Report to
City of Sydney

INTEGRATED TRANSPORT STRATEGY–MASS TRANSIT FOR CBD AND INNER SYDNEY

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Binary Consultants Pty Ltd

REPORT TO CITY OF SYDNEY

INTEGRATED TRANSPORT STRATEGY–MASS TRANSIT FOR CBD AND INNER SYDNEY

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- The benefits of using light rail as the basis of a mass transit system
- An outline of proposed light rail routes, why they were selected, how the bus system would be rationalised, and how light rail can facilitate walking and cycling

The Inner Sydney Transport Challenge

Sydney is Australia's global city. At its core lie the City of Sydney and the inner suburbs. This area has the nation's highest concentration of jobs, population and tourist attractions. It is estimated that the City of Sydney alone generates economic activity of $60 billion annually, 8% of the nation's GDP.

Sydney is also Australia's oldest city. Originally built around an extensive tramway and railway network, many of its inner areas were never designed for the car. While its narrow streets and harbour-side setting add to its charm, they also create traffic bottlenecks.

Sydney is also a fast growing city. In the 1990's the City of Sydney added 60,000 jobs, and had the highest population growth rate of any local government area.

The inner suburbs are also growing strongly with the rise of apartment living. International visitors, almost half of whom arrive in Sydney, doubled during the 90's, and the City has three-quarters of all hotel accommodation in the Sydney region.

As a result, the city's transport systems are at capacity. Despite addition of new roads such as the Eastern Distributor, traffic on remaining roads in the inner suburbs grew by 20% in the 1990's. Bus and rail patronage also rose strongly in the last decade, and there are now 7,400 State Transit bus movements, plus growing numbers of private buses and tourist coaches, traversing the CBD daily. Despite the addition of bus lanes, buses typically average less than 10 kph in the city centre. Hundreds of buses travel slowly nose to tail in long queues between Central and Circular Quay every morning and evening. Space for buses to layover between runs is at a premium, with significant congestion in several streets used for bus layovers.

These transport and traffic problems will get worse. Both population and employment in inner Sydney are expected to grow by 20% by 2021, more if there is intensified development along Parramatta Road and in the southern corridor to the airport. The demand for travel within the CBD is estimated to rise by 32% by 2021, while the demand for travel to and from the CBD will rise by 22%. Longer term, the medium migration forecasts suggest Sydney as a whole will grow by 44% to 5.9 million by mid-century.

At the same time, there is rising concern at the environmental and health impacts of transport. Mobile sources account for 80% of Sydney's emissions of nitrogen oxides, almost 50% of volatile organic compounds, and 20% of particulates. Diesel-powered vehicles are a major source of particulates and NOx, as well air toxics, such as toluene and benzene.

Walking has been in decline in Sydney for some time, whilst cycling plays a very minor role for most people. Growing obesity levels and their health effects are one side effect of the lack of regular exercise by large numbers of people. Cars are a major cause of this – whereas half of all walking trips are part of a public transport journey, cars tend to substitute for walking. In addition the growing volume of traffic makes cycling all but impossible except for the few cycle paths available in the inner suburbs.

Continuing to rely on current surface transit options, in particular on cars and buses, will become increasingly inefficient and unworkable. This will erode the amenity of the city and undermine its economic potential.

Inner Sydney needs a world-class transport system if Sydney is to remain a world-class city.

Goals and Objectives of the Strategy

A new integrated transport strategy is needed to achieve a world class transport system. Key goals for this strategy are to:

- Enhance Sydney's role as Australia's economic powerhouse
- Cater for future growth in travel demand whilst minimising the adverse congestion, environmental and health impacts of travel
- Increase the share of trips by walking, cycling and public transport and to reduce the share by car
- Improve the efficiency and appeal of the public transport system for inner Sydney and the CBD.

Specific objectives to achieve these goals are:

- To improve footpaths and increase the amount of pedestrianised streets in the city centre
- To provide a set of safe cycling routes throughout the inner suburbs and the CBD, enabling cyclists to access regional cycleway networks and major activity generators such as universities, employment and retail centres and major recreational facilities.
- To increase the capacity of the on-street public transport system linking the inner suburbs to the CBD by at least 35% by 2021 and 60% by 2051
- To reduce the number of buses entering the CBD daily by at least a third, and to reduce the number of buses travelling on key north-south routes through the CBD by at least 50% by 2021, compared with a "business as usual" scenario.
- To improve cross-regional public transport services throughout the inner suburbs, to allow more local car trips to be taken by public transport
- To encourage travel demand management measures to reduce the need for inner suburban residents to own and use private cars.

Key Elements

Key elements of a strategy to tackle these objectives include:

- **Developing a new mass transit network** in the CBD and on key corridors linking the city with the inner suburbs. Potential corridors include:
  - CBD to Maroubra Junction via UNSW
  - CBD to Burwood via Lillyfield
  - CBD to Mascot via Green Square
  - CBD to Burwood via Parramatta Road
  - CBD to Bondi via Bondi Junction.
- **Re-organising bus routes** to act as feeders, and to increase the number of cross-regional bus services.
- **Improving the integration** of all modes through high quality interchanges, integrated ticketing and fares and real-time information.
- **Limiting parking levels** in the CBD in commercial parking stations at current levels and providing incentives for developers to minimise the amount of parking provided for new development generally in the city.
- **Providing additional park and ride opportunities** at strategic locations in the inner suburbs, especially on light rail routes, to encourage current car drivers to make at least part of their journeys on public rather than driving right into the city centre.
- **Providing wider footpaths and cycle lanes** in city streets and other locations in conjunction with the establishment of the light rail system.
- **Adding at least one kilometre** of fully pedestrianised streets to the city centre by 2021.
- **Supporting the development of car-sharing, individual travel marketing schemes and travel demand management strategies.**

Routes and Staging

The five proposed mass transit corridors were developed by analysing current patronage volumes, ease of implementation, future growth potential and the existence of competing heavy rail systems. Within the CBD, three potential alignments have been identified: George Street (2- way); Castlereagh Street (2-way); and Pitt and Castlereagh (Figure 8). Eventually both the George Street route and one of the other two routes will be needed for capacity reasons. The formal choice of routes and the staging of construction are subject to discussion with State and Local Governments and other key stake-holders and further analysis of traffic and other issues.

