Infrastructure Partnerships Australia
ABN 22 604 585 506
Suite 3.03 Level 3 | 95 Pitt Street | Sydney NSW 2000
PO Box R1771 | Royal Exchange NSW 1225
T +61 2 9152 6000 | **F** +61 2 9152 6005
E contact@infrastructure.org.au | **www.infrastructure.org.au**

INFRASTRUCTURE PARTNERSHIPS AUSTRALIA
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31 August 2015

The Chairman
The Independent Pricing and Regulatory Tribunal of New South Wales
Level 15, 2-24 Rawson Place
Sydney NSW 2000

Dear Sir/Madam

RE: ***FINDING THE BEST FARE STRUCTRUE FOR OPAL***

Infrastructure Partnerships Australia (IPA) welcomes the opportunity to comment on the IPART Discussion Paper *"Finding the best fare structure for Opal"*; and the issue of fare integration across the wider transport network.

To assist the Tribunal, we are delighted to enclose the following submission, together with our annexed policy paper, *Integrating Australia's Transport Systems: A Strategy for an Efficient Transport Future.*

We hope that our submission assists you in your inquiries into this matter.

Fare Integration

Opal provides a technology platform which, well-used, allows fare structures to be fundamentally restructured, ensuring that the price of transport network fares signal users in a manner which aligns with broader transport policy priorities.

In this way, we consider that effective fare integration allows commuters to choose the most efficient journey path, through a multimodal corridor.

As noted in the introduction, we have annexed our report *Integrating Australia's Transport Systems: A Strategy for an Efficient Transport Future'.* This study explores the features of effective transport integration, outlining an implementation pathway for Australia's transport policymakers.

Our report identifies areas of integration which underpin good practice in transport service delivery, being:

1. physical integration;
2. network integration;
3. fare integration;
4. information integration; and
5. institutional integration.

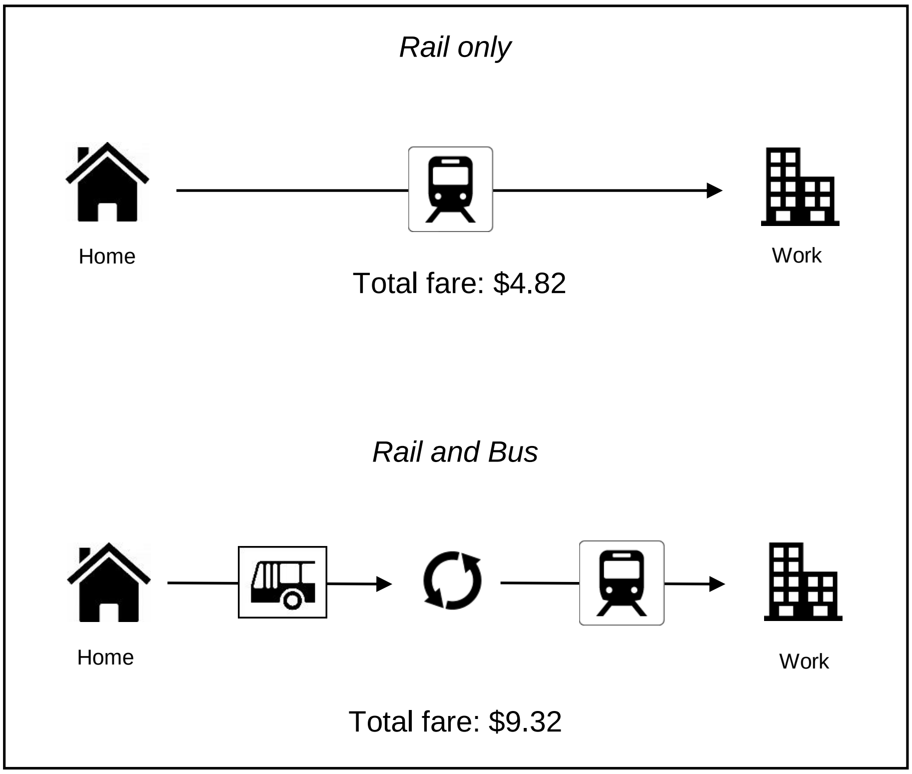
In our view, fare integration forms the foundation of an integrated network and is key to improving network efficiency.

The existing fare structure in NSW is inequitable and inefficient. It unfairly penalises commuters who need to change between transport modes and distorts decision making on journey choice. Figure 1 compares two journeys of comparable distances, from Western

Infrastructure Partnerships Australia
ABN 22 604 585 506
Suite 3.03 Level 3 | 95 Pitt Street | Sydney NSW 2000
PO Box R1771 | Royal Exchange NSW 1225
T +61 2 9152 6000 | F +61 2 9152 6005
E contact@infrastructure.org.au | www.infrastructure.org.au

Sydney to the Sydney CBD. It shows a significant increase in journey cost when the commuter has to make an interchange between bus and rail services, despite no real differences in the overall journey length.

Figure 1: Journey comparison by mode



Source: IPA

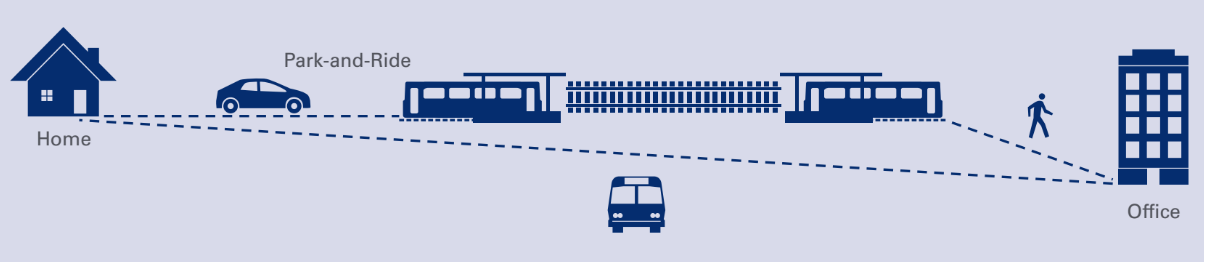
Fare integration offers the opportunity to limit or eliminate such unintended price penalties when commuters switch between transport modes. This removes distortions in a commuter's journey choice caused by fare structure differences, encouraging that person to undertake the most efficient journey. Consequently, this helps to optimise the transport network, through promoting multi-modal journeys where appropriate and encouraging decisions to switch from private to public transport when efficiency gains can be made.

Fare integration also improves transport planning and coordination between different modes along multimodal corridors. Firstly it incentivises transport service providers to take account of other transport modes along the same corridor when scheduling services. This not only increases the efficiency of their own services, but also allows for more effective interchange between modes.

Secondly, greater integration helps minimise inefficient doubling up of services along the same transport corridor when they are not justified by capacity needs. Figure 2 shows an example of a multi-modal transport corridor where rail and bus services are performing the same function.

Infrastructure Partnerships Australia
ABN 22 604 585 506
Suite 3.03 Level 3 | 95 Pitt Street | Sydney NSW 2000
PO Box R1771 | Royal Exchange NSW 1225
T +61 2 9152 6000 | F +61 2 9152 6005
E contact@infrastructure.org.au | www.infrastructure.org.au

Figure 2: Multi-modal corridor



Source: IPA

Depending on transport demand along this corridor, it may be suboptimal to have both services running in parallel, and efficiencies can be gained from a different arrangement – such as rerouting buses to feed into rail services instead. In order to facilitate such changes, fare integration is essential.

Our report considers the transport networks of Hong Kong, Singapore and London as best practice examples on how to foster greater network integration and improve transport outcomes. A number of key themes were drawn from these cities (see pages 38 – 49 of our report), first and foremost among which is the need for comprehensive fare integration where the monetary cost of changing modes is limited or eliminated.

We also found that when transport integration has been successful, it has been implemented across the entire network, as opposed to individually to each new project. Hence it will not be sufficient to pursue integration as new links are added to the network or only within distinct transport modes.

Our report concludes with a number of recommendations on how to approach network integration and deliver better value for commuters (see pages 12 – 13 of our report).

Fare Structure

The current public transport fare structure in NSW is primarily distance based and does not differentiate between journeys in different locations around the city. This can lead to inequities because not all journeys are of equal value.

A journey into the CBD would likely be of higher value than a journey to a suburban residential area, meaning a commuter’s willingness to pay for inner city journeys will likely be much higher than journeys to the urban fringes. Furthermore the social cost of each journey, such as congestion, also differs significantly. Under the current distance based fare structure however, if both journeys are of similar length, the fares would be the same (see figure 3).

Figure 3: Journey comparison by location

Journey	Distance	Fare
Wentworthville to Parramatta	3.5 km	$3.38
Edgecliff to Town Hall	3.2 km	$3.38

Source: IPA

In our view a fare structure based on charging zones can address this inequity. Under such a system, the fare for accessing each zone would differ depending on the value of accessing that zone. This means the fare cost of transport services to the central zones near the city's CBD will be higher than services to suburban areas on the peripheral of the city.

London's public transport system adopts a zoned fare structure, see appendix 1 for a map depicting the fare structure applied in London. The fare for travelling between the central zones 1 and 2 in London is £2.9 ($6.26), whereas the fare for travelling between zones 5 and 6 is £1.7 ($3.67). This difference reflects the greater value and costs associated with accessing areas near the CBD compared to the value and costs associated with accessing suburban areas in zone 6.

Distance is also accounted for in this system, as the more zones a commuter travels through, the higher his/her total fare – the fare for travelling from zone 1 to zone 6 is £5.10 ($11.01).

Recommendations

1. Pursue network wide fare integration

We recommend that the tribunal integrate fares across the transport network for all transport modes. This removes distortions in price signals and allows commuters to choose the most efficient journey regardless of mode choice, thereby removing inequities and improving transport network efficiency.

2. Adopt a fare structure based on fare zones

We recommend that the tribunal replace the existing distance based fare structure with one based on fare zones. This effectively differentiates between journeys of different values and improves equity through reflecting the value and cost of each journey in the fare cost.

We remain eager to assist the Government on improving fare integration across the transport network. To this end, should you have any questions or wish to discuss aspects of this submission further, please contact IPA's Policy Officer, David Jiang.

Yours sincerely,

Brendan Lyon
CHIEF EXECUTIVE OFFICER

Infrastructure Partnerships Australia
ABN 22 604 585 506
Suite 3.03 Level 3 | 95 Pitt Street | Sydney NSW 2000
PO Box R1771 | Royal Exchange NSW 1225
T +61 2 9152 6000 | **F** +61 2 9152 6005
E contact@infrastructure.org.au | **www.infrastructure.org.au**

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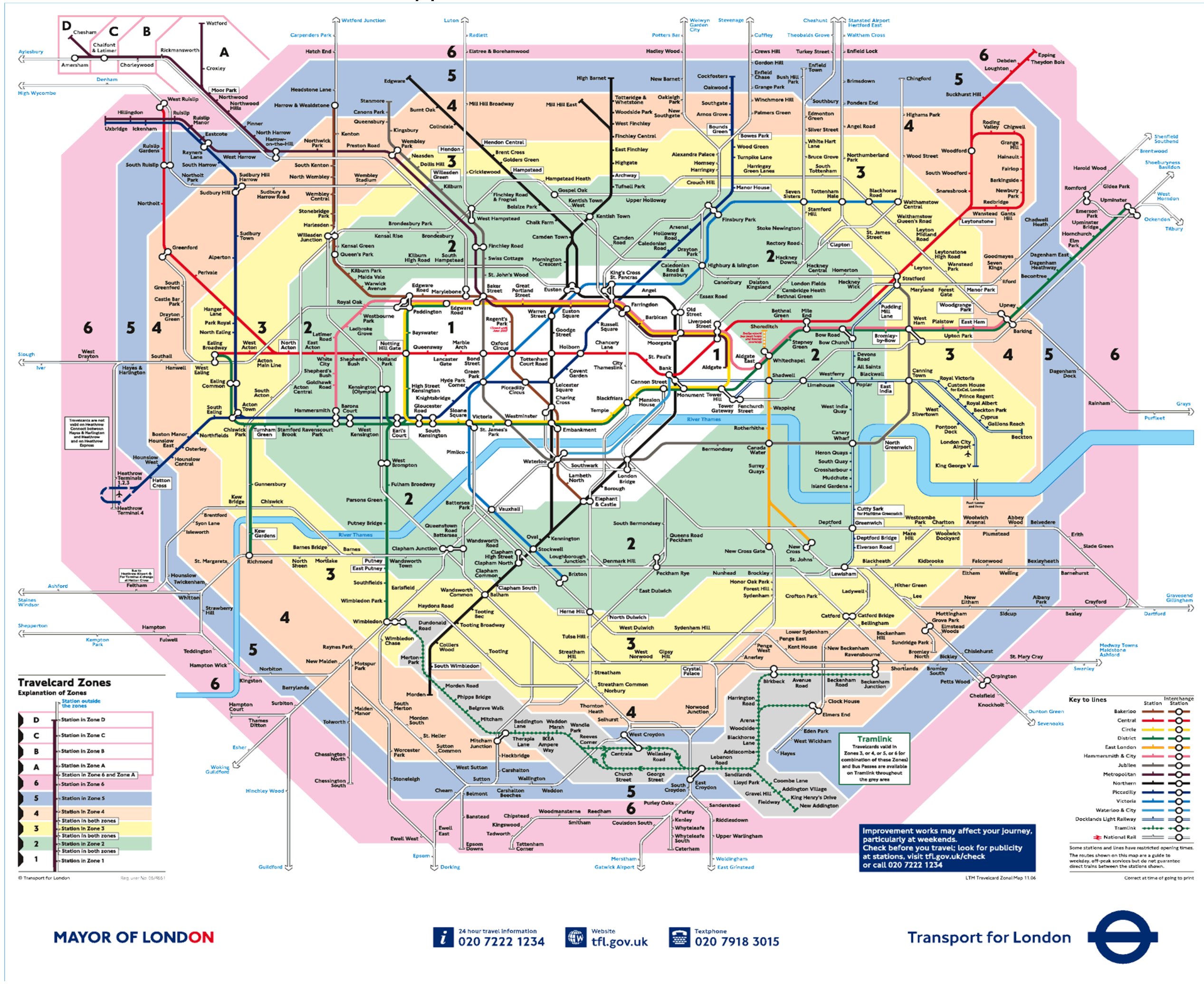
Appendix 1: London Travel Zones



Source: Transport for London

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INTEGRATING AUSTRALIA'S TRANSPORT SYSTEMS:

A Strategy for an Efficient Transport Future

booz&co.

Please note

The authors of this report are employed by Booz & Company. The work reported herein was carried out in response to a request by Infrastructure Partnerships Australia ('IPA'). This paper was prepared solely for the information and use of IPA. No third parties shall have a right to rely on the report or be regarded as a third-party beneficiary of the arrangement between IPA and Booz & Company. The paper was prepared by Booz & Company after due and careful enquiry, based on publicly available information on which Booz & Company relied and did not independently verify. The paper states a number of assumptions made during our analysis.

Infrastructure Partnerships Australia
8th Floor
8-10 Loftus Street
Sydney NSW 2000
T 02 9240 2050
F 02 9240 2055
W www.infrastructure.org.au

For more information please contact:

Brendan Lyon
Chief Executive Officer
Infrastructure Partnerships Australia
T 02 9240 2050
E brendan.lyon@infrastructure.org.au

Adrian Dwyer
Director, Policy
Infrastructure Partnerships Australia
T 02 9240 2056
E adrian.dwyer@infrastructure.org.au

Robert Williams
Partner
Booz and Company (Aust) Pty Ltd
Level 7, 7 Macquarie Place
Sydney, NSW, 2000
T 02 9321 1900
E robert.williams@booz.com

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Cover: Courtesy of Industry Funds Management (IFM)

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EXECUTIVE SUMMARY

Over time, there has been a natural tendency for transport planning to be captured by individual modes or projects, such as rail, light rail, metro, busways or motorways, rather than taking a whole of network approach in which each mode can play its proper role in the broader integrated transport task.

This focus on individual modes has its roots in government structures which have seen mode specific agencies responsible for the capital programme. An example might be a public rail operator planning for new heavy rail links; or a road authority planning a new motorway. While this division between modes is understandable in an operational context, it has contributed to an infrastructure planning debate that has at times given insufficient consideration and evaluation to the relative strengths of all modes in an integrated, multi-modal environment.

The consequence of these structures mean an infrastructure and public transport debate that is about projects, rather than networks, which can result in disjointed transport networks that fail to deliver the best outcome for commuters and other users.

Infrastructure Partnerships Australia (IPA) engaged Booz & Company to develop a policy framework that articulates the case for a new approach to transport infrastructure planning that is based around integrated network outcomes. This paper explores the benefits of including alternative transit modes in strategic transport corridor evaluation and identifies practical steps governments can take to ensure policy makers have the best information available when making modal and whole of network decisions.

This paper calls for a clear action agenda for better integration of Australia's transport systems. Integration provides the key to greater utility and usage of public transport, while supporting the needs of a burgeoning population.

Our research of global best practice has identified five areas of integration for successful transport delivery:

- Institutional Integration – to ensure the right transport choices are made for commuters;
- Physical Integration – to ensure commuters can enjoy the most convenient travel experience possible;
- Network Integration – to ensure commuters can make a joined up journey from origin to destination;
- Information Integration – to ensure commuters can make informed decisions before and during their journey; and
- Fare Integration – to ensure commuters aren't penalised for making the most efficient use of an integrated transport system.

It will not be enough to simply pursue integration as new links are added to networks; governments must relentlessly target integration on new and existing transport infrastructure – recognising that the dividends of transport integration are of greatest value when applied to all five key areas and across the whole network.

The paper identifies practical examples of best practice from integrated transport systems around the world and seeks to apply those lessons to an Australian context. Bringing together these broad themes, the paper makes a series of recommendations to Australian governments to ensure the right transport governance and planning structures are in place to deliver the right transport solutions.

Historically, in most states within Australia, individual appraisal guidance documents existed for each mode. For example, in NSW, the State Rail Authority's *Guide to the Evaluation of Capital Projects*[1] provided guidance on the appraisal of heavy rail projects, whilst the Roads and Traffic Authority's (now Roads and Maritime Services) *Economic Analysis Manual*[2] guided the evaluation of road projects. One of the key implications of having single-mode appraisal guidance documents is that they do not encourage consideration of multi-modal and/or integrated transport options during the optioneering stage. For instance, the options considered to develop a new rail line might be:

- Option 1 – The Base Case – Do Nothing;
- Option 2 – Build a single track line from A to B;
- Option 3 – Build a single track line with a passing loop; and
- Option 4 – Build a double track line.

This focus has several negative consequences:

- The potential for an alternative mode to meet project objectives can be overlooked;
- It can detract from the original objectives of transit investment as pursuit of a specific solution takes over as the driver of project implementation; and
- In implementation, a rational discussion of the pros and cons of modal alternatives can be overtaken by the urge to 'put down' detractors who can put committed investments at risk.

An integrated multi-modal transport approach, on the other hand, may consider alternative options e.g. run buses from A to B and/or build light rail from A to B. This is in line with the arguments presented in Australia's National Guidelines on transport system appraisal, which recommend that governments undertake an options analysis including an 'options list' that "encourages consideration of a full range of policy instruments"[3]. These approaches are designed to ensure the best outcomes emerge from policy development.

A high-level strategic assessment of alternative transport modes was carried out, first by outlining each transport mode's key characteristics and highlighting its strengths and weaknesses, and second by identifying and carrying out a study of two key strategic transport corridors in Sydney and Melbourne:

- Sydney – CBD to Penrith; and
- Melbourne – CBD to Pakenham.

The relative trip costs of the existing transport options along these corridors were assessed, from a user's perspective, over a range of distances to understand typical user preferences and responses over various distances. The characteristics and benefits of an integrated systems based approach to transport planning and evaluation were explored, and potential multi-modal evaluation techniques developed.

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1 State Rail Authority of New South Wales (1995), Guide to the Evaluation of Capital Projects, New South Wales.

2 New South Wales Roads and Traffic Authority (1999), Economic Analysis Manual, New South Wales.

3 Australian Transport Council (2006), National Guidelines for Transport System Management in Australia, 2nd edition, Volumes 1, Canberra, p.14.

The common themes that have emerged from the analyses of the strategic transport corridors in Sydney and Melbourne are:

- It is clear from both pieces of analysis that heavy rail is the most suitable transport mode for trips greater than 25km – 30km on strategic commuter corridors, given its lower generalised trip costs; in both Sydney and Melbourne, heavy rail and cars become most cost-effective, from the user's perspective, as the trip distance increases beyond 10km;

- Active transport modes such as cycling and walking are most cost-effective, from the user perspective, for those trips of less than 10km (or those less than 20km for cycling); however, it should be noted that active transport can be strenuous which is likely to limit the length of journeys;

- Generalised trip costs vary by mode and over different intermediate distances with different modal implications; in particular, analysis of the 0-10km range for both corridors suggest that trip costs do not increase linearly and cross at various points:

  - In Sydney, both light rail and ferries show the highest generalised trip costs for journeys less than 10km; however, it must be recognised that users of these modes enjoy relatively new rolling stock in the case of light rail, unsurpassed harbour views in the case of ferries, and relatively low peak crowding in both cases. Therefore, these modes play a role in providing direct main mode services in inner city areas.

  - In Melbourne, buses have the highest generalised trip costs between 4km and 16km due to the slow vehicle speeds and the longer headways between services, followed by trams which have the second highest generalised trip costs between 4km and 9km; initially, the margin is quite small but it increases quite rapidly after the 5km mark making it unlikely rational users would prefer bus for travel beyond 15km. In Sydney, even though bus and heavy rail trips have similar trip costs initially, as the distance increases beyond the 3km mark, heavy rail clearly becomes more cost-effective as line speeds increase for longer distances on rail lines and enjoy the absence of road congestion. In general, passengers prefer rail modes to on-street bus due to higher service levels, better ride quality and intuitive network design.

  - It is interesting to note that, for most of the Sydney corridor, the generalised trip cost for bus is higher than that for cars. This is not surprising given that there are very few bus services in Sydney with a "turn-up-and-go" frequency, a lack of timetable connectivity between bus services, relatively high bus fares on a per km basis over short distances, and no discounted fares for bus-bus transfers.

While a need for objective cross-modal evaluation is clear, government authorities have a difficult task in undertaking an objective appraisal of alternative transit modes using objective and comparable methods. There is a need to provide a better range of guidance to authorities on the relative roles and attributes of each of the different conventional transit modes. To improve the quality of evaluation undertaken in corridor studies, guidance is also required on how alternative modes perform in terms of costs, benefits and land use impacts.

Too often, transport infrastructure is designed around 'filling a gap' in a network, rather than as the result of an arm's length assessment of delivering the right project, at the right time, based on the best transport outcomes. This paper is designed to encourage governments to adopt a more rigorous approach to transport project prioritisation and funding, and to provide guidance on the ongoing structures required to deliver fully integrated transport solutions.

To provide examples of best practice in integrated multi-modal transport, we considered three international case studies and how they foster integration. The international case studies used were:

- London;
- Hong Kong; and
- Singapore.

The case studies identify a clear series of integration themes that were consistent across the cities studied. Although each of the cities display varying degrees of integration in each element – institutional, physical, network, information, and fare – all are present in each city and can be used as a guide to best practice in transport integration.

