp. 204-205).

Types of lines that converge or diverge on dominant (usually radial) travel desire lines or corridors can also be classified based on function, resulting in an inherent hierarchy. It is when discussing the relationship between these lines, that the concept of an integrated network

becomes important. The basis of the corridor is the trunk line or trunk corridor, where prevailing function or task is to satisfy the convergence of desire lines. As population density falls in relation to distance from the CBD, the area coverage must also increase to maximise the catchment coverage of the trunk to facilitate the collection of passengers (Vuchic, 2005, p. 208). There are two ways that transit lines that can fulfil this requirement:

- **Branches –** where trunk corridors are created from the convergence of branch lines travel directly to the CBD
- **Feeders –** where independent lines intersect with a trunk line or corridor, requiring a transfer or interchange between the trunk and the feeder. The modes servicing either feeders or trunks can also differ.

The characteristics of either arrangement are listed in Table 17.

Table 17: Characteristics of Branchers and Feeders

Branches	***Feeders***
• Continuous integrated service without transfers between the city centre and outer suburbs • Capacity constraints on trunk can limit frequency on branches • Due to longer routes, less time required on an overall network basis required for services to layover at terminating points • Suburban transfer stations or hubs not required	• Each route or line can be optimised by mode, vehicle type and level of service • The trunk can be served by more comfortable, cost-effective, high-capacity modes. • Relying on feeders avoids excessive duplication of resources. • Service reliability or punctuality is increased as feeders and trunks are operationally physically separated and any delays are unlikely to spread across the network. • Suburban hubs accommodate trunk-feeder transfers, but also feeder-feeder transfers, thus increasing connectivity and directness of travel for suburb to suburb trips.

Adapted from (Vuchic, 2005, p. 210)

Whether the network of any metropolitan area is dominated by branch or feeder operations, has a significant influence on the geometry of the network as a whole. There are three geometric forms of networks that can either be used to categorise individual or multiple modes (Vuchic, 2005, pp. 236-245):

- **Radial networks –** oriented toward the commuter market, are dominated by radial trunks converging on the CBD, with most branches or feeders serving radial corridors.
- **Radial/Circumferential networks –** where trunk corridors are include both radial and circumferential corridors.

- **Rectangular or Grid networks –** ideal for metropolitan areas have large dense inner areas, rather than an extreme concentration. The trunk corridors are parallel or perpendicular to each other and due to lack of convergence, these are reliant on feeders and transfers at multiple hubs to provide coverage between trunks.

Integration can be examined at a line or corridor operational scale, or a network scale. Integrated lines or routes are those that "have branches, converge, diverge, and mutually overlap on portions of their alignments" such as roads or railway tracks (Vuchic, 2005, p. 196). The converse is independent lines, where each line has independent alignments without overlaps (Vuchic, 2005, p. 195). An integrated network is holistically integrated; it can consist of integrated or independent lines, as long as transfers between lines or modes are convenient.

The best public transport systems, according to Mees (2000, p. 134) are those that "rely on a high rate of interchange between routes". Mees (2000, p. 134) cites Cervero (1986) who summarises the importance of transfers, particularly in low-density cities where trip generators are dispersed across the metro area; "Commuters abhor the hassle of transferring or anything that disrupts the process of making a trip. When densities are low, trip ends dispersed, and networks laid out on a grid, transferring becomes an unavoidable way of life. Near effortless connections of modes thus become imperative if motorists are to be won over transit". High service frequency and extended service hours (4.3) and fare integration (4.2) are essential in an integrated public transport system as:

- "frequencies and hours of operation must be set to maximise opportunities for travel and possibilities for connections, even if this mean some services are more lightly loaded than others" (Mees, 2000, p. 135)
- "transferring between services is an inconvenience: requiring an extra fare for the disservice is adding insult to injury" (Mees, 2000, p. 137)
- "there will always be some trips involving interchange, commonly including hospital vistis, those to friends and relatives and home-to-work journeys where the workplace is outside the central or large enough to be served by a special route" (White, 2002, p. 92)

4.4.2 Sydney

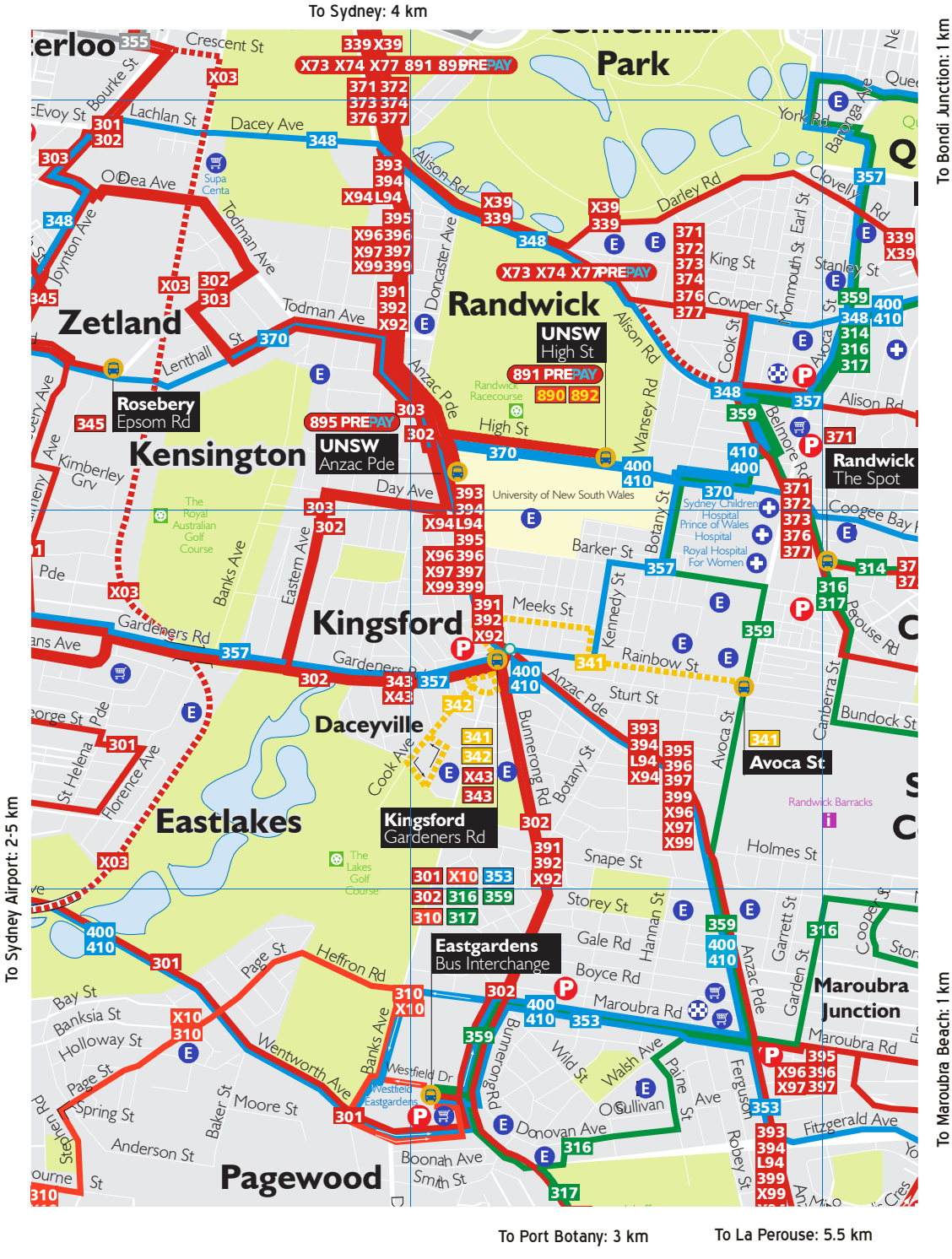
The CityRail network is generally radial in geometry (Figure 29). The Northern Line is radial in practice as it is used as the 'Main North' corridor heading out of Sydney, in contradiction with what is depicted in Figure 29 and the official CityRail map as circumferential. The only loop or circle line is the Bankstown line, which only serves a small proportion of the southern suburbs. The other circumferential line is the Cumberland line; however this line only sees five trains per day, in either direction.

Bus networks across Sydney tend to consist either of radial-branch routes directly to the Sydney CBD, or radial feeder routes feeding the local CityRail station. The following series of figures illustrate some of the route types and network geometry across Sydney. It is assumed the radial corridor is either the trunk corridor to the Sydney CBD, or the CityRail network. Although some suburban radial-feeders may appear to be tangential in geometry, for clarity and differentiation, routes marked as circumferential are at least 15 km in length and tangential routes are at least 5 km in length. Either must have major trip generators at both termini, or allow transfer between at least two different railway lines or other high frequency service. Routes marked as radial-feeders have only one major trip generator or transfer point to a trunk service.

Figure 34 is an extract of Sydney Buses' network map of the south-eastern suburbs, along the Anzac Parade corridor. Most radial-branch routes radiate from the top left corner of the map, which is in the direction of the Sydney CBD. All of the tangential and circumferential routes are radiating out of the top-right corner of the map, toward Bondi Junction where a major multi-modal transport interchange and suburban CBD is located.

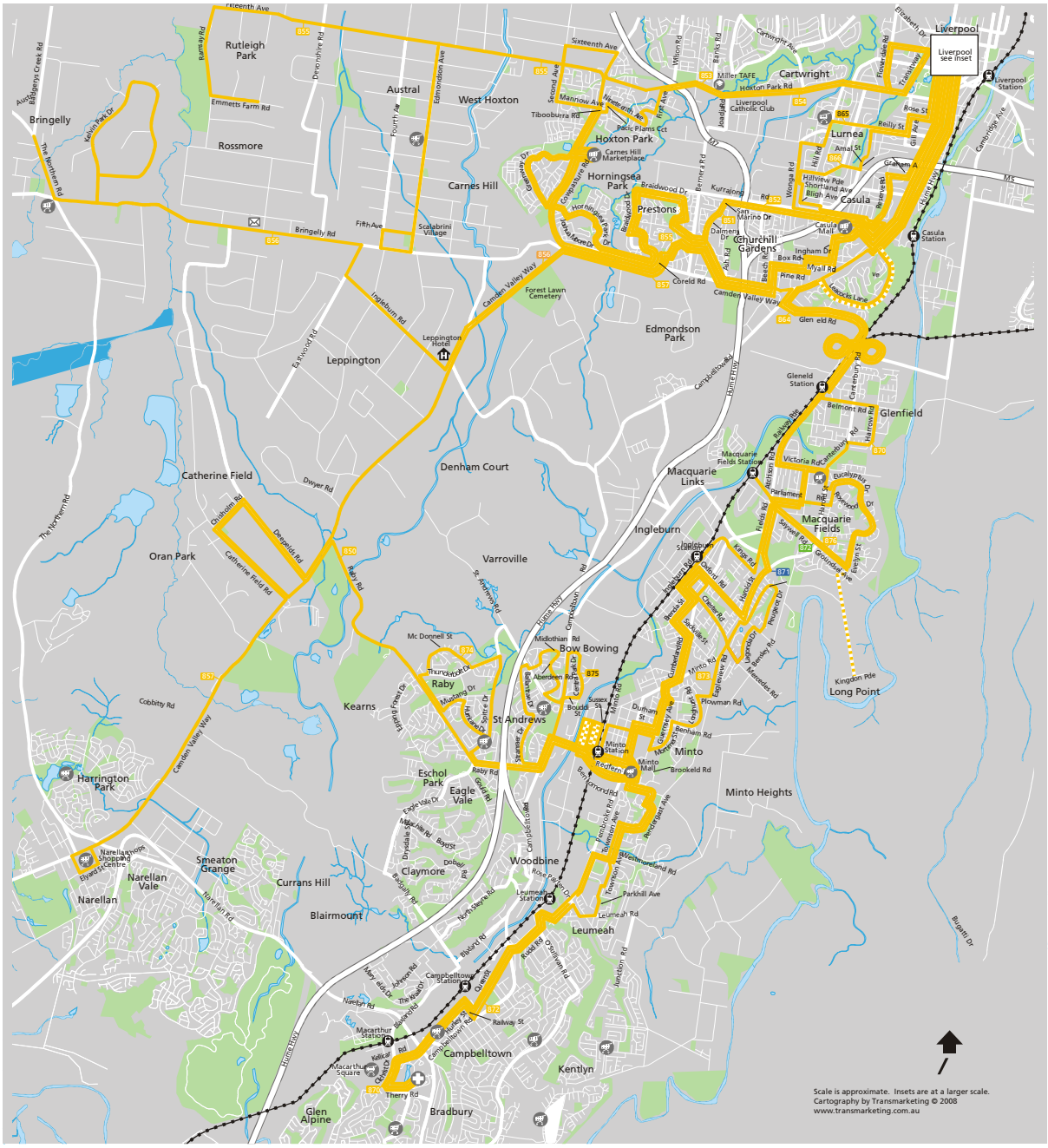
On the outer fringes of Sydney, most routes are radial-feeders that feed CityRail's radial network, such as MBSC Region 2 depicted in Figure 35. The hub in the top half of Figure 35 is the City of Liverpool, located 34 kilometres by road from the Sydney CBD. Some of the routes extend from Liverpool to Campbelltown appear to compete with the CityRail service; these have been marked as radial-feeder as they routes feed into the CityRail stations and are generally parallel to the railway line, thus radial in geometry. Contract Region 2 has completed the MoT-mandated network review. During peak periods, CityRail offers competitive travel times with private motor vehicles; therefore it is preferred mode for radial demand.

Figure 34: Extract of Sydney Buses' Bus Network Map of Anzac Parade corridor in Sydney's South Eastern Suburbs, with route types colour-coded.



Base map sourced from Sydney Buses, Eastern Region Guide, February 27, 2008. Colour-coding of routes made by author.

Figure 35: Region 2 Bus Network Map, with route types colour-coded.