Benefits from the Strategy

The proposed strategy will:

- Reduce buses coming into the city by 36%, reduce the number of buses in north-bound streets by 54% compared with a "business as usual" situation, and reduce the pressure on the heavy rail system.
- Increase capacity of the inner Sydney public transport network to enable it to cater for growth and a shift from cars
- Improve amenity and maintain Sydney's world city status, supporting the economic growth of the entire Sydney region
- Facilitate walking and cycling in the City and Inner Suburbs

Rationale for Mode Choice

Continuing to rely on the current bus based system into the future is not considered sustainable or desirable:

- Buses are already a major source of noise and emissions in the city centre
- The anticipated growth in demand would mean over 9,400 State Transit buses alone driving through the city centre on weekdays by 2021
- Bus congestion is already bad. The system is inefficient despite the use of bus lanes, and will worsen with more buses and traffic
- Buses operating in mixed traffic are slow and unreliable and not likely to attract customers out of their cars.
- Continuing with the "Business as Usual" approach of trying to squeeze more buses into the city centre will result in potential loss of economic activity to Sydney, which competes with other world cities on the basis of its quality of life.

Options for improving the quality and capacity of mass transit in the CBD and inner suburbs include:

- Articulated buses and guided buses
- Light Rail
- Underground metro rail
- Various forms of above ground automated systems.

These alternatives have been evaluated in various studies. For example:

- Walsh and Associates (2002) found that light rail was the preferred mode, scoring highest on the criteria of capacity, external impacts, and service quality, and overall.
- Parsons Brinkerhoff (2004b) compared continuing with current buses, introducing high capacity buses and light rail. Light Rail was found to be the best or equal best option in 11 of the 12 criteria used.
- Studies by the Department of Infrastructure, Planning and Natural Resources found metro rail, followed by light rail, to be the preferred modes for five key corridors from the inner suburbs to the CBD. However only the northern corridor requires metro rail capacity.

Overseas experience clearly backs light rail as the preferred mode for these types of applications:

- In the last decade, over 100 cities world wide have built new light rail systems or expanded their existing systems. By contrast, only around ten cities have adopted guided bus technologies.
- Light rail vehicles have higher capacity than guided buses, and hence lower operating costs.
- The UITP committee on Light Rail and Guided buses found little difference in capital cost between the modes if electrification and full priority is to be provided. These characteristics are essential to a high quality, high capacity system for inner Sydney.
- Guided bus systems are still under development, with technical problems being experienced by some systems. The different guidance systems are also incompatible, meaning that a city adopting one system will be limited to a single manufacturer to supply future vehicles.

Light Rail has therefore been identified as the key element of the strategy to boost the capacity and quality of the mass transit system for the inner suburbs and CBD:

- It is the most appropriate mode given the nature of the transport task and the environmental and other conditions in the area
- It is affordable and cost-effective
- It is backed by experience elsewhere
- It is designed to be completed in a fifteen year timeframe.

CHAPTER 1: INTEGRATED TRANSPORT STRATEGY

Inner Sydney is crucial to maintaining Sydney as Australia's world city. Rapid growth in the 1990's has left all transport systems close to capacity. Street space is in especially short supply. The need to expand capacity to meet future growth and to improve environmental outcomes demands a new integrated transport strategy.

The Inner Sydney Transport Challenge

Sydney City is the traditional heart of Australia's global city: It has the highest concentration of jobs in the country, with over 350,000 people working inside the City's new boundaries. It generates $63 billion in economic activity, 8% of national income, and almost a third of Sydney's Gross Regional Income.

It is the also the most important tourist destination in Australia, with the seven most popular international tourist destinations in the country and two-thirds of the total tourist accommodation in the Sydney region.

The 1990's saw unprecedented growth:

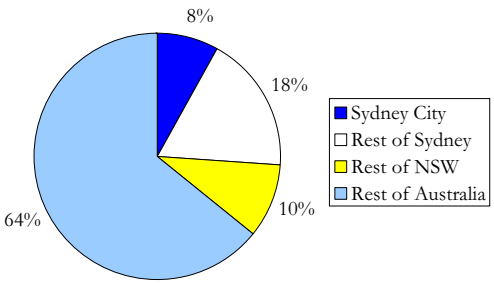
- Employment in the CBD rose from 200,000 to 260,000, or by 30%
- Sydney City (old boundaries) had the fastest population growth of any Local Government Area in the country in the 1990's
- International tourism to Australia doubled, with almost half of all arrivals coming through Sydney airport.

While Sydney is Australia's largest and most dynamic city, it is also our oldest. Sydney's harbour-side charm and narrow streets provide a unique environment but also pose a major transport challenge.

The limited space in the CBD and indeed throughout the inner suburbs makes Sydney particularly vulnerable to traffic congestion. As people have returned to the city, and as activity increases, our growing reliance on the car is threatening both the quality of life and economic efficiency.

A new integrated transport strategy is needed to address this challenge. Sydney needs a world class transport system if it is to remain a world class city. While there are important transport needs across the Sydney region, the specific characteristics of inner Sydney demand a particular response for this important area.

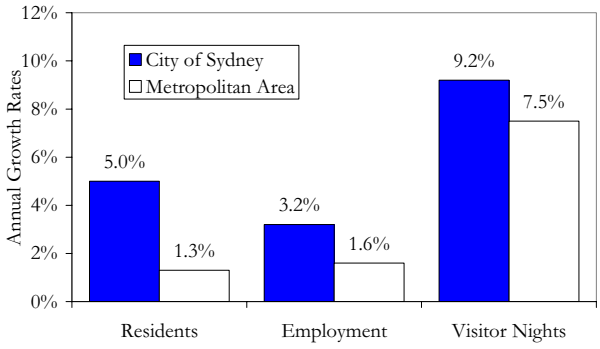
Share of National Income



Source: City of Sydney and ABS

Sydney is Australia's Global City

Growth Rates in Sydney City vs Metropolitan Area 1991-2001



Source: City of Sydney and ABS. Uses City of Sydney boundaries as at 2001, before incorporation of South Sydney and parts of Leichhardt.