This paper argues that the frameworks for integrated transport planning must embed a structure where the right transport solution is selected – not the most obvious or the first mode suggested. Too often, the corridor is chosen to fit the mode – not the mode to fit the corridor.

By integrating transport planning across modes, corridors and networks, policy makers can structurally eliminate modal bias – ensuring transport solutions solve problems, before they build legacies.

Integrated transport agencies at the state level should be tasked with producing Metropolitan Corridor Plans that identify strategic transport corridors in wider metropolitan areas, quantify future needs and preserve those corridors where appropriate. State transport planning agencies should include local and federal governments, industry, experts and the community in producing Metropolitan Corridor Plans to ensure a transparent and accountable identification of long-term transport needs.

Metropolitan Corridor Plans should identify and quantify transport corridors over a long-term planning horizon – they should also include assessment of the capacity of existing corridors to identify growth needs or future modal additions and duplications. The most successful transport planning processes have typically looked many decades into the future and developed a strategy to deal with potential and projected growth. Identifying corridors over a long-term horizon, in a thorough, transparent and considered fashion will allow for their preservation and reduce the costs of transport infrastructure provision in the future – they will also provide a consistent and detailed basis for future modal decisions. By aligning Metropolitan Corridor Plans with the planning system, corridors can be zoned and protected in line with future growth needs and identify transit-oriented development opportunities.

With corridors identified and preserved, the methodology outlined in this paper could provide the building blocks for a toolkit to make sure the right mode is selected for the right motive.

RECOMMENDATIONS

This Paper's analysis of global best practice points to a suite of substantial reforms that will be needed to deliver better conceived and better value transport infrastructure networks. Specifically, Australia's governments should:

1. **Develop network wide Metropolitan Corridor Plans that identify and protect strategic transport corridors.**

   Australia's states should develop long-term Metropolitan Corridor Plans that identify and protect the surface and underground corridors needed for new and expanded transport infrastructure. These plans should be modally agnostic and ensure that strategic transport alignments are not lost to competing developments. These Metropolitan Corridor Plans would identify the corridors that will form the spine of fully integrated metropolitan transport networks.

2. **Capture global best-practice in the integration of transport modes across five key areas.**

   Investment in new or renewed transport infrastructure in Australia's cities should be informed by an overarching and fully integrated strategy. Global best practice demands that five key areas of integration must form the basis of these strategies, they are:

i. Institutional Integration – Achieving network integration and better service outcomes demands a radical change in the way Australia's passenger transport networks are planned and regulated. Planning functions should be vested in a single agency that ensures transport planning, pricing and operational aspects span all modes, creating the preconditions for the integrations recommended below.

ii. Fare Integration – The integration of fares is a fundamental aspect of delivering a systems approach to passenger transport. Global experience has shown that integration of fares across public transport modes, through technologies such as electronic smart cards, makes mode switching more seamless from a customer experience viewpoint and ensures common pricing across the transport network, removing price disadvantages that might exist under current arrangements.

iii. Physical Integration – Developing an integrated transport network demands that modes seamlessly connect, making journeys intuitive and 'pain free' for commuters. Examples of physical integration include interchange facilities that provide covered walkways, transport hubs, park-and-ride facilities and the integration of transport hubs and commercial precincts.

iv. Network Integration – Physical integration must be supported by a full integration of transport networks and modes. Examples might include bus services that are timetabled to connect to rail services, or a move to 'turn up and go' rather than timetabled frequency, ensuring that different transport modes complement each other as part of a whole network, rather than compete with one another.

v. Information Integration – To encourage commuters to travel across public transport modes, a much smarter approach to journey information is required. Electronic signage, easy to access smartphone apps and uniform, high grade signage across all modes ensures that journeys are intuitive and easy for commuters. Real time transit information, such as next service countdown timers are equally important to provide journey time certainty to commuters.

3. **Deliver a transport and project planning process that is free of modal bias, selecting the best mode to support broader network outcomes.**

   The integration of network planning and governance in a single agency allows transport planning to be modally agnostic when transport investment decisions are being made. Existing arrangements mean that rail authorities plan for rail projects, road agencies plan for road projects and so forth; institutional integration will allow for a robust assessment of all mode options within a corridor, allowing for 'best for network' investment decisions for new (or renewed) transport projects.

   Too often, transport planning can be driven in pursuit of a 'pet project' or a legacy. The integration of transport planning and project selection will allow transport planning to transcend political cycles and allow for a long-term approach that harnesses strong political will and political consensus about transport infrastructure project priorities.

   Robust transport planning will achieve stronger political and community support, but political will remains fundamental to the inception of major projects.

4. **Ensure the selection and prioritisation of transport projects in Metropolitan Corridor Plans are accompanied by a transparent assessment of alternative options.**

   The selection of a particular mode, such as rail, light rail or a busway, should be accompanied by a transparent assessment of why a particular mode has been chosen. This assessment should include a full and robust analysis of the benefits and costs of alternative modes. This level of accountability will help to ensure that public investments are directed to the highest value projects and underpin the credibility of transport infrastructure investment.

5. **Develop comprehensive transport planning tools to guide project selection in transport networks.**

   The fundamental overhaul of transport planning and mode selection recommended in this paper points to a requirement for further work to develop a suite of transport planning and mode prioritisation tools. These refined selection tools will allow for the kind of transparent and dispassionate modal assessments recommended in this paper.

INTRODUCTION

1 INTRODUCTION

1.1 Context

There has been a tendency for recent public transport planning studies, and the infrastructure planning debate in general, to be overly focused on mode specific projects e.g. rail, light rail, metro or busway, rather than undertaking an objective analysis of the benefits that might be offered by different modes across an individual corridor – and indeed, across an integrated, multimodal transport network.

A mode specific focus can have several negative consequences, including:

- A lack of thorough assessment of the strengths and weaknesses that different modes might offer in meeting the outcomes sought by a project;
- The focus on supporting an individual mode can become the primary driver of an individual project's implementation, rather than meeting specific mobility objectives;
- Without a firm basis for a modal decision, and a rational discussion about the relative modal merits, a project can be vulnerable to greater criticism from detractors.

Australia's National Guidelines on transport system appraisal recommend that governments undertake an options analysis including an 'options list' that *"encourages consideration of a full range of policy instruments"*[4]. This approach is designed to ensure the best outcomes emerge from transport planning.

Despite a range of advocacy positions, which suggest one transit mode is better than another, there is no evidence in research or practice that a specific mode or service solution is the best in every case. Rather, different patterns of modes and services can be adopted for particular conditions. Heavy rail, for example, is best suited to longer distance travel and larger volume or capacity of service – but heavy rail is also most effective when supported by efficient and integrated feeder services which broaden its catchment.

Transport planners face a difficult task in evaluating public transport modes, because of the variety of possible project solutions – and the complexities that arise from their deployment. For example:

- Service level and price features, including frequency and service spans act to increase the range of possible options in public transport service design;
- Modes can vary between street transit (bus or streetcar) to rapid transit using rail. For each, a range of service patterns (express, skip stop, all stop) and technology variants diversify the range of possible service offerings;
- Right of way can vary from on-street in mixed traffic to a fully controlled (signalised) guideway, each with varying impact on performance and cost. Designs often require a combination of rights of way, further compounding the complexity of evaluation;
- Added to this is the development of new public transport technologies which make for a wide and diverse range of possible solutions to corridor transport problems, all at varying investment cost.

4 Australian Transport Council (2006), National Guidelines for Transport System Management in Australia, 2nd edition, Volumes 1, Canberra, p.14.

1.2 Project Overview

In light of the issues outlined above, Infrastructure Partnerships Australia ("IPA") engaged Booz & Company to develop a policy discussion paper that puts forward the argument for outcome-based transport system planning. In support of this, the paper explores the benefits of including alternative transit modes in strategic transport corridor evaluation.

This document constitutes the final paper on the study.

1.2.1 Project Objectives

The overall aim of the research is to provide advice to planners and governments to encourage the objective evaluation of a range of public transport modes and services, particularly integrated multi-modal transport, rather than focusing on single mode or project-based evaluation. To achieve this, the research project has the following aims:

1. To explore the benefits of evaluating several modes rather than focusing on a single mode in public transport corridor evaluation;

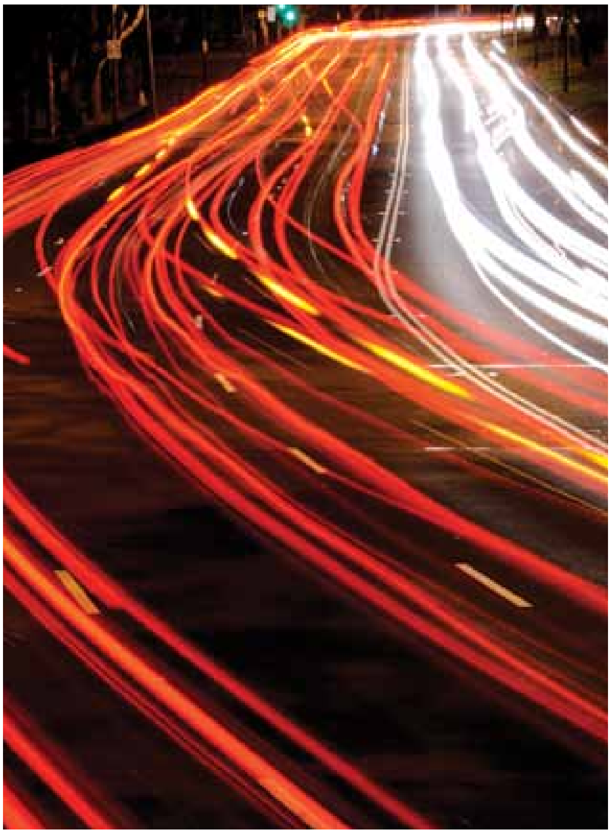
2. To identify appropriate roles and characteristics of alternative public transport modes so that they may be more appropriately deployed in the assessment of options for transport corridor analysis;

3. To understand the characteristics/dimensions, and hence the strengths and weaknesses of alternative transit modes, in terms of operational performance, user preferences and development impact, to better inform their deployment in network design;

4. To identify key features of an open, objective and defensible evaluation approach which considers alternative public transport mode design options in an unbiased manner; and

5. To promote the thorough evaluation of all modes by governments with a focus on outcomes, rather than individual projects.

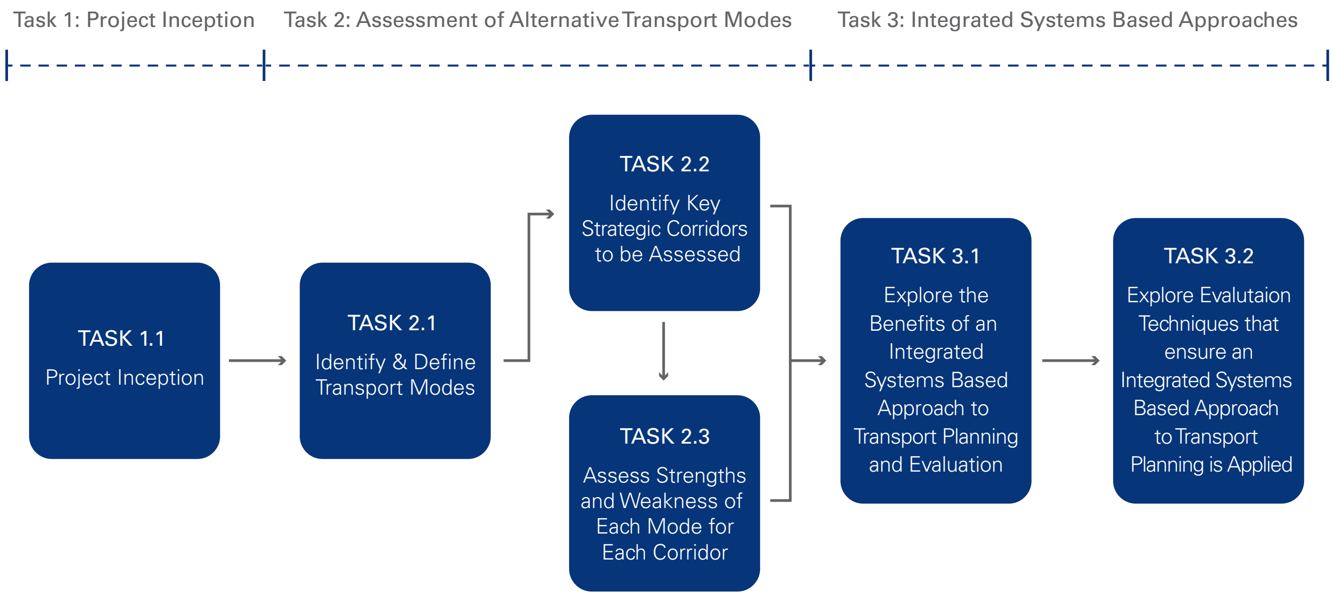
The study focuses on conventional transport modes, including bus, light rail, heavy rail, metro, ferry, walking, cycling and private vehicles. At this stage, we have not considered the monorail that operates in the Sydney CBD area, on the basis that it operates in a loop and plays only a boutique role in the transport network. At present, we have also excluded taxis and hire cars.



1.3 Project Methodology

Figure 1.1 outlines the approach undertaken to conduct this project.

FIGURE 1.1 Project Methodology



As highlighted above, the project comprises three key tasks:

- Task 1: Project inception;
- Task 2: Assessment of alternative transport modes; and
- Task 3: Integrated systems based approaches.

1.3.1. Task 1: Project Inception

Task 1.1 – An initial inception meeting was held with Infrastructure Partnerships Australia to discuss and confirm the project scope.

1.3.2. Task 2: Assessment of Alternative Transport Modes

Task 2.1 – This section provides an overview of each transport mode, outlining the key characteristics, strengths and weaknesses of each mode. This section also identifies best practice examples for each mode.

Task 2.2 – This section identifies a key strategic corridor in both Sydney and Melbourne, and assesses existing transport options. This section also considers factors including population density, existing transport services in each city, diversity of land use and socio-economic groups. The strategic transport corridors considered are:

- Sydney – CBD to Penrith
- Melbourne – CBD to Pakenham

Task 2.3 – This section compares each transport mode based on an assessment of generalised trip costs over a range of trip distances.

The concept of generalised trip costs aims to measure the utility (or usefulness) a passenger derives from the trip. The generalised trip costs are made up of two key components: the generalised journey time incurred by the passenger; and the monetary amount paid by the passenger (i.e. the fare or vehicle operating costs). The lower the generalised trip costs, the higher the utility, which provides the basis for modal decisions, i.e. a rational passenger is likely to choose a mode which minimises his/her overall generalised trip costs.

Specifically, the total generalised trip cost per passenger journey consists of the following components:

- the access time (to the mode);
- the waiting time (for the mode);
- the in-vehicle journey time (on the mode);
- the egress time (from the mode);
- the transfer penalty, measured as the nominal interchange time allowed between modes;
- the price of the effective fare (for public transport trips); and
- the vehicle operating costs (for private vehicles and bicycles).

The variables above are calculated for each mode in a multi-modal journey. The modelling is based on a typical notional trip, which assumes standard passenger responses. In the real world, the diversity and range of actual trips will vary in each corridor.

Appendix 1 contains a description of generalised trip cost calculations, including the constituent parts of the calculations and the assumptions for values of time and the standard weightings applied to non in-vehicle journey time.

1.3.3 Task 3: Integrated Systems Based Approaches

Task 3.1 – This section explores the characteristics and benefits of an integrated systems based approach to transport planning and evaluation; and

Task 3.2 – This section outlines the potential multi-modal evaluation techniques that are required to ensure the most effective transport mode or modes are developed.

1.4 Structure of the Report

The remainder of the report is structured as follows:

- Chapter 2 describes the roles and characteristics of each transport mode and presents examples where each mode has been successfully implemented;
- Chapter 3 describes the need for an integrated transport network and explores how this could be delivered through the integrated operation of different modes;
- Chapter 4 compares the relative trip costs of each mode with particular reference to a number of key strategic corridors within Australia;
- Chapter 5 examines the case for integrated and multi-modal project evaluation in appraisal guidelines;
- Chapter 6 outlines the conclusions emerging from our analysis and research; and
- Chapter 7 provides the list of references consulted in this paper.

Appendix 1 describes our corridor assessment methodology and Appendix 2 provides the detailed results of the corridor assessment from the user's perspective.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EXPLORING THE ROLES AND CHARACTERISTICS OF ALTERNATIVE TRANSPORT MODES

2 EXPLORING THE ROLES AND CHARACTERISTICS OF ALTERNATIVE TRANSPORT MODES

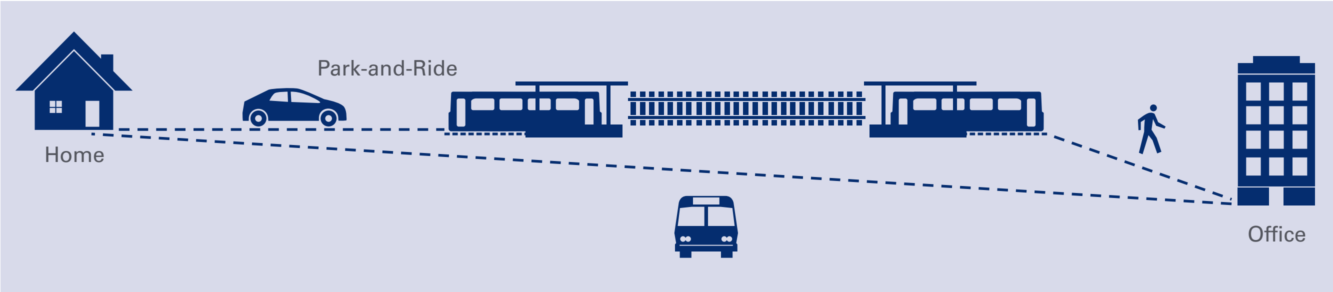
2.1 Introduction

Different transport modes have different characteristics in terms of accessibility, speed, frequency, fares, capacity and the like. This chapter explores the roles and characteristics of a range of transport modes that could potentially exist along a corridor and presents examples where each mode has been successfully implemented.

2.2 Transport Corridors

As outlined in the Australian Transport Council ("ATC")[5] National Guidelines for Transport System Management in Australia (The National Guidelines), a corridor comprises the parallel/competing modal routes between two locations. Within a transport corridor, many alternative transport modes may exist. A corridor is multi-modal when more than one mode operates. Figure 2.1 illustrates a conceptual example of a multi-modal transport corridor.

FIGURE 2.1 Example of a Multi-modal Transport Corridor



The characteristics that define a strategic transport corridor include:

- A corridor of substantial length, circa 30-50 kilometres, covering a variety of land uses;
- A corridor which provides connections to, from and between cities or regional centres;
- Corridors which service areas of projected high population growth;
- Corridors which carry a high volume of passengers;
- Corridors which are experiencing a sustained growth in transport demand;
- Corridors which support major freight movements; and/or
- Corridors which make a substantial contribution to economic growth and development.

5 In February 2011, the Council of Australian Governments (COAG) agreed to a new Council System consisting of Standing Councils, Select Councils, and Legislative and Governance Fora. On 17 September 2011, COAG withdrew the remit of the Australian Transport Council and replaced it with the Standing Council on Transport and Infrastructure (SCOTI). The inaugural meeting of the Standing Council was held on Friday, 4 November 2011.

2.3 Transport Modes Roles and Characteristics

Each transport mode has different characteristics and plays a different role in meeting the various requirements along and within a corridor. Table 2–1 summarises the fundamental characteristics of the transport modes analysed in this paper.

TABLE 2–1 Characteristics of Transport Modes

Modes	Motorised	Public or Private	Role/ Suitability of Use	Typical Capacity	Constraints
Walking	• No	• Private	• Access Journey • Egress Journey • Main Journey	• 1 user	• Limited distance and carrying capacity • Difficult or unsafe in some areas
Cycling	• No	• Private	• Access Journey • Egress Journey • Main Journey	• Mostly 1 but 2 or 3 users are possible[1]	• Limited distance and carrying capacity • Operating costs
Bus	• Yes	• Public	• Main Journey • Access Journey • Egress Journey • To feed main line routes	• Approximately up to 6,000 pph*	• Poor reliability due to congestion • Low speed
BRT	• Yes	• Public	• Main Journey	• Approximately 6,000 to 11,000 pph* (operating in a segregated right of way) • Curitiba BRT – 15,000 pphpd (average speeds just over 20 kph in a single traffic lane)** • Bogatá BRT (i.e.TransMilenio) – 35,000 pphpd (and average speeds of 29 kph)**	• Road space (i.e. requires a clear corridor) • Often compared unfavourably against light rail • Infrastructure costs required • Safety issues for pedestrians and cyclists • Security (e.g. vandalism)
Heavy Rail/Metro	• Yes	• Public	• Main Journey	• 12,600 to 17,100pph[2]	• High cost per passenger kilometre • Limited walkable catchment
Light Rail	• Yes	• Public	• Main Journey	• Approximately up to 6,000 pph*	• Limited speed • Lower reliability due to on-street running (if not grade separated) • High cost of implementation
Ferry	• Yes	• Public	• Main Journey	• Generally, low capacity, depending on the overall size of the fleet[3]	• Limited speed • Easily affected by adverse weather conditions and maritime conditions • Expensive fares
Private Vehicle (Car)	• Yes	• Private	• Main Journey • Access Journey • Egress Journey	• Generally, 1 to 4 people[4]	• Congestion • Parking • Operating costs

** Source: TRB (2003),Transit Capacity and Quality of Service – Manual, (2nd edition), TCRP Report 100, October.*
*** Source: Hook, W. (2009), Bus Rapid Transit – A Cost-Effective Mass Transit Technology,em- Air & Waste Management Association, June, p.27. Notes: (1) If it is tandem bicycle or a bicycle with child seats; (2) TfNSW, "Rail Options for Sydney Greater Metropolitan Area" 'November 2011, P9; (3) However, the capacity of the ferries network (i.e. Sydney Harbour) is high. TfNSW, "Rail Options for Sydney Greater Metropolitan Area"' November; (4) More in station wagons or people movers 2011, P9.*

2.3.1 Public Transport Modes

Each public transport mode is characterised by different features. The following section provides an overview of each of the public transport modes analysed:

(a) Bus

Buses are a flexible transport mode that can be adapted to changing travel patterns. Buses can be used to cover the main journey as well as the access and egress trips (feeder trips into another mode, such as rail and BRT systems). Thanks to its relative cost-effectiveness, this mode can serve both high and low density areas collecting and delivering people closer to their homes and destinations compared to other public transport modes[6]. The distance between bus stops is usually of 0.25 to 0.5 kilometres[7], which translates in a higher walkable catchment than rail. "Buses, especially those enjoying priority systems like dedicated busways or high-occupancy vehicle lanes, are capable of moving comparable volumes at less cost than rail,"[8] as demonstrated, for instance, by Bus Rapid Transit systems (BRT systems) (see next section).

From a socio-economic aspect, bus users benefit generally from lower fares. In practice, the majority of people using buses belong to lower income groups, compared to users of other public transport modes, particularly heavy rail.