Radial-Branch | Radial-Feeder | Tangential | Circumferential

Base map sourced from Ministry of Transport, Region 2 Network Map, July 30, 2008. Colour-coding of routes made by author.

In both the above cases, the network geometry strays from the 'grid-like' pattern advocated by Mees (2000). Whilst Figure 34 appears to be over-reliant on radial-branch routes, due to the lack of a fixed high-capacity transit mode, the geometry does suit the constraints of the region. Whilst cross-suburban travel is more difficult with trunk-branch routes, the existence of tangential and circumferential routes ameliorates this to some degree. In outer-suburban locations as that in Figure 35, demand is likely to be low for circumferential or tangential bus routes as most of the urban development in the region follows the railway, the result of deliberate land use planning policies.

The lack of fare integration or high frequency services as mentioned in 4.2.2 and 4.3.2 is apparent in the network geometry of bus and radial networks including those both in the outer suburbs where rail coverage may be poor but still accessible, and inner suburbs of Sydney where rail coverage is extensive. Part of the reason for the prevalence of radial-branch operations in Sydney is the lack of the aforementioned features, discouraging people to transfer between modes, resulting in inefficient operations due the mismatching of modes, the longer distances travelled or the unnecessary duplication of services by different transit modes to serve the same travel desire lines. Furthermore the prevalence of radial-branch operations results in Park and Ride demand becomes artificially inflated at CityRail stations and major bus stops. The practice of 'railheading' is a significant problem, where commuters attempt to park near major stations where railway lines converge or are served by express trains. Approximately 16% of train users park and ride, whilst a further 19% kiss and ride (Transport and Population Data Centre, 2006). Although park and ride can increase the catchment of any transit network, the subsidisation of such facilities is significant compared to patronage gained; furthermore subsidising park and ride is inequitable as it favours those who can afford car ownership, compared to the transit-dependent.

Figure 36 illustrates the network geometry of the bus network in the North-Western suburbs after the North-West T-way was completed and the MoT-supervised network review was implemented. As seen in this figure, there are 13 bus routes operated by Hillsbus that fulfil a trunk-branch function, converging on the M2 (Hills Motorway) to travel over 28 km on freeway to reach Sydney CBD or 'City', in addition to several other routes use the motorway to reach other closer destinations. On-board travel times by the direct bus to the city remain comparable to taking a feeder bus to Parramatta and a train to the City; however potential waiting times to transfer and fare flag falls discourage the latter. During off-peak periods, few of the trunk-branch routes are in operation due to perceived low demand; yet due to lack of fare integration and lower frequencies, passengers may prefer to drive than to interchange at Parramatta. Table

18 illustrates these differences. The mismatching and lack of integration of modes on the North-West corridor has manifested itself in significant bus congestion further downstream in the Sydney CBD, exacerbated as trunk-branch services from the middle-ring suburbs and North Shore (other regions where lack of fare integration has exaggerated bus demand), also converge on the Warringah Freeway. Hillsbus carries over 12,000 passengers per day on the M2 motorway, using over 140 buses to do so (Besser, 2008f); this is the equivalent of just 14 CityRail double-deck suburban trains, assuming most passengers are seated.

Table 18: Public transport travel time and cost from North Western Sydney to Sydney CBD via M2 (mostly freeway) compared to via Parramatta Station

To Sydney Town Hall/Town Hall Station, from[a]:	***Mode***	***Weekday Peak (arrive approx 7:30 to 8:30 AM)***			***Weekday Inter-peak (arrive approx 12:30PM to 1:30PM)***			***Total Fare Cost (One-way)^***
		# of routes or stopping patterns	*Total Frequency (per hour)*	*Total Travel time (min)+*	*# of routes or stopping patterns*	*Total Frequency (per hour)*	*Total Travel time (min)+*	
South of Baulkham Hills Junction *(south of intersection of Windsor Rd and Old Northern Rd, north of M2)*								
Via Parramatta (for interchange/transfer)	Bus~ Train*	3 3	5 12	51-59	3 3	4 5	50-55	$7.60
Via M2 Hills Motorway	Bus°	4	19	40-50	2	4	50-60	$5.80
Windsor Rd, *near Churchill Dr, Northmead (south of M2)*								
Via Parramatta (for interchange/transfer)	Bus~ Train*	5 3	8 12	48-56	5 3	6 5	47-50	$7.60
Via M2 Hills Motorway	Bus°	2	5	45-55	N/A			$5.80
Old Windsor Rd, *near Troubadour or Joseph Banks T-way Stations*								
Via Parramatta (for interchange/transfer)	Bus~ Train*	5 3	10 12	50-60	5 3	7 5	53-58	$8.60
Via M2 Hills Motorway	Bus	3	9	50-60	N/A			$5.80

[a]Locations chosen based on last stop before routes enter the motorway. In suburbs furthest away from motorway, number of routes and frequency is lower, travel times and fare cost higher.
+Excludes transfer and waiting times, although the frequency should provide some idea of transfer waiting time. Travel times are based on published timetables. Anecdotal evidence suggest travel times by bus can be double that published due to traffic (Besser, 2008f).
^Return tickets on buses are not discounted, but return tickets for trains bought after the AM peak are discounted by at least 30%. Periodical tickets for both modes provide discounts compared to single fares.
~During peak, buses arriving at Parramatta between 7-8 AM were counted. During Inter-peak, buses arriving at Parramatta between Midday and 1PM were counted.
*Excludes Intercity CityRail services that terminate Central and require interchange to reach Central. Travel time on Intercity service from Parramatta to Central is 25-29 minutes.
°Includes both buses that run via Epping Rd and stop at Lane Cove Interchange, and those that run express via Lane Cove Tunnel. The surface route takes approximately 10 minutes longer in journey time.

(CityRail, 2008e; CityRail, 2008a; Hillsbus, 2008a; Hillsbus, 2008b)

Figure 36: Bus network in the North Western Suburbs with route types colour-coded.

Radial-Branch Radial-Feeder Tangential Circumferential

Base map sourced from (NSW Government, 2007b). Modifications made by author.

The major government transport commitment for the Outer North West, which continues to grow in population, was for North West Rail Link, as part of the CityRail network-wide Metropolitan Rail Expansion Program, due for completion by 2017. The line would feed directly into the CityRail network at Epping and onto the Epping to Chatswood Rail Line, and thus providing direct service to the 'Global Economic Corridor' and Sydney CBD itself (Department of Planning, 2005; Premier's Department, 2006). On 18 March 2008, this had been replaced by the $12 billion North-West Metro, a 38 kilometre long, single-deck, automated underground metro, that stopped at Epping before proceeding to the Sydney CBD, but followed a new alignment completely missing the aforementioned employment centres (Besser & Smith, 2008). Whilst there was scant detail on the proposal, the discussion paper (NSW Government, 2008a) included photos of the Copenhagen metro sourced from Wikipedia (2008), which uses trains that have only 96 seats on lines only half of the length of the NW metro. In the following months, experts (Besser, 2008b; Besser, 2008i; Planning Institute of Australia: NSW Division, April 2008) criticised the proposal for:

- Being a mode ill-suited for suburban distances when passengers expect to be seated (the equivalent of 120 Copenhagen metro trains would be needed to seat *only* the Hillsbus passengers);
- Disregarding years of land-use planning in anticipation of North-West residents using the Epping to Chatswood Rail Link to access employment and services;
- Overloading the CityRail system from Epping station inward as passengers would be forced to transfer to reach destinations on the north side of the harbour.
- Abandoning the Metropolitan Rail Expansion Program, needed to provide capacity on the CityRail network.

As of 31 October 2008, the North-West Metro was "deferred indefinitely". The North West is to be placated with an allocation of 100 new buses dedicated (and 200 for the rest of Sydney and NSW) over the next year (Robins, 2008). The importance of mode selection should not be understated as the long-term reliance on buses being used in trunk-branch operations is unsustainable in Sydney; particularly if peak oil and climate change have the potential to radically change the public transport market (Besser, 2008j). Unfortunately, CityRail's frequencies, particularly during the off-peak (Table 12) remain too low to adequately meet the radial transport task in the Sydney metro area as well as support feeder services.

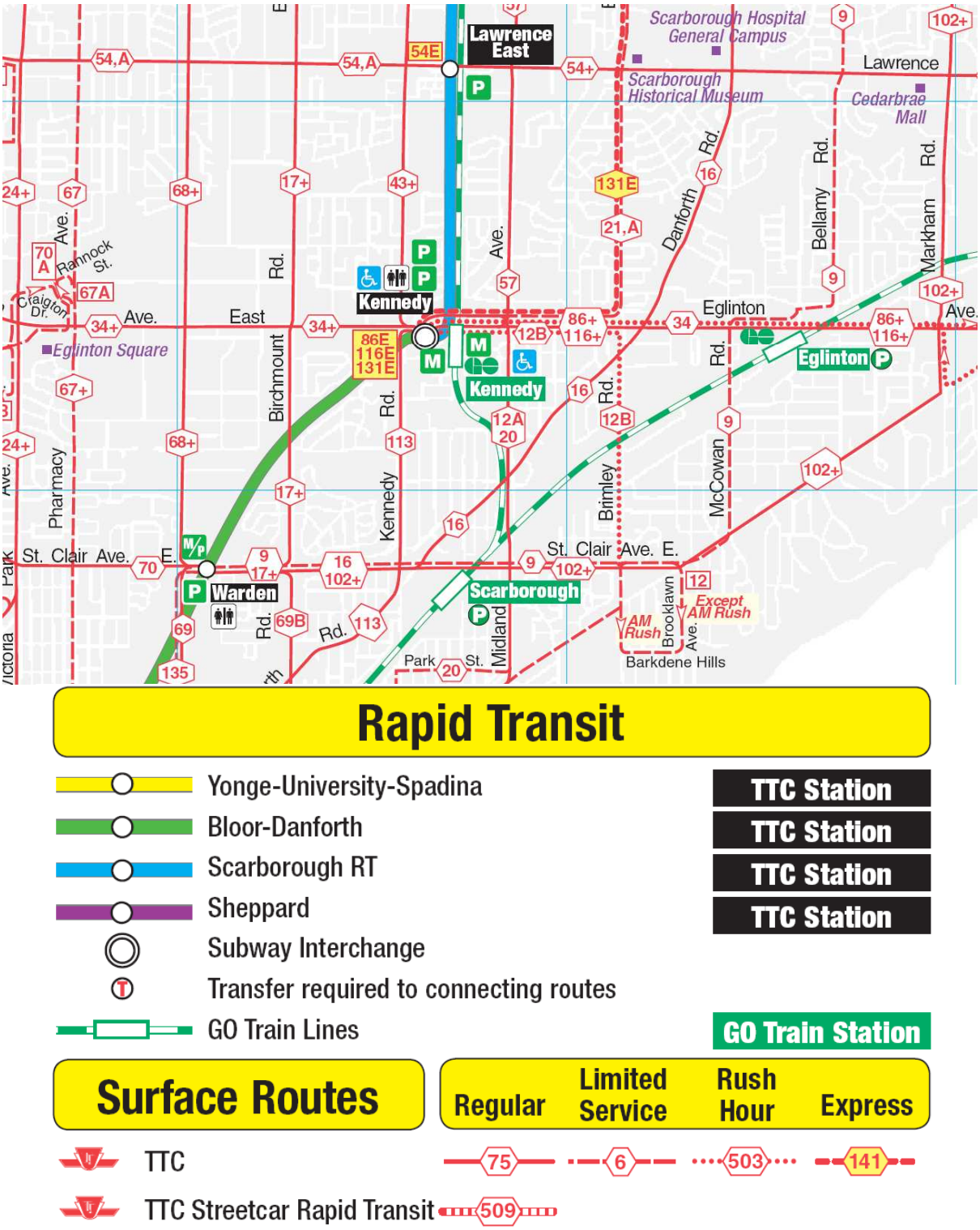
4.4.3 Toronto

The GO Train rail network is configured in a radial-branch manner, with the GO Bus network complementing with a loose grid network across the Greater Toronto Area. However, the low service intensity (Table 15) results in GO Transit being more suitable for long-distance travel, where GO Transit's larger station/stop spacing and thus longer access times and higher average operating speeds can compensate for low frequency of service and limited service hours. As a consequence, the local transit networks in the Toronto metro area do not feed GO Transit railway stations in the intensive manner seen with Sydney's CityRail network, although most local transit routes that pass GO stations do allow for passengers to transfer.

The Toronto Transit Commission's subway network is hybrid of two network typologies; the Yonge-University-Spadina line meets the rectangular/grid type as the U-shaped line results in either end radiating roughly parallel to each other away from the CBD, whilst the Bloor-Danforth line is diametrical line. However, considering the TTC's network in its totality (subway + bus + streetcar), the City of Toronto is essentially served by a large grid of lines and routes. Unlike Sydney's bus network, there is very little evidence of radial-trunk or radial-branch type routes operated by the TTC – most routes outside the downtown area are tangential, facilitated by the grid of main or 'concession' roads whose alignment was set during early European settlement. Nonetheless, most bus routes do simultaneously perform a feeder function as all routes accommodate transfers to the subway system; as most subway stations are located directly underneath intersecting roads, bus routes do not have to deviate far from their main alignment to accommodate such transfers. There are exceptions to the grid pattern, where the gridded road network is not dense enough to provide adequate transit coverage, the topography does not suit a gridded road network, or major trip generators are located away from main roads. The TTC's grid network complies with Mees' criteria for a well integrated transit network (see 4.4.1).

Figure 37 illustrates the configuration of bus routes feeding into Kennedy station (pictured Figure 38 and Figure 39) as well as some nearby TTC stations, and the predominantly gridded nature of the TTC route network, with the exception of Danforth Rd. Lake Ontario in the bottom-right corner is the major topographical constraint. Toronto CBD is located to the West-Southwest, 20-30 minutes by subway. Although Kennedy GO Station is well served by TTC subway and bus routes, other nearby GO stations such as Scarborough and Eglinton are served only by intersecting bus routes where buses are not required to deviate from the main road.