A Little History

Australia's earliest European settlement grew up rapidly to become the major city. Sydney was fortunate in developing an extensive heavy rail and tramway system during the last decades of the 19th and the first decades of the 20th century. Patronage on both systems grew rapidly, with 400 million passengers using what was one of the largest street-based tramway systems in the world in the 1940's.

In common with many other cities ranging from Brisbane to London, the trams were removed in the 1950's under the prevailing philosophy of car-based transport, and replaced with buses which were considered more flexible. However even today, State Transit Authority buses carry fewer than half the number of people once carried by the trams. Indeed, the buses both suffer from and contribute to growing road congestion.

Many other cities around the world have come to regret removing their trams, and have begun to re-install them in the form of modernised light rail systems. Examples range from Paris, London and Strasbourg, to Philadelphia, New Orleans and Pittsburgh. Other cities, such as many of the rapidly growing metropolises in Asia which never had trams, have installed totally new systems.

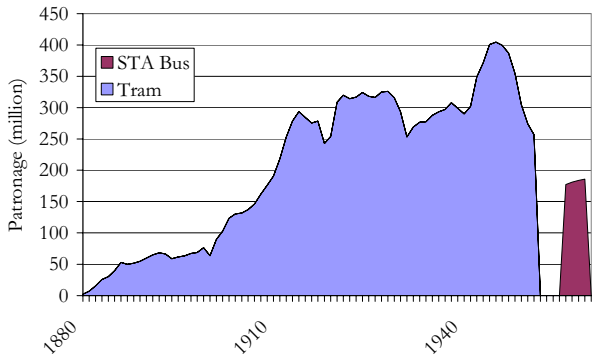
This follows a world wide trend to recapture the cities for pedestrians and to improve environmental quality and urban amenity, which have been eroded under the onslaught of ever rising traffic. Light rail and tramway systems are seen as having the capacity and environmental benefits to revitalise on-street transport networks, and to complement underground or in some cases overhead rail based systems in larger cities.

Sydney now stands at a crossroads. With over $10 billion invested in motorways in the last decade, Sydney has not solved its rising traffic problem. Indeed, this has helped encourage a mode shift away from public transport, walking and cycling, and fuelled growth in traffic. This has been exacerbated by a rapid rise in car use and car ownership, with record car sales in the last few years.

Most transport commentators have concluded that the trends in Sydney are undesirable from an environmental, social and economic perspective, and are unsustainable into the future. A shift in the balance of our transport investment is now urgently required.

Trams at Randwick on Race Day

Patronage on Sydney's Trams and STA Buses



Croydon Tramlink in London. London is one of many cities to reinstall Light Rail after previously closing down their Tramway Systems

Transport Systems are at Capacity

The growth in population, employment, tourism and education in inner Sydney has led to rapid growth in traffic and in public transport use, especially on key approaches to the CBD:

- **Traffic** in the inner suburbs has grown by 20% since the late 1980's, not counting traffic on new roads such as the Eastern Distributor and M5 East. While these roads have provided relief on certain parallel routes such as Bourke and Crown Streets, they have increased traffic generally and encouraged a shift away from public transport.
- **CityRail patronage** also increased sharply in the late 1990's, with morning peak exits at the seven CBD stations increasing from around 108,000 in the early 1990's to around 130,000 after 2000.
- **Bus patronage** on State Transit Authority buses has increased from around 170 million p.a. during the 1980s and early 1990's to around 190 million now.

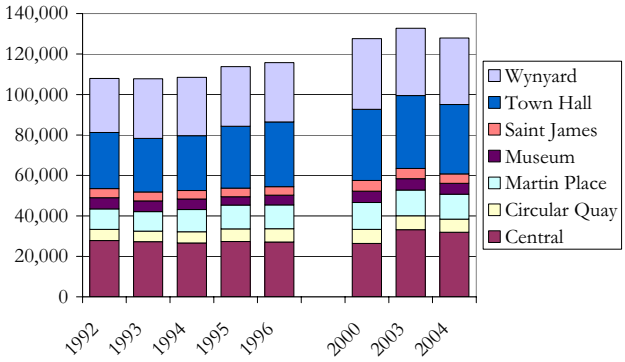
As a result, there is limited capacity left in the transport systems in peak periods:

- Travel speeds in the CBD are low. While the Cross-City tunnel will provide some relief, the relentless growth in traffic is likely to erode these benefits over time unless measures are taken to limit traffic and shift some trips to public transport, walking and cycling.
- Rail lines are expected to be at peak capacity by 2015 – 2020 when additional trains from the Eastern Suburbs, Southern Suburbs, South-Western Suburbs and North-Western Suburbs will use up the current (limited) space capacity and that to be added by the clearways program and the addition of the Epping – Chatswood line. The longer term answer will be the addition of a new north-south rail link through the CBD from Central to Chatswood. This will however mainly assist longer distance travellers from the middle and outer suburbs.
- Platforms at Town Hall in particular are close to capacity in peak periods and there is limited capacity to improve this until a new north-south rail line is built through the city.