(b) Bus Rapid Transit (BRT)

Bus Rapid Transit (BRT) is "a flexible, high performance rapid transit mode that combines a variety of physical, operating and system elements into a permanently integrated system with a quality image and unique identity"[9]. Latin America provides some of the strongest examples of BRT usage, with "speed, capacity, and quality of service [that] rival all but the best metro and light rail systems"[10].

The world's first BRT in Curitiba (Brazil), was opened in 1974, and is regarded as one of the best in the world. The Curitiba BRT features the following characteristics[11]:

- Physically segregated exclusive bus lanes, which allow higher travel time savings and reliability compared to local bus routes;
- Large, comfortable articulated or bi-articulated buses;
- Fully enclosed bus stops that feel like a metro station, where passengers pay to enter the BRT station through a turnstile rather than paying the bus driver;
- A bus station platform level with the bus floor;
- Free and convenient transfer between lines at enclosed transfer stations;
- Bus priority at intersections, largely by restricting left hand turns by mixed traffic vehicles; and
- Private bus operators paid by the kilometre.

The popularity of BRT in Latin America is probably due to the fact that "BRT systems are less expensive to build and can be implemented much faster [than modes such as light and heavy rail]"[12].

In Australia, Brisbane leads the way with the most extensive and segregated BRT network, although other cities such as Sydney (with the T-Ways) and Adelaide (with the O-Bahn) also have limited BRT systems.

6 Industry Commission (1994), Urban Transport - Volume 1: Report, Australian Government Publishing Service, Melbourne, p.340.
7 Jenkins, M. (2008), Attributes of a Metro. [shown at RTSA: METROS – Future Rail for Sydney] [viewed in 2008].
8 Industry Commission (1994), Urban Transport - Volume 1: Report, Australian Government Publishing Service, Melbourne, p.340.
9 Levinson at al., Bus Rapid Transit – Implementation Guidelines, TCRP Report 90-Volume II, cited in FTA and US DOT (prepared by Booz Allen Hamilton) (2004), Characteristics of Bus Rapid Transit for Decision-Making, August, p.1-1.
10 Hook, W. (2009), Bus Rapid Transit – A Cost-Effective Mass Transit Technology, em- Air & Waste Management Association, June, p.27.
11 Ibid.
12 Ibid.

(c) Heavy Rail and Metro

Heavy rail often forms the backbone of the transport system in major cities[13]. This 'heavy lifter' of the transport modes is particularly successful in moving large numbers of people efficiently. However, it is not suitable as a mobility solution for the penetration of all local streets in low-density suburban residential areas where buses have a more logical role. As presented in Currie (2009)[14], when compared to on-street bus services, rail is usually the preferred travel mode for a number of reasons. These factors include:

- The relative simplicity of network;
- The relatively faster travel speed of rail;
- The relatively higher reliability of the journey into the city centres due to its separation from on-street traffic, hence avoiding surface congestion; and
- The volume of amenities offered at stations and the relative ease for passengers to locate stations and understand network design.

The frequency of stops along rail lines can range from 3 to 15 kilometres[15], which means a smaller walkable catchment is available (compared to other modes). As a relatively capital intensive mode, heavy rail is particularly well-suited to serve high-density areas. Therefore, the modern day urban sprawl creates an obstacle to the introduction of fixed-route systems because low-density areas spread outward and ultimately undermine the economies of scale which suit heavy rail.

Metropolitan railways ("metros") share common traits with the heavy rail system. For instance, they are high capacity people movers, which are segregated, electrically powered and service urban areas[16]. The main distinction between the two systems is that a metro service provides a higher service frequency based on a "turn up and go" schedule, and that the distance between stops is approximately 1 to 2 kilometres[17].

Rail infrastructure typically has considerably higher capital expenditure costs than other modes. The National Guidelines estimate heavy rail construction costs to be around 5 times higher than light rail construction costs and around 10 times higher than dedicated bus lane construction costs[18].

d) Tram and Light Rail

Light rail is best suited to inner city areas because the distance between stops are as short as 0.75 to 1.5 kilometres[19].

Legacy light rail systems tend to have an in-street alignment (e.g. Melbourne's trams) sharing the street space with individual transport such as cars, bikes and pedestrians. Newer systems tend to run on a grade separated tracks alignment (e.g. Sydney light rail for most sections).[20] Even though conflicts between LRT, cars, bikes and pedestrians can be overcome, the performance of mixed traffic services is often impeded and can result in reduced performance and reliability of both the LRT and the other modes.

Many have argued that light rail is the most desirable way of restructuring our cities. However, others have argued, "'rail-based' transport is an unnecessarily expensive mode to complement more intensive development and that busways could achieve a similar result for a significantly lower cost"[21]. Light rail is also regarded as a comparatively environmentally friendly transport mode as it runs on electricity.

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13 Glazebrook, G. (2009), Designing a Thirty Year Public Transport Plan for Sydney – Attachments, p.10. Retrieved 21 December 2010 from: http://www.dab.uts.edu.au/research/outcomes/garry-glazebrook-attach.pdf
14 Currie, G. (2009), Research Perspectives on the Merits of Light Rail vs Bus, [shown at BITRE Colloquium 18-19 June 2009].
15 Jenkins, M. (2008), Attributes of a Metro [shown at RTSA: METROS – Future Rail for Sydney] [viewed in 2008].
16 Ibid.
17 Ibid.
18 Australian Transport Council (2006), National Guidelines for Transport System Management in Australia, 2nd edition, Volumes 4, Canberra, p.43.
19 Jenkins, M. (2008), Attributes of a Metro [shown at RTSA: METROS – Future Rail for Sydney] [viewed in 2008].
20 UITP (2009), Light Rail Transit – A Safe Means of Transport, Core Brief, p.1.
21 Hensher and Waters (1993) cited in Industry Commission (1994), Urban Transport – Volume 1: Report, Australian Government Publishing Service, Melbourne, p.332.

© Courtesy of Roads and Maritime Services/Ethan Rohloff Photography

(e) Ferry

Even in Sydney, where ferries transport 14.5 million passengers a year, the majority of trips made by ferry are for leisure[22]. Ferries best serve areas close to the city due to their lower speed. They are a reliable mode in that they are not affected by road traffic and congestion. Adverse weather conditions may affect services for limited periods.

22 Sydney Ferries, Annual Report 2010-11.

2.3.2 Private Transport Modes

Walking and cycling are categorised as active transport. An overview of each of these modes is provided below.

(a) Walking

The majority of access and egress trips to other modes are made by walking. This mode does not require significant provision of infrastructure, compared to other modes, and represents a critical link between land-uses and other transport modes. As Allan (2001) observes, distances up to 2km (approximately 20 minutes) can be reasonably covered by walking and may even be competitive with public transport[23].

"The typical walking gait of a normal healthy adult would be about 6km/h (i.e. 1.67m/s) … however, as fatigue sets in, a walker's speed for a person of average fitness would decrease. Also, adverse weather conditions, such as heat or rain, and the effects of carrying luggage (such as shopping, gym bags and laptops) may compromise walking performance. Hence, a walker may be able to maintain a steady 6km/h walking gait for only 20 minutes, but over 30 minutes this average may decline to 5km/h and over an hour, drop to 4km/h"[24]. For planning purposes, it is conventional to adopt an average walking speed of 4kph as a modeling assumption.

(b) Cycling

Cycling, like walking, is an environmentally friendly mode that can offer significant health benefits. However, a lack of comfort and the inconvenience of cycling, compared to other modes, deter greater use of this mode. In addition, the high number of bicycle accidents and the risk of bicycle theft[25] are also factors which could be addressed to improve cyclists' safety and security. Indeed, "the average Australian adult bicycle travels only about 12km per week. As a result, its overall operating cost per kilometre is comparable to that of a small car"[26].

Modal integration between cycling and public transport, for instance, by offering bike facilities at interchanges (e.g. showers, bike storage), may serve to increase attractiveness of this mode.

(c) Private Vehicle (car)

Since its invention, no other mode has influenced economic development and growth as much as the motor car. It quickly became an integral part of the movement of people and personal goods. Apart from its actual size and the operation of parking restraints, the motor vehicle offers the drivers and other passengers virtually unlimited flexibility and freedom, and avoids the need to plan for and await public transport, and hence waiting and interchange time.

However, urban congestion is having an increasing impact on the utility of private vehicles in major cities. The NSW Auditor-General's 2011 report on the performance of transport found that, over the preceding 12 months, the average peak speed fell on six out of seven major commuter routes - including the M4/ Parramatta Road corridor which saw average AM peak speeds decline from 28 km/h in 2010 to 25km/h in 2011.[27]

(d) Motorcycles and Scooters

While the use of motorcycles and scooters has been growing rapidly in Australia at around 6.8% per annum, the mode still only makes up less than 1% of all journeys to work in Sydney based on Census data in 2006 (City of Sydney, 2008)[28]. The popularity of motorcycles and scooters has increased with the worsening road congestion in Sydney and this is expected to increase as the vehicle kilometres travelled (VKT) for the motorcycle fleet grew at an annual average of 2.8% per annum, compared to the 1.8% per annum for cars and light commercial vehicles.

However, given its very small mode share, it is common to exclude motorcycles and scooters or to include them in private cars in conventional demand forecasting methods and analysis. On the basis that the daily number of vehicle trips per day was estimated to be around 574 on Census day in 2006 for the motorcycle fleet, we have not included this mode in the generalised trip cost analysis for the purposes of this discussion paper, although it should be recognised that its growing popularity means that future multi-modal network models may need to consider this mode for commuter trips to and from the CBD.

23 Allan, A. (2001), Walking as a Local Transport Modal Choice in Adelaide, Australia: Walking the 21st Century – 20th to 22nd February 2001 - Perth, Western Australia, pp.124-125.

24 Ibid.

25 Industry Commission (1994), Urban Transport - Volume 1: Report, Australian Government Publishing Service, Melbourne, p.425-428.

26 Arundell, L. (2007), The Cost of Cycling, Thinking on Two Wheels Cycling Conferences, p.1.

27 NSW Auditor General, Financial Audit Volume Eight 2011: Focusing on Transport and Ports.

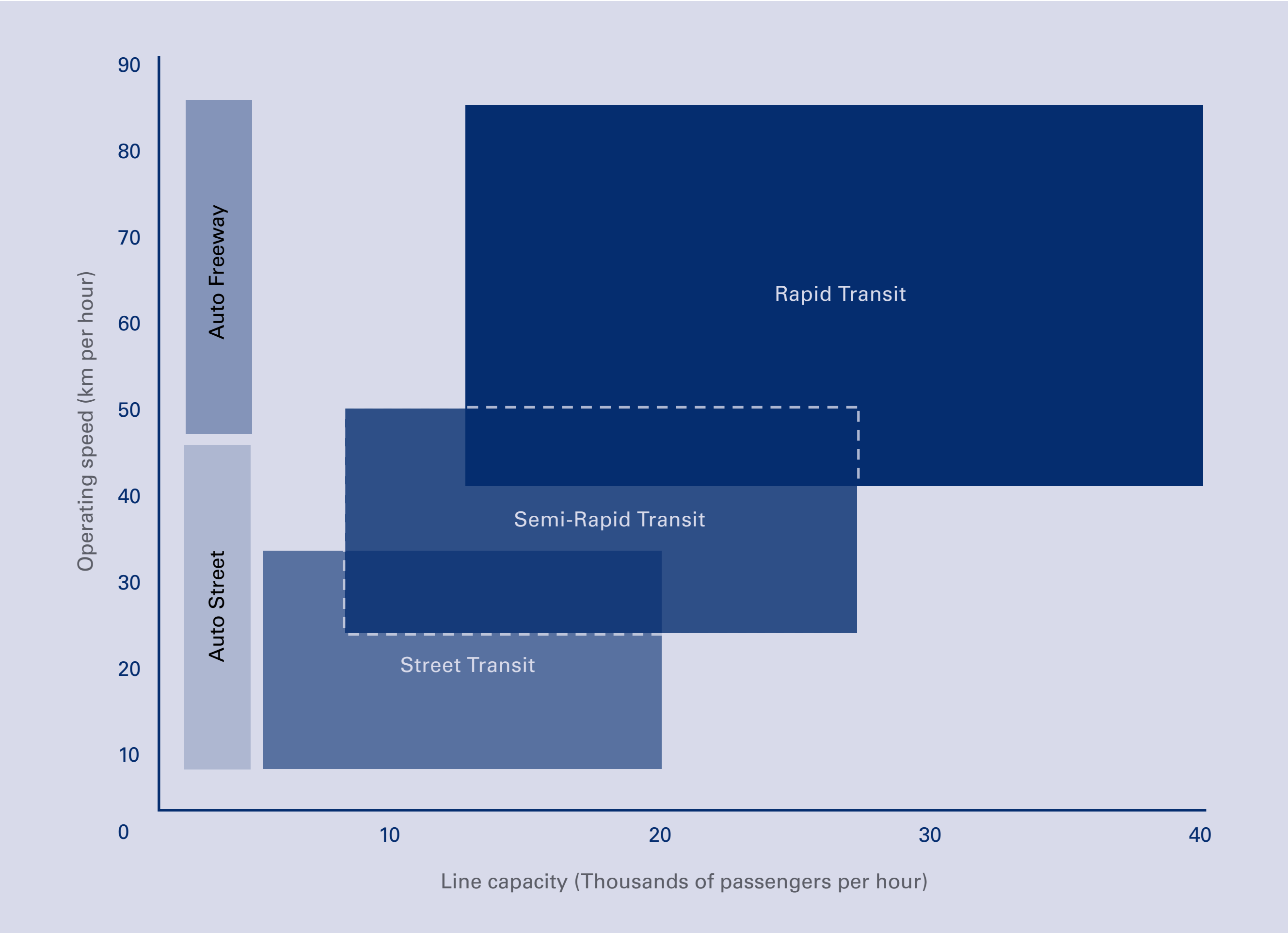
28 City of Sydney Council (Transport Strategy Unit) (2008), Motorcycle and Scooter Strategy and Action Plan 2008 - 2011, June, p.2.

2.3.3 Operating Speeds of Modes

Figure 2.2 illustrates the typical relationship between operating speeds and total line capacity.

The below figure illustrates that, in most instances, higher operating speeds allow rapid transit modes (such as heavy rail trains and metros) to carry more passengers through the system as the higher speeds typically increase network capacity.

FIGURE 2.2 Operating Speeds v. Line Capacity

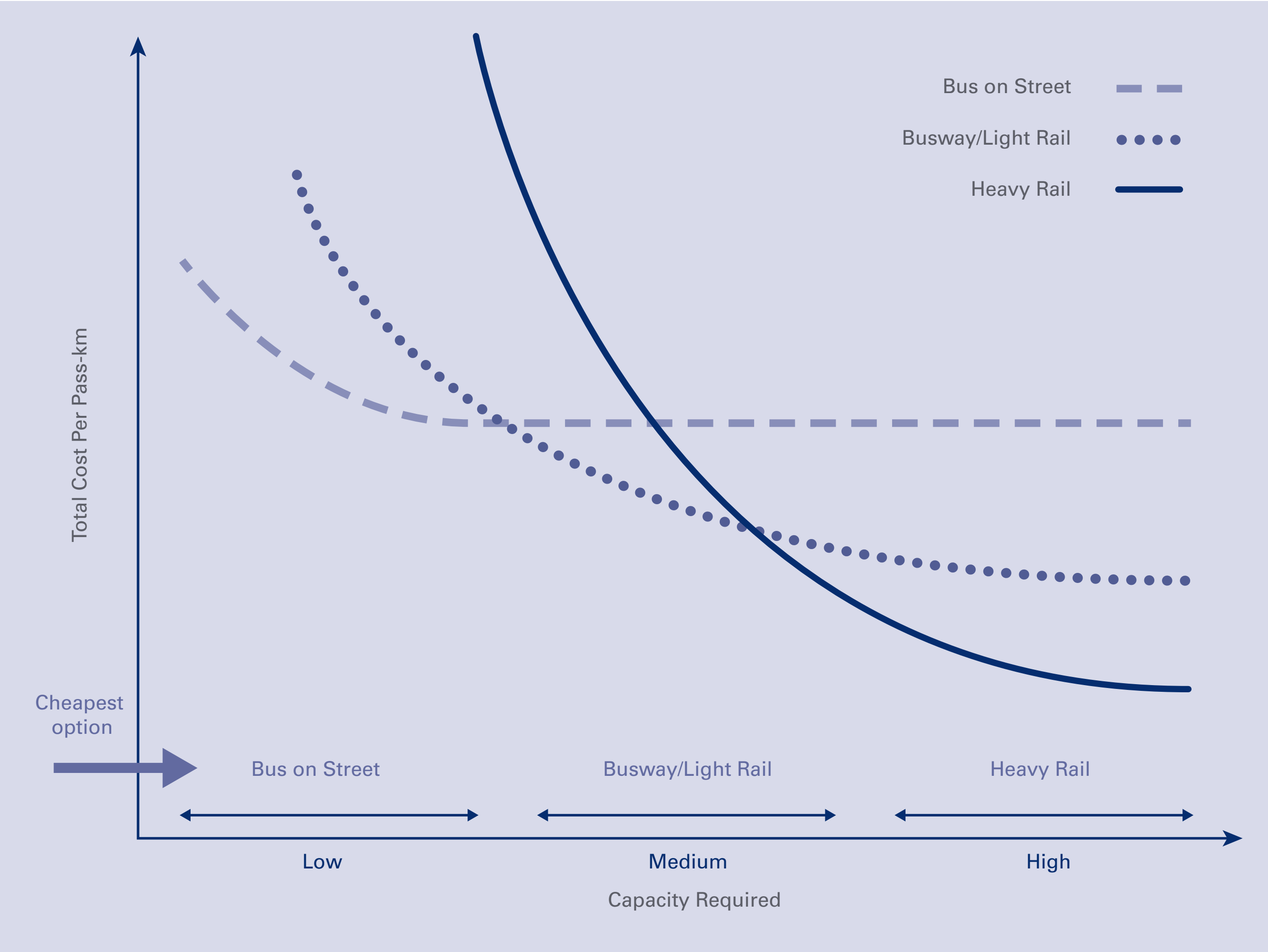


Source: Adapted from Vuchic, V. (1981), as presented in Jenkins (2008), Attributes of a Metro.

2.3.4 Cost-effectiveness of Modes

For governments and operators, cost-effectiveness is one of the critical differentiators between modes that, in turn, influence their viability. Figure 2.3 shows the typical cost-effectiveness of operating mass transport modes with regard to capacity.

FIGURE 2.3 Cost-effectiveness of the Main Mass Transit Modes



Source: Adapted from Glazebrook, G. (2009), Designing a Thirty Year Public Transport Plan for Sydney, p.32.

The above figure suggests that heavy rail/metro generally have the lowest operating cost per passenger kilometre when moving a large number of people, busway/light rail are the cheapest mode for a medium level of capacity, and on-street bus is the most cost-effective mode in locations where there are low capacity requirements (e.g. local suburbs and villages).

It should also be noted that, although not present in Figure 2.3 , a similar comparison could be made with respect to the viability of private and active transport modes (i.e. car, bicycle, walking).

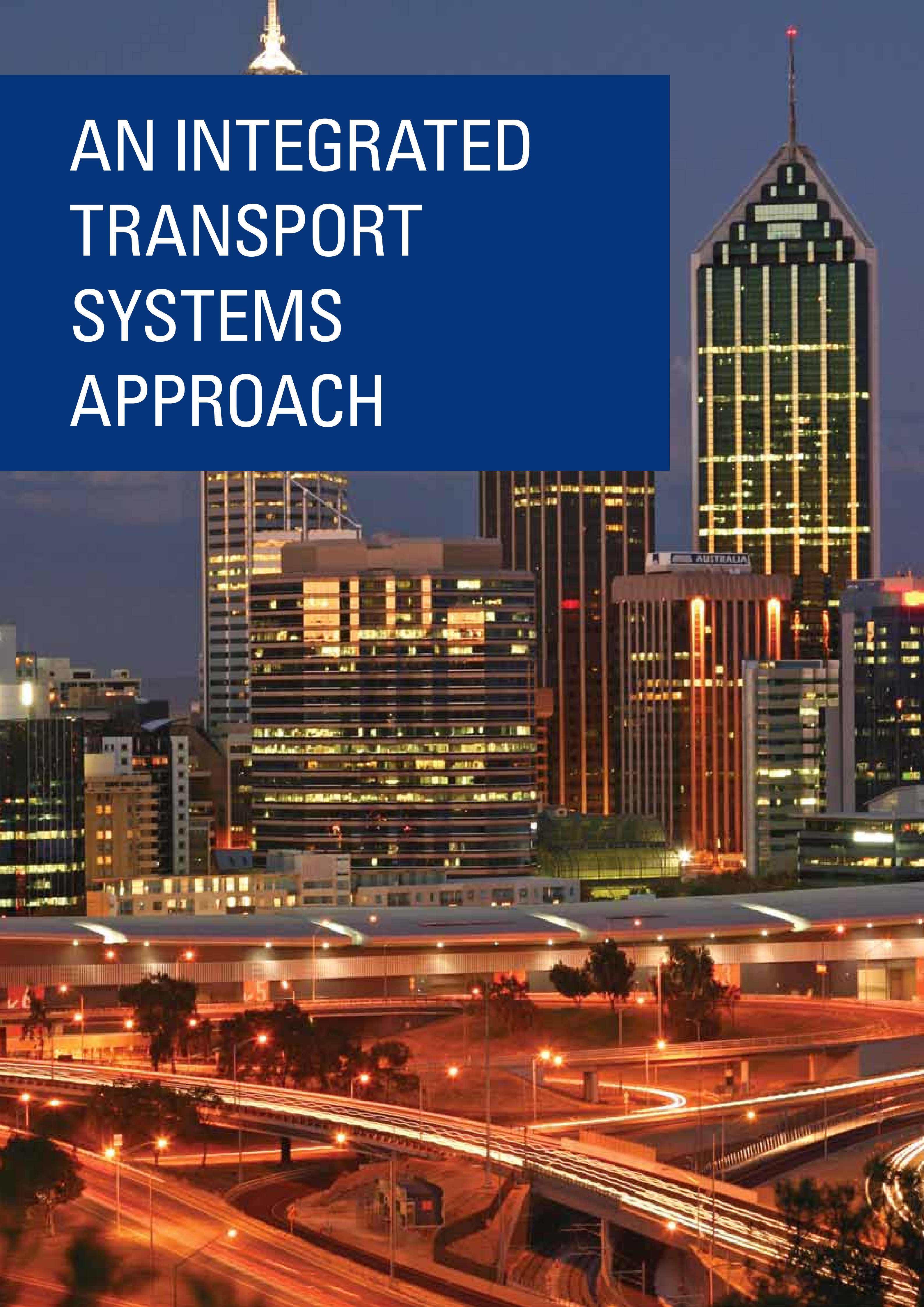
2.3.5 Connection Between Land Use Patterns and Transit Modes

There is a direct two-way relationship between land use patterns and transport demand. The character of an area; the level of density and the mix of residential, commercial and industrial properties, will influence the amount and type of transit journeys to and from a location. In turn, the level of access and convenience provided by a transport service has an impact on the demand for and use of land surrounding the transport service.