Figure 37: Bus routes feeding into Kennedy Subway and RT Station, and surrounding routes and stations.



(Toronto Transit Commission, 2008b)

Figure 38: Kennedy Station, Subway Level, below ground

Figure 39: Kennedy Station, RT level, elevated

Ong, V. 2008.

Local transit operators from the regions surrounding the City of Toronto have networks that differ somewhat from that of the TTC's. The gridded road network extends across much of the province and thus these transit operators can rely on these roads to provide a gridded bus network. However, the street layout of post-war suburbs and lower densities make it less ideal for a gridded route network and thus many bus routes do become less direct.

In the suburbs closest to the City of Toronto, York Region Transit (YRT) maintains an extensive gridded route network (York Region Transit, 2008b). Most conventional bus routes intersect with VIVA corridors. VIVA provides trunk services for most of York Region due to its high frequency and extended service hours. Further away from Toronto where the population lives in discrete towns, YRT maintains a hub and spoke model, with local routes feeding into local transit hubs that are served by VIVA or GO Transit.

Routes in Mississauga, Durham Region, Brampton and Oakville are configured in a hub and spoke manner, with routes radiating out of several transit hubs located within each area. The location of transit hubs differs from region, as it depends primarily upon the quality of GO Transit services. Throughout most of Mississauga and Brampton, GO Trains only operate during peak periods (refer to 3.3.2.1.1) and therefore GO train stations make less than ideal locations for hubs; thus most hubs dispersed and are located in local CBDs or near large shopping centres. These hubs can still be served by GO Bus. In Durham Region and Oakville, transit hubs are located adjacent to railway stations as there is a somewhat frequent GO Train service all day (refer to 3.3.2.1.1). In all of these regions, GO Train is complemented by cross-regional GO Bus.

In most cases, GO Transit is used for journeys that require crossing local government boundaries and only a limited number of transit routes may cross into the territory of neighbouring transit agencies. There are some major exceptions to this:

- YRT operates 30 weekday radial-feeder routes to Downsview, Finch (Figure 20), or Don Mills TTC Subway Stations (York Region Transit, 2008b);
- All VIVA routes feed into Downsview, Finch (Figure 21), or Don Mills TTC Subway Stations (York Region Transit, 2008b);
- Mississauga Transit operates 22 routes on weekdays to Kipling TTC Subway Station (Mississauga Transit, 2008);
- 14 TTC Routes cross into either Brampton's, Mississauga's or York's territory (Toronto Transit Commission, 2008f) although an additional fare must be paid (refer to 4.2.3).

The network integration of transit agencies as a result of fare integration, service frequency, and network geometry, as well as availability of subways and streetcars, has a significant impact on the number of transfers made per trip. The average number of transfers made per transit trip in Toronto is 60% greater than Sydney (Table 19). However this can vary significantly depending upon the operator, reflecting the service quality, network geometry of individual operators, as well as demographic, urban form and land use factors. As seen in Table 20, trips involving at least 1 TTC trip are far more likely to involve multiple transfers. The improved integration, at least within the TTC territory alone, results in transit mode share that is over four times greater for trips where the City of Toronto is the origin or destination compared to the rest of Toronto CMA (see Table 21 for further detail). See Section 3.4 for comparison between Sydney and Toronto's mode share – the difference between the two case studies is significant.

Table 19: Average Number of Transit Links or Boardings per Trip where Transit is Primary Mode, or Ratio of Unlinked Transit Trips to Linked Transit Trips (Weekday) by location of household

TTC^	***Toronto CMA***	***Sydney SD****
1.63	1.91	1.19

^Counts only TTC boardings and transfers or TTC-only links per TTC trip
*Train trips are counted as 1 unlinked trip or 1 transit link. RailCorp estimates at least 158,500 rail to rail interchange movements are made on the CityRail network each weekday. Including these results in a ratio of 1.30. However, this includes transfers between local and express services, a phenomenon which is unlikely to occur in Toronto, with exception to GO Transit, YRT and VIVA.

Calculations made by author. (Toronto Transit Commission, 2008b; Data Management Group, 2008a; Transport Data Centre, 2008)

Table 20: Indicators of multi-link transit trips by Primary Mode and Use of TTC (Weekday), where person is resident of Toronto CMA

Primary Mode	***At least 1 link on TTC***		***No Links on TTC***		***Total***	
	Average number of links	***Percentage of trips with more than one link***	***Average number of links***	***Percentage of trips with more than one link***	***Average number of links***	***Percentage of trips with more than one link***
GO Train only	-	-	1.01	0.7%	1.01	0.7%
Joint GO Rail and Local Public Transit	2.31	100%	2.17	100%	2.27	100%
Transit excluding GO Train	2.03	68%	1.42	35.8%	1.95	64.2%
Total	2.04	68.9%	1.2	26.8%	1.91	61.3%

(Data Management Group, University of Toronto, 2008b)

Table 21: Mode Share by Origin, Destination and Place of Residence

Mode	Trip Origin^		Trip Destination*		Residents of Toronto CMA°
	City of Toronto~	Rest of Toronto CMA	City of Toronto~	Rest of Toronto CMA	
Walk	6.6%	4.8%	6.6%	4.8%	5.8%
Other	0.1%	0.1%	0.1%	0.1%	0.1%
GO rail only	1.1%	0.7%	1.2%	0.7%	0.9%
Auto passenger	14.1%	16.9%	14.1%	16.9%	15.6%
Transit excluding GO rail	22.0%	4.0%	22.0%	4.0%	13.2%
Joint GO rail and public transit	0.5%	0.4%	0.5%	0.4%	0.4%
Schoolbus	0.6%	2.6%	0.6%	2.6%	1.6%
Cycle	1.0%	0.3%	1.0%	0.3%	0.7%
Taxi passenger	0.7%	0.3%	0.7%	0.3%	0.5%
Auto driver	53.2%	70.0%	53.2%	70.1%	61.3%
Motorcycle	0.0%	0.0%	0.0%	0.0%	0.0%
Unknown	0.0%	0.0%	0.0%	0.0%	0.0%

^Includes trips where the destination is outside of the Toronto CMA and within the Greater Toronto and Hamilton Area
* Includes trips where the origin is outside of the Toronto CMA and within the Greater Toronto and Hamilton Area
°Not directly comparable to Trip Origin or Trip Destination; included here for reference. See ^ and *. Only this column should be used to compare with Sydney SD mode share.
~City of Toronto's local transit agency is the TTC

(Data Management Group, 2008a)

In recent times, Toronto has had its own problems in selecting modes for investment in increasing the capacity, convenience or coverage of the system. In 2002, the Sheppard Subway Line, with 4 new stations, was completed at a price of $1 billion (Adel & Bow, 2007; Lorinc, 2008, p. 244). Intended to become part of a tangential subway line through Toronto's northern suburbs, today it is a 4 kilometre long stub line, with an interchange at Sheppard-Yonge (12 km north of Toronto CBD) on one end and a suburban shopping mall at the other (station pictured in Figure 40). The line has been described as a "politically expedient route" to nowhere chosen by municipal and provincial leaders against the recommendations of transit planners (Lorinc, 2008, p. 244). Urban consolidation has occurred rapidly along the Sheppard line since it opened (Tossell, 2007). Nevertheless, priorities have changed in the short term, partly due to the expense of subway construction, particularly in a suburban context (Adel & Bow, 2007).

In its draft Regional Transportation Plan (September 2008), Metrolinx has proposed 48 transit infrastructure improvements over the next 25 years, only 3 of which are new or extensions of subways; 4 are 'express rail', average speed 50-80 km/h at 5 minute headways; 15 are 'regional rail' comprising of expansion of GO Transit route km and service hours; and 30 being 'rapid transit' involving bus, light rail or any new technology more suitable outside the CBD. Should

such plans be fulfilled but without the adequate funding for frequent all-day service, GO Transit could be in a similar situation to CityRail which is the 'jack of all trades and master of none' in trying to function as a full-time trunk mode; whereas GO's current role as a long-distance primarily commuter service is unambiguous, and the current localisation of transit services in the Toronto metro area subtly encourages shorter trips and appears designed as such.

Figure 40: Don Mills Subway Station

Ong, V. 2008.

4.5 Information on and Marketing of Integrated Public Transport and the Institutional impacts upon it

4.5.1 Theory

The importance of institutions in comprehensive intermodal metropolitan-wide transport planning is not being disregarded as the need for the latter to be performed remains essential (Banister, 2002; Victoria Transport Policy Institute, 2008a; Vuchic, 2005; Transit Cooperative Research Program, 1996). However, public transport service is just one mode or aspect of transport planning. Furthermore, much of the theory in integrated public transport has already been discussed as the criteria – these are the outcomes that should be achieved – institutional reform isn't always necessary, particularly if the outcomes can be met satisfactorily without undertaking disruptive organisational changes.

The discussion in this criterion will align itself close to the matter of integrated public transport planning outcomes and the importance of how the public perceives the integration of public transport on a metropolitan area scale. This theoretical part only establishes the public transport marketing context. The institutional context will be discussed only in relation to the specific case studies.

There are two types of transit users (Vuchic, 2005):

- Present users: Regular users that are familiar with some aspects of the system
- Potential users: Incidental users or visitors that need to know how to use the system

The ideal public or marketing campaign should ideally suit both types of users as transit agencies should try to maintain their market or mode share as well as increase it.

The maintaining consistent branding or theme of the transit system through reading literature, marketing materials, at stations or stops, and on vehicles helps portray an image of coordination and integration across what may actually be a multi-modal, multi-agency or multi-operator transit system. A positive brand or identity can instil a sense of pride or appreciation amongst current users (CUTA, 2005). Consistent branding can bring confidence to potential users seeking to use the transit services by assisting in the identification of services, stops, and official sources of information, and assure infrequent users that quality of service is consistent across all services. Ideally, in any given metro area, one brand should be used to identify all transit services to maintain the image of an integrated system.

Mass-market information campaigns "focus on providing general information to the population as a whole about some or all aspects of transit services and related programs system wide"

(Transit Cooperative Research Program, 2003, pp. 11-7). Such campaigns can be used to promote new aspects of the system, new services or longer service hours. An example of such a campaign can involve the release of a Multi-Modal Access Guide to "provide concise, customized information on how to access a particular destination by various travel modes, with special consideration of efficient modes such as walking, cycling and public transport" (Victoria Transport Policy Institute, 2008c).

Mass-market promotions are more persuasive, as they attempt to attract new and potential users by marketing the image or brand of the transit system, or try offer incentives such as free fares, or coupons for fares or other goods and services to entice new users to try the transit service. Fare free days in major metropolitan areas may also be reported by news media, resulting in free advertising for the system as well as incentivising potential users. For example, a free fare day for 30 transit agencies in the San Francisco Bay Area in June 2008 brought 'elbow-to-elbow crowds' on local systems such as Caltrain, BART and VTA (Richards, 2008).

Individualised marketing campaigns are those customised to an individual's needs. This usually requires a transit agency representative to contact potential users to understand their needs, before providing information in response to such needs (Transit Cooperative Research Program, 2003). One particular brand of individualised marketing in Australia is 'TravelSmart', promoted as a means of reducing one's ecological footprint by voluntary travel behaviour change (Department of the Environment, Water, Heritage and the Arts, 2006).

Individualised trip-planning service is important for potential users wishing to determine the best route to complete a trip. Such services may be delivered in person at dedication transit information centres, by phone or through websites (Transit Cooperative Research Program, 2003). Information desired from such a pre-trip service includes maps with interchanges, quickest route, total travel time, interchanges en route, departure times, waiting times, real-time delay info, alterations or cancellations, and route advice to avoid delays (Grotenhuis, Wiegmans, & Rietveld, 2007, p. 32). Google Transit uses the web-based Google Maps interface for transit trip planning. Due to the ubiquity of Google Maps for trip planning (by car or transit), Google Transit has great potential in encouraging more transit trips (Jerome, 2008). TransPerth, Perth's public transit brand currently uses Google Transit to offer trip planning capabilities

Wayside or on-board information is information which is provided at the station or stop, or on-board the transit vehicle. Ideal information that should be offered includes interchanges en route, alterations or cancellations, delay to own vehicle or connecting vehicles, route advice to avoid delays, real-time delay information, and platform information (Grotenhuis, Wiegmans, &

Rietveld, 2007). Such information is required to minimise travel time and reduce amount of physical or mental effort needed to undertake the trip, particularly if it requires transfers.

4.5.2 Sydney

Transport planning in New South Wales is undertaken by the NSW Ministry of Transport (MoT) (Ministry of Transport, 2007e). It is responsible for:

- "developing and coordinating high level transport priorities in NSW
- "providing funding for NSW public transport services and major capital works
- "planning and implementing NSW transport priorities in collaboration with other agencies
- "integrating policies, regulations and service initiatives across metropolitan and rural and regional NSW
- "regulating the NSW bus, taxi and hire car industries
- "managing NSW bus and ferry contracts."

Land use planning is managed by the NSW Department of Planning (DoP). However, there is no clear definition as to the formal obligations between the DoP and MoT, although the MoT website does suggest it "works collaboratively" with other government agencies (Ministry of Transport, 2007d). Yet, prior to the retirement of Premier Bob Carr in 2005, it would've been assumed that most of the transport planning would be better managed by the much larger Department of Planning, Infrastructure and Natural Resources (DIPNR), rather than MoT.

In practice, MoT's main sphere of influence is in the area of bus planning, where it manages the MSBC. Rail planning and operations is a specialty left to RailCorp, and as a result RailCorp's obligations in integrating public transport are vague. The Roads and Traffic Authority, which manages the NSW road network, also remains a rival to any change government spending in transport, as "roads have always had powerful patrons... in the form of Ministers for Roads... who have traditionally enjoyed far more powerful Cabinet status than their equivalents with responsibility for environmental and planning portfolios" (Gleeson, Curtis, & Low, 2008, p. 207).