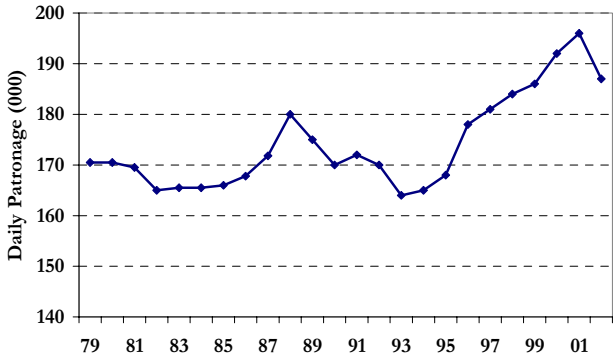
The problems for on-street transport and for buses are particularly apparent:

- Streets in the CBD, particularly the key north-south streets, are clogged with buses. Notwithstanding the introduction of bus lanes, bus speeds are below

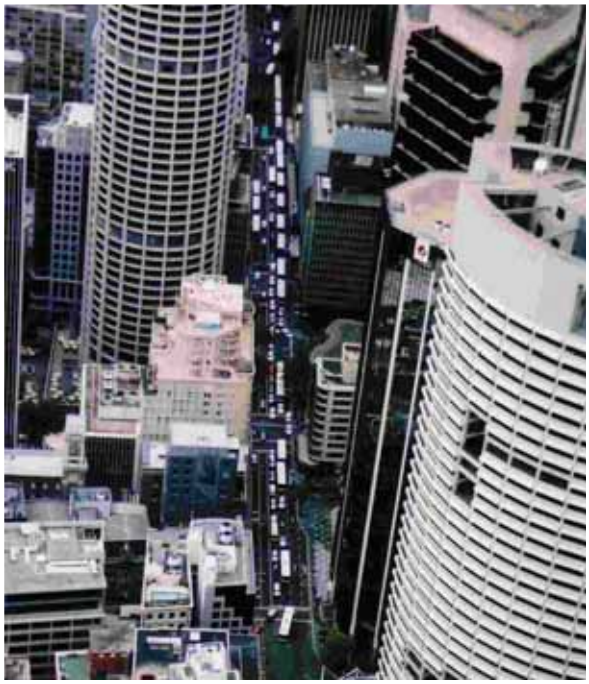
AM Peak Exits at CBD Stations



STA Bus Patronage



Buses Nose to Tail in George Street in the morning peak. Twenty-five buses are visible within a few blocks.



10 kph between Central and Circular Quay in peak periods, tying up hundreds of buses and drivers every morning and evening.

- There is also a lack of space for bus layovers. Already State Transit buses occupy large amounts of space at Circular Quay and the Queen Victoria Building. The situation is compounded by the rise in the number of private buses entering the city from the north. Lack of space at Wynyard (and now around the Queen Victoria Building) is forcing more and more of these buses all the way up George Street to Central.
- Travel times are unpredictable and bus bunching frequently occurs, meaning that a service with a nominal frequency of 10 minutes effectively can become 20 minutes. Bus travel times from Central to Circular Quay can be up to 35 minutes despite the introduction of bus lanes. There have been many reports of insufficient capacity on the bus system in recent years, and of passengers left at the roadside unable to board overcrowded buses.
- The large number of bus routes through the city makes the system difficult to understand, even for regular users, but more particularly for tourists and other visitors.

Environmental and Health Issues

The growth in traffic has already had a significant impact on amenity, health and the quality of life, with major campaigns by residents objecting to the location of ventilation stacks from road tunnels.

Mobile sources account for almost half of the emissions of volatile organic compounds, 80% of nitrogen oxides, and almost 20% of particulates. Diesel-powered vehicles in particular contribute to nitrogen oxides and particulates emissions, as well as being a major source of air toxics such as Xylenes, Toluene, Styrene, PAH's, Formaldehyde, Ethylbenzene and Benzene.

Concentrations of these chemicals are a particular issue in inner city streets where large numbers of buses operate, and where the highest concentrations of pedestrians occur.

In addition, buses are a major source of noise in the CBD and along major arterials. With 7,400 State Transit Buses alone, as well as increasing numbers of private buses and tourist coaches driving through the city daily, the amenity of the city is significantly impacted.

At a wider level, there is growing concern at obesity and its related health effects in Australia. Whereas public transport trips almost always involve a walking component (half of all walk trips are associated with a

Finding layover space for buses is a problem

ease QVB bus jams

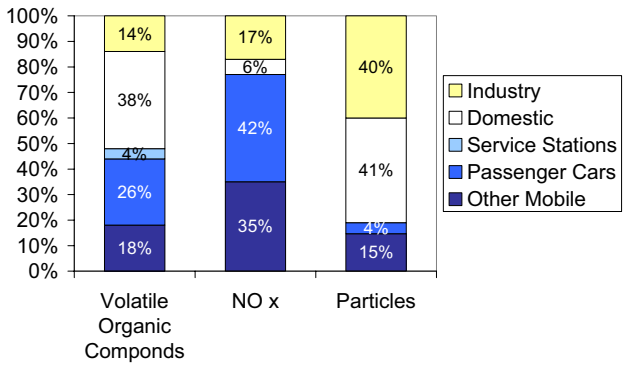
Joseph Kerr
Transport Reporter

Some buses will be moved on from the city's crowded heart from tomorrow, as drivers are fed up with having to drive in circles in the streets around the Queen Victoria Building because they cannot find a park.

Source: Sydney Morning Herald, October 2004

Buses Around the Town Hall and Queen Victoria Building

Sources of Air Pollution in Sydney



Source: Department of Environment and Conservation, 2004

public transport trip), car trips act as a substitute for walking. The high and growing volume of traffic on inner city streets has all but made cycling impossible except for a few isolated locations where cycle paths are available. There is an urgent need to increase the amount of space available for both pedestrians and cyclists and to improve the amenity and safety for those engaging in active transport.

The City of Sydney is developing a cycling strategy to assist in this regard, and some steps have been taken over the years to close selected streets in the city to traffic, including Martin Place, Hay Street, and the Pitt Street Mall. However Sydney lags well behind leading cities overseas, which have up to four times more pedestrianised streets than Sydney.

It is interesting that many of the cities which are leading in this respect also have major tourist industries. If Sydney is to maintain its international appeal, it will need to keep up with other world cities or face the possibility of losing valuable tourist revenue, including from the growing conference tourism and business tourism markets.

The importance of improving pedestrian space, safety and amenity is underlined by the fact that there are 550,000 pedestrian trips daily in Central Sydney, and that these make up 85% of all trips.