Beyond the broad impact of transport on land use patterns, individual transit modes can have specific land use implications for an area. For example, public transit modes that require the provision of fixed infrastructure such as heavy rail, light rail and grade separated bus rapid transit, are likely to encourage increased density and particular types of land use in an area. Public transport which does not require fixed infrastructure – such as buses and ferries – are likely to induce (or service) different land use outcomes. For example, buses and ferries may not create a market demand for higher densities as it is much more difficult and costly for providers to remove a rail service than it is to redirect a bus route; meaning investors and developers have more confidence that public transport will be provided over the long term on the same configuration where a significant investment has been made in fixed infrastructure.

The causal relationship between land use patterns and different transit modes is not fixed, other factors such as the character of the location, the quality of the transport service and the regulatory and policy framework of government, will alter how one influences the other.

AN INTEGRATED TRANSPORT SYSTEMS APPROACH



3 AN INTEGRATED TRANSPORT SYSTEMS APPROACH

3.1 Introduction

To meet the differing transport needs and requirements that are present in a transport corridor, a range of transport modes may be required. This chapter considers the elements that define an integrated transport network and explores how this could be delivered through the integrated operation of different modes. In this chapter, we also consider current examples of international best practice for integrated multi-modal transport.

3.2 Integrated Multi-modal Transport Network

The transport system is made up of a network of interconnected infrastructure and/or services. As such, no one mode can operate in isolation if it is to play a role in an integrated network. A combination of modes and complementary services is typically required as each mode is suitable for different journey types.

It has been argued that "combining private and public transport in a truly multi-modal system offers opportunities to capitalise on the strengths of the various systems while avoiding their weaknesses"[29]. Similarly, Glazebrook[30] defines:

"The task for transport and land use planners is to develop an overall strategy using the best mode for each particular role rather than ruling out any mode or assuming all problems can be handled by a single solution."

In addition, the recent development of multi-modal transport appraisal guidelines both in Australia and overseas[31] illustrates the increasing awareness of the need for multi-modal transport solutions. Multi-modal project evaluation is further explored in Chapter 5.

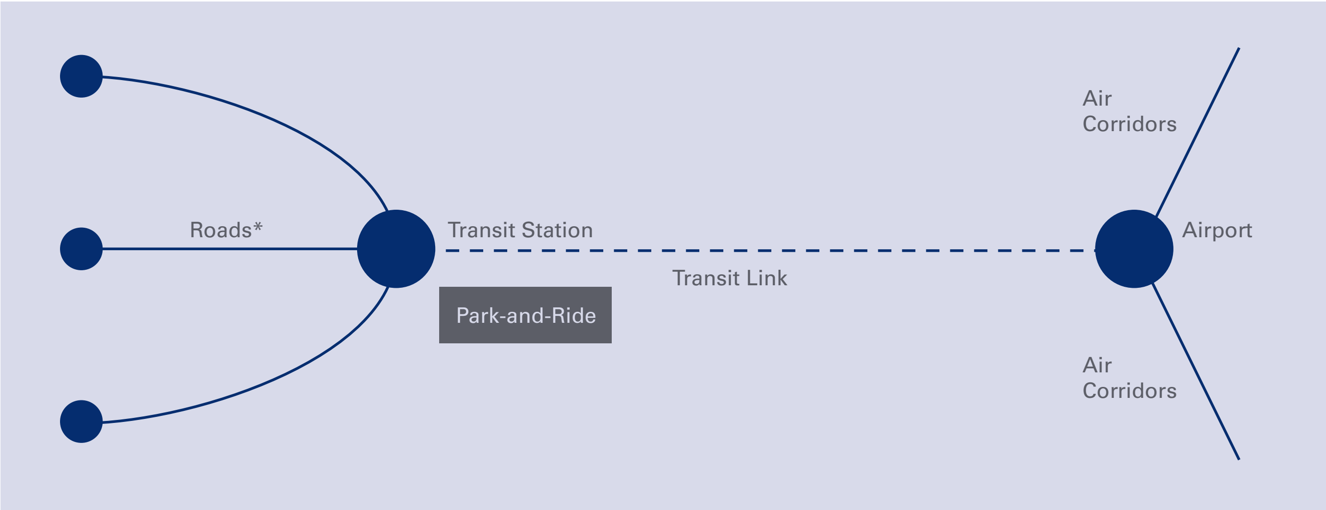
A transport network is constituted by a combination of links and nodes. Links typically represent highways, rail lines, air corridors, etc., while nodes, which generally represent physical places such as terminals, stations, parking lots, function as the connection between the various links of a network.

29 Van Nes, R. (2002), Design of Multi-modal Transport Networks – A Hierarchical Approach, TRAIL –Thesis Series T2002/5, DUP Science, The Netherlands, p.vii.

30 Glazebrook, G. (2009), Designing a Thirty Year Public Transport Plan for Sydney. Retrieved 21 December 2010 from: http://www.dab.uts.edu.au/research/outcomes/garry-glazebrook-main.pdf, p.32.

31 Examples include the Australian Transport Council National Guidelines and the UK Department for Transport's (DfT) "Transport Analysis Guidance".

FIGURE 3.1 An Example of an Integrated Multi-modal Network



Source: Reproduction of Intermodal Network as presented in Sussman (2000), Introduction to Transportation Systems, p.52.
*Note: *used by cars, buses, taxis*

Figure 3.1 shows an example of the interconnection between links and nodes which work together to form a multi-modal transport network.

Within Australia, the development of integrated transport networks range from emerging to relatively mature and the promotion of integrated transport has been encouraged by various bodies at different times. Most recently, the National Guidelines[32] presented and recommended a framework for project evaluation that considers the full range of potential solutions or options, moving beyond the narrow focus on infrastructure and single-mode solutions.

In practice, the success of transport integration typically depends on a range of integration characteristics or measures, including[33]:

- Physical Integration – "the close proximity and ease of access at mode interchanges will greatly enhance public transport services. Walkways should be carefully designed for passengers to change mode. Passengers should be within a short walking distance from their residences to a transit stop". Cities like Hong Kong and Singapore have been able to build mass transit stops in the heart of neighbourhoods, thereby providing close proximity to residences, offices and retail outlets.
- Network Integration – "bus and rail systems should be an integrated network in their own right and these separate networks should further complement one another. Feeder services using buses, trams or light rail should be designed to maximise the patronage of the trunk routes. Network integration is closely linked to physical integration and both contribute towards the integration of infrastructure". For instance, it is relatively easy to change between different lines on the London Underground (tube) network as tube stations have been designed with a number of interchange points between tube lines. Cities such as Hong Kong, Singapore and Kuala Lumpur have been able to redesign bus routes so that they feed into, and support the mass transit/metro lines. Similarly, London's underground and buses connect with the above ground heavy rail network to take passengers to their final destinations. An essential part of network integration involves timetabling services so that intramodal and intermodal services connect efficiently and effectively.

32 Australian Transport Council (2006), National Guidelines for Transport System Management in Australia, 2nd edition, Volumes 1, Canberra, p.14.
33 Luk and Olszewski 2001; Luk and Yang 2001; Konopatzki 2002, cited in Luk, J. and Olszewski, P. (2003), Integrated Public Transport in Singapore and Hong Kong, Road and Transport Research.

- Fare Integration – "a single fare card for multiple transit services will facilitate the transfer between modes. Rebates can be implemented as an inducement for those who transfer from one mode to another", e.g. zonal rebates in Vancouver. Whilst electronic ticketing is not a prerequisite for integrated ticketing, it does provide a very powerful mechanism to efficiently and effectively operate an integrated fares structure, for example, Hong Kong, Singapore and London all have a smart card system in place which has underpinned the increase of public transport usage. For example, public transport in Hong Kong accounts for approximately 85 per cent of all main mode trips respectively. In London, journey stages by public transport modes (defined as bus, tram, Underground, DLR, rail, taxis and private hire vehicles) increased in share from 30 per cent in 1993 to 34 per cent by 2000, and to 41 per cent by 2008 and 2009. The 7 per cent increase in the share of public transport usage between 2000 and 2009 is equivalent to a 5 per cent increase in trip based mode share for public transport in London[34]. While other factors have driven patronage growth in these examples, fare integration has underpinned and supported integration in the networks. Recent examples of fare integration in Australia are represented by the introduction of the Go Card in Brisbane, the MyMulti card in Sydney, the Myki card in Melbourne and the Metroticket in Adelaide.

- Information Integration – "a comprehensive, easy-to-use passenger travel guide is critical to successful multi-modal travel. The signage at rail and bus stations should be properly designed to convey effective information to travellers. Information Technologies (IT) and Intelligent Transport Systems (ITS) can play important roles in integrated transport in general and information integration in general"; for example, at the major railway stations in Japan, they have very clear signs differentiating directions to the high speed rail network, the intercity trains network and the suburban/local trains network. In addition, websites provide public transport users with information on the multi-modal transport options available and the related details.

- Institutional Integration – "a common institutional framework is better able to undertake land-use planning, travel demand management and integrated public transport services. In the absence of such common framework, cooperation and coordination amongst government agencies, and between the private and public sectors, become vitally important"; the evidence suggests that fewer layers of government are conducive to providing integrated multi-modal transport, e.g. the city states of Hong Kong and Singapore.

Interestingly, in NSW, there has been a recent integration of transport agencies (including RailCorp, Sydney Ferries and the RMS) to create a superagency, *Transport for NSW*, which is responsible for transport co-ordination, policy and planning for all modes including rail, bus, ferry, taxi services and related infrastructure, while line agencies focus on service delivery. Both Victoria and Queensland have established institutional integration which encompasses transport network planning across modes. In Victoria franchised public transport service providers have a contractual relationship with the Victorian Department of Transport which retains control over whole-of-system planning for public transport.[35] In Brisbane public transport, including buses, trains and ferry services, are delivered by the public sector under the single brand – TransLink – with the Department of Transport and Main Roads retaining responsibility for transport network planning and strategy.

34 Transport for London (2010), Travel in London, Report 3, p.44, Table 2.4.

35 In 2011 the Victorian Government established the Public Transport Development Authority (PTDA) as an independent statutory authority to integrate a number of public transport agencies and authorities. It will administer trains, trams and buses and be the primary liaison point with franchisees and agencies.

3.3 Complementary Transport Services

3.3.1 Direct v. Feeder Services

Direct and feeder services characterise the kind of services that can be provided along a transport corridor. On some short journeys, the forced need to transfer represents a substantial disincentive to use public transport[36] particularly when there is no fare integration. Therefore, direct services are often the preferred option by commuters, as they do not require additional transfer time. For longer journeys, the best solution for the user depends on a number of factors (e.g. cost or time savings, punctuality and reliability of different alternatives)[37]. Feeder services, which entail the use of bus, tram or light rail as feeders to fixed rail systems could well serve the needs of passengers that need to cover medium to long distances. However, users of this kind of service often incur significant transfer penalties, due to the lack of physical and network integration (in particular, the lack of connectivity in timetables).

The transfer penalty that a commuter would incur when interchanging modes, and which would add to the generalised cost of the trip (i.e. extra travel time and/or travel costs where the fares flagfall is effectively charged twice), represents one of the main disadvantages between taking multi-modal and single mode trips. Thus, it has been argued that "the disutility of a transfer should be compensated for by the characteristics of [the] main transport service used. [For instance], the speed or the costs of [the] transport service [should] compensate for the delay and inconvenience of the transfer"[38].

The weight of transfer penalties could also be minimised through the physical integration of networks of different modes and the creation of interchanges which permit seamless transfers, and the fares integration where a second journey does not incur the fares flagfall.

Various studies have highlighted bus passengers' preference for direct services, as they have a strong resistance to transfer due to the extra time and inconvenience of changing modes or sectors during their journey. Hence, forced transfers often result in passengers switching to the car instead of travelling by public transport[39], even though the overall generalised trip costs might be lower by a multi-modal trip as illustrated in Figure 3.2.

Figure 3.2 compares the hypothetical time/costs of a multi-modal trip over different distances, compared to a single mode trip.

This type of service is supported by the claim that "a direct bus solution is cheaper and more flexible to operate than a combination of local feeder bus and a rail service to the regional centre"[40]. It has been argued that too many buses travelling to the CBD create congestion, and hence the bus journey would be slower and less comfortable than the alternative train journey[41].

36 Nielsen, G. and Lange, T. (nd), Network Design for Public Transport Success – Theory and Examples. Retrieved 21 December 2010, from: http://www.thredbo-conference-series.org/downloads/thredbo10_papers/thredbo10-themeE-Nielsen-Lange.pdf

37 Ibid.

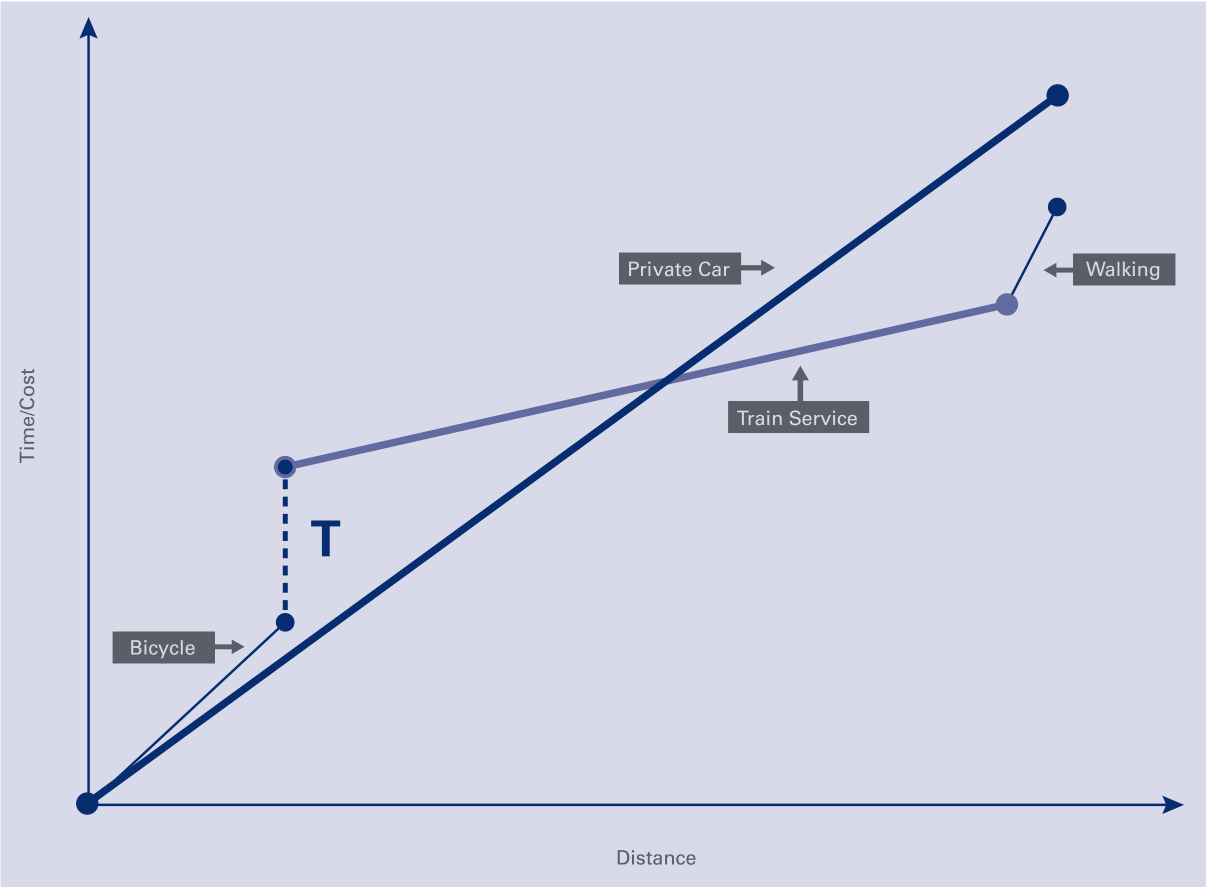
38 Van Nes, R. (2002), Design of Multi-modal Transport Networks – A Hierarchical Approach, TRAIL – Thesis Series T2002/5, DUP Science, The Netherlands, p.12 & 30.

39 Nielsen, G. and Lange, T. (nd), Network Design for Public Transport Success – Theory and Examples. Retrieved 21 December 2010, from: http://www.thredbo-conference-series.org/downloads/thredbo10_papers/thredbo10-themeE-Nielsen-Lange.pdf

40 Ibid.

41 Ibid.

FIGURE 3.2 Time/Cost-Distance Diagram of a Unimodal and a Multi-modal Trip



Source: Adapted from Van Nes (2002), Design of Multi-modal Transport Networks – A Hierarchical Approach, p.12.

Notably, it has been argued that "feeder services create a more integrated network with better local travel opportunities by the transfer of operating resources from parallel bus and rail operation to a more economic division of roles between bus and rail"[42]. It has also been added that "a feeder service can often provide a more frequent and useful local service and thus generate more local journeys if there is potential in the market"[43]. Through the use of feeder services, it would be possible to create a network where each mode performs what it does best e.g. rail and express bus systems (e.g. the metrobus in Sydney, and the smartbus in Melbourne) as the true trunk routes, and local buses and light rail (in some instances) as feeder services. In some cases, light rail/tram routes will form the trunk routes in the absence of heavy rail main lines in some areas (e.g. in Melbourne and Manchester).

However, it should be noted that the willingness to interchange and subsequently incur a transfer penalty is dependent on the purpose of the trip. For instance, a commuter travelling to work may be willing to interchange, if this will get him to work faster than a direct service would. On the other hand, someone travelling for leisure or travelling with children or elderly people will be more resistant to transfer.

42 Nielsen, G. and Lange, T. (nd), Network Design for Public Transport Success – Theory and Examples. Retrieved 21 December 2010, from: http://www.thredbo-conference-series.org/downloads/thredbo10_papers/thredbo10-themeE-Nielsen-Lange.pdf

43 Ibid.

3.3.2 Park-and-Ride Facilities

In addition to walking, cycling and driving are the primary private modes used to reach the closest transport interchange. A common strategy adopted for rail systems (and occasionally bus systems) is to provide park-and-ride facilities at stations to facilitate access and make the transfer between car and the other mode seamless for commuters. Park-and-Ride facilities, therefore, allow people to drive to public transport, park their car and take the public transport system into the urban area. In some countries, these kinds of facilities are also being made available for bicycles to promote and facilitate the citywide use of this mode, particularly in cities where bike hire programs have been introduced (e.g. Paris and London). Figure 3.3 shows the newly built park-and-ride facility at Wollongong Station.

Whilst park-and-ride facilities enjoyed some popularity in the UK in the 1990s, there have been persistent debates about the true net benefits of park-and-rides because of the congestion created in the peaks and to and from the car parks, and the subsequent crowding effects on the rail network as the congestion cascades onto the trains and eventually the feeder buses.

FIGURE 3.3 Wollongong Commuter Car Park

Source: Transport Construction Authority (TCA).Retrieved 14 March 2011 from <http://www.tca.nsw.gov.au/Images/UserUploadedImages/200/Wollongong.jpg


P
PARK
& RIDE

3.4 Best Practice Examples

For the purpose of this paper, we have considered three international best practice examples of transport network integration:

- London;
- Hong Kong; and
- Singapore.

3.4.1 Example 1: London

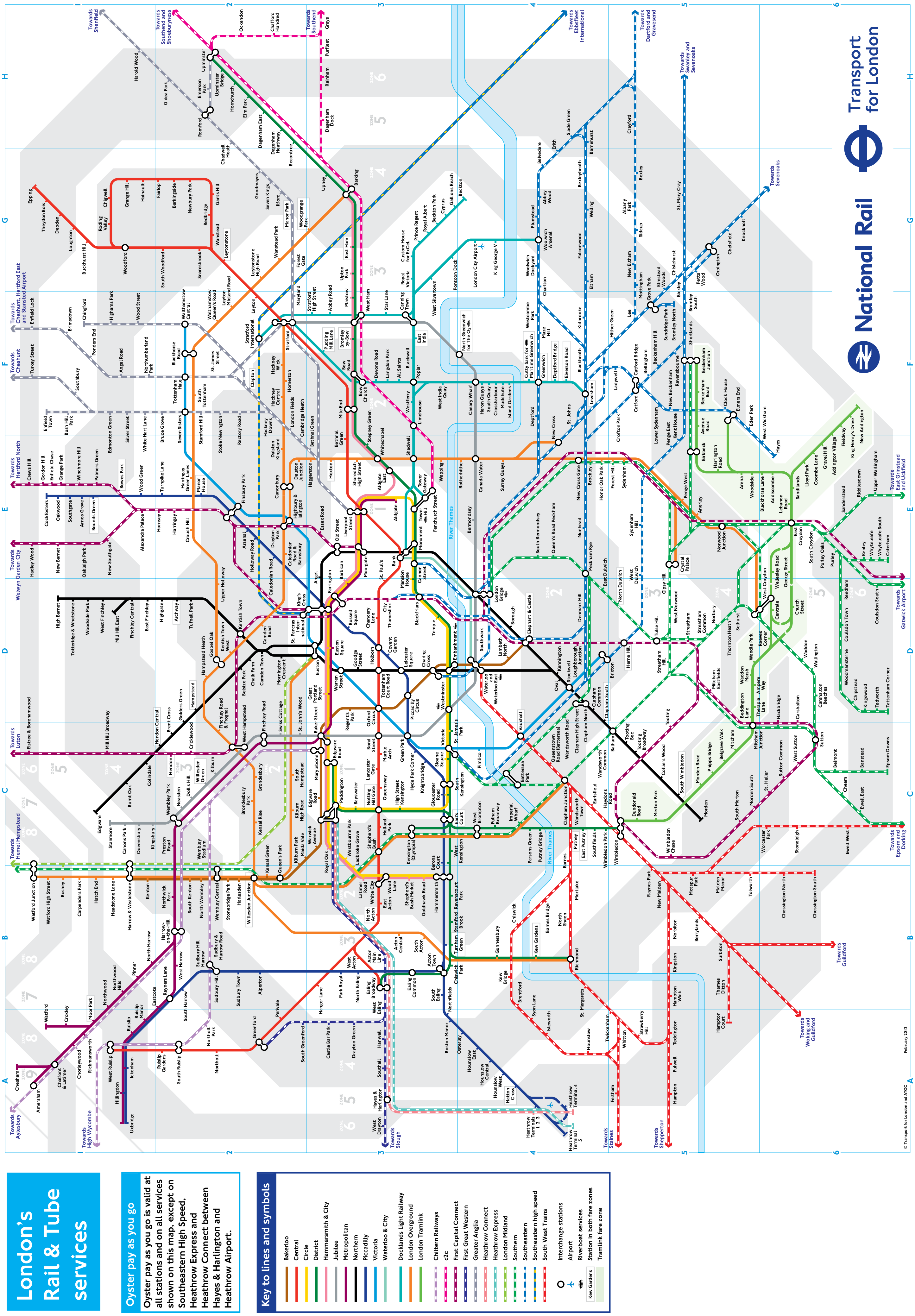
London's overall public transport network is characterised by a well-established historical and modern fixed infrastructure networks (the heavy rail network, the London underground, Docklands Light Rail and Croydon Light Rail), complemented by an extensive bus network and a well functioning ferry network along the Thames.

The fixed infrastructure networks are integrated by interchange stations which in, most cases, are physically connected and, in many cases, designed for ease of interchange for high volumes of passengers (e.g. island platform interchanges, special connecting passages for adjacent lines in the underground system and undercover walkways).