The branding of public transport services in Sydney is prominent across all modes, however it is not consistent. Each agency or operator, including private bus operators, feature their own brands on marketing material, fleet, and signage, increasing confusion for any potential users. The former chief of State Transit was reported to have said that "a "consistent image", with signage and terminology, would show buses are an integrated transport solution" (Besser, 2007). The lack of an integrated fare system (4.2.2) can also increase the effort required by any

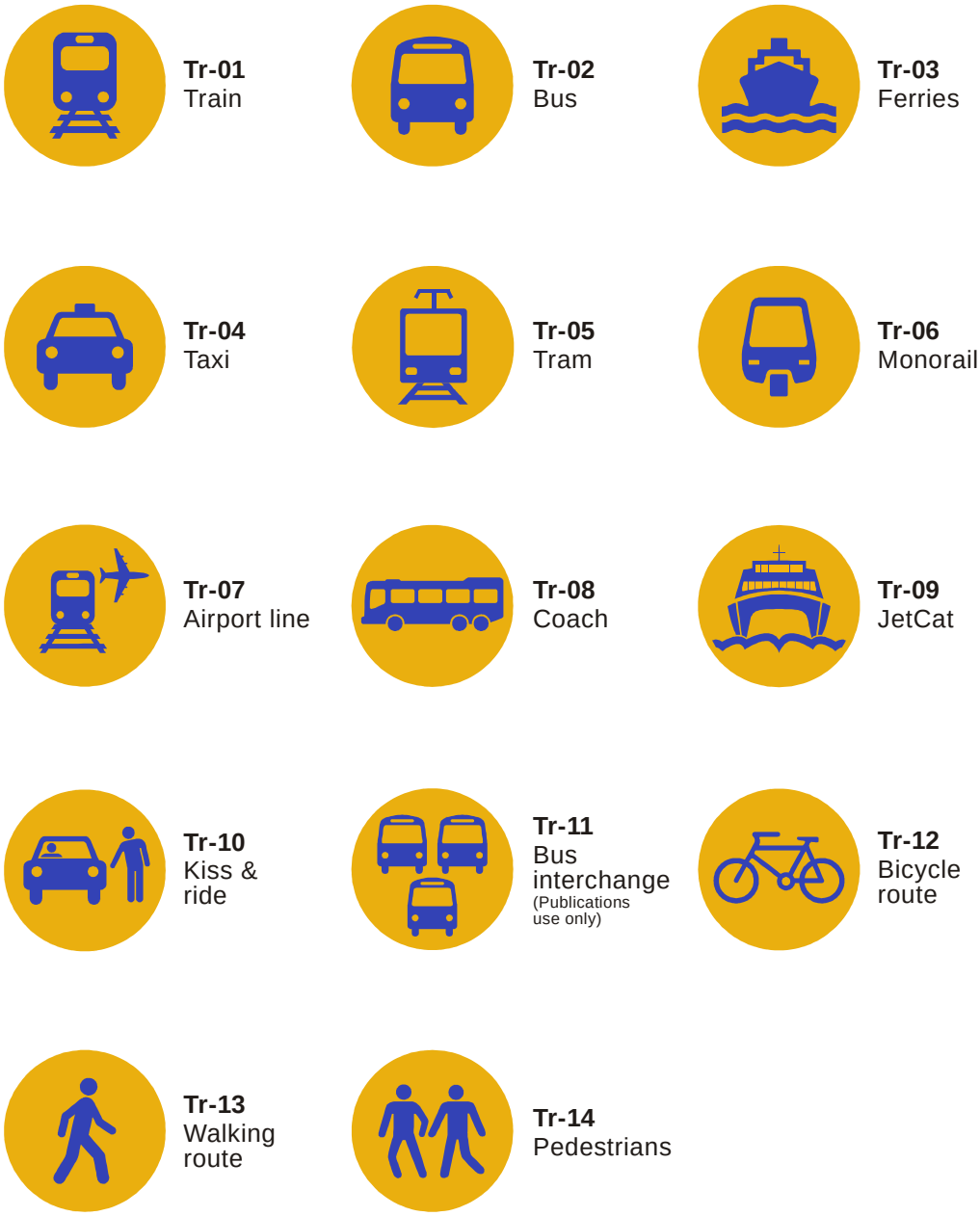
potential user to learn how to use the system. One significant exception is the implementation of graphics standards (see Figure 41 for excerpt) for transport signage and maps, specifying fonts, icons, colours and sizes to be used (Ministry of Transport, 2008b).

Mass marketing of public transport also reflects the lack of coordination with other transit services. Figure 42 is an example of the RailCorp full-page newsletter, updated in the local free commuter newspaper – no other transit operator has initiated a campaign on a similar scale. Individualised marketing such as TravelSmart is mentioned on the MoT website, but no mention is made of its implementation in NSW (Ministry of Transport, 2007d).

One laudable achievement is the individualised, multi-modal trip planning offered by the Transport Infoline (NSW Government, 2008b), which offers public transport trip planning through its website or over the phone. However, the trip planner relies on schedules and pre-programmed data and does not offer any real-time advice on delays, nor does it calculate the fare. The Infoline uses its own mapping system to graphically depict itineraries.

The formal release of real-time information about delays, alterations or cancellations is non-existent for all bus operators. CityRail can and usually does update passengers on delays via its website and through announcements at railway stations and on-board trains. Nonetheless, it has been reported that 32% of respondents to a CityRail survey were dissatisfied with information on service disruptions (RailCorp, 2008).

Figure 41: Pictograms for Modes of Transport



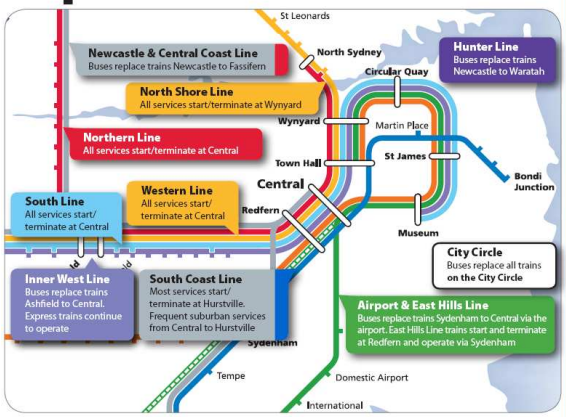
(Ministry of Transport, 2007c, p. 2.1)

Figure 42: CityRail Express Newsletter

CityRail Xpress

Travel and commuter information every Wednesday
Edition no. 55
www.cityrail.info/xpress

All hands on deck for 'Operation CBD'



Trackwork this weekend set to improve safety, reliability

To provide safer and more reliable train services, CityRail will this weekend undertake vital track upgrading work in the Sydney CBD.

Service changes will be noticeable on most service lines.

For more detailed information, customers should see the Trackwork column (right), visit the CityRail website at **www.cityrail.info**, or pick up the 'Operation CBD' brochure available at stations.

Services on the City Circle will not operate and CBD stations Circular Quay, St James and Museum will be temporarily closed while the work is completed.

"A range of projects will be undertaken in the 48-hour period, including track reconditioning work between Newtown and Redfern so that ballast and underlying foundations can be replaced," says CityRail's head of asset management, Gary Seabury.

"We have a great deal of work to complete in a very short timeframe and we will work around the clock to deliver on the projects," Gary adds.

CityRail has made alternative arrangements so you can travel into the city, but customers will need to travel differently this weekend.

"We apologise to customers who will be affected by the service changes. Nevertheless, this work is vital: It will provide greater track stability and lead to safer, more reliable services for customers in the long term."

This weekend's events

This weekend's major events include horse racing at Rosehill Gardens; the Dove Pink Star Walk in aid of breast cancer research; concerts at the Acer Arena, Olympic Park; and the Opening Ceremony of the Rugby League World Cup 2008 at Sydney Football Stadium, Moore Park, after which Australia face off against New Zealand.

Please remember there are plenty of buses to replace trains in areas affected by trackwork, but you should still plan your travel carefully and leave for your destination earlier.

CountryLink's seriously spooky Halloween special

This Halloween, CountryLink customers will be able to take advantage of a scarily good value, one-day only discount.

On Friday 31 October, CountryLink is giving customers the opportunity to travel anywhere on the network in economy class for just $31 each way.

"It's a one-day only offer that's all treat, and no trick," says CountryLink General Manager Greg McLeod.

"Also, Halloween fares in first class are only $41 each way," Greg adds. "With savings like these, it's hard to say no."

Bookings at these spine-chillingly good prices can be made right through to Friday 31 October.

For full details, customers should visit the CountryLink website at **www.countrylink.info** or call 13 22 32.

NightRide buses: new timetable

Customers who use NightRide bus services are advised that new timetables will be in effect from next Monday 27 October.

Details of the new timetable are available from the CityRail website or from local bus drivers.

Alterations to the timetable are being made because of road traffic changes and the impact of speed limits and roundabouts on travel time.

Most trains do not operate between midnight and 4.30am and the special NightRide service is available for the convenience of customers during these hours.

Any valid CityRail return, pensioner, weekly or longer ticket can be used on a NightRide bus; alternatively, tickets can be purchased from local bus drivers. Single tickets, however, are not valid on NightRide services.

All buses are in radio contact with taxi operators and a taxi can be requested to meet you at your destination.

For more information on NightRide buses, and the new timetable, please visit the CityRail website at **www.cityrail.info** or call the Transport Infoline on 131500.

trackwork

This weekend 25/26 Oct

Sat 25 to Sun 26 Oct

Eastern Suburbs & Illawarra Line Customers are advised to use Martin Place if arriving or departing the City to prevent crowding at Town Hall due to trackwork. An additional shuttle train service will operate between Bondi Junction and Hurstville. Illawarra Line customers travelling to stations on the Airport Line should change at Sydenham or Central for a bus service. Airport Line replacement buses do not stop at Wolli Creek.

City Circle Buses replace trains – please refer to the 'Operation CBD' brochure, available from your local station, for more details.

Bankstown Line Trains start and terminate at Sydenham.

Inner West Line Buses replace trains between Central and Ashfield. Express trains continue to operate.

Airport & East Hills Line Airport Line trains do not operate. Buses replace trains between Central and Sydenham via the airport. Replacement buses do not stop at Wolli Creek. East Hills Line trains start and terminate at Redfern.

South Line Trains start and terminate at Central.

North Shore Line Trains operate between Berowra and Wynyard only.

Western Line Trains start and terminate at Central.

Northern Line Trains start and terminate at Central.

South Coast Line Most South Coast Line trains operate between Hurstville and Bomaderry (Nowra) only.

Southern Highlands Line Customers travelling from the City to Campbelltown to connect with Southern Highlands Line trains should depart 30 minutes earlier than normal and change at Redfern.

Newcastle & Central Coast Line Buses replace trains between Newcastle and Fassifern, departing stations between Newcastle and Booragul up to 35 minutes earlier than the normal train timetable.

Hunter Line Buses replace trains between Newcastle and Waratah.

Next week

Mon 27 to Thu 30 Oct

City Circle Nightly between 9:30pm and 2am, trains operate in one direction only, from Central via Town Hall.

Customers travelling from City Circle stations may need to change trains at Central to complete their journey.

Airport & East Hills Line Nightly between 9:30pm and 2am, trains to the City terminate at Central.

North Shore Line Nightly between 10:30 pm and 2am, trains operate between Wynyard and Hornsby only.

Western Line Nightly between 10:30 pm and 2am, trains start and terminate at Central.

Northern Line Trains start and terminate at Central.

Wed 29 Oct

Carlingford Line Between 7.10am and 3pm, buses replace trains between Carlingford and Clyde.

Keep up-to-date with all trackwork affecting your line. Subscribe by email at www.cityrail.info/trackwork

(RailCorp, 2008)

4.5.3 Toronto

Transport planning in the Toronto metro area is managed by Metrolinx, legally known as the Greater Toronto Transportation Authority (GTTA). It was established in 2006 by the provincial government to plan a "seamless, integrated transportation network" for the Greater Toronto Area (GTA) that transcended municipal boundaries (Metrolinx, 2007a). Whilst it's Draft Regional Transportation Plan (RTP) for $55 billion in spending over 25 years has now been released for public consultation (Metrolinx, September 2008), questions remain over Metrolinx's future capabilities (Hume, 2008). Based on one survey of policymakers in the GTA, the consensus was that "the GTTA will end up as "a forum where people will get together and talk about what they would like to happen without being able to make it happen" (Hatzopoulou & Miller, 2008, p. 157). The prospect of Metrolinx taking over TTC was raised early in 2008 (Benzie & Kalinowski, 2008). In September, the draft RTP and the TTC's own Transit City Plan (which includes $10 billion in light rail) appeared to be "on separate tracks" (Kalinowski, 2008c); however, quotes from the Metrolinx chief suggested that Metrolinx wanted to 'aim for consensus' with the TTC (Lewington, 2008).

The planning and operations of transit services today remains within the control of local governments throughout the Toronto metro area. Whilst there is a lack of fare integration or consistent branding between different agencies, marketing material from most local transit agencies do at least recognise the existence of neighbouring agencies, although in some cases it is because other agencies may be relied upon for trunk service to Toronto. For instance, the TTC Ride Guide (Figure 43) depicts bus routes of neighbouring transit agencies in different colours to the TTC's routes.