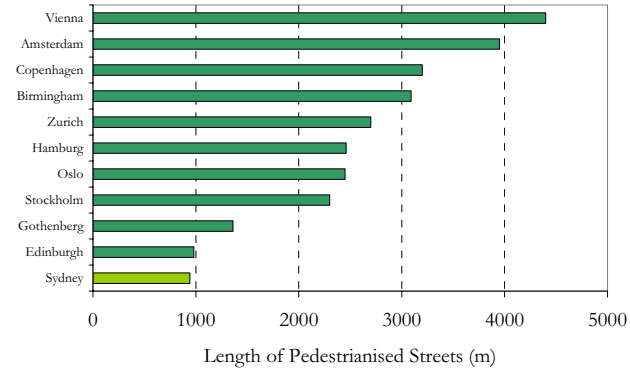
Future Growth in the Travel Task

While there has been a pause in the growth in travel demand in Inner Sydney since the Olympics-related peak in 2000/2001, it can confidently be expected that growth will resume:

- Tourism is already recovering, with visitor arrivals now at record levels and hotel occupancy running at high levels
- Residential construction has continued at a high level, although somewhat lower than in the height of the boom. The Department of Infrastructure, Planning and Natural Resources (DIPNR) forecasts population in the City of Sydney (new boundaries) will grow from 140,000 to 180,000 or by 30%.
- There are signs of a resurgence in office occupancy rates and interest from developers in office construction. There are currently over 700 sites in the CBD capable of redevelopment which could produce an additional 2 million sq. m. of floor-space, not including recently announced office development at the Darling Harbour East wharves.

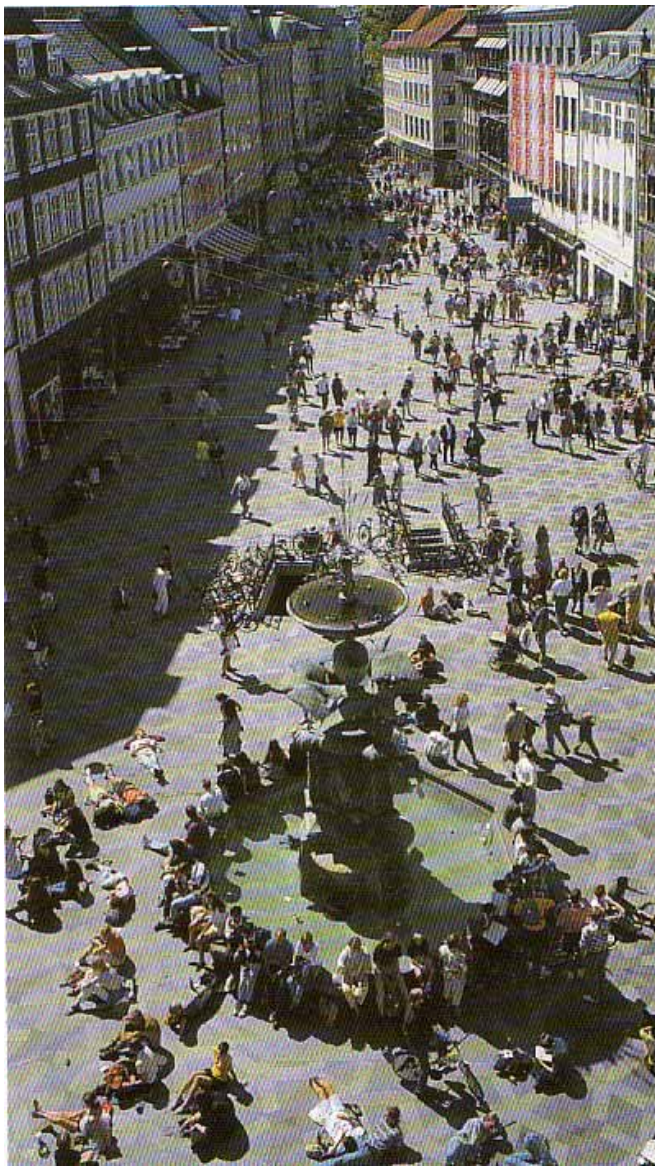
Latest forecasts by DIPNR indicate that:

Length of Pedestrianised Streets in Selected Cities



Source: Gehl and Gemzoe.

Pedestrianisation in a Town Centre - Copenhagen



- Employment in the CBD is expected to grow by 20% by 2021
- Population in the inner suburbs is also expected to grow by 20% in that timeframe
- These growth rates will be even faster under the Parramatta Road scenario, which assumes accelerated growth in that corridor. Very significant growth is also expected in the southern corridor between the city and the airport.
- Sydney as a whole is expected to grow from 4.1 million to 5.9 million by 2051 (44% growth) on the medium migration scenario (DIPNR 2004).

Estimates of travel demand (Martin Walsh and Associates, 2002) indicate that there is likely to be growth by 2021 of :

- 22% in trips between Central Sydney and areas outside it (including both inner and outer suburbs).
- 32% increase in internal travel within the CBD.
- 25% increase in the overall travel market to, from and within Central Sydney to almost 2 million trips per day (by all modes).

If traffic growth is to be slowed or reversed, then the growth rates for public transport, walking and cycling must be higher than these.

Implications of "Business as Usual"

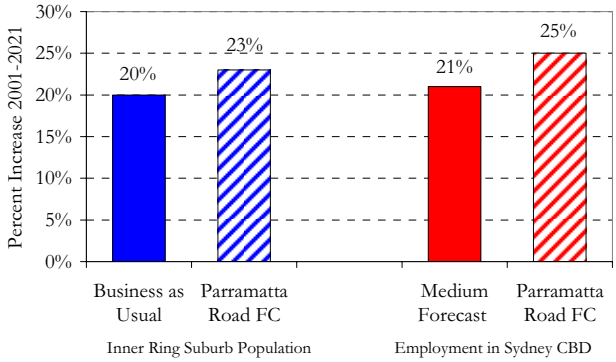
What is likely to happen if we continue to take a "business as usual" approach? The data suggests that:

- Traffic will continue to grow rapidly, congestion will worsen and travel times will increase.
- Public transport will become more crowded and less efficient. The number of buses entering the CBD will rise. Already there are 7,400 STA buses entering or leaving the CBD daily. This would rise to around 9,400 by 2021 to cater for growth and a small increase in mode share.
- The city's accessibility and amenity will decline.