At major stations, purpose built bus interchanges have been developed to be within walking distance of the railway and underground stations, often manned by bus station staff and furbished with real time information systems (e.g. Countdown – which shows the number of minutes until the next bus is due to arrive).

Figure 3.4 illustrates the vast scale of the integrated rail networks in London.

FIGURE 3.4 London's Rail Networks – National Rail, Underground, Overground and Light Rail *Source: Transport for London, viewed on 16 January 2011.*



Whilst, on first sight, Figure 3.4 may appear overly complex or unwieldy, on closer inspection, the map clearly demonstrates the extent of connectivity between different rail networks and different lines within each network, and hence connectivity between locations and regions. For example, both Victoria and Waterloo stations are major transport hubs that offer interchange for rail-rail transfers, rail-tube transfers, and tube-tube transfers (note that the map has not shown bus connections that are also available at both hubs).

Additionally, an extensive bus network operates in London, with many services operating at regular intervals (i.e. every 8-10 minutes on weekdays).

Figure 3.5 illustrates the Central London section of London's extensive bus network.

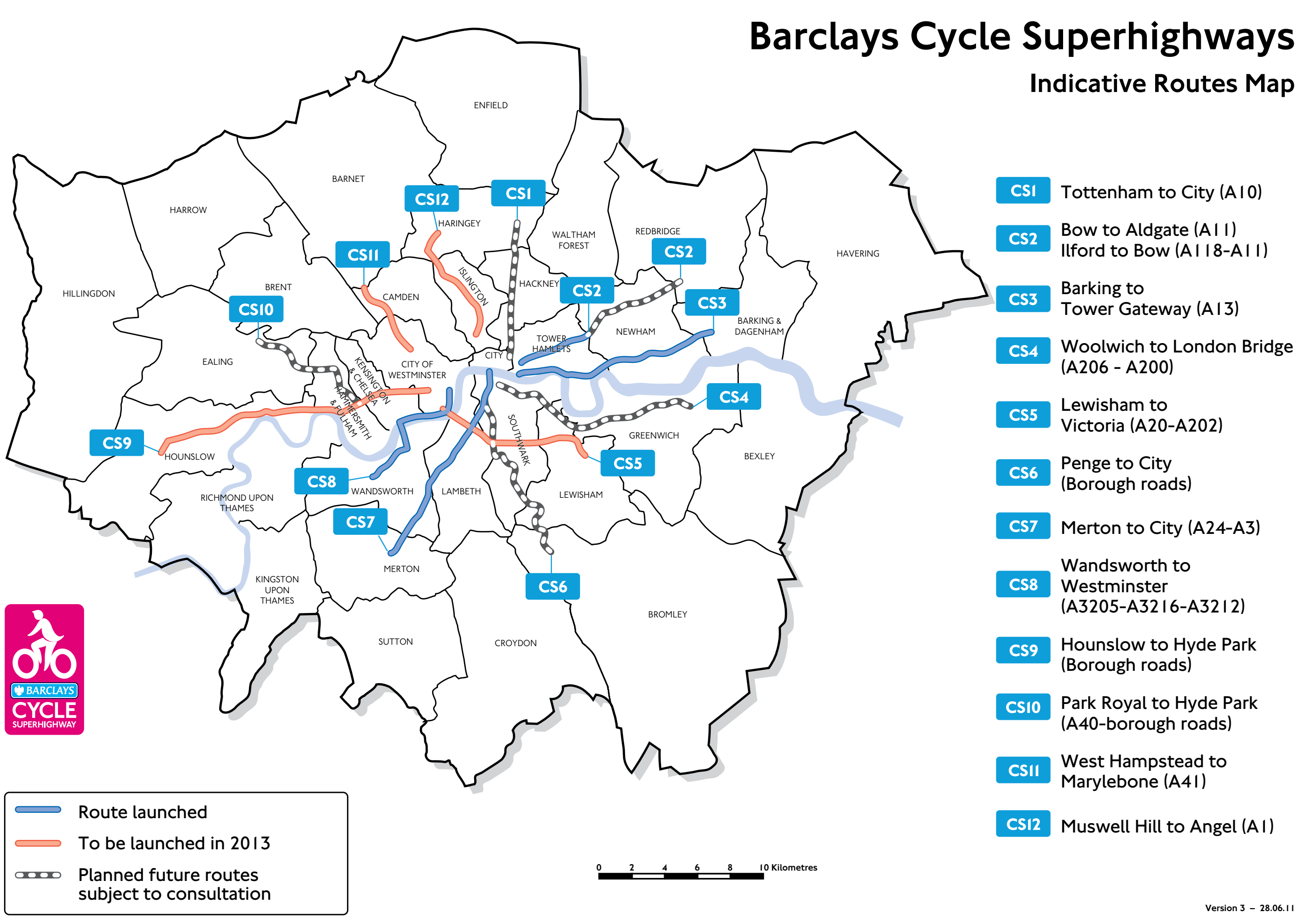
FIGURE 3.5 Central London Bus Network

Source: Transport for London, viewed on 17 January 2011.

Over the last five years, there has been an intense effort to promote cycling in London. As part of the campaign, a network of "Cycle Superhighways" has been launched.

Figure 3.6 provides a map of the current "Cycle Superhighways" in London.

FIGURE 3.6 London's Barclays Cycle Superhighways



Source: Transport for London, viewed on 17 January 2011.

Table 3–1 summarises the examples of integration in the London Transport System.

TABLE 3–1 Integration in the London Transport System

Types of Integration	Specific Examples
Physical Integration	• An extensive network of transport nodes and hubs with embedded interchange facilities (e.g. island platform interchanges, special connecting passages for adjacent lines in the underground system, undercover walkways and retail centres) throughout the city.
Network Integration	• Integrated fixed infrastructure networks: the National Rail (heavy rail) network, the London Underground (tube) network, Docklands Light Rail and Croydon Light Rail, e.g. where stations can serve a number of modes, e.g. Bank. • The "turn-up-and-go" service frequencies of most bus and underground services mean that timetable connectivity between rail, bus and tube services is reasonably well-embedded in the system. • Network integration is also strong for airports as airport access is provided by airport express services (such as Heathrow Express and Gatwick Express), the underground (the Piccadilly Line), heavy rail (by South West Trains) and coaches and buses.
Fare Integration	• The Oyster card was first introduced in 2003 in limited form and as a fully functioning smart card in 2007. • High take-up of Oyster.
Information Integration	• London has led the way in public transport signage since the development of its internationally recognised roundel sign for London Underground in 1908, and has since developed an extensive range of signage for all modes of transport and direction signage over the decades.
Institutional Integration	• The City of London, under Ken Livingstone, assumed control of London Underground network, which further paved the way for even stronger integration of transport services in London, including the introduction of the Oyster card.

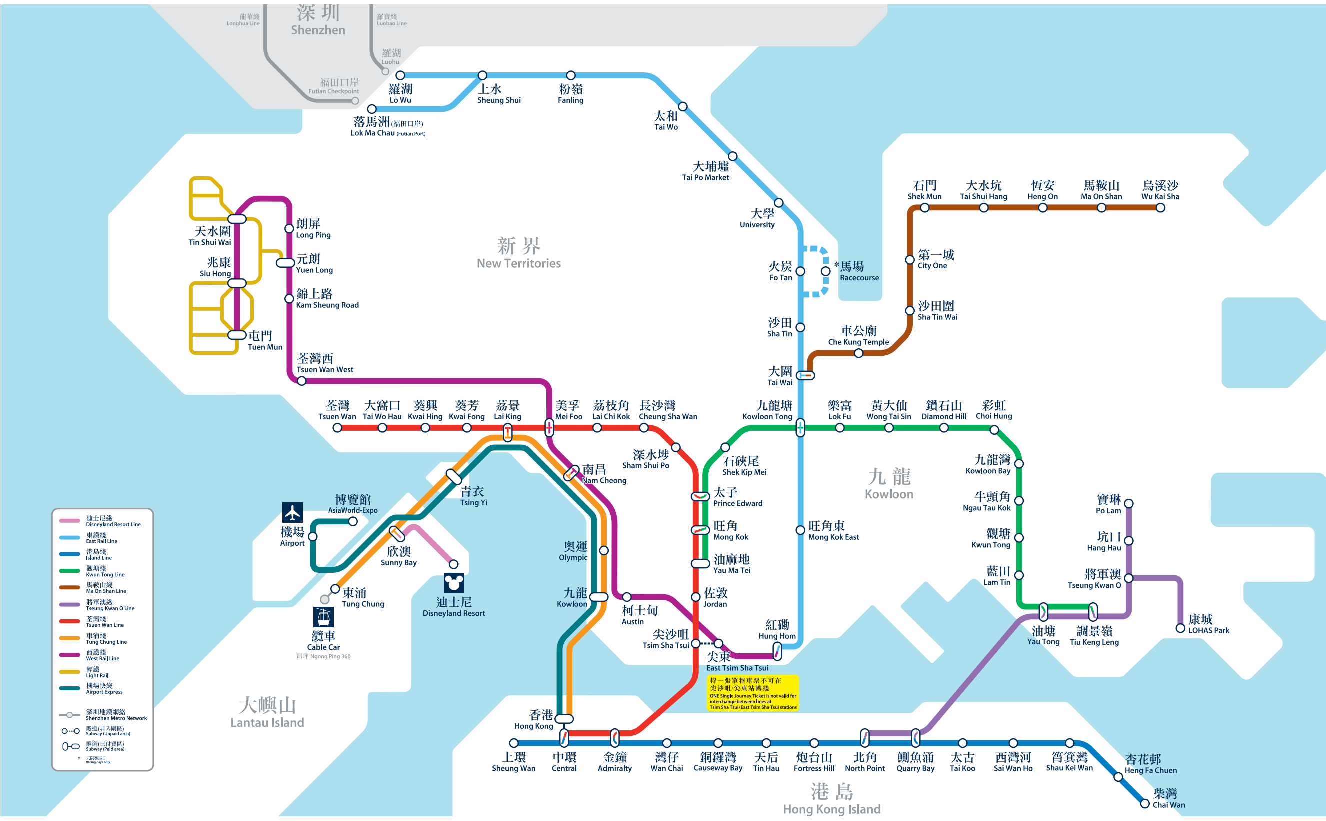
3.4.2 Example 2: Hong Kong

Public transit services in Hong Kong superbly address the accessibility needs of the city. Every day, about 11.3 million passenger journeys are made on the public transport system[44], which include railways, trams, buses, minibuses, taxis and ferries. An astonishing 90 per cent of Hong Kong's daily trips are made on public transport[45]. Also remarkable is the very low car ownership at 50 cars per thousand population.

Figure 3.7 illustrates the recently combined railway network in Hong Kong.

Figure 3.7 shows the route map for the current Mass Transit Railway (MTR) network that comprises an underground metro system and the original Kowloon-Canton Railway Corporation (KCRC) heavy rail network in Hong Kong, which merged into MTR Corporation in 2007.

FIGURE 3.7 Hong Kong MTR System Map



Source: MTR, viewed on 17 January 2011.

44 Hong Kong Transport Department (2010), Hong Kong: The Facts, Information Services Department.

45 Lo, H.K., Tang, S. and Wang, D. Z. W. (2008), Managing the Accessibility on Mass Public Transit: The Case of Hong Kong, Journal of Transport and Land Use, Vol 1, No. 2, p.23.

FIGURE 3.8 Hong Kong's Transport Network

Figure 3.8 overlays the ferry and tram services onto Hong Kong's rail map.

The transport network in Hong Kong is served by a number of operators, including:

- MTR (incorporating Kowloon-Canton Railway Corporation (KCRC)) - one of the most utilised mass transit railway systems in the world, operating six lines on 91 kilometres of tracks through 53 stations, and serving over 2.4 million passengers daily. As a result of the MTR and KCRC merger, MTR now operates both the heavy rail and metro rail services[46];
- The original KCRC lines were East Rail, West Rail and Ma On Shan lines;
- Kowloon Motor Bus (KMB) – operates franchised bus services in and between the urban and suburban areas of Hong Kong. It is one of the biggest bus operators in the world, operating over 4,000 buses on more than 400 bus routes, and serving over 2.8 million passengers per day[47];
- Star Ferry – operates ferry services from Kowloon peninsula to Hong Kong Island and other islands; and
- Trams – A compact tramway, using double decker trams, is still in existence on Hong Kong Island.

46 Lo, H. K., Tang, S. and Wang, D. Z. W. (2008), Managing the Accessibility on Mass Public Transit: The Case of Hong Kong, Journal of Transport and Land Use, Vol 1, No. 2, pp.23-49.

47 Ibid.

Table 3-2 summarises the examples of integration in the Hong Kong transport system.

TABLE 3–2 Integration in the Hong Kong Transport System

Types of Integration	Specific Examples
Physical Integration	• Government focus on infrastructure investments to facilitate integration through the creation of more and better modal interchanges and extra heavy and light rail routes(1): "Extension of the southern terminal of the East Rail by 1.6km to facilitate interchange with MTR station at Tsim Sha Tsui"; "Construction of the West Rail and better integration with the Light Rail Transit (LRT) in the west side of New Territories"; and "Construction of the Ma On Shan rail to the Sha Tin Station of the East Rail". • Good integration of MTR stations with activity centres and local neighbourhoods. • Location of bus stops and taxi ranks close to MTR and KCRC stations and at the airport.
Network Integration	• Several networks are connected by well-designed nodes/hubs such as Tsim Sha Shui. • Buses and mini-buses are timetabled to meet trains and MTR at the outer suburbs.
Fare Integration	• Octopus integrated fare collection system introduced in 1997 which facilitates multi-modal transport. • High take-up of Octopus.
Information Integration	• Good signage to facilitate intramodal and intermodal connections.
Institutional Integration	• Single governing authority helps to implement integration with a minimum of political obstacles.

Source: (1) Luk, J. and Olszewski, P. (2003), Integrated Public Transport in Singapore and Hong Kong, Road and Transport Research. Retrieved 16 December 2010 from: http://findarticles.com/p/articles/mi_qa3927/is_200312/ai_n9318847/?tag=content;col1

In order to promote integration, the Hong Kong Government has invested significantly in infrastructure such as modal interchanges, and heavy and light rail routes. At present, there are plans to increase investments in rail to raise the rail modal share from 30% to 45% by 2016[48].

48 Lo, H. K., Tang, S. and Wang, D. Z. W. (2008), Managing the Accessibility on Mass Public Transit: The Case of Hong Kong, Journal of Transport and Land Use, Vol 1, No. 2, pp.23-49.

3.4.3 Example 3: Singapore

In less than two decades, Singapore has become an international benchmark in offering easy and accessible integrated multi-modal transport. Despite a small population of 4.2 million inhabitants, it has made significant achievements[49]:

- Home of the world's first Area Licensing Scheme (ALS) and subsequent Electronic Road Pricing (ERP) system;
- Vehicle Quota System – quota for new vehicles kept fixed at 3% of the previous year's vehicle population;
- Transit's modal share is high, accounting for 63% of all motorised trips;
- Government plans to continue to invest in public transport (especially rail) to reach a modal split target of 75% of all motorised trips (2003);
- Government provides funding for the infrastructure construction; the transit operator funds the rolling stock, other mechanical and electrical system replacement costs and the on-going operating cost;
- SBS Transit and Trans-Island Bus Services (TIBS) provide bus services on the island; and
- In 2002 TIBS was merged with the SMRT Group which operates all the heavy and light rail systems in Singapore.

49 Luk, J. and Olszewski, P. (2003), Integrated Public Transport in Singapore and Hong Kong, Road and Transport Research. Retrieved 16 December 2010 from: http://findarticles.com/p/articles/mi_qa3927/is_200312/ai_n9318847/?tag=content;col1.

Table 3–3 summarises the examples of integration in the Singapore transport system.

TABLE 3–3 Integration in the Singapore Transport System[50]

Types of Integration	Specific Examples
Physical Integration	• New transit stations are designed to integrate with commercial development and at least one other transport mode; new stations offered covered walkways to connecting modes; • The North-East Line, which opened in June 2003, has all its stations well-integrated with adjacent activity centres; • The Senkang LRT and the Punggol LRT act as feeder services to the North-East Line and are integrated with local neighbourhoods; • Existing MRT stations upgraded to achieve better integration e.g. Woodland MRT/Bus interchange; Novena MRT integrated with nearby commercial development; and • Architectural design of new MRT stations is important from both aesthetic and accessibility point of view – safe and easy walk paths and elevators are now provided for all users, especially for the disabled and elderly.
Network Integration	• Increase percentage of population within the MRT catchment area from 19 to 24% with the completion of the North-East Line (2002); • In general, it has been estimated that 50% of the Singaporean population live within 500 metres of a MRT station[51]. • Current catchment of bus network very extensive with 90% of the population living within 300 metres of a bus stop (bus network backbone of the PT services supporting almost 41% of all motorised trips); and • There is active advice to use Bus or LRT network only as a feeder service to MRT so that there is less surface congestion on arterial roads.
Fare Integration	• A single fare card usable on all public transport modes which greatly facilitates integrated transport called the EZ card also suitable for other applications such as park-and-ride and small retail purchases; and • Rebates for intermodal transfers using EZ card (e.g. rebate of up to $0.25 is given to an individual passenger who transfers from an MRT station to a bus within 30 mins).
Information Integration	• TransitLink Guide provides coordinated and a comprehensive information on all aspects of travelling on bus, MRT and LRT; • Signage system improved to facilitate multi-modal travel; and • Suggestions to introduce an 'i-Transport platform' – IT platform that integrates traffic information from road based ITS measures and transit based measures.
Institutional Integration	• First step towards integration taken in 1989 with TransitLink; • 1995 – the Land Transport Authority (LTA) was formed; • Publication in 1996 of the LTA's White Paper major milestone in promoting PT; • Corporate co-operation, for example, between the SMRT Group and SBS Transit; and • Some overlap of the bus network of SBS Transit and TIBS, and hence some competition.

50 Luk, J. and Olszewski, P. (2003), Integrated Public Transport in Singapore and Hong Kong, Road and Transport Research. Retrieved 16 December 2010 from: http://findarticles.com/p/articles/mi_qa3927/is_200312/ai_n9318847/?tag=content;col1.

51 Kenworthy, J. (2000), The Singapore/Hong Kong Success Stories and their Implications for Developing Cities. Retrieved December 2010 from: http://www.istp.murdoch.edu.au/ISTP/casestudies/Case_Studies_Asia/modasia/modasia.html.

3.4.4 Best Practice Themes

The best practice examples outlined on the previous pages each feature a high degree of integration across a number of measures, including physical, network, fare, information and institutional integration. In more practical terms some of the key common themes of transport network integration include:

- Comprehensive interchange integration – particularly in ticketing, where the monetary cost to the user of changing modes is limited or eliminated;
- Consistent and high quality signage designed with the user experience in mind – this includes cross network branding and real-time transit information;
- An applied disincentive to car use or ownership such as a congestion charge, taxation and registration costs designed to limit ownership, restrictions of available parking or a mandated limit on number of vehicles;
- Delivery of a safe, secure and efficient service (from the user's perspective);
- A high-frequency/non-timetabled service or an integrated timetable where modes at transfer nodes are designed to allow for an efficient interchange; and
- Modal neutrality in transport network decision making – with the best mode selected to suit the task.

In each of the examples explored, integration has been pursued at a strategic level rather than a project or node level – while each project, interchange and node has focused on integration as an outcome they have been part of broader strategies to create a fully integrated greater urban transport network.

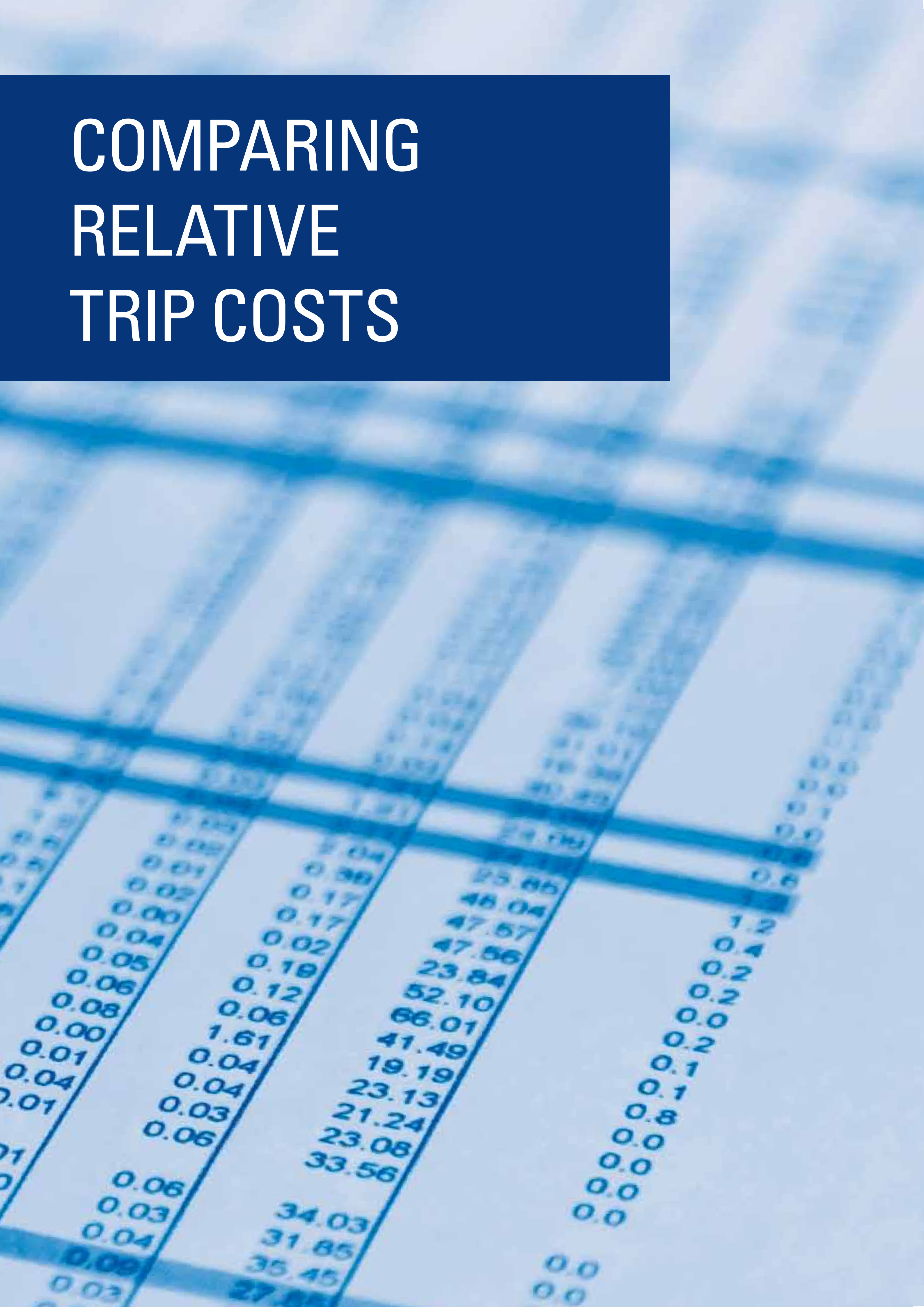
True integration of the example networks – particularly London – has occurred incrementally over time in line with a broad strategic plan for the network. While some level of integration in Australian urban transport networks has occurred, its implementation has largely been in project specific or isolated settings.