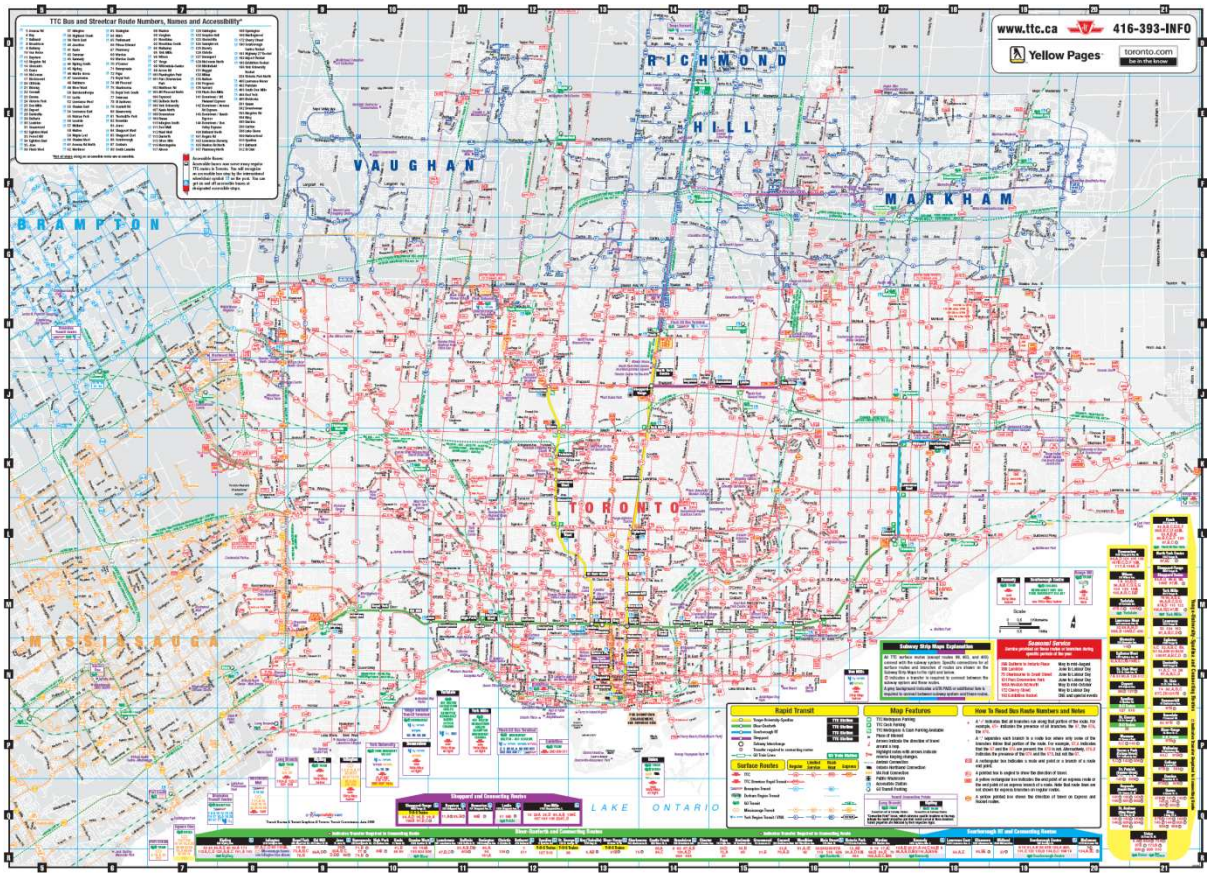
Torontonians remain eager to see a trip planner on the TTC website, which will not be ready for public use until July 2009; meanwhile York Region and Mississauga already have online trip planners in operation (Kalinowski, 2008b). Nonetheless, a trip planner for the entire metro area remains lacking.

The TTC is currently investing in real-time information systems to inform customers of delays or remaining minutes for the next train on its subway system (Figure 44) (Kalinowski, 2008d). VIVA already offers such features at its stops. In addition, unlike Sydney's buses, all TTC buses feature LED screens displaying the name of intersecting street at the next stop.

An interesting phenomenon in Toronto compared to Sydney, is the attention that the TTC receives from its customers and the media. For example, whilst the TTC is still testing its trip planner, one TTC fan already created their own at myttc.ca (Kalinowski, 2008a). The same

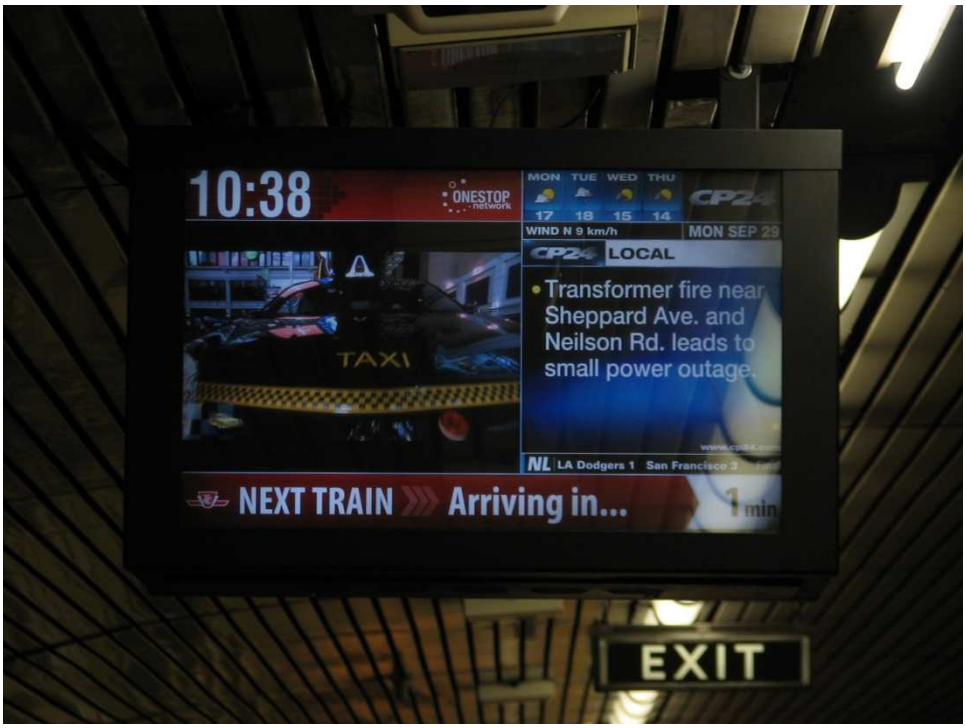
article cites other numerous TTC fan sites, including two referenced in this thesis. Other TTC fan creations that have become merchandising successes include decals of subway station signs in the TTC font, and subway station buttons (Figure 45) depicting the name and decor of each subway station (Baute, 2008). The Toronto Star also features a column known as 'The Fixer', which regularly receives complaints about TTC, GO Transit and other transit agencies, and attempts to seek remedies. Complaints in recent times have included broken down escalators (Lakey, Whitby escalators leave GO commuters unmoved, 2008c), missing bus shelters (Lakey, 2008e), leaks in station roofs causing ice patches to form on station platforms (Lakey, 2008b), benches with bottoms missing (Lakey, 2008a), and TTC signs pointing in the wrong direction (Lakey, 2008d).

Figure 43: TTC Ride Guide



(Toronto Transit Commission, 2008b)

Figure 44: Passenger Information Display on Platform combined with News, Weather and Advertising at Dundas Subway Station



Ong, V. 2008.

Figure 45: Subway Station Buttons by Spacing Publications

(Spacing, 2005)

5 Recommendations and Conclusions

For a more sustainable future it is recommended that:

- A integrated fare structure be implemented across Sydney, using smart card technology to collect fares based on distance travelled without charging flag falls for transfers to maximise equity.
- In the long-term, the creation of gridded bus network should be implemented in Sydney's inner and middle ring suburbs to maximise the network effect and flexibility in trip planning for users, and to improve accessibility for members of society who do not benefit from radial services and are disadvantaged from an allocation of scarce transit resources biased towards the commuter market.
- CityRail service frequencies should be increased so that there is little distinction between peak and off-peak frequencies at all stations, and to demonstrate that CityRail is the preferred mode for radial travel. This will also allow inefficient trunk-branch bus routes to be rationalised to become feeders into the CityRail network.
- Service frequency and service hour standards on bus routes should be increased in Sydney to TTC standards. The lack of light rail in Sydney should not preclude high service intensities or patronage.
- Metro lines or subways should be investigated on current major trunk-branch corridors such as the Anzac Parade corridor, where the demand is likely to exist and likely travel distances are short, thus appropriate for metro or light-metro systems.
- Extension of suburban railway lines to outer suburbs where demand for suburb to BD travel warrants such investment. However, bus networks must be reconfigured to be feeders and provide adequate tangential and circumferential coverage.
- Whilst outer-suburban Toronto remains poorly served compared to the City of Toronto, they integrate well across agencies and modes, and can follow in the TTC's footsteps.

As public transport integration is improved, as well as continued land use and transport integration, the resultant increase in patronage could allow the transit system can itself become more financially sustainable, such as the case with the TTC, whose non-governmental revenue now covers 80% of operating costs (Toronto Transit Commission, 2007), whereas Sydney's cost recovery is 35-45% (IPART, 2007b; IPART, 2007a). An integrated public transport system not only encourages Sydneysiders to become more sustainable, but the system itself can become sustainable.

6 Bibliography

AAP. (2007, April 23). *Climate not main challenge: PM.* Retrieved October 18, 2008, from The Sydney Morning Herald: http://www.smh.com.au/news/national/climate-not-main-challenge-pm/2007/04/23/1177180540877.html

AAP. (2008, October 21). *Rees looks to privatise Sydney Ferries.* Retrieved October 23, 2008, from The Sydney Morning Herald: http://news.smh.com.au/national/rees-looks-to-privatise-sydney-ferries-20081021-5553.html

Adel, A., & Bow, J. (2007, May 10). *The Sheppard Subway.* Retrieved November 2, 2008, from Transit Toronto: http://transit.toronto.on.ca/subway/5110.shtml

American Public Transportation Association. (2008a, February). *Public Transportation Reduces Greenhouse Gases and Conserves Energy.* Retrieved October 20, 2008, from APTA: http://www.apta.com/research/info/online/documents/greenhouse_brochure.pdf

American Public Transportation Association. (2008b, September 9). *Public Transit Ridership Surges in 2nd Quarter - News Release.* Retrieved October 20, 2008, from APTA: http://www.apta.com/media/releases/080909_ridership_report.cfm

American Public Transportation Association. (2008c, September 9). *Eighty Five Percent of Public Transit Systems Experience Capacity Problems as Ridership Surges - News Release.* Retrieved October 20, 2008, from APTA: http://www.apta.com/media/releases/080909_capacity_report.cfm

Aplin, G. (2000). From colonial village to world metropolis. In J. Connell, *Sydney: The Emergence of a World City* (pp. 56-75). South Melbourne, Victoria: Oxford University Press.

Australian Bureau of Statistics. (2008a, February 29). *2006 Census Community Profile Series : Sydney (Statistical Division).* Retrieved October 22, 2008, from Australian Bureau of Statistics: http://www.censusdata.abs.gov.au/ABSNavigation/prenav/ViewData?action=402&documentproductno=105&documenttype=Main%20Features&order=1&tabname=Summary&areacode=105&issue=2006&producttype=Community%20Profiles&&producttype=Community%20Profiles&javascript=true

Australian Bureau of Statistics. (2008b, February 29). *2006 Census Community Profile Series : Sydney (Urban Centre/Locality).* Retrieved October 22, 2008, from Australian Bureau of Statistics: http://www.censusdata.abs.gov.au/ABSNavigation/prenav/ViewData?action=402&documentpro

ductno=UCL171400&documenttype=Main%20Features&order=1&tabname=Summary&areacode=UCL171400&issue=2006&producttype=Community%20Profiles&&producttype=Community%20Profiles&jav

Australian Bureau of Statistics. (2008c, March 31). *3218.0 - Regional Population Growth, Australia, 2006-07.* Retrieved October 22, 2008, from Australian Bureau of Statistics: http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/3218.0Main%20Features42006-07?opendocument&tabname=Summary&prodno=3218.0&issue=2006-07&num=&view=

Australian Bureau of Statistics. (2004). *6403.0 - Average Retail Prices of Selected Items, Eight Capital Cities, Sep 2004* . Canberra, ACT: Commonwealth of Australia.

Australian Bureau of Statistics. (2007). *Motor Vehicle Census.* Sydney, NSW: Commonwealth of Austalia.

Australian Rail Maps. (2006, October 29). *Rail and Ferry Map - Sydney.* Retrieved October 29, 2008, from Australian Rail Maps: http://www.railmaps.com.au/sydney.htm

Baker, J. (2007, March 19). Tcard far too complex to work, say experts. *The Sydney Morning Herald* .

Banister, D. (2002). *Transport Planning: Second Edition.* London: Spon Press.

Banister, D., & Stead, D. (2002). Reducing Transport Intensity. *EJTIR , 2* (3/4), 161-178.

Barter, P., Kenworthy, J., & Laube, F. (2003). Lessons from Asia on Sustainable Urban Transport. In N. Low, & B. Gleeson, *Making Urban Transport Sustainable* (pp. 252-270). New York, NY: Palgrave Macmillan.

Baute, N. (2008, October 21). Stuck on the TTC. *Toronto Star* .

Benzie, R., & Kalinowski, T. (2008, February 15). Premier backs TTC takeover. *Toronto Star* .

Besser, L. (2007, November 1). Bus stop blues keep people away. *The Sydney Morning Herald* , p. 2.

Besser, L. (2008a, February 19). The dumb card: relic bus ticket system for Sydney. *The Sydney Morning Herald* , p. 1.

Besser, L. (2008b, April 5). Metro expert rails at 'fantasy' train. *The Sydney Morning Herald* , p. 9.

Besser, L. (2008d, April 29). Your ticket to ride for free on a rail system in chaos. *The Sydney Morning Herald* , p. 1.

Besser, L. (2008e, June 11). Lack of will killed Tcard, papers show. *The Sydney Morning Herald* .

Besser, L. (2008f, June 30). Over the Hills in overcrowded buses. *The Sydney Morning Herald* , pp. http://www.smh.com.au/news/national/over-the-hills-in-overcrowded-buses/2008/06/29/1214677850264.html.