Under this scenario, it is likely that business would suffer in the city, and Sydney will lose out on international investment, jobs and economic activity.

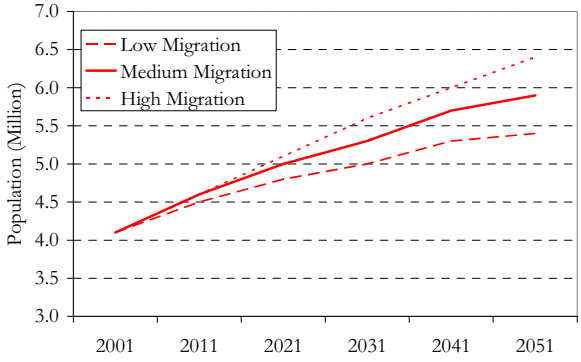
Sydney's main competitors are overseas world cities, rather than regional centres in NSW or other State capitals. Modern financial and other businesses can readily relocate to cities which offer the best overall business climate and quality of life, the key to attracting and holding staff in a globally competitive world.

Forecasts to 2021 for Inner Sydney



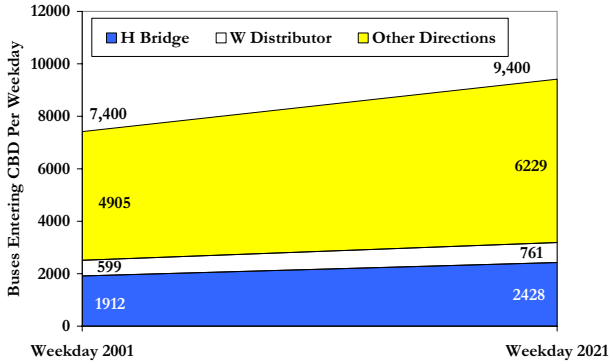
Source: DIPNR 2004

Population Growth in Sydney to 2051



Source: DIPNR 2004

Estimated Number of State Transit Buses travelling to and from CBD on a weekday



As London discovered, there are long-term costs of inaction on transport. Their response has been to introduce a congestion charge to free up the city, improve its amenity, and to encourage a shift to public transport. Sydney will need to be pro-active if it is to compete with other global cities

Integrated Transport Strategy

A new Integrated Transport Strategy is needed to achieve a world class transport system for Inner Sydney. Key, Goals, Objectives and Elements of the Strategy are outlined below:

Key Goals

- To enhance Sydney's role as Australia's economic powerhouse.
- To cater for future growth in travel demand whilst minimising the adverse congestion, environmental and health impacts of travel.
- To increase the share of trips by walking, cycling and public transport and reduce the share by car.
- To improve the efficiency and appeal of the public transport system for Inner Sydney and the CBD.

Specific Objectives

- To increase the space available for pedestrians in the CBD and inner city.
- To provide a network of safe cycling routes throughout the inner suburbs and CBD enabling cyclists to access regional cycleway connections as well as major activity generators such as universities, employment concentrations, major recreational facilities and retail centres.
- To increase the capacity of the on-street public transport system linking the inner suburbs to the city centre by at least 35% by 2021 and 60% by 2051.
- To reduce bus congestion and impacts by reducing the number of buses entering the CBD daily by at least a third, and the number of buses travelling on key north-south routes through the city centre by at least 50% by 2021, compared with the "business as usual" scenario.
- To improve cross-regional public transport services throughout the inner suburbs, to allow more local trips by public transport rather than by car.
- To manage demand for private car trips through the use of demand management measures.

Key Elements of the Plan

Development of a Light Rail network in the CBD and on key corridors linking to the CBD from the inner suburbs to the Inner Western, Southern, South-Eastern and Eastern suburbs. The network would be provided with a high level of traffic priority using a combination of exclusive lanes where possible, and signal priority at intersections.

- **Re-organising certain bus routes** over time to act as feeders to the light rail network, and to improve cross – regional services.
- **Improving the integration** between all modes of transport through improved interchanges, integrated ticketing and fares, and real-time information
- **Limiting parking levels in the CBD** for commercial purposes and providing incentives to developers to minimise the amount of parking provided for new development generally in the city.
- **Providing additional park and ride opportunities** at strategic locations on the light rail network in the inner suburbs to encourage car drivers to undertake part of their journey by public transport.
- **Developing a network of cycle routes** through the CBD linking with regional cycle routes to allow access to key activity generators and to residential areas. This would take advantage of the creation of additional space when the light rail network is created
- **Providing additional footpath space** in city streets and other key streets with high pedestrian concentrations.
- **Adding at least 1 km of pedestrianised streets** in the city centre to further enhance amenity and safety in the city.
- **Supporting the development of demand management** measures such as car sharing schemes and by providing individualised information to people on their travel choices.

CHAPTER 2: MASS TRANSIT OPTIONS

Inner Sydney Mass Transit Options

Sydney has an extensive suburban rail system, which focuses mainly on longer distance travel between the CBD and the outer suburbs. For the inner suburbs, buses form the main mass transit mode, supplemented by ferries from specific harbour-side locations.

In considering the transport needs of Inner Sydney, the unique attributes of all modes need to be considered in relation to the conditions in the CBD and Inner Sydney. The cheapest option in capital costs for meeting the growing public transport needs of Inner Sydney would be to continue with conventional diesel and CNG-powered buses. However this option is not considered to be sustainable into the future as travel demand rises:

- The number of State Transit Buses travelling to and from the CBD daily would rise from 7,400 per day now to 9,400 per day by 2021 to cater for increasing employment and population in the inner suburbs, and a small mode shift to public transport. There are also likely to be increased numbers of private buses and tourist coaches.
- This will add to the already existing noise, emissions and amenity impacts from buses in the city and on major arterials.
- It will also add to bus congestion and to problems with finding enough bus layover space.
- Buses operating in such numbers represent an inefficient use of resources, as operating costs are high because of slow speeds in congested conditions and the relatively limited capacity per vehicle.