In Brisbane, the Queensland Department of Transport and Main Roads have introduced the Brisbane Busways; a network of grade separated lanes exclusively reserved for buses, which pick up and set down passengers at station-styled bus stops, featuring platforms and electronic timetabling information. Bicycle trips from home to busway stations are facilitated with busway stations designed to enable easy access for bicycles and provision of bicycle storage facilities.

In Western Australia, the Mandurah line was opened in December 2007 - the 72 kilometre railway line, with 11 stations, connects Perth with Western Australia's second largest city, Mandurah. The opening of the new line saw the introduction of partial network integration and fare integration to Perth's transport network. The construction of the Mandurah line is coupled with the creation of 62 new feeder bus routes, which connect the suburbs surrounding the Mandurah line with its 11 stations. The bus feeder services have train service integrated timetables – meaning the buses and trains are co-ordinated at interchange points, reducing the time-cost of modal interchange on passengers. The integration of these two modes is supported by the introduction of fare integration in Perth. Rather than mode specific, public transport fares in Perth are priced based on movement between zones; meaning that a ticket is purchased for a time period of access to Perth's transport services. The integration of fares is coupled with the introduction of the SmartRider card, which allows passengers to pre-load value onto their cards, which is then deducted from the card when passengers tag off at the end of their multi-modal journey.

These two examples represent positive steps towards an integrated transport system approach in an Australian context. However, in both examples the integration of the transport network has not been wholesale; integration has been chiefly localised to an individual transport corridor in Perth and a single mode in Brisbane.

COMPARING RELATIVE TRIP COSTS



4 COMPARING RELATIVE TRIP COSTS

4.1 Introduction

This chapter presents two case studies that explore the relative trip costs of transit modes, from a user's perspective, over a range of distances for two key strategic corridors within Australia. The analysis seeks to understand typical user preferences and travel decisions for a variety of mode and distance choices.

4.2 What is a Strategic Transport Corridor?

As defined in Chapter 2, a transport corridor comprises the parallel/competing modal routes between two locations. Typically, strategic corridors are part of a well-connected and integrated transport network, which is reliable and capable of catering for future forecast demand, linking the key centres or areas of importance.

For comparison, the following two strategic corridors have been chosen for this assessment:

- Sydney: Penrith to Sydney CBD; and
- Melbourne: Pakenham to Melbourne CBD.

4.3 Corridors Assessment Approach

As outlined above, our assessment explores the relative costs of a number of transport modes servicing the Sydney based and Melbourne based corridors. Estimates of generalised travel costs (GTC), which provide an estimate of the "total cost" of a journey (i.e. the combination of travel time and the associated financial costs), are used to explore the relative costs of the different modes within the observed corridors.

Appendix 1 describes the methodology used to estimate generalised trip costs.

For the purposes of this study, 'construction and maintenance costs' have not been included since the study is concerned about user costs and user benefits. In addition, other factors such as safety and externalities along with congestion have not been taken into account, as they are not normally included in the estimation of generalised travel costs.

4.4 Penrith to Sydney CBD Corridor Assessment

The Penrith to Sydney CBD represents a major strategic transport corridor within Sydney. Penrith is located approximately 55 kilometres west of the Sydney CBD. The corridor contains key business districts such as Parramatta and a number of key suburban/residential areas including Strathfield, Lidcombe and Blacktown.

Figure 4.1 identifies the Penrith to Sydney CBD corridor and highlights key transport modes.

4.4.1 Penrith to Sydney CBD Transport Modes

A large number of transport modes operate within the Penrith to Sydney CBD corridor:

- Walking – While there is not a designated continuous walking route between Penrith and the CBD, the Sydney CBD and the inner city is reasonably served by dedicated walkways, particularly harbourside and bayside walks close to the CBD (e.g. Darling Harbour, Pyrmont, Glebe);

- Cycling – As part of the RMS cycleways program, a network of on-road cycleway facilities are in place along the corridor[52]. Within the Sydney CBD and in areas closer to the Sydney CBD, dedicated cycleway facilities with traffic separation exist[53] (e.g. Kent Street and King Street) and more are under construction;

- Bus – Sydney Buses operates the bus services along the corridor. In many instances, travel by bus would not be a primary transport mode, as there are few direct services between major centres (e.g. Strathfield and Lidcombe) and the CBD. This circumstance is more prevalent as the distance from the CBD increases. As a result, multiple transfers between buses would be required for locations beyond the inner city area (e.g. from Leichhardt/ Petersham). It should also be noted that a form of BRT system is present on the section running from Parramatta to Liverpool (the Liverpool – Parramatta Transit Way, operated by Western Sydney Buses – a unit of the NSW State Transit Authority);

- Heavy Rail – CityRail operates the heavy rail network along the corridor, providing a mix of stopper (all stations), semi-express and express services. At present, during the AM peak hour, services between Parramatta and the CBD depart around every 3 – 6 minutes;

- Ferry – Sydney Ferries operates the ferry network along the corridor, providing regular ferry services from Parramatta to the CBD. As travel by ferry is not possible along the entire corridor, our analysis assumes that any trips further west than Parramatta would require a transfer to another mode (we have assumed a heavy rail transfer on the basis that it is the fastest);

- Light Rail – The light rail network in Sydney is operated by Metro Transport. Light rail services are provided at regular intervals between Central Station and Lilyfield with key stops including residential areas such as Pyrmont, Glebe and Rozelle Bay. As light rail services are only provided to Lilyfield, our analysis assumes that any trips further west than Lilyfield would require a transfer to bus and then a transfer to heavy rail; and

- Private Vehicle – The Western Motorway (M4) and the Great Western Highway/Parramatta Road provides access along the corridor from Penrith to the Sydney CBD. For the purpose of this study, the GTC estimates for private vehicles have been calculated using the Great Western Highway as the preferred route. We have also assumed the current situation where there is no toll on the M4.

As indicated in Chapter 1, we have not included the monorail and taxis that also operate in this corridor.

Generalised trip costs for each of the transport modes along the corridor have been calculated and are illustrated in Figure 4.1.

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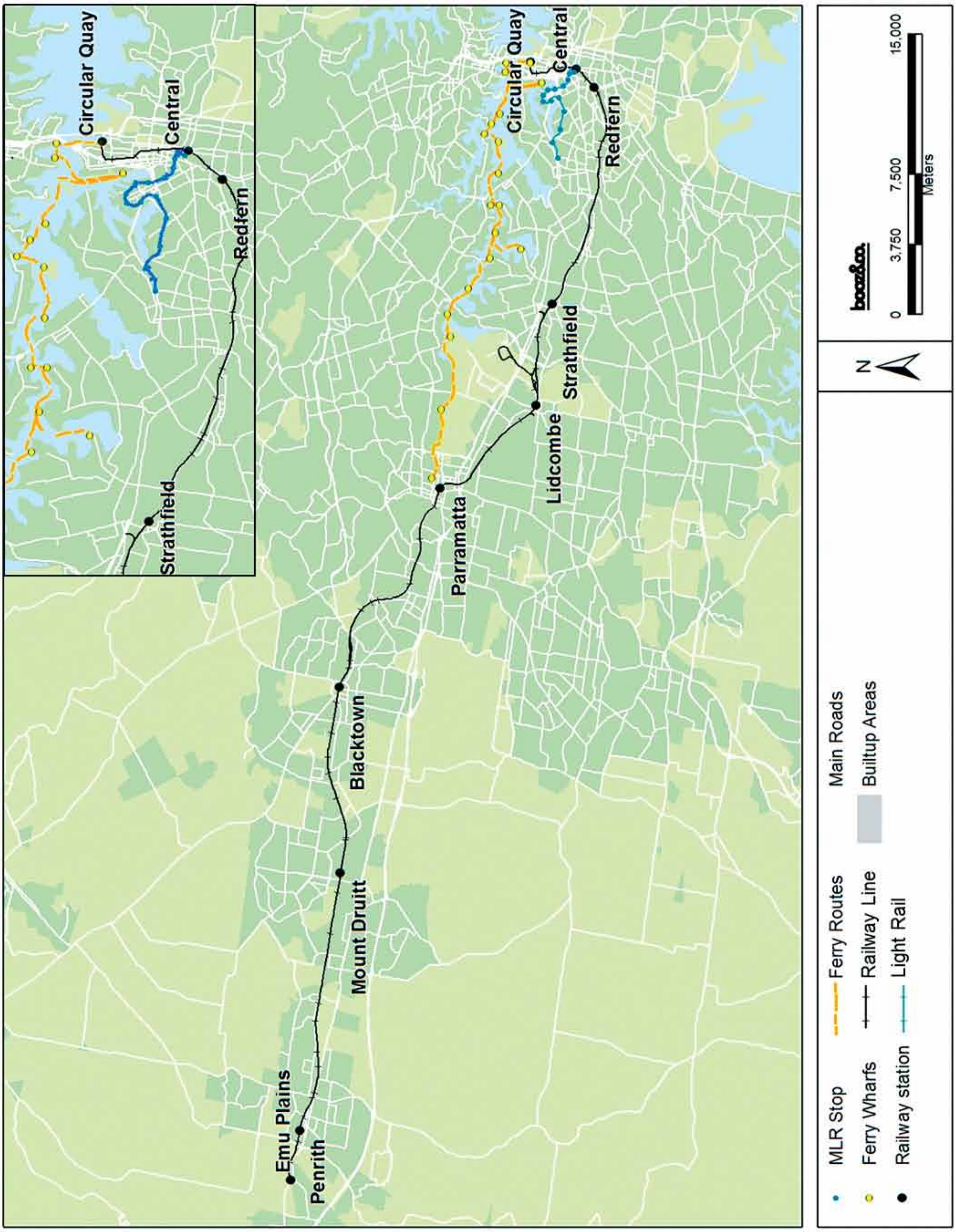
52 Source: RTA, Sydney Metropolitan Cycleways Maps. Retrieved on 20 December 2010 from: http://www.rta.nsw.gov.au/trafficinformation/downloads/penrith_plt.pdf

53 Source: RTA, Sydney Metropolitan Cycleways Maps. Retrieved on 20 December 2010 from: http://www.rta.nsw.gov.au/usingroads/downloads/sydney_parramatta_bikemap_p1.pdf

FIGURE 4.1 GIS Map of the Penrith to Sydney CBD Transport Corridor *Source: Booz & Company, 2011*



The following points emerge from Figure 4.2.

- For distances under 10km, cycling emerges as the most trip *cost-effective* mode from a user's perspective, with walking also being relatively cost-effective.

- The reason for this is that comparative analysis has been undertaken whereby the fare component of the generalised trip costs is high for these relatively short distances (given the current fare structure in Sydney and compared to, say, London buses), there is a lack of fare integration (intra- and inter-modal transfers are financially penalised) and a lack of network integration (timetables are not generally designed to facilitate connectivity and passengers incur heavy interchange penalties). However, in reality, increased cost-effectiveness does not automatically mean a greater inclination for travellers/commuters to take up these modes due to the physical exertion, and subsequent discomfort and inconvenience, coupled with the limited load carrying capacity when cycling and walking;

- The generalised trip costs of both ferry and light rail in Sydney increase rapidly and peak by around the 1km mark and remain the highest cost modes until they are overtaken by walking at around the 14km and the 25km mark respectively. This level of trip costs is consistent with the observation that both modes tend to be used by relatively affluent passengers in the inner city or harbourside/riverside locations.

- Users are extremely unlikely to use light rail along the corridor beyond its current terminating point at Lilyfield as it would require multiple interchanges on buses and trains to reach Western Sydney, hence the very high cost for the "light rail+bus+rail" option between 8km and 25km; this also reflects the poor connectivity of the light rail system in Sydney with the rest of the transport network (e.g. only one bus connects at the Lilyfield terminus).

- Bus and heavy rail trips have similar trip costs initially but, as the distance increases beyond the 3km mark, heavy rail clearly becomes more cost-effective as line speeds increase for longer distances on rail lines and enjoy the absence of road congestion;

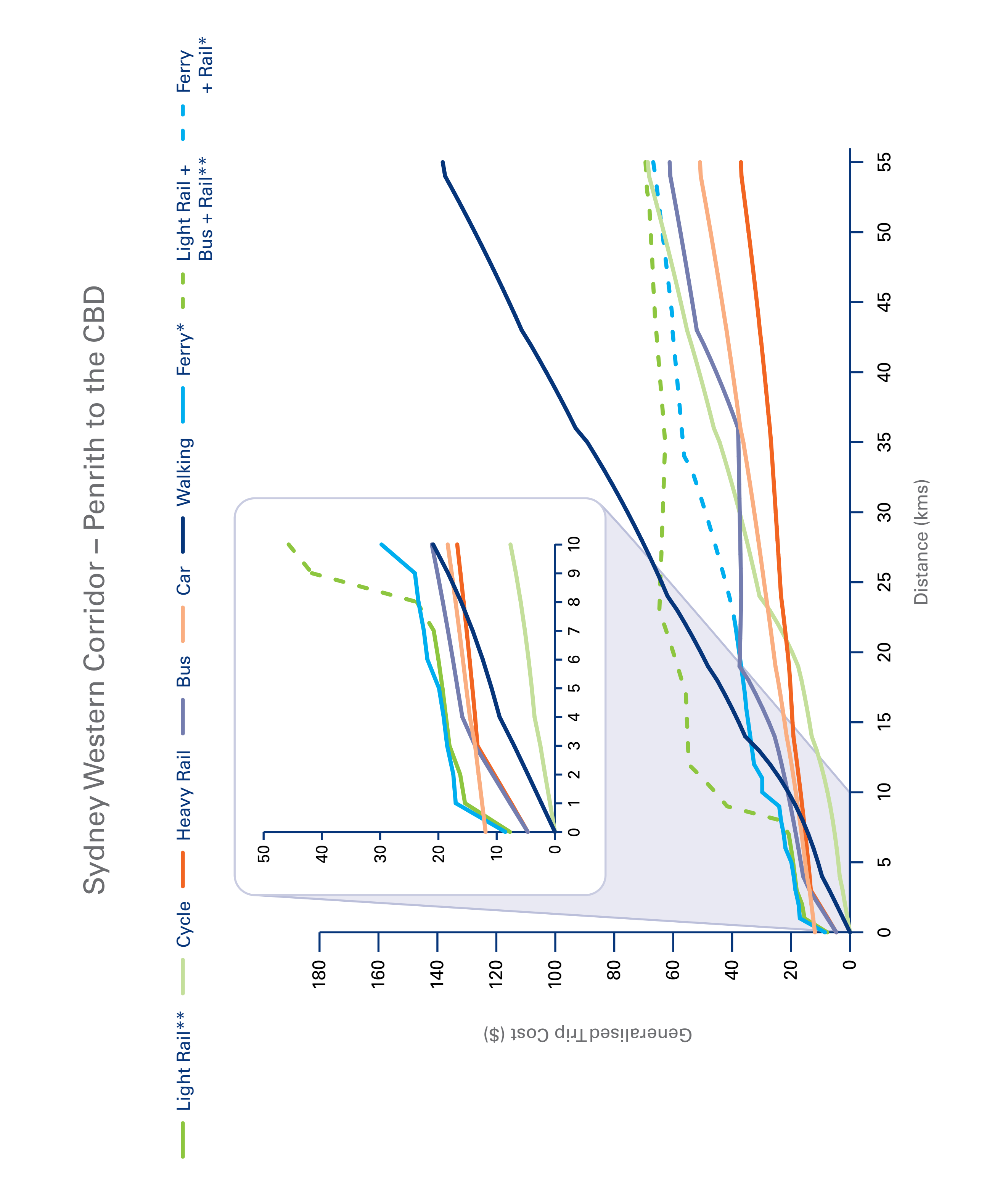
- It is interesting to note that, for most of the corridor, the generalised trip cost for bus is higher than that for cars. This is not surprising given that there are very few bus services in Sydney with a "turn-up-and-go" frequency, a lack of timetable connectivity between bus services, relatively high bus fares on a per km basis over short distances; and no discounted fares for bus-bus transfers;

- For trips between 10km and 21km, cycling emerges as the most cost-effective mode for users. However, as indicated above, the cost-effectiveness estimation has not captured the disutility associated with the hardship and discomfort of cycling over those distances; and

- Beyond 30km, the most cost-effective options in Sydney are clearly motorised modes such as bus, car and heavy rail;

  – For longer trips in Sydney (21km or more), heavy rail stands out as the most trip cost-effective mode due to its relative frequent service, speed and relatively lower monetary component (the fare).

FIGURE 4.2 Graphical Representation of Generalised Trip Cost by Mode for the Penrith to Sydney CBD Corridor



4.5 Pakenham to Melbourne CBD Corridor Assessment

The outer portion of the corridor is one of Melbourne's key growth areas, which is currently experiencing urbanisation. An outline of the corridor is provided in Figure 4.3.

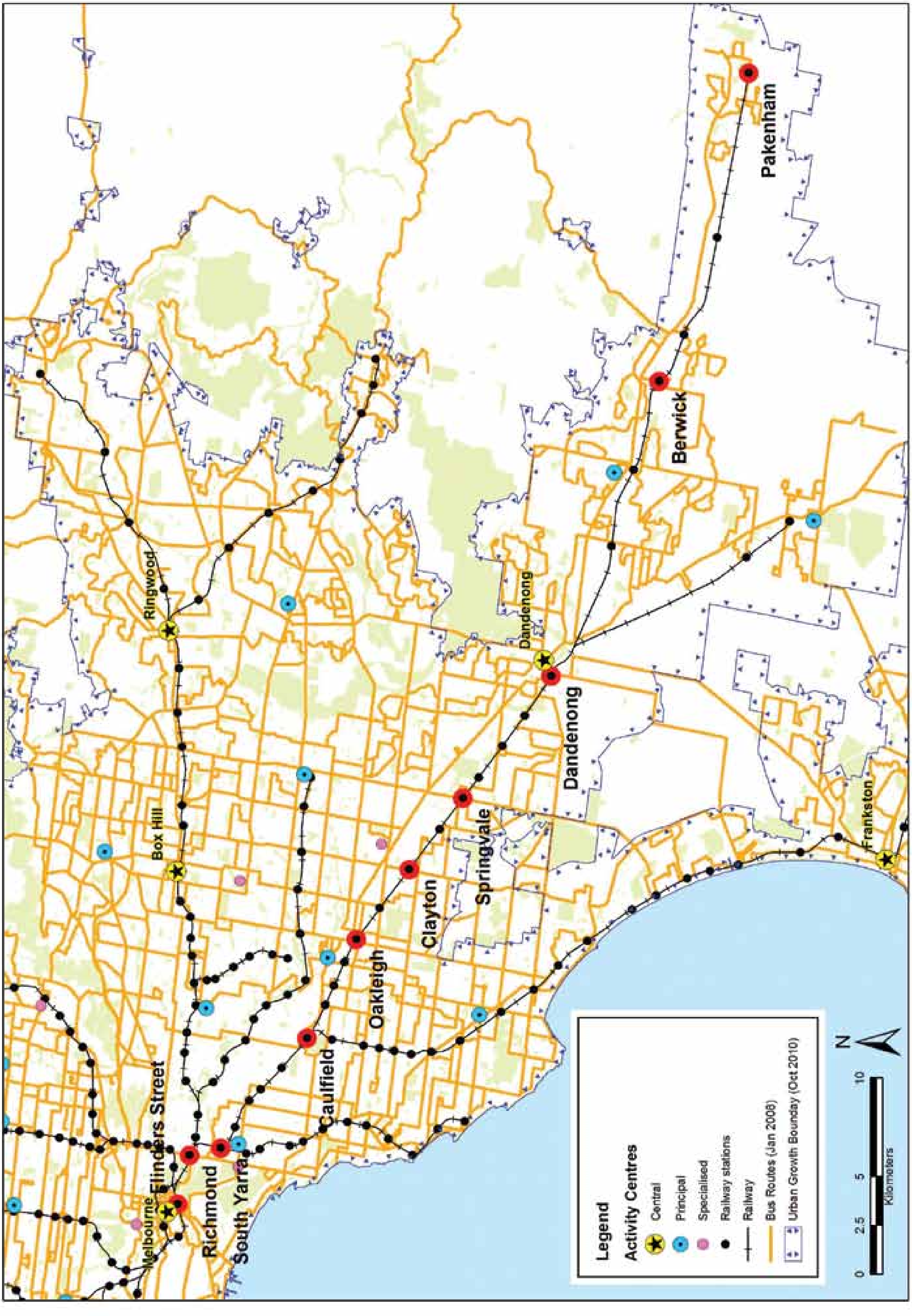
4.5.1. Pakenham to Melbourne CBD Transport Modes

Like the Penrith to Sydney CBD corridor, a large number of transport modes operate within the Pakenham to Melbourne CBD corridor:

- **Walking –** There is no designated walking corridor between Pakenham and the CBD; the routes chosen in the analysis are typically along main roads;
- **Cycling –** A network of bicycle paths is provided along the corridor, stretching out beyond Berwick;
- **Bus –** The Melbourne bus network is operated by a number of bus corporations and provides local connecting services as many trips along the corridor rely predominantly on the inner-city tram network and metro train network. As such, in most instances bus trips from the south eastern suburbs to the Melbourne CBD require at least one and, in many cases, two transfers between bus services;
- **Heavy Rail –** The Melbourne trains' franchisee, Metro Trains Melbourne (MTM), operates the key suburban rail services along the corridor with inter-urban services operated by V/Line (the Government regional operator). The rail corridor provides regular passenger rail services into the CBD from a range of key areas, including: Caulfield, Oakleigh, Westall, Dandenong and Berwick;
- **Light Rail –** Melbourne has the largest tram network in the world[54]. The Melbourne trams' franchisee, Yarra Trams, operates services along this south eastern corridor. Tram services are not available along the whole corridor and span only from the Melbourne CBD to Oakleigh. As such, our analysis assumes that trips further on from Oakleigh would require a transfer to another mode, in this instance heavy rail; and
- **Private Vehicle/Car –** The Monash/Princess Freeway (M1), along with the Princess Highway provides access along the corridor from Pakenham to the Melbourne CBD.