Besser, L. (2008g, July 3). Tcard: here we go again. *The Sydney Morning Herald* .

Besser, L. (2008h, July 4). New Tcard to bypass ticketing system. *The Sydney Morning Herald* .

Besser, L. (2008i, July 30). Metro a $12b disaster, says buried report. *The Sydney Morning Herald* .

Besser, L. (2008j, September 15). If your bus is crowded, here's a real oil shock. *The Sydney Morning Herald* , p. 1.

Besser, L. (2008k, October 16). Transport minister bungles Tcard dates. *The Sydney Morning Herald* , p. 2.

Besser, L., & Burke, K. (2008, May 30). *Petrol crisis fuels bus, train crush.* Retrieved October 20, 2008, from The Sydney Morning Herald: http://www.smh.com.au/news/national/petrol-crisis-fuels-train-bus-crush/2008/05/29/1211654221491.html

Besser, L., & Sexton, E. (2007, November 17). A deal stuck in transit. *The Sydney Morning Herald* .

Besser, L., & Smith, A. (2008, March 19). City catches $12b metro. *The Sydney Morning Herald* , p. 1.

Bloomberg News. (2008, October 20). *Aussie's plunge far from over.* Retrieved October 20, 2008, from The Sydney Morning Herald: http://business.smh.com.au/business/aussies-plunge-far-from-over-20081020-548x.html

Bloomberg. (2008, October 18). *Oil rises on signs OPEC will cut output.* Retrieved October 19, 2008, from The Sydney Morning Herald: http://business.smh.com.au/business/oil-rises-on-signs-opec-will-cut-output-20081018-53eg.html

Bow, J. (2006a, November 10). *Route 510 - The Spadina Streetcar.* Retrieved October 23, 2008, from Transit Toronto: http://transit.toronto.on.ca/streetcar/4108.shtml

Bow, J. (2006b, November 10). *Transit Toronto Q & A.* Retrieved October 26, 2008, from Transit Toronto: http://transit.toronto.on.ca/spare/0011.shtml

Brampton Transit. (2008, January 28). *Fares.* Retrieved October 28, 2008, from The Official Website of the City of Brampton, Ontario: http://www.brampton.ca/transit/fares.taf

Bureau of Infrastructure, Transport and Regional Economics. (2008). *BITRE Briefing - 1: How do fuel use and emissions respond to price changes.* Canberra, ACT: Department of Infrastructure, Transport, Regional Development and Local Government, Commonwealth of Australia.

Bureau of Transport and Regional Economics. (2005). *Working Paper 61 - Is the world running out of oil?* Canberra, ACT: Department of Transport and Regional Services, Commonwealth of Australia.

Caltex Australia Petroleum. (2008). *Pricing - Historical.* Retrieved 2008, from Caltex: http://www.caltex.com.au/pricing_his.asp

Campoy, A. (2008, October 10). *Cash-Strapped Drivers Scrimp Despite Cheaper Gas* . Retrieved October 20, 2008, from The Wall Street Journal: http://online.wsj.com/article/SB122359292105920987.html

Carr, K. (2008). Qualitative Research to Assess Interest in Public Transportation for Work Commute. *Journal of Public Transportation , 11* (1), 1-16.

Cervero, R. (1998). *The Transit Metropolis, A Global Inquiry.* Washington, DC: Island Press.

Cervero, R., & Duncan, M. (2003). Walking, bicycling, and urban landscapes: Evidence from the San Francisco Bay Area. *American Journal of Public Health , 93* (9), 1478-1483.

Cervero, R., & Radisch, C. (1996). Travel choices in pedestrian versus automobile oriented neighborhoods. *Transport Policy , 3* (3), 127-141.

Charles River Associates. (1997). *Transit Cooperative Research Program Report 27, Building Transit Ridership: An Exploration of Transit's Market Share.* Washington, DC: National Academy Press.

City of Mississauga. (2008a, February 25). *Bus Fares.* Retrieved October 28, 2008, from Mississauga Transit: http://www.mississauga.ca/file/COM/BusFares_25Feb2008.pdf

City of Mississauga. (2008b). *BRT Basics > Featured Article > Backgrounder on Mississauga's BRT.* Retrieved October 24, 2008, from Mississauga.ca: http://www.mississauga.ca/portal/residents/brtbasics?paf_gear_id=9700018&itemId=102600571n

City of Mississauga. (2008c, September). *Transfers.* Retrieved October 28, 2008, from Mississauga.ca: http://www.mississauga.ca/file/COM/Transfers.pdf

City of Toronto. (2008). *Toronto Island Park.* Retrieved October 24, 2008, from City of Toronto: http://www.toronto.ca/parks/island/index.htm

CityRail. (2008). *Leisure Tickets.* Retrieved October 28, 2008, from CityRail - Tickets & Fares: http://www.cityrail.info/fares/leisure_tickets.jsp#DayTripper

CityRail. (2008a, August 4). *Fare Calculator.* Retrieved November 1, 2008, from CityRail - Tickets & Fares: http://www.cityrail.info/fares/calculator.jsp

CityRail. (2008b). *Fare Evasion - it costs us all.* Retrieved October 28, 2008, from CityRail - Tickets & Fares: http://www.cityrail.info/fares/evasion.jsp

CityRail. (2008c). *Passenger Fares and Coaching Rates Handbook.* Sydney, NSW: Rail Corporation NSW.

CityRail. (2008d). *Pensioners and seniors.* Retrieved October 28, 2008, from Tickets & Fares: http://www.cityrail.info/fares/pensioners.jsp

CityRail. (2008e). *The Timetable.* Retrieved 2008, from CityRail: http://www.cityrail.info/timetable/index.jsp

CityRail. (2008f). *TravelPass tickets.* Retrieved October 28, 2008, from CityRail - Tickets & Fares: http://www.cityrail.info/fares/travelpass.jsp

Copenhagen Metro. (2008, October 18). Retrieved November 1, 2008, from Wikipedia, the free encyclopedia: http://en.wikipedia.org/wiki/Copenhagen_metro

Crane, R. (1996). Cars and drivers in the new suburbs. *Journal of the American Planning Association , 62* (1), 51-65.

Creagh, S., & Besser, L. (2008, June 27). lemma turning Sydney into joke. *The Sydney Morning Herald* , p. 1.

Currie, G. (2006). Bus Rapid Transit in Australasia: Performance, Lessons Learned and Futures. *Journal of Public Transportation , 9* (3), 1-22.

Currie, G., & Walliss, I. (2008). Effective ways to grow urban bus markets - a synthesis of evidence. *Journal of Transport Geography , 16*, 419-429.

CUTA. (2005). *Issue Paper 14: Marketing Transit in Canada: Meeting the Ridership Challenge.* Toronto, ON: Canadian Urban Transit Association.

Data Management Group. (2003). *2001 Transportation Tomorrow Survey - City of Toronto.* Toronto, ON: Joint Program in Transportation, University of Toronto.

Data Management Group. (2008a). 2006 Tomorrow Transportation Survey [Database]. Toronto, Ontario, Canada: Urban Transportation Research and Advancement Centre, Department of Civil Engineering, University of Toronto.

Data Management Group, University of Toronto. (2008b). *Transportation Tomorrow Survey.* Retrieved October 25, 2008, from Data Management Group: http://www.dmg.utoronto.ca/transportationtomorrowsurvey/index.html

Davidson, L. J., & Knowles, R. D. (2006). Bus quality partnerships, modal shift and traffic decongestion. *Journal of Transport Geography , 14*, 177-194.

Davies, J.-A. (2008, October 13). *Dollar dive sucks up savings from oil price fall.* Retrieved October 20, 2008, from The Australian: http://www.theaustralian.news.com.au/story/0,25197,24486084-2702,00.html

Department of Climate Change. (2008b, September 1). *About Us.* Retrieved October 18, 2008, from Department of Climate Change: http://www.climatechange.gov.au/about/index.html

Department of Climate Change. (2008a). *National Greenhouse Gas Inventory 2006: Accounting for the Kyoto Target.* Canberra, ACT: Commonwealth of Australia.

Department of Planning. (2005). *City of Cities: A Plan for Sydney's Future: Metropolitan Strategy.* Sydney, NSW: NSW Government.

Department of Planning. (2006). *Parramatta City Centre Plan - Vision.* Parramatta, NSW: NSW Department of Planning.

Department of the Environment, Water, Heritage and the Arts. (2006, August 20). *About Us*. Retrieved November 2, 2008, from TravelSmart Australia: http://www.travelsmart.gov.au/about.html

Dodson, J., & Sipe, N. (2008). *Research Paper 17: Unsettling Suburbia: The New Landscape of Oil and Mortgage Vulnerability in Australian Cities.* Nathan, Qld: Urban Research Program, Griffith University.

Dodson, J., Buchanan, N., Gleeson, B., & Sipe, N. (2006). Investigating the Social Dimensions of Transport Disadvantage-I. Towards New Concepts and Methods. *Urban Policy and Research , 24* (4), 433-453.

Donaghy, K. P., Poppelreuter, S., & Rudinger, G. (2005). *Social dimensions of sustainable transport: transatlantic perspectives.* Aldershot, Hants, England: Ashgate.

Downs, A. (2004). *Still Stuck in Traffic: Coping With Peak Hour Traffic Congestion.* Washington, DC: The Brookings Institution.

Durham Region Transit. (2008, July 31). *Fares.* Retrieved October 28, 2008, from Durham Region Transit - Connecting Communities: http://www.durhamregiontransit.com/durham/index_e.aspx?ArticleID=80

El Nasser, H. (2008, July 29). *Gas prices drive push to reinvent America's suburbs.* Retrieved July 29, 2008, from USA Today: http://www.usatoday.com/news/nation/2008-07-29-nosale_N.htm#

Espino, R., Ortuzar, J. d., & Roman, C. (2007). Understanding suburban travel demand: Flexible modelling with revealed and stated choice data. *Transportation Research Part A , 41*, 899-912.

Farrell, D. (2006). *Statistical Geography: Volume 3 - Australian Standard Geographical Classification (ASGC) Urban Centres/Localities.* Belconnen, ACT: Australian Bureau of Statistics.

Filey, M. (1996). *The TTC Story: The First Seventy-Five Years.* Toronto, Ontario: Dundurn Press.

Freestone, R. (2000). Planning Sydney: Historical trajectories and contemporary debates. In J. Connell, *Sydney: The Emergence of a World City* (pp. 119-143). South Melbourne, Victoria: Oxford University Press.

Gelpke, B., McCormack, R., & Caduff, R. (Directors). (2006). *A Crude Awakening: The Oil Crash* [Motion Picture].

Gibbons, R. (1983). The 'fall of the giant': trams versus trains and buses in Sydney, 1900-61. In G. Wotherspoon, *Sydney's Transport: Studies in Urban History* (pp. 155-176). Sydney, NSW: Hale & Iremonger.

Gilbert, R., & Perl, A. (2008). *Transport Revolutions: Moving People and Freight Without Oil.* London, UK: Earthscan.

Girard, D. (2008, June 14). Select routes due for price cut. *Toronto Star* , p. A08.

Gittins, R. (2008, June 11). *Too gutless to give us the bad oil.* Retrieved July 20, 2008, from The Sydney Morning Herald: http://business.smh.com.au/business/too-gutless-to-give-us-the-bad-oil-20080610-2ogn.html

Giuliano, G., & Dargay, J. (2006). Car ownership, travel and land use: a comparison of the US and Great Britain. *Transportation Research Part A , 40*, 106-124.

Gleeson, B., Curtis, C., & Low, N. (2008). Barriers to Sustainable Transport in Australia. In N. Low, & B. Gleeson, *Making Urban Transport Sustainable* (pp. 201-220). New York, NY: Palgrave Macmillan.

Gombi, P. (2008, May 31). Reinventin suburbia; An ambitious provincial strategy is forcing the 905 to remake itself. Will developers and residents let it happen? *Toronto Star* , p. ID01.

Greater Toronto Transit Authority. (2007). *the future is now - Get on the GO - the year in review 2006-07.* Toronto, Ontario: Greater Toronto Transit Authority.

Greater Toronto Transit Authority. (2008a, October 06). *Fare Finder.* Retrieved October 28, 2008, from GO Transit: http://www.gotransit.com/publicroot/en/fares/fndfare.aspx

Greater Toronto Transit Authority. (2008b, October 06). *Train and Bus Schedules*. Retrieved October 30, 2008, from GO Transit: http://www.gotransit.com/publicroot/en/schedule/trainbusschedule.aspx

Greater Toronto Transit Authority. (2008c, October 21). *What is GO?* Retrieved October 24, 2008, from GO Transit: http://www.gotransit.com/public/en/aboutgo/whatisgo.htm

Greater Toronto Transit Authority. (2008d, October 24). *How GO fares work*. Retrieved October 24, 2008, from GO Transit: http://www.gotransit.com/PUBLIC/en/FARES/HOWFARESWORK.HTM

Greater Toronto Transit Authority. (2008e, October 24). *GO Transit Fare Integration (Co-Fare) Program.* Retrieved October 28, 2008, from GO Transit: http://www.gotransit.com/PUBLIC/en/gettogo/fareintegration.htm

Greater Toronto Transit Authority. (2008f, October 24). *Ticket types.* Retrieved October 28, 2008, from GO Transit: http://www.gotransit.com/PUBLIC/en/FARES/TICKETS.HTM

Silverthorn, B. (Producer), & Greene, G. (Director). (2004). *The End of Suburbia: Oil Depletion and The Collapse of The American Dream* [Motion Picture].

Greenwald, M. J. (2003). The Road Less Traveled: New Urbanist Inducements to Travel Mode for Nonwork Trips. *Journal of Planning Education and Research* , *23* (1), 39-57.

Grotenhuis, J.-W., Wiegmans, B. W., & Rietveld, P. (2007). The desired quality of integrated multimodal travel information in public transport: Customer needs for time and effort savings. *Transport Policy* , *14* (1), 27-38.