Cities all over the world facing these challenges are improving their public transport systems by:

- Providing priority for public transport
- Using higher capacity vehicles
- Introducing electrically powered modes

Options for improving mass transit for Inner Sydney and the CBD include:

- Articulated diesel/CNG buses
- Guided electric bus-based systems
- Light rail
- Underground metro-rail
- Various forms of above-ground automated systems

Horses for Courses

- *Walking and cycling are the most environmentally friendly and healthy modes, and need to be encouraged for short trips*
- *Ferries are ideal for trips along the inner and outer harbour*
- *Buses suit cross-regional routes, express routes and routes serving lower density areas*
- *Light rail is ideal for medium-length, medium-demand corridors and for applications in city centres*
- *Heavy rail suits long-distance, high-volume corridors*
- *Metros suit high-volume, medium-distance corridors*
- *Taxis provide flexible, door-door travel*
- *Cars suit a wide variety of trips, but are less appropriate for higher density areas, where space is at a premium.*

The role of transport planning is to ensure the most appropriate modes are used for particular tasks, and to integrate all of those modes into a seamless system. This is analogous to selecting the best mix of fast bowlers, spin bowlers, batsmen and specialist fielders, and then welding them into a powerful cricket team.

Alternatives Mode Options for Inner Sydney

High Capacity guided bus (Translohr)

Light Rail

Underground (Metro)

Ultra-light Rail (Austrans)

Monorail

Evaluation of the Options

Various studies have evaluated these options:

- The Central Sydney Light Rail Strategic Context Study (Martin Walsh and Associates, 2003) examined this issue in depth, and found that light rail was the preferred mode for the CBD, scoring higher than the alternatives on most criteria, and in overall terms. The criteria considered were cost efficiency, service quality, external impacts and capacity (see graph opposite).
- A study by Parsons Brinkerhoff (2004b) compared the options of continuing with current buses, introducing high capacity buses, or introducing light rail for the CBD. It found light rail was the best or equal best option when evaluated against all criteria except for the cost of the necessary supporting infrastructure. (See table opposite).
- The Inner Sydney Transport Working Group examined options for various corridors in Inner Sydney, concluding that underground metro was the preferred mode for these corridors, followed by light rail, on the basis of all criteria except capital cost. However most Inner Sydney corridors only require 4,000 – 8,000 passengers per track/lane per hour, even in twenty years' time, and only the northern corridor has sufficient demand to justify the high cost (around $100 m per kilometre) and capacity (20,000 passengers / hour) of metro rail. (See Attachment 2 discussion).

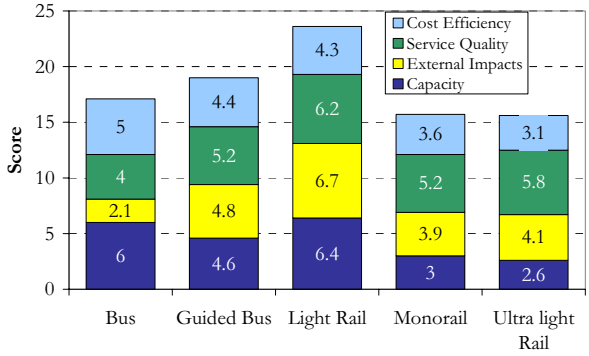
Ranking of Modes for Inner Sydney Corridors

Corridor	Score (1=best, 6=worst)					
	Conventional Bus	Articulated Bus	BRT – Articulated	BRT – Civis Equivalent	Light Rail	Metro Rail
CBD– Bondi Jcn via Oxford Street	5	6	4	3	2	1
Bondi Jcn–Bondi via Bondi Road	5	6	4	3	2	1
CBD-Spit Junction via Harbour Bridge	6	5	4	3	2	1
Spit Junction – Spit Bridge	6	6	4	3	2	1
CBD – Burwood (Parramatta Rd)	6	6	4	3	2	1
Leichhardt – Burwood (Queens Rd/Ramsey St)	4	6	5	3	2	1
Parramatta Rd – Lilyfield (Norton Street)	4	6	5	3	2	1
CBD – Mascot via Green Square	5	6	3	4	2	1
CBD – Maroubra via UNSW	5	6	4	3	2	1

Source: Inner Sydney Transport Working Group (2004)

Note: Includes all criteria except infrastructure cost.

Evaluation of Alternative Modes
(the best alternative scores highest)



Source: Martin Walsh and Associates (2002)

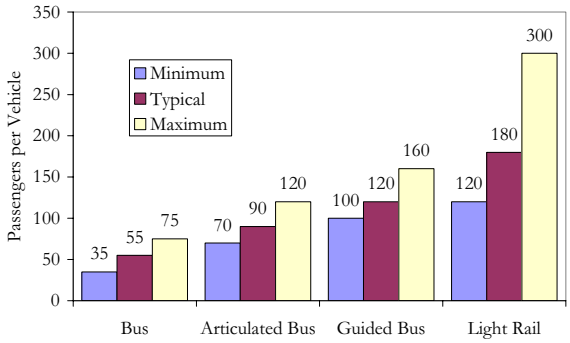
Summary of Mode Comparisons for Central-Circular Quay

Criterion	Rank (1=best, 3=worst)			Preferred Mode
	Bus	High Capacity Bus	Light Rail	
Capacity	3	2	1	Light Rail
Staffing	3	2	1	Light Rail
Frequency	2	2	1	Light Rail
Efficiency	3	2	1	Light Rail
Veh. Cost	3	2	1	Light Rail
Infrastructure	1	2	3	Bus
Reliability	3	2	1	Light Rail
Legibility	3	1	1	LR / HC Bus
Travel Time	3	2	1	Light Rail
Congestion	3	2	1	Light Rail
Mode Shift	3	1	1	LR / HC Bus
Cyclist & Ped Safety	3	1	1	LR / HC Bus

Source: Parson Brinkerhoff (2004b)

Modern light rail vehicles typically have a capacity of 2 to 4 standard buses, and 1.5 to 2 articulated or guided buses, resulting in less congestion, lower operating costs per passenger, and more growth potential.

Capacities of Buses and Light Rail Vehicles



Note: Capacities vary with specific vehicle design and density for standing passengers. Design loads are lower than typical loads.