54 Victorian Department of Transport (2008), Investing in Transport. Retrieved 17 January 2011 from: http://210.15.220.118/east_west_report/Investing_in_Transport_East_West-Chapter03.pdf

FIGURE 4.3 GIS Map of Pakenham to Melbourne CBD Transport Corridor *Source: Booz & Company, 2011*

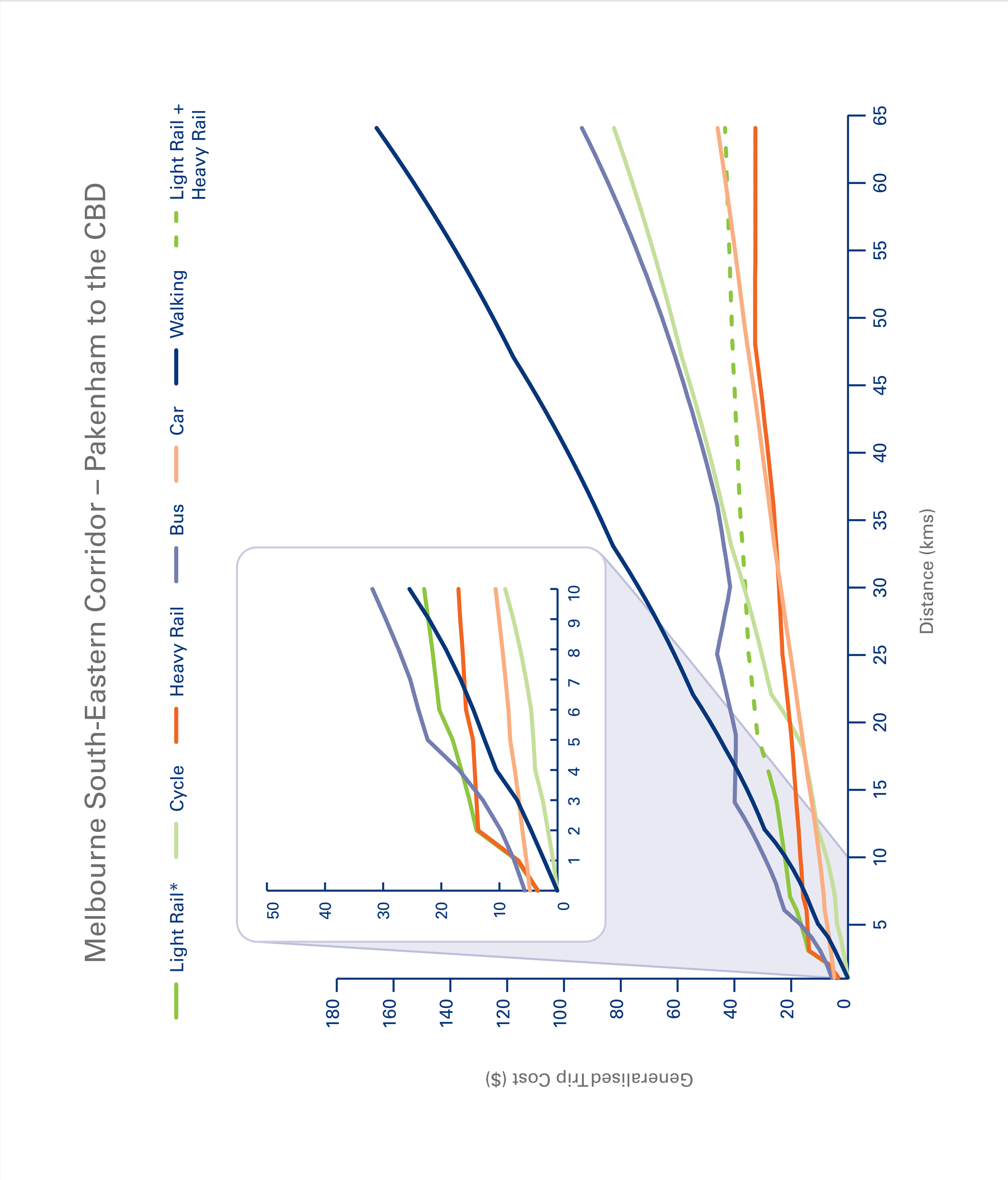


Generalised trip costs for each of the transport modes along the corridor have been calculated and are illustrated in Figure 4.4.

Similar to the Sydney corridor analysis, clear distinctions can be seen between trip distance and the most optimal mode choice with respect to generalised trip costs, for example:

- For trips less than 10km, cycling, is the most cost-effective mode from a user's perspective, with walking also being a relatively cost-effective mode for trips around 3km or less;
  - As indicated earlier, this is not surprising given that there is no waiting or transfer times involved and the relatively low financial outlays involved (free in the case of walking); however, generalised trip cost methods do not fully take account of the discomfort (the disutility) of walking or cycling, otherwise, there would be a much greater take-up of these modes beyond the 2km – 5km distance (cf. a 1.6% mode share in 2006).
- Both heavy rail and car become more cost-effective as the trip distance increases to 10km which is similar to the Sydney analysis;
- However, the Melbourne case study offers a more robust comparison between heavy rail and light rail/tram because the Melbourne tram network has longer routes, is well-established and is better connected to other modes:
  - For almost the entire corridor, apart from the first 2km, heavy rail has lower generalised journey costs than trams. However, the short distance between tram stops, and hence accessibility to the final destination (e.g. shops on the main street), make trams a popular mode in the city and the inner city areas.
- Also, similar to the Sydney corridor analysis, heavy rail is the most cost-effective mode for trips greater than around 25km (rail has the lowest generalised cost after 31km); however, the combined "light rail+heavy rail" option has the second lowest costs, reflecting that the reach of the tram line in this corridor (approximately 17km) extends further than the current light rail line in the Sydney corridor (approximately 7km) and has better connectivity with the heavy rail network.

FIGURE 4.4 Graphical Representation of Generalised Trip Cost by Mode for the Pakenham to Melbourne CBD Corridor



4.6 Summary

In comparing the results for the Sydney and Melbourne corridor, some common themes emerge:

- It is clear from both pieces of analysis that heavy rail is the most suitable transport mode for trips greater than 25km given its lower generalised trip costs, and it performs well in the 10km – 25km zone;
- Active transport modes such as cycling and walking are most cost-effective from the user cost perspective for those trips less than around 10km (or those less than 20km, at a maximum, for cycling); and
- Generalised trip costs vary by mode and over different intermediate distances with different modal implications; in particular, the 10km insets (See Figure 4.2 and 4.4) for both corridors suggest that trip costs do not increase linearly and cross at various points:
  - In Sydney, both light rail and ferries show the highest generalised trip costs for journeys less than 10km; however, it must be recognised that users of these modes enjoy relatively new rolling stock in the case of light rail, unsurpassed harbour views in the case of ferries, very good reliability due to lack of congestion, and relatively lower peak crowding in both cases. Therefore, these modes play a role in providing direct main mode services in the inner city areas.
  - In Melbourne, buses have the highest generalised trip costs between 4km and 16km due to the slow vehicle speeds and the longer headways between services, followed by trams which have the second highest generalised trip costs between 4km and 9km; initially, the margin is quite small but it increases quite rapidly after the 5km mark so that it is highly unlikely that users would prefer bus for travel beyond, say, 15km.
  - Cars perform better than buses in both instances for long-distance travel, meaning that in areas where there is no heavy rail link, it is more cost-effective for users to drive than catch a bus.

There is a growing body of evidence suggesting that passengers have inherent preferences for a given public transport mode over another and that this influences ridership levels and usage profiles[55]. In general, passengers prefer rail modes to on-street bus due to higher service levels, better ride quality and a simpler/easier to understand design proposition. However, bus rapid transit services can have similar ridership impacts to rail in some conditions[56]. Different transit modes also lend themselves to different types of network structure or service patterns. Rail based modes can encourage interchange transfers which are not usually enjoyed by passengers and can often offset mode preference benefits.

While the solution to developing integrated transport corridors may seem simple, this is not the case. Transport patterns and needs are diverse with a vast array of possible trip origins and destinations. Typical trips are not always between the suburbs and a single central business district in the capital city. The challenge for governments and transport planners is how to develop and implement integrated multi-modal transport networks given these disparate transport patterns.

55 Booz Allen Hamilton (2000), Valuation of Public Transport Attributes. Final Report. Booz Allen Hamilton for Transfund New Zealand.
56 Currie, G. (2005), The Demand Performance of Bus Rapid Transit, Journal of Public Transportation, Vol 8, No.1, pp. 41-55.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MULTI-MODAL TRANSPORT APPRAISALS

5 MULTI-MODAL TRANSPORT APPRAISALS

5.1 Overview

This chapter considers project appraisal and presents arguments for a more comprehensive approach to ensure a wide range of integrated and multi-modal options are considered in transport project/policy development and prioritisation.

Given the transport system is an interconnected network, project evaluations should not focus on a single mode or be pursued in isolation from each other. Factors to be considered in a comprehensive approach are likely to include:

- the types and extent of benefits (as well as the associated costs) are likely to differ greatly given the level of infrastructure and/or services already in place; and
- identification of the requirements for a multi-modal network wide evaluation of projects, particularly given the unique nature of each city/corridor:
  - This could potentially be a two-stage approach, with Stage 1 focusing on the strategic corridor evaluation and Stage 2 evaluating the range of complementary services required to get the best network-wide outcomes.

In recent years, there have been examples of projects progressing with and without sufficient planning behind them. For example, the Epping to Parramatta Rail Link in NSW is an example of a project in which a single mode solution has been chosen and progressed without detailed assessment of various project options at the time of announcement.

On the other hand, the *Melbourne East-West Needs Assessment project* represents a landmark process in Australia in which a range of options (including private and public transport) for improving east-west transport connections across Melbourne were considered and assessed.

5.2 Historical Context and Recent Developments

Historically, in most states within Australia, individual appraisal guidance documents existed for each mode. For example, in NSW, the State Rail Authority's **Guide to the Evaluation of Capital Projects**[57] provided guidance on the appraisal of heavy rail projects, whilst the RMS **Economic Analysis Manual**[58] guided the evaluation of road projects. One of the key implications of having single-mode appraisal guidance documents is that they do not encourage multi-modal and/or integrated transport options during the optioneering stage of the appraisal process. For instance, the options to develop a new rail line might be:

- Option 1 – The Base Case – Do Nothing;
- Option 2 – Build a single track line from A to B;
- Option 3 – Build a single track line with a passing loop; and
- Option 4 – Build a double track line.

Whereas an integrated multi-modal transport approach may consider other options e.g. run buses from A to B and/or provide taxis from A to B.

However, more recently, there has been a move towards multi-modal project evaluation. An assessment of a range of transport appraisal guidelines both within Australia (federal and state based) and internationally identified the following multi-modal transport appraisal guidance material.

57 State Rail Authority of New South Wales (1995), Guide to the Evaluation of Capital Projects, New South Wales.
58 New South Wales Roads and Traffic Authority (1999), Economic Analysis Manual, New South Wales.

Case Study 1: East-West Link Needs Assessment

In 2006, the Victorian Government asked Sir Rod Eddington to undertake a comprehensive study into improving east-west transport connections across Melbourne. In March 2008, Sir Rod Eddington completed the East–West Link Needs Assessment (EWLNA) and delivered his report to government.

The EWLNA report demonstrates the type of strategic approach to transport planning this paper advocates. It had been identified that Melbourne as a city was over reliant on the Monash – CityLink – West Gate corridor and that this would be unsustainable in the face of a growing population and economy.

The report sets out to investigate a wide range of options for improving this corridor that could equip Melbourne with the requisite capacity to accommodate more people and hence transport users.

The investigation covered public transport opportunities, enhanced freight access, urban amenity, road network connectivity, economic benefits, congestion and costs and funding options.

Importantly, the report was instigated with no pre-conceived ideas of what transport modes were needed or would be best. The disparate current and potential problems were identified and the best 'workable solution' for each was to be found. A large part of the report's findings were the result of the consultation process, which incorporated the views of business, industry bodies and the general public.

The results of the report were a series of recommendations to Government that have since flowed through to transport planning and have spanned both road and rail infrastructure projects as well as building capacity for better cycling and pedestrian access.

- The Australian Transport Council's (ATC) "National Guidelines"[59] presents a framework for multi-modal project evaluation that considers the full range of potential solutions or options, thus moving beyond the narrow focus on infrastructure and single-mode solutions alone;
- The UK Department for Transport's (DfT) "Transport Analysis Guidance" (TAG)[60] provides guidance for estimating multi-modal and network effects; and
- Additionally, *Infrastructure Australia* (IA) advocates the evaluation and appraisal of a range of options or potential solutions to transport problems including build, non-build and multi-modal solutions[61].

To a certain extent, the natural inclination to focus on own mode projects by agencies will only be discouraged by transport appraisal guidance developed at the industry level. For example, the UK DfT's TAG provides guidance on multi-modal effects and hence encourages the development of multi-modal transport options. Similarly, "integration" was one of the key criteria in the UK Government's "New Approach to Appraisal" (NATA) framework in 1997.

At present, the current framework of mode based appraisal guidance framework do not encourage the States to develop integrated and/or multi-modal transport options during the appraisal process, rather it reinforces the development of single-mode/own mode options.

59 Australian Transport Council (2006), National Guidelines for Transport System Management in Australia, 2nd edition, Volumes 1-5, Canberra.

60 United Kingdom Department for Transport (updated February 2010), Transport Analysis Guidance (TAG). Retrieved December 2010 from: http://www.dft.gov.uk/webtag/

61 Infrastructure Australia (2009), Better Infrastructure Decision-Making: Guidelines for Making Submissions to Infrastructure Australia's Infrastructure Planning Process, through Infrastructure Australia's Reform and Investment Framework, Canberra.

5.3 Alternative Approaches

5.3.1 Strategic Approaches

One alternative would be for State transport agencies to adopt a single transport appraisal guidance approach, similar to the UK DfT's NATA and TAG approaches, to encourage transport integration and multi-modal transport.

Another alternative would be to modify existing appraisal guidance documents to stipulate that the optioneering stage of the appraisal process needs to consider alternative transport mode options.

The above two approaches could be reinforced through the State Treasury Gateway Review Process to ensure that alternative modes have been considered.

5.3.2 Specific Appraisal Requirements

Because of the complex trade-offs between mode types and the strategies to deploy them, an objective framework is needed to appropriately compare modes in a rational and objective manner. An objective approach to evaluation needs to[62]:

- Use comparable assumptions on the design of alternative modes; for example, comparing a new bus system with refurbishment of a 50 year old railway is not a valid assessment of alternatives;
- If different technologies are to be compared, each requires optimisation; there is a danger that an evaluation of poorly optimised mode A will be rejected in favour of optimised mode B when an optimisation of mode A would be the best solution;
- It is useful to evaluate alternative modes by classifying design issues separately, including mode technologies, operating patterns and service types;

62 Vuchic, V. (2005), Urban Transit: Operations, Planning and Economics, Hoboken, New Jersey, USA: John Wiley & Sons Inc.

Case Study 2: Gold Coast Rapid Transit

The Gold Coast Rapid Transit (GCRT) project is a new light rail link that aims to reduce congestion and improve public transport services at the Gold Coast. When completed, the 40km route will link Helensvale in the north to Coolangatta and the Gold Coast Airport.

The project is being delivered by the Queensland Government (through the Department of Transport and Main Roads), in partnership with the Australian Government and Gold Coast City Council.

The relevance of the GCRT project to this paper lies in the way the transport mode was selected and the process of decision making that lead to it.

With rapid growth in population and inadequacies in the existing public transport system, a decision was made that a North-South rapid transit system was required for the Gold Coast region. The Queensland Government formulated the Central Design & Implementation Management Plan (CDIMP) that would fully investigate both bus transit and light rail systems that had been identified as possible options for the GCRT project.

Throughout the consultation phase of the project, the two modes of rapid transit were investigated in detail. The vehicles were compared against a number of criteria including capacity, passenger comfort, reliability, safety, sustainability and value for money. While both modes proved competitive, light rail was deemed the preferred choice for the Gold Coast community because:

- light rail vehicles can carry up to 100, 000 passengers per day — these figures cannot be matched by bus rapid transit;
- the length and capacity of light rail vehicles can be increased to meet the demands of the Gold Coast's fast-growing population;
- light rail technology has a proven vehicle life of 30 years or more;
- over time, operating a light rail system provides better value for money than operating a bus rapid transit system;
- light rail provides superior levels of passenger comfort when compared with other modes of transport; and
- the Gold Coast community showed strong support for light rail over bus rapid transit.

Importantly, the GCRT project is only a part of long-term transport planning on the Gold Coast. Plans to improve and extend the heavy rail line linking Coolangatta and Brisbane are being considered, as are better bus services for cross-city journeys that will better integrate the bus system with the light rail line.

The GCRT project is a good example of long-term transport planning. It demonstrates a thorough and well-considered approach to mode selection and the ensuing decision making process. A need for new transport was identified, possible options were canvassed and duly considered with the option considered the most appropriate implemented and integrated with existing and future transit systems.

- All transit systems involve a network and how each transit option fits into that network is critical to system wide performance. Hence a network-wide design is required for all options;

- Investment cost is a major element of mode selection and, in general, there is a link between high impact and quality mode solutions and high cost. If modes are to be reasonably compared, it is invalid to test a high cost and a low cost option unless variation in investment cost is an important area being explored in an appraisal;

- Transit modes can have varying long term impacts on land use and should be included in an evaluation. Research literature suggests bigger impacts on development density for rail based modes[63]; however, similar impacts can be seen in large bus rapid transit system investment[64]; and

- The greater the differences between the transit modes being compared, the more comprehensive must be the evaluation procedure being deployed[65] .

Overall, it is clear that a range of public transport solutions can be deployed in a wide range of patterns and designs for a given transport task. Current evaluation processes are limited by mode specific evaluation methods rather than an objective comparison between modal options. This is limiting the effectiveness of government investment and is a poor use of economic appraisal techniques, which have been designed to explore the full range of options available. It is also in contrast to the practices outlined in the National Guidelines.

5.4 Summary

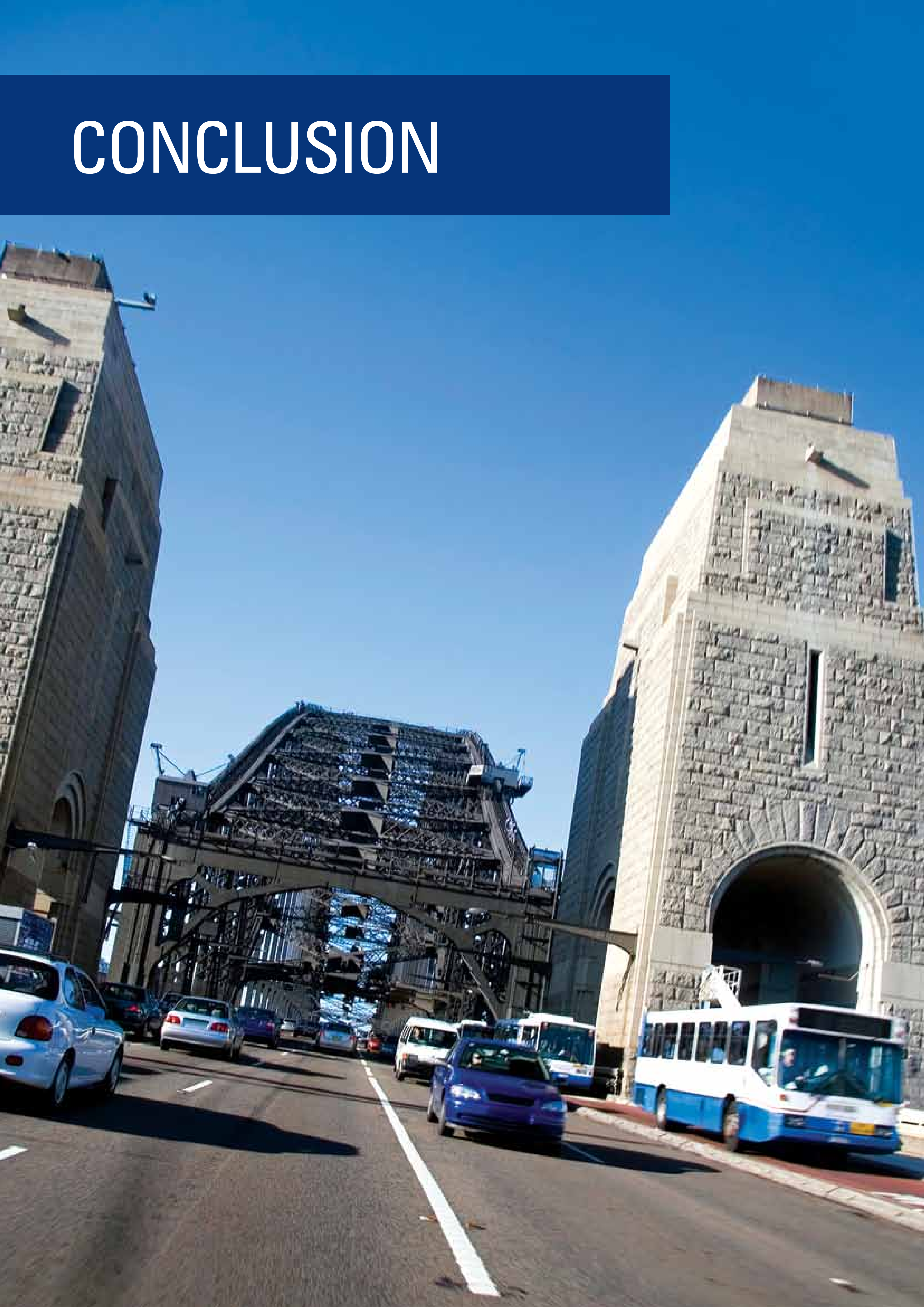
While a need for objective cross-modal evaluation is clear, government authorities have a difficult task in undertaking an appraisal of alternative transit modes using objective and comparable methods. There is a need to provide a better range of guidance to authorities on the relative roles and attributes of each of the different conventional transit modes. Guidance on how alternative modes perform in terms of costs, benefits and transport and land use system impacts is also needed to improve the quality of evaluation undertaken in corridor studies.

63 Dittmar, H. and O. G,(2004), The New Transit Town: Best Practices in Transit Oriented Developmen,: Island Press.

64 Currie, G. (2006) Bus Transit Oriented Development - Strengths and Weaknesses Relative to Rail, Journal of Public Transportation, Volume 9 No 4.

65 Booz Allen Hamilton (2000), Valuation of Public Transport Attributes, Final Report. Booz Allen Hamilton for Transfund New Zealand.

CONCLUSION



6 CONCLUSION

As cities grow in size and population, it is common for the roles and functions served by the existing transport network to change and evolve, particularly, in the light of new transport proposals. Many modern cities, including those in Australia, have found it is often no longer sufficient to rely on a single mode of transport to meet all the different user needs in a transport corridor.

The appraisal of transport corridors in Sydney and Melbourne undertaken in this study demonstrate the need to make detailed and informed assessments before committing to a mode. The appraisals revealed similarities between the corridors but showed that a one-size-fits-all approach to modal selection could result in a sub-optimal solution.

Our analysis has shown that governments around Australia should adopt a mode-neutral stance at the early stages of transport projects. The justification for the eventual mode, or modes, selected should be clear, complete and made public. Once a mode is selected, it should be pursued vigorously through planning and procurement on a strong foundation that the most appropriate option has been selected.

Developing Metropolitan Corridor Plans in a mode neutral environment will allow policymakers to identify, protect and preserve strategic corridors. Metropolitan Corridor Plans will also allow state and local governments to identify growth in existing corridors, allowing for better planning of future modal additions and duplications. A consistent approach to corridor planning, through Metropolitan Corridor Plans, will give governments a coherent and detailed basis for future modal decisions – thereby reducing modal bias to arrive at the best transport planning and prioritisation decisions.

We have presented three examples of international best practice for integrated multi-modal transport. The lessons learnt focused on the key ingredients of transport integration and how different modes of transport work together to successfully deliver services for the user. All three cities – London, Hong Kong and Singapore – have delivered integrated transport by achieving integration at both the strategic and practical level of transport planning and service delivery, including:

- Institutional Integration;
- Physical Integration;
- Network Integration;
- Information Integration; and
- Fare Integration.