Hamnett, S. (2000). The late 1990s: competitive versus sustainable cities. In S. Hamnett, & R. Freestone, *The Australian Metropolis: A Planning History* (pp. 168-188). St Leonards, NSW: Allen & Unwin.

Hatzopoulou, M., & Miller, E. J. (2008). Institutional integration for sustainable transportation policy in Canada. *Transport Policy , 15*, 149-162.

Hayes, D. (2008). *Historical Atlas of Toronto.* Vancouver, British Columbia: Douglas & McIntyre.

Hensher, D. A. (2007). *Bus Transport: Economics, Policy and Planning Research in Transportation Economics.* Oxford, UK: Elsevier.

Hensher, D. A. (2008). Climate change, enhanced greenhouse gas emissions and passenger transport - what can we do to make a difference. *Transportation Research Part D , 13*, 95-111.

Hillsbus. (2008a, October 1). *Bus Fares.* Retrieved November 1, 2008, from Hillsbus: http://www.hillsbus.com.au/timetables/fares_list.asp

Hillsbus. (2008b). *Timetables.* Retrieved November 1, 2008, from Hillsbus: http://www.hillsbus.com.au/timetables/timetable_list.asp

Hine, J., Wardman, M., & Stradling, S. G. (2003). Interchange and Seamless Travel. In J. Hine, & J. Preston, *Integrated Futures and Transport Choices* (pp. 116-131). Aldershot, England: Ashgate Publishing.

Hume, C. (2008, July 21). Good governance essential for regional transit. *Toronto Star* , p. A12.

IPART. (2007a). *CityRail fares from 11 November 2007.* Sydney, NSW: Independent Pricing and Regulatory Tribunal.

IPART. (2007b). *Review if fares for metropolitan and outer-metropolitan bus services from 2 January 2008.* Sydney, NSW: Independent Pricing and Regulatory Tribunal.

IPART. (2008). *Deciding on the structure and level of CityRail fares: Discussion Paper.* Sydney, NSW: Independent Pricing and Regulatory Tribunal of New South Wales.

IPCC. (2004, December). *16 Years of Scientific Assessment in Support of the Climate Convention.* Retrieved October 18, 2008, from Intergovernmental Panel on Climate Change: http://www.ipcc.ch/pdf/10th-anniversary/anniversary-brochure.pdf

ITSRR. (2008). *Survey of CityRail Customers 2008.* Sydney, NSW: Independent Transport Safety and Reliability Regulator (ITSRR).

Jerome, M. (2008, April 9). *Google Transit Gets Smarter and Smarter*. Retrieved July 19, 2008, from Wired: Blog Network: http://blog.wired.com/cars/2008/04/google-transi-1.html

Kalinowski, T. (2008a, August 9). Web activists show TTC a better way; 'Fan' websites providing lively input on transit issues are miles ahead at engaging city readers. *Toronto Star* , p. A09.

Kalinowski, T. (2008b, August 9). TTC charting 10,000 stops to map your trip. *Toronto Star* , p. A09.

Kalinowski, T. (2008c, September 4). Toronto's transit plans on separate tracks. *Toronto Star* .

Kalinowski, T. (2008d, September 5). When's the next subway train? Look up; TTC tries out signs offering real-time info. *Toronto Star* , p. A15.

Kalinowski, T. (2008e, September 17). Smartcard faces bumpy ride. *Toronto Star* , p. A12.

Kyonka, N. (2008, July 12). Rising fuel prices driving riders to transit, GO says. *Toronto Star* , p. A06.

Lakey, J. (2008a, January 22). Commuters are eager to get to bottom of this. *Toronto Star* , p. A10.

Lakey, J. (2008b, February 21). 2 minutes for icing at Davisville subway station. *Toronto Star* , p. A13.

Lakey, J. (2008c, April 28). Whitby escalators leave GO commuters unmoved. *Toronto Star* , p. A10.

Lakey, J. (2008d, June 12). Sign points TTC rider in wrong direction. *Toronto Star* , p. A10.

Lakey, J. (2008e, July 7). Riders left without cover say gimme (TTC) shelter. *Toronto Star* , p. A09.

Lee, M. (2008, September 27-28). Personal Communication. (V. Ong, Interviewer)

Legacy, C., Glover, L., & Low, N. (2007). *Investigation of Greenhouse Impacts of Different Transport Modes in Australian Cities.* University of Melbourne, Victoria: Australasian Centre for the Governance and Management of Urban Transport (GAMUT).

Lenzen, M. (1999). Total requirements of energy and greenhouse gases for Australian transport. *Transportation Research Part D , 4* (4), 265-290.

Lewington, J. (2008, September 5). Metrolinx aims for consensus with TTC. *The Globe and Mail* .

Litman, T. (2008). *Transport Elasticities: How Prices and Other Factors Affect Travel Behavior.* Victoria, BC: Victoria Transport Policy Institute.

Lorinc, J. (2008). *The New City: How the Crisis of Canada's Cities is Reshaping Our Nation.* Toronto, Ontario: Penguin Group.

Low, N. (2003). Is Urban Transport Sustainable? In N. Low, & B. Gleeson, *Making Urban Transport Sustainable* (pp. 1-22). New York, NY: Palgrave Macmillan.

Lucas, K. (2004). *Running on empty: transport, social exclusion and environmental justice.* Bristol, UK: Policy Press.

Madrigal, A. (2008, July 17). *Amazing Stat: California Uses More Gas than China.* Retrieved July 25, 2008, from Wired Science from Wired.com: http://blog.wired.com/wiredscience/2008/07/amazing-stat-ca.html

Market Development and Research, Product Development, RailCorp. (2008). *A Compendium of CityRail Travel Statistics - Sixth Edition.* Chippendale, NSW: RailCorp.

Mason, L. (2008, February 14). Tcard mess a no-brainer: simplify fares. *The Sydney Morning Herald* , p. 17.

Matas, A. (2004). Demand and Revenue Implications of an Integrated Public Transport Policy: The Case of Madrid. *Transport Reviews , 24* (2), 195-217.

Mees, P. (2000). *A Very Public Solution: Transport in the Dispersed City.* Carlton South, Victoria: Melbourne University Press.

Metro Transport Sydney. (2008). *About Us.* Retrieved October 23, 2008, from Corporate/Business | Metro Transport: http://www.metrotransport.com.au/index.php/about-us

Metro Transport Sydney. (2006, March 7). *Technical Details and all that stuff...* Retrieved October 23, 2008, from Metro Transport: http://www.metrotransport.com.au/PDF/LightRailTechSheet.pdf

Metrolinx. (2007a). *History.* Retrieved November 2, 2008, from Metrolinx: http://www.metrolinx.com/en/history.aspx

Metrolinx. (2007b). *Towards Sustainable Development: Discussion Paper #1.* Toronto, ON: Government of Ontario.

Metrolinx. (2008a). *Green Paper # 7: Transit Development of a Regional Transportation Plan for the Greater Toronto and Hamilton Area.* Toronto, ON: Government of Ontario.

Metrolinx. (2008b). *Backgrounder - Draft Regional Transport Plan - Transit Technologies.* Toronto, ON: Metrolinx.

Metrolinx. (September 2008). *Draft Regional Transportation Plan.* Toronto, ON: Government of Ontario.

Microsoft. (2008). Retrieved November 3, 2008, from Live Search Maps: http://maps.live.com/

Ministry of Transport. (2006). *Service Planning Guidelines: Sydney Contract Regions.* Sydney, NSW: NSW Ministry of Transport.

Ministry of Transport. (2007a). *Fact Sheet: Fairer Fares.* Retrieved August 19, 2007, from NSW Ministy of Transport: http://www.transport.nsw.gov.au/abouttrans/fact-sheet-fairer-fairs.pdf

Ministry of Transport. (2007c). *Pictogram Standards 2007.* Sydney, NSW: NSW Ministry of Transport.

Ministry of Transport. (2007b, March 5). *Your guide to services at Parramatta Transport Interchange.* Retrieved October 29, 2008, from NSW Ministry of Transport: http://www.transport.nsw.gov.au/publications/parramatta-trans-interchange.pdf

Ministry of Transport. (2007c, March 12). *Fact Sheet: New bus regions.* Retrieved August 19, 2007, from Transport Planning - NSW Ministry of Transport: http://www.transport.nsw.gov.au/abouttrans/fact-sheet-new-bus-regions.pdf

Ministry of Transport. (2007d, March 12). *Land Use and Transport Planning.* Retrieved October 30, 2008, from NSW Ministry of Transport: http://www.transport.nsw.gov.au/abouttrans/planners-land-use.html

Ministry of Transport. (2007e, December 11). *What We Do*. Retrieved November 2, 2008, from NSW Ministry of Transport: http://www.transport.nsw.gov.au/aboutus/whatdo.html

Ministry of Transport. (2008a). *Contract Region 13 Profile.* Sydney, NSW: NSW Ministry of Transport.

Ministry of Transport. (2008b). *Introduction to Graphic Standards for Public Transport Information in New South Wales.* Sydney, NSW: NSW Ministry of Transport.

Ministry of Transport. (2008c, March 11). *Your Guide to Bus Services at Lane Cove Bus Interchange.* Retrieved October 29, 2008, from NSW Ministry of Transport: http://www.transport.nsw.gov.au/news/Lane-Cove-Interchange.pdf

Ministry of Transport. (2008d). *Submission to the Independent Pricing and Regulatory Tribunal (IPART) on Bus Fares 2009.* Sydney: New South Wales Ministry of Transport.

Ministry of Transport. (2008e, October 1). *Weekly Bus Tickets.* Retrieved October 18, 2008, from NSW Ministry of Transport: http://www.transport.nsw.gov.au/news/weekly-bus-tickets.html

Mississauga Transit. (2008, October 20). *Weekday Service Map* . Mississauga, ON: City of Mississauga.

Mississauga Transit. (2008, October 20). *Sunday Service Map* . Mississauga, ON: City of Mississauga.

Muller, P. O. (2004). Transportation and Urban Form: Stages in the Spatial Evolution of the American Metropolis. In S. Hanson, & G. Giuliano, *The Geography of Urban Transportation: Third Edition* (pp. 59-85). New York, NY: The Guilford Press.

Munro, S. (2008, October 25). *Ridership Growth Service Changes in Late November 2008 (Updated).* Retrieved October 30, 2008, from Steve Munro's Web Site: http://stevemunro.ca/?p=1329#comments

Newman, P., & Kenworthy, J. (1996). The land use - transport connection. *Land Use Policy , 13* (1), 1-22.

Newman, P., & Kenworthy, J. (1999). *Sustainability and Cities: Overcoming Automobile Dependence.* Washington, DC: Island Press.

Newman, P., Kenworthy, J., & Bachels, M. (2001). How We Compare: Patterns and Trends in Australian and New Zealand Cities. In P. Laird, P. Newman, M. Bachels, & J. Kenworthy, *Back on Track: Rethinking Transport Policy in Australia and New Zealand* (pp. 45-67). UNSW, Sydney, NSW: University of New South Wales Press.

NSW Government. (2004). *Review of Bus Services in New South Wales - Final Report.* Sydney, NSW: NSW Government.

NSW Government. (2007a). *Design.* Retrieved October 23, 2008, from T-Way: http://www.t-way.nsw.gov.au/nw/nw-design.htm

NSW Government. (2007b). *Bus Services.* Retrieved October 23, 2008, from T-Way: http://www.t-way.nsw.gov.au/nw/bus-services.htm

NSW Government. (2008a). *SydneyLink: The future of Sydney's Transport.* Sydney, NSW: NSW Government.

NSW Government. (2008b, November 1). *Home.* Retrieved November 2, 2008, from 131500 Transport Infoline: http://www.131500.info/

Oakville Transit. (2008, July 1). *Fares + Policies.* Retrieved October 28, 2008, from Oakville Transit: http://www.oakvilletransit.com/fares.htm

Paulley, N., Balcombe, R., Mackett, R., Titheridge, P., Wardman, M., Shires, J., et al. (2006). The demand for public transport: The effects of fares, quality of service, income and car ownership. *Transport Policy , 13*, 295-306.

Pickup, L., & Giuliano, G. (2005). Transport and Social Exclusion in Europe and the USA. In K. P. Donaghy, S. Poppelreuter, & G. Rudinger, *Social dimensions of sustainable transport: tranatlantic perspectives.* Aldershot, Hants, England: Ashgate.

Pink, B. (2007). *Australian Standard Geographical Classification.* Belconnen, ACT: Australian Bureau of Statistics.

Pink, B. (2008). *Australian Standard Geographical Classification (ASGC): New South Wales maps.* Belconnen, ACT: Australian Bureau of Statistics.

Planning Institute of Australia: NSW Division. (April 2008). *PIA Position Statement on Sydneylink Proposal.* North Sydney, NSW: Planning Institute of Australia: NSW Division.

Potts, D. (2008, July 27). *Food versus fuel: something to chew on.* Retrieved August 3, 2008, from The Sydney Morning Herald: http://www.smh.com.au/news/planning/food-versus-fuel-something-to-chew-on/2008/07/26/1216492794309.html

Premier's Department. (2006). *Urban Transport Statement.* Sydney, NSW: NSW Government.

Pucher, J. (2004). Public Transportation. In S. Hanson, & G. Giuliano, *The Geography of Urban Transportation: Third Edition* (pp. 199-236). New York, NY: The Guilford Press.

Pund, G. (2001). City density and public transport. *Australian Planner , 38* (2), 74-79.

Queensland Transport. (2007). *Annual Report, 2006-07, Vol 1.* Brisbane, Qld: Queensland Government.

Rail Corporation New South Wales. (2008). *Our performance - Our customers - passenger journeys.* Retrieved 2008, from CityRail: http://www.cityrail.info/aboutus/our_performance/customers.jsp

RailCorp. (2005). Retrieved October 24, 2008, from 150 Years of NSW Railways: http://www.railcorp.info/150years/

RailCorp. (2008). *Customer Service Improvement Program: Handling of Delays and Train Announcements Module.* Sydney, NSW: Rail Corporation NSW.