For the benefits of alternative modes to be realised in an integrated transport environment, the governance of transport appraisals also needs to be revisited. Historically, the majority of state-based transport appraisals in NSW have been conducted in accordance with single mode appraisal guidelines. For transport integration of multi-modal services to be taken seriously, it is essential that appraisal guidance encourages identification of alternative modes and explores them during the optioneering stage of transport appraisals.

This paper has been undertaken primarily at a strategic level, for illustrative purposes, to demonstrate that we cannot rely solely on single mode projects in strategic transport corridors and that a mix of transport modes are required to meet the different transport needs of the users. Further research and analysis could be undertaken to build a more comprehensive case for integrated multi-modal transport, for example:

- Considering different combinations of multi-modal transport within the corridor (e.g. other multi-modal options could consist of bus movements, bus-rail movements, car rail-movements)[66];
- Undertaking further research to test the sensitivity of the parameters and the fares on the two case studies;
- Examining other strategic corridors in Sydney (e.g. North West corridor in Sydney, North Shore and South West) and Melbourne (e.g. the Western corridor to Geelong and the Northern suburbs);
- Extending the analysis to other capital cities by, for instance, looking at other strategic corridors in Brisbane, Adelaide or Perth; and
- Extending the analysis to international capital cities in Europe, Asia and North America.

The development of a truly integrated transport network remains a challenge for most Australian cities. However, increasing awareness of successfully integrated networks around the world – through both international travel and environmental concerns – has put the need for transport integration and multi-modal services at the top of the transport planning agenda.

66 Except for the combination of light rail with bus and heavy rail, and ferry with heavy rail in the Sydney corridor and light rail with heavy rail in Melbourne.

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APPENDIX 1. CORRIDOR ASSESSMENT METHODOLOGY

APPENDIX 1. CORRIDOR ASSESSMENT METHODOLOGY

As outlined in Chapter 4, our assessment explores the relative costs of a number of transport modes servicing the Sydney based and Melbourne based corridors. Estimates of generalised trip costs (GTC) are used to explore these relative costs. An overview of the methodology applied when estimating generalised trip costs is outlined to the right.

A1.1 Generalised Trip Cost Calculations

As an overview, the analysis calculates the GTC of each transport mode over the total distance of the corridor. The data is presented in graph form to illustrate how the most cost-effective mode changes as the distance travelled increases.

The generalised trip cost values provide an estimate of the "total cost" of a journey taking into account factors such as:

- Fare price (for public transport trips)
- Vehicle operating costs (for private vehicles)
- Travel time
- Access and egress time
- Transfer time
- Wait time

The generalised trip cost calculation elements for each mode of the Sydney corridor is further explained in Table A1-1.

TABLE A1-1 Sydney corridor GTC Calculation Elements

Mode	GTC Calculation Elements
Private vehicle (car)	• Vehicle operating costs – calculated as per Austroads Guide to Project Evaluation Part 4 • All day average parking costs – estimated at $35 per day[67] • Travel time – estimated applying a peak average travel speed of 36 kph[68]
Walking	• Travel time – estimated applying an average walking speed of 4.8 kph[69]
Cycling	• Travel time – estimated applying an average cycling speed of 19 kph for the first 19 km and of 12.5 kph for the rest of the journey • Cycling vehicle operating costs – based on value presented at the 'Thinking on Two Wheels Cycling Conference' equivalent to $0.29 per vkm
Ferry	• GTC estimates for ferry are based on travel between Circular Quay and Parramatta by ferry and Parramatta to Penrith by train. • Fare – as per Sydney Ferries standard fares • Travel Time – as per Sydney Ferries timetable • Access and Egress Time – based on average values taken from The NSW Department of Planning Transport and Population Data Centre • Transfer Penalty – see Table A1-3 • Wait Time – calculated taking half the average time between services
Heavy Rail	• Fare – as per City Rail standard fares • Travel Time – as per City Rail timetable • Access and Egress Time – based on values taken from The NSW Department of Planning Transport and Population Data Centre • Transfer Penalty – see Table A1-3 • Wait Time – calculated taking half the average time between services
Light Rail	As the light rail network currently only covers 6.7km (from Central to Lilyfield), the remainder of the journey was assumed to be undertaken by bus (from Lilyfield to Petersham) and heavy rail (from Petersham to Penrith, plus an additional transfer to an express rail service at Parramatta). • Fare – as per Sydney Light Rail standard fares • Travel Time – as per Sydney Light Rail transport timetable • Access and Egress Time – based on average values taken from The NSW Department of Planning Transport and Population Data Centre • Wait Time – calculated taking half the average time between services
Bus	In many instances, there are no direct bus services between many of the key locations further along the corridor (e.g. Penrith, Mt Druitt and Blacktown) and the CBD. As a result, typically one or more transfers are required. For example, a bus trip from Penrith to the Sydney CBD requires travel on three separate bus routes as outlined below: 1. Route 776 bus from Penrith Railway Station to St Marys Railway Station 2. Route 745 bus from St Marys Railway Station to Castle Hill Interchange 3. Route M61 bus from Castle Hill Interchange to Sydney CBD The generalised trip costs are calculated based on: • Fare – as per Sydney Buses standard fares • Travel Time – as per Sydney Buses timetable • Access and Egress Time – based on average values taken from The NSW Department of Planning Transport and Population Data Centre • Transfer Penalty – see Table A1-3 • Wait Time – calculated taking half the average time between services

67 Based on the analysis presented at: http://www.cbre.com.au/NR/rdonlyres/BCAB4BE0-A000-412F-A891-6853E01F485A/726328/CarParkingViewPoint.pdf

68 Based on RMS estimates of average travel speeds, available from http://www.rta.nsw.gov.au/publicationsstatisticsforms/downloads/annual_speed_and_traffic_volume_data_2009-2010.pdf

69 Based on the analysis presented within Aspelin, K (2005) "Establishing Pedestrian Walking Speeds. Portland State University.

Table A1-2 outlines the generalised trips cost calculation elements for the Melbourne corridor.

TABLE A1-2 Melbourne Corridor GTC Calculation Elements

Mode	GTC Calculation Elements
Private vehicle (car)	• Vehicle operating costs – calculated as per Austroads Guide to Project Evaluation Part 4 • All day average parking costs – estimated at $14 per day[70] • Travel time – estimated applying an peak average travel speed of 41 kph[71]
Walking	• Travel time – estimated applying an average walking speed of 4.8 kph[72]
Cycling	• Travel time – estimated applying an average cycling speed of 19 kph for the first 17 km and of 12.5 kmh for the rest of the journey • Cycling vehicle operating costs – based on value presented at the 'Thinking on Two Wheels Cycling Conference' equivalent to $0.29 per vkm
Heavy Rail	• Fare – as per Metcard 2 hour standard fares • Travel Time – as per Metlink timetable • Access and Egress Time – based on average values taken from Sydney access and egress time values • Transfer Penalty – see Table A1-3 • Wait Time – calculated taking half the average time between services
Light Rail/Tram	As the light rail network does not cover the full length of the corridor under consideration, running only from the CBD to Caulfield, the remainder of the journey from Oakleigh to Pakenham was assumed to be by heavy rail. • Fare – as per the Metcard 2 hour standard fares • Travel Time – as per Yarra Trams transport timetable • Access and Egress Time – based on average values taken from Sydney access and egress time values • Wait Time – calculated taking half the average time between services
Bus	In many instances, there are no direct bus services between many of the key locations along the corridor and the CBD. Many of the bus routes along this corridor link into other transport modes or service local shopping centres and major routes across suburbs. As a result, typically one or more transfers are required. For example, a bus trip from Berwick to the Melbourne CBD requires travel on three separate bus routes as outlined below: 1. Route 828 bus from Berwick Railway Station (Reserve Street) to Dandenong Railway Station (Foster Street) 2. Route 901 bus from Dandenong Railway Station (Foster Street) to Doncaster East (Beverley St/Blackburn Rd) 3. Route 906 bus from Doncaster East (Beverley St/Blackburn Rd) to Melbourne CBD The generalised trip costs are calculated based on: • Fare – as per the Metcard 2 hour standard fares • Travel Time – as per Metlink timetable • Access and Egress Time – based on average values taken from Sydney access and egress time values • Transfer Penalty – see Table A1-3 below • Wait Time – calculated taking half the average time between services

70 Source: http://www.wilsonparking.com.au/go/wilson-car-parks/vic/melbourne-central.
71 Tranter, P (2004), Effective Speeds: Car Costs are Slowing Us Down, Australian Greenhouse Office.
72 Based on the analysis presented within Aspelin, K (2005), Establishing Pedestrian Walking Speeds, Portland State University.

The Value of Time

Calculating the GTC for each mode requires the monetisation of time. A value of $0.21 per minute (2010 value) has been applied as per the travel time values outlined in Austroads Guide to Project Evaluation Part 4 (updated to 2010 dollars using an average annual inflation rate of 3.0%).

Standard Weightings

As the value of time, as outlined previously, differs for each aspect of the journey, standard weightings have been applied to take into account these differences. Table A1-3 outlines the standard weightings that have been applied in the analysis. These values are consistent with those outlined in both The National Guidelines for Transport System Management in Australia and the UK Department for Transport WebTAG Guidelines.

TABLE A1-3 Standard Weightings

Item	Weighting/Value
In-vehicle time	x 1
Access time	x 2
Egress time	x 2
Transfer time penalty	Bus – Bus: equivalent to 13 minutes LRT – Bus: equivalent to 19 minutes [1] LRT – Heavy Rail: equivalent to 10 minutes Heavy Rail – Heavy Rail: equivalent to 10 minutes [1] Ferry – Heavy Rail: equivalent to 13 minutes
Wait time	x 2

Note: [1]Currie G (2005), "The Demand Performance of Bus Rapid Transit", Journal of Public Transportation, Volume 8, No.1, pp 41—55, http://www.nctr.usf.edu/jpt/pdf/JPT%208-1%20Currie.pdf; and Booz Allen Hamilton (2000), Valuation of public transport attributes, Final Report. Booz Allen Hamilton for Transfund New Zealand.

APPENDIX 2. CORRIDOR ASSESSMENT DETAILED RESULTS

APPENDIX 2. CORRIDOR ASSESSMENT DETAILED RESULTS

A2.1 Penrith to Sydney CBD Detailed Results

Outlined below in Table A2-1 to A2-7 are the generalised trip cost calculations and estimates for the Penrith to Sydney CBD corridor.

TABLE A2-1 Generalised Trip Cost Estimates for Ferry Trips

Ferry									
Origin	Distance	Travel Time	Access Time	Average Wait Time	Egress Time	Average Interchange Time	Total Generalised Travel Time	Fare ($)	Generalised Trip Cost Estimate
Penrith	55	127	33	25	7	13	269	$ 11.20	$ 66.76
Mt Druitt	44	94	30	29	7	13	238	$ 11.20	$ 60.29
Blacktown	34	80	31	26	7	13	221	$ 10.60	$ 56.26
Parramatta	23	74	14	23	7		161	$ 6.60	$ 39.78
Rydalmere	17	54	14	23	7		141	$ 6.60	$ 35.65
Cabarita	12	39	14	23	7		126	$ 6.60	$ 32.56
Abbottsford	10	34	14	18	7		112	$ 6.60	$ 29.77
Chiswick	9	29	14	7	7		85	$ 6.60	$ 24.03
Huntleys Pt	8	26	14	7	7		82	$ 6.60	$ 23.42
Drummoyne	6	20	14	6	7		74	$ 6.60	$ 21.89
McMahons Pt	2	7	14	5	7		59	$ 5.30	$ 17.44
Milsons Pt	2	5	14	5	7		57	$ 5.30	$ 17.03

TABLE A2-2 Generalised Trip Cost Estimates for Bus Trips

Bus									
Origin	Distance	Travel Time	Access Time	Average Wait Time	Egress Time	Average Interchange Time	Total Generalised Travel Time	Fare ($)	Generalised Trip Cost Estimate
Penrith	55	160	18	15	7	26	266	$ 6.30	$ 61.24
Mt Druitt	43	124	15	14	7	26	222	$ 6.30	$ 51.99
Blacktown	36	85	16	5	7	13	154	$ 6.30	$ 37.98
Parramatta	24	83	14	5	7	13	148	$ 6.30	$ 36.90
Lidcombe	19	85	12	3	7	26	154	$ 5.70	$ 37.47
Strathfield	14	55	13	2	7		99	$ 5.10	$ 25.57
Redfern	4	26	11	3	7		68	$ 2.00	$ 15.95
Central	3	18	11	1	7		57	$ 2.00	$ 13.71

TABLE A2-3 Generalised Trip Cost Estimates for Heavy Rail Trips

Heavy Rail									
Origin	Distance	Travel Time	Access Time	Average Wait Time	Egress Time	Average Interchange Time	Total Generalised Travel Time	Fare ($)	Generalised Trip Cost Estimate
Penrith	55	96	18	2	7		150.4	$ 6.00	$ 37.02
Mt Druitt	43	63	15	6	7		119.1	$ 6.00	$ 30.55
Blacktown	36	50	16	4	7		102.9	$ 6.00	$ 27.23
Parramatta	24	43	14	2	7		91.3	$ 4.60	$ 23.43
Lidcombe	19	38	12	3	7		80.8	$ 4.00	$ 20.66
Strathfield	14	31	13	1	7		73.9	$ 4.00	$ 19.24
Redfern	4	11	11	2	7		50.9	$ 3.20	$ 13.69
Central	3	9	11	2	7		48.9	$ 3.20	$ 13.28

TABLE A2-4 Generalised Trip Cost Estimates for Car Trips

Car									
Origin	Distance	Travel Time	Access Time	Average Wait Time	Egress Time	Average Interchange Time	Total Generalised Travel Time	Fare ($)	Generalised Trip Cost Estimate
Penrith	57	95					95	$ 19.42	$ 50.91
Mt Druitt	44	73					73	$ 14.95	$ 41.95
Blacktown	37	62					62	$ 12.60	$ 37.22
Parramatta	24	41					41	$ 8.28	$ 28.53
Lidcombe	20	33					33	$ 6.68	$ 25.32
Strathfield	14	23					23	$ 4.77	$ 21.48
Redfern	4	7					7	$ 1.36	$ 14.64
Central	3	4					4	$ 0.89	$ 13.68

TABLE A2-5 Generalised Trip Cost Estimates for Walking Trips

Walking									
Origin	Distance	Travel Time	Access Time	Average Wait Time	Egress Time	Average Interchange Time	Total Generalised Travel Time	Fare ($)	Generalised Trip Cost Estimate
Penrith	54	670					670		$ 138.17
Mt Druitt	43	540					540		$ 111.36
Blacktown	36	451					451		$ 93.06
Parramatta	24	300					300		$ 61.87
Lidcombe	19	234					234		$ 48.20
Strathfield	14	173					173		$ 35.57
Redfern	4	46					46		$ 9.54
Central	3	34					34		$ 6.96

TABLE A2-6 Generalised Trip Cost Estimates for Cycling Trips

Cycling									
Origin	**Distance**	**Travel Time**	**Access Time**	**Average Wait Time**	**Egress Time**	**Average Interchange Time**	**Total Generalised Travel Time**	**Fare ($)**	**Generalised Trip Cost Estimate**
Penrith	54	257					257	$ 15.53	$ 68.59
Mt Druitt	43	207					207	$ 12.52	$ 55.28
Blacktown	36	173					173	$ 10.46	$ 46.20
Parramatta	24	115					115	$ 6.96	$ 30.71
Lidcombe	19	59					59	$ 5.42	$ 17.60
Strathfield	14	44					44	$ 4.00	$ 12.99
Redfern	4	12					12	$ 1.07	$ 3.48
Central	3	9					9	$ 0.78	$ 2.54

TABLE A2-7 Generalised Trip Cost Estimates for Light Rail Trips

Light Rail									
Origin	**Distance**	**Travel Time**	**Access Time**	**Average Wait Time**	**Egress Time**	**Average Interchange Time**	**Total Generalised Travel Time**	**Fare ($)**	**Generalised Trip Cost Estimate**
Lilyfield	7	25	14	6	7		79	$ 4.40	$ 20.77
Rozelle Bay	6	22	14	6	7		76	$ 4.40	$ 20.15
Jubilee Park	6	21	14	6	7		75	$ 4.40	$ 19.94
Glebe	5	19	14	6	7		73	$ 4.40	$ 19.53
Wentworth Park	5	17	14	6	7		71	$ 4.40	$ 19.12
Fish Market	4	15	14	6	7		69	$ 4.40	$ 18.71
John St. Square	3	13	14	6	7		67	$ 4.40	$ 18.29
The Star	3	12	14	6	7		66	$ 4.40	$ 18.09
Pyrmont Bay	3	11	14	6	7		65	$ 4.40	$ 17.88
Darling Harbour/ Convention	2	9	14	6	7		63	$ 3.40	$ 16.47
Exhibition Centre	2	7	14	6	7		61	$ 3.40	$ 16.06
Chinatown/Paddy's Markets	1	5	14	6	7		59	$ 3.40	$ 15.64
Capitol Square	1	3	14	6	7		57	$ 3.40	$ 15.23

A2.2 Pakenham to Melbourne CBD Detailed Results

Outlined in Table A2-8 to Table A2-13 are the generalised trip cost calculations and estimates for the Pakenham to Melbourne CBD corridor.

TABLE A2-8 Generalised Trip Cost Estimates for Bus Trips

Bus									
Origin	Distance	Travel Time	Access Time	Average Wait Time	Egress Time	Average Interchange Time	Total Generalised Travel Time	Fare ($)	Generalised Trip Cost Estimate
Flinders St Station	2						0	$ –	$ –
Richmond	5	24	14	6	7	13	91	$ 3.70	$ 22.37
South Yarra	5	30	14	6	7	13	97	$ 3.70	$ 23.61
Caulfield	13	67	14	20	7	26	176	$ 3.70	$ 39.90
Oakleigh	18	75	14	15	7	26	173	$ 3.70	$ 39.45
Clayton	24	93	14	17	7	26	196	$ 5.80	$ 46.13
Springvale	29	94	14	12	7	13	173	$ 5.80	$ 41.45
Dandenong	35	115	14	13	7	13	195	$ 5.80	$ 45.99
Berwick	47	158	14	24	7	26	274	$ 5.80	$ 62.38
Packenham	61							$ –	$ –

TABLE A2-9 Generalised Trip Cost Estimates for Heavy Rail Trips

Heavy Rail - Metro									
Origin	Distance	Travel Time	Access Time	Average Wait Time	Egress Time	Average Interchange Time	Total Generalised Travel Time	Fare ($)	Generalised Trip Cost Estimate
Flinders St Station	2	5	14	1	7		48	$ 3.70	$ 13.68
Richmond	5	9	14	1	7		53	$ 3.70	$ 14.60
South Yarra	5	10	14	3	7		59	$ 3.70	$ 15.77
Caulfield	13	24	14	2	7		70	$ 3.70	$ 18.16
Oakleigh	18	29	14	4	7		79	$ 3.70	$ 19.97
Clayton	24	34	14	4	7		84	$ 5.80	$ 23.10
Springvale	29	40	14	4	7		90	$ 5.80	$ 24.33
Dandenong	35	49	14	4	7		99	$ 5.80	$ 26.19
Berwick	47	62	14	13	7		130	$ 5.80	$ 32.67
Packenham	61	73	14	8	7		130	$ 5.80	$ 32.62

TABLE A2-10 Generalised Trip Cost Estimates for Car Trips

Car									
Origin	Distance	Travel Time	Access Time	Average Wait Time	Egress Time	Average Interchange Time	Total Generalised Travel Time	Fare ($)	Generalised Trip Cost Estimate
Flinders St Station	3	5					5	$ 0.90	$ 6.66
Richmond	5	9					9	$ 1.65	$ 8.23
South Yarra	6	10					10	$ 1.77	$ 8.49
Caulfield	15	24					24	$ 4.54	$ 14.32
Oakleigh	20	33					33	$ 6.09	$ 17.59
Clayton	26	43					43	$ 8.05	$ 21.72
Springvale	32	54					54	$ 10.04	$ 25.91
Dandenong	38	63					63	$ 11.79	$ 29.57
Berwick	48	80					80	$ 14.96	$ 36.25
Packenham	63	105					105	$ 19.56	$ 45.94

TABLE A2-11 Generalised Trip Cost Estimates for Walking Trips

Walking									
Origin	Distance	Travel Time	Access Time	Average Wait Time	Egress Time	Average Interchange Time	Total Generalised Travel Time	Fare ($)	Generalised Trip Cost Estimate
Flinders St Station	2	23					23		$ 4.64
Richmond	4	51					51		$ 10.57
South Yarra	5	61					61		$ 12.63
Caulfield	11	143					143		$ 29.39
Oakleigh	17	210					210		$ 43.31
Clayton	21	265					265		$ 54.65
Springvale	26	320					320		$ 65.99
Dandenong	32	401					401		$ 82.75
Berwick	46	571					571		$ 117.81
Packenham	59	743					743		$ 153.12

TABLE A2-12 Generalised Trip Cost Estimates for Cycling Trips

Cycling									
Origin	Distance	Travel Time	Access Time	Average Wait Time	Egress Time	Average Interchange Time	Total Generalised Travel Time	Fare ($)	Generalised Trip Cost Estimate
Flinders St Station	2	6					6	$ 1.00	$ 1.69
Richmond	4	13					13	$ 1.00	$ 3.86
South Yarra	5	15					15	$ 1.00	$ 4.61
Caulfield	11	36					36	$ 3.00	$ 10.73
Oakleigh	17	53					53	$ 5.00	$ 15.81
Clayton	21	102					102	$ 6.00	$ 27.13
Springvale	26	123					123	$ 7.00	$ 32.76
Dandenong	32	154					154	$ 9.00	$ 41.08
Berwick	46	219					219	$ 13.00	$ 58.48
Packenham	59	285					285	$ 17.00	$ 76.01

TABLE A2-13 Generalised Trip Cost Estimates for Light Rail Trips

Light Rail									
Origin	Distance	Travel Time	Access Time	Average Wait Time	Egress Time	Average Interchange Time	Total Generalised Travel Time	Fare ($)	Generalised Trip Cost Estimate
Flinders St Station	2	3	14	3	7		50	$ 3.70	$ 13.99
Richmond	5	17	14	6	7		70	$ 3.70	$ 18.11
South Yarra	5	34	14	3	7		81	$ 3.70	$ 20.38
Caulfield	13	47	14	7	7		104	$ 3.70	$ 25.10
Oakleigh	18	52	14	16	7	10	137	$ 3.70	$ 31.86
Clayton	24	57	14	16	7	10	142	$ 5.80	$ 34.99
Springvale	29	63	14	16	7	10	148	$ 5.80	$ 36.23
Dandenong	35	72	14	16	7	10	157	$ 5.80	$ 38.08
Berwick	47	85	14	16	7	10	169	$ 5.80	$ 40.71
Packenham	61	96	14	16	7	10	180	$ 5.80	$ 42.93

Infrastructure
Partnerships
Australia

8th Floor
8-10 Loftus Street
Sydney NSW 2000
T +612 9240 2050
F +612 9240 2055
E contact@infrastructure.org.au
www.infrastructure.org.au