Reinhold, T. (2008). More Passengers and Reduced Costs - The Optimization of the Berlin Public Transport Network. *Journal of Public Transportation , 11* (3), 57-76.

Richards, G. (2008, June 20). Roadshow: Free rides bring elbow-to-elbow crowds. *San Jose Mercury* .

Robins, B. (2008, October 31). Rail links 'shelved'. *The Sydney Morning Herald* .

Royal Commission on Environmental Pollution. (2007, March). *The Urban Environment.* Retrieved September 8, 2008, from Royal Commission on Environmental Pollution: http://www.rcep.org.uk/urban/report/urban-environment.pdf

Rudd, K. (2008, October 14). *Kevin Rudd's address to the nation (full transcript).* Retrieved October 20, 2008, from The Australian: http://www.theaustralian.news.com.au/story/0,25197,24496809-5013871,00.html

Sexton, R. (2008, August 24). *City's trains buckling under record demand.* Retrieved October 20, 2008, from The Age: http://www.theage.com.au/national/citys-trains-buckling-under-record-demand-20080823-40xi.html

Shaller, B. (1998, Fall/Winter). *Lessons From MetroCard Fare Initiatives.* Retrieved October 28, 2008, from Schaller Consulting: http://www.schallerconsult.com/pub/metrocrd.htm

Shepherd, S. P., Zhang, X., Emberger, G., Hudson, M., May, A. D., & Paulley, N. (2006). Designing optimal urban transport strategies: The role of individual policy instruments and the impact of financial constraints. *Transport Policy , 13*, 49-65.

Smith, A. (2008a, January 25). TCard firm blasts ministers for lack of interest. *The Sydney Morning Herald* .

Smith, A. (2008b, January 30). Complicated fare structure will lead us nowhere, bus operators warn. *The Sydney Morning Herald* .

Solomon, L. (2007). *Toronto Sprawls: A History.* Toronto, Ontario: University of Toronto Centre for Public Management.

Spacing. (2005). *Subway Station Buttons.* Retrieved October 25, 2008, from s p a c i n g: http://spacing.ca/buttons.htm

Spearritt, P. (2000). *Sydney's Century: A History.* University of New South Wales, Sydney: University of New South Wales Press.

State Rail. (2001). *An introduction to State Rail planning processes for future rail operations and infrastructure in Greater Sydney and metropolitan area.* Sydney, NSW: State Rail.

State Transit Authority of NSW. (2007). *Annual Report 2006-2007.* Strawberry Hills, NSW: State Transit Authority of NSW.

State Transit Authority of NSW. (2008, July 1). *Corporate.* Retrieved October 23, 2008, from Sydney Buses: http://www.sydneybuses.info/corporate.htm

Statistics Canada. (2007, January 22). Census Tract Reference Maps by Census Metropolitan Areas or Census Agglormerations. *Toronto* . Ottawa, ON: Statisics Canada.

Statistics Canada. (2007a, March 13). *Toronto, Ontario (table). 2006 Community Profiles. 2006 Census.* Retrieved October 22, 2008, from Statistics Canada: http://www12.statcan.ca/english/census06/data/profiles/community/Index.cfm?Lang=E

Statistics Canada. (2007b, March 13). *Population and dwelling counts, for urban areas, 2006 and 2001 censuses - 100% data (table). Population and Dwelling Count Highlight Tables. 2006 Census.* Retrieved October 22, 2008, from 2006 Census of Population: http://www12.statcan.ca/english/census06/data/popdwell/Table.cfm?T=801&SR=1&S=1&O=A&RPP=9999&PR=0&CMA=0

Statistics Canada. (2007c, March 13). *Population and dwelling counts, for census metropolitan areas, 2006 and 2001 censuses - 100% data (table). Population and Dwelling Count Highlight Tables. 2006 Census.* Retrieved October 22, 2008, from 2006 Census of Population: http://www12.statcan.ca/english/census06/data/popdwell/Table.cfm?T=205&SR=1&S=0&O=A&RPP=50&PR=0&CMA=0

Statistics Canada. (2007d, March 13). *Population and dwelling counts, for census metropolitan areas, 2006 and 2001 censuses - 100% data (table). Population and Dwelling Count Highlight Tables. 2006 Census.* Retrieved October 22, 2008, from Statistics Canada, 2006 Census of Population.: http://www12.statcan.ca/english/census06/data/popdwell/Table.cfm?T=205&SR=1&S=0&O=A&RPP=50&PR=0&CMA=0

Statistics Canada. (2007e, September 5). *2006 Census Dictionary > Urban area (UA) - Geography.* Retrieved October 22, 2008, from Statistics Canada: http://www12.statcan.ca/english/census06/reference/dictionary/geo049.cfm

Statistics Canada. (2007f, December 11). *2006 Census Dictionary > Census metropolitan area (CMA) and census agglomeration (CA) - Geography.* Retrieved October 22, 2008, from Statistics Canada: http://www12.statcan.ca/english/census06/reference/dictionary/geo009.cfm

Stradling, S., Carreno, M., Rye, T., & Noble, A. (2007). Passenger perceptions and the ideal urban bus journey experience. *Transport Policy , 14*, 283-292.

Sydney Ferries. (2007). *About Us.* Retrieved October 23, 2008, from Sydney Ferries: http://www.sydneyferries.info/about-us.htm

Sydney Ferries. (2007). *Annual Report 2006-07.* Circular Quay, Sydney, NSW: Sydney Ferries Corporation.

Taylor, B. D., Miller, D., Iseki, H., & Fink, C. (2008). Nature and/or nurture? Analyzing the determinants of transit ridership across US urbanised areas. *Transportation Research A* , Article in Press.

The World Bank Group. (2008). *Data - Country Groups.* Retrieved October 22, 2008, from The World Bank: http://go.worldbank.org/D7SN0B8YU0

Toronto Transit Commission. (2003). *Ridership Growth Strategy.* Toronto, ON: Toronto Transit Commission.

Toronto Transit Commission. (2007). *Annual Report 2006.* Toronto, ON: Toronto Transit Commission.

Toronto Transit Commission. (2008a). *Service Improvements for 2008.* Toronto, ON: Toronto Transit Commission.

Toronto Transit Commission. (2008b, June). *TTC Ride Guide* . Toronto, ON: Toronto Transit Commission.

Toronto Transit Commission. (2008c). *TTC Prices.* Retrieved October 28, 2008, from The Toronto Transit Commission - TTC: http://www3.ttc.ca/Fares_and_passes/Prices/index.jsp

Toronto Transit Commission. (2008d). *TTC Operating Statistics.* Retrieved October 24, 2008, from The Toronto Transit Commission - TTC: http://www3.ttc.ca/About_the_TTC/Operating_statistics.jsp

Toronto Transit Commission. (2008e). *TTC Milestones.* Retrieved October 24, 2008, from The Toronto Transit Commission - The TTC: http://www3.ttc.ca/About_the_TTC/History/Milestones.jsp

Toronto Transit Commission. (2008f). *TTC General Information.* Retrieved November 1, 2008, from The Toronto Transit Commission - TTC: http://www3.ttc.ca/Routes/General_Information/General_Information.jsp

Toronto Transit Commission. (2008g). *Schedules and Maps*. Retrieved October 30, 2008, from The Toronto Transit Commission - TTC: http://www3.ttc.ca/Routes/index.jsp

Toronto Transit Commission. (2008h). *Greater Toronto Area (GTA) Weekly Pass.* Retrieved October 28, 2008, from The Toronto Transit Commission - TTC: http://www3.ttc.ca/Fares_and_passes/Passes/GTA_pass.jsp

Tossell, I. (2007, November 24). Still a subway to nowhere? Construction booms, but opinions remain sharply divided as the often derided Sheppard line turns 5. *Toronto Star* , p. CO01.

Town of Milton. (2007, April 2). *Transit Fare Agents.* Retrieved October 28, 2008, from Town of Milton: http://www.milton.ca/residents/transit/miltontransit/busfares.htm

Transit Australia. (2004). Exploring South East Queensland. *Transit Australia , 59* (9), 263-271.

Transit Australia. (2008). Transit Newsfile: Queensland. *Transit Australia , 63* (5), 141-146.

Transport and Population Data Centre. (2006). *Transfigures: Train Access and Egress Modes.* Redfern, NSW: Department of Planning.

Transit Cooperative Research Program. (1996). *Institutional Barriers to Intermodal Transportation Policies and Planning in Metropolitan Areas.* Washington, DC: Transportation Research Board, National Research Coincil.

Transit Cooperative Research Program. (2003). *TCRP Report 95: Traveler Response to Transportation System Changes: Chapter11-Transit Information and Promotion.* Washington, DC: Transportation Research Board.

Transport Cooperative Research Program. (2004). *TCRP Report 95: Chapter 12 - Transit Pricing and Fares: Traveler Response to Transportation System Changes.* Washington, DC: Transportation Research Board of the National Academies.

Transport Data Centre. (2002). *Bus Users in Sydney.* Sydney, NSW: Transport NSW.

Transport Data Centre. (2008). *2006 Household Travel Survey Summary Report.* Sydney, NSW: Ministry of Transport.

Transportation Research Board. (1996). *Transit Cooperative Research Program: Synthesis of Transit Practice 19: Passenger Transfer System Review.* Washington, DC: National Academy Press.

UNFCCC. (2008c). *Essential Background > Feeling the Heat > Current Evidence of Climate Change.* Retrieved October 18, 2008, from United Nations Framework Convention on Climate Change: http://unfccc.int/essential_background/feeling_the_heat/items/2904.php

UNFCCC. (2008d). *Essential Background > Feeling the Heat > Future Effects.* Retrieved October 18, 2008, from United States Framework on Climate Change: http://unfccc.int/essential_background/feeling_the_heat/items/2905.php

UNFCCC. (2008a). *Essential Background > Feeling the Heat > Introduction.* Retrieved October 18, 2008, from United Nations Framework Convention on Climate Change: http://unfccc.int/essential_background/feeling_the_heat/items/2917.php

UNFCCC. (2008b). *Essential Background > Feeling the Heat > The Greenhouse Effect and the Carbon Cycle.* Retrieved October 18, 2008, from United Nations Framework Convention on Climate Change: http://unfccc.int/essential_background/feeling_the_heat/items/2903.php

United Nations. (1948, December 10). *Universal Declaration of Human Rights*. Retrieved September 8, 2008, from United Nations: http://www.un.org/Overview/rights.html

Victoria Transport Policy Institute. (2008a, July 22). *Comprehensive Transport Planning.* Retrieved November 2, 2008, from Online TDM Encylcopedia: http://www.vtpi.org/tdm/tdm76.htm

Victoria Transport Policy Institute. (2008b, July 22). *Guaranteed Ride Home: A Backup For Commuters Who Use Alternative Modes.* Retrieved October 30, 2008, from Online TDM Encyclopedia: http://www.vtpi.org/tdm/tdm18.htm

Victoria Transport Policy Institute. (2008c, July 22). *Multi-Modal Access Guides: Directions to Specific Destinations*. Retrieved October 26, 2008, from TDM Encyclopedia: http://www.vtpi.org/tdm/tdm113.htm

Victoria Transport Policy Institute. (2008d, August 18). *Multi-Modal Level-of-Service Indicators.* Retrieved October 26, 2008, from Online TDM Encyclopedia: http://www.vtpi.org/tdm/tdm129.htm

Vielkind, J., Nearing, B., & Churchill, C. (2008, July 13). *A changing American Dream.* Retrieved August 16, 2008, from Albany, NY: Timesunion.com: http://timesunion.com/AspStories/storyprint.asp?StoryID=703268

Vuchic, V. R. (2005). *Urban Transit: Operations, Planning and Economics.* Hoboken, NJ: John Wiley & Sons.

Wall, G., & McDonald, M. (2007). Improving bus service quality and information in Winchester. *Transport Policy , 14*, 165-179.

Ward, S. V. (2002). *Planning the Twentieth-Century City.* Hichester, West Sussex: John Wiley & Sons.

Western Sydney Buses. (2008, May 26). *Liverpool-Parramatta T-Way T80 Timetable.* Retrieved October 23, 2008, from Western Sydney Buses - Sydney Buses: http://www.sydneybuses.info/uploads/File/pdfs/tway_services/T80tt.pdf

White, P. (2002). *Public transport: it's planning, management and operation.* London, UK: Spon Press.

Whitelegg, J., & Low, N. (2003). Managing Transport Demand in European Countries. In N. Low, & B. Gleeson, *Making Urban Transport Sustainable* (pp. 240-251). New York, NY: Palgrave Macmillan.

Williams, P. (2007). The Natural Environment. In S. Thompson, *Planning Australia* (pp. 117-139). Port Melbourne, Victoria: Cambridge University Press.

York Region Rapid Transit Corporation. (2004b). *Frequency: Where to VIVA, when to VIVA*. Retrieved October 30, 2008, from - viva - York Region's new rapid transit system: http://www.vivayork.com/?go=feature_Frequence

York Region Rapid Transit Corporation. (2004a). *VIVA from A to Being...more informed*. Retrieved October 24, 2008, from VIVA - York Region's new rapid transit system: http://www.vivayork.com/

York Region Rapid Transit Corporation. (2008, October 10). *Press releases: ATU Local 113 operators reach agreement with Veolia Transportation.* Retrieved October 24, 2008, from VIVA - York Regions new rapid transit system: http://www.vivayork.com/?go=info_Press

York Region Transit. (2008a, January 1). *Fares.* Retrieved October 28, 2008, from York Region Transit: http://www.yrt.ca/fares/index.asp

York Region Transit. (2008b, August 31). *YRT-Viva Weekday System Map* . Richmond Hill, ON: York Region Transit Corporation.