Experience Elsewhere

Both overseas and local experience highlights the benefits of light rail as a medium capacity public transport system for urban environments.

- Over 100 cities have built new light rail / tramway systems, or expanded their existing systems, in the last decade (see attachment for full list). Altogether there are over 400 light rail systems now in operation world wide.
- By contrast, only around 10 cities have introduced guided bus systems, despite the first such system (the Adelaide 0-bahn) being first adopted two decades ago (see attachment).
- A number of cities are building busways, usually with conventional diesel or CNG powered buses. These are appropriate for suburban areas, particularly low density suburbs, where the flexibility and low capacity of buses matches the demand.
- However those cities which have invested heavily in buses have found it can create congestion problems for the city centre. For example, Brisbane had to build an underground bus station under Queen Street, and is now investing over $140 million for a one kilometre tunnel to link this to the Inner Northern Busway. This reflects the adverse impact of large numbers of buses in city centres, and the problems of congestion and inefficiency arising from trying to move too many buses through crowded city streets.

Experience with Light Rail

As noted above, there has been a major revival of light rail around the world in the last two decades. While some new light rail systems have had disappointing patronage, many have exceeded expectations, and those cities which have adopted a strategic approach to planning and implementation have experienced major benefits. For example:

- Strasbourg re-introduced light rail in 1995, after previously abandoning its tram system. The initiative was combined with re-organising bus routes to feed the light rail, introduction of park and ride stations at 12 light rail stations and at the edge of the CBD, and pedestrianising the city centre. Total public transport patronage has jumped from 42 million before light rail to 78 million 8 years later, while the number of journeys (discounting transfers) has risen 56%.
- A key feature of the approach was the use of well-designed interchanges, coupled with highly attractive "Eurotrams" operating at high

Examples of Cities Installing Light Rail Systems

Examples of Light Rail Systems

Amsterdam, Netherlands

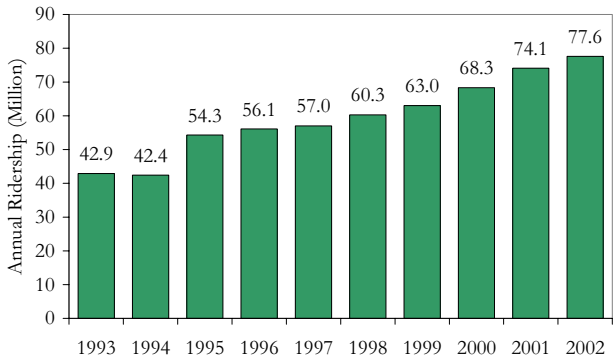
Oberhausen, Germany

Hiroshima, Japan

Houston, USA

frequencies. This allowed total capacity to be increased while reducing the number of buses in the city. The success of the approach has led to introduction of high capacity LRT vehicles carrying up to 270 passengers, while a fifth line and extensions to the other lines are to open in 2008.

Ridership trends on Strasbourg's Public Transport (Bus plus Light Rail combined)



- Portland in Oregon is another leading city in the light rail revolution, after a citizen movement stopped construction of a downtown motorway. The first line was opened in 1986, and was extended in 1988. Subsequently the Airport line and the red lines have opened, with the yellow line due to open shortly, with daily patronage expected to increase to close to 100,000.
- Following in Portland's footsteps have been many other US cities, including many of the cities most dependent on automobiles such as Phoenix, Houston, Dallas and Denver. Light rail patronage in US cities grew strongly in the 1990's to be over 320 million pa by the year 2000, up 12% on 1999, one reason why transit as a whole grew faster than use of automobiles in that decade. Patronage on many of the light rail systems exceeded expectations, such as Denver, where the Southwest corridor line was 56% ahead of Ridership projections, and Salt Lake City, where the TRAX system carried 20,000 passengers per day in 2000 compared with a predicted 14,000.
- Cities like Melbourne, which retained their tram networks, are now re-investing in modern, articulated easy-access light rail vehicles, upgrading their infrastructure with new "super stops" with real-time information and better passenger facilities, and are also extending their networks further into the suburbs.

These and many other examples (see Attachment) highlight why cities young and old, large and small, and from Europe to North America are embracing a return to this technology to reinvigorate their public transport and more importantly their urban amenity.

Eurotram in Strasbourg's Pedestrianised City Centre

Light Rail vehicle undergoing testing on Portland's latest Yellow Line Route Extension

Eurotram in Melbourne

Experience with Guided Buses

The first guided bus system in the world was the Adelaide O-bahn. This uses a mechanical wheel-based guidance system attached to otherwise conventional diesel-powered buses to allow them to travel at high speeds on a special guideway. Similar systems were installed in Essen, Mannheim and Leeds, though the Adelaide system was never extended. The guidance system is not suitable for use in central business districts or on regular streets, and the buses operate as conventional vehicles once in the city or when operating off the special guideway.

More recently, several other guided bus systems have been developed or are under development, including:

- The TVR / GLT system developed by Bombardier, uses a mechanical guidance system provided by a central rail, with electrical power picked up by single or double overhead wires.
- The Translohr system, which also uses mechanical guidance with a track in the roadway.
- The CIVIS bus developed by IRISBUS, which uses optical guidance to allow articulated buses to pull in at stops more accurately. Buses can be diesel or CNG powered.
- Various systems using magnetic guidance, such as the Phileas system being developed in Eindhoven.

Experience suggests some caution with guided buses:

- Nancy, in France, has had to close its new TVR system for periods due to technical problems with the guidance system, and there have also been problems with blown tyres with some systems (UITP 2004).
- Another issue with guided buses is that the various systems being offered by suppliers are not compatible, as they use different guidance technologies. Consequently a decision to purchase a system can lock a city into a single vehicle supplier.
- A third issue is that none have been in operation for long enough (other than the O-Bahn, which is not relevant for Sydney CBD or inner suburbs) for confidence as to their long run operating costs.

While there is reported capital cost savings with some types of guided bus systems compared with heavy rail, these are mainly for non-electrically powered systems. A study by the UITP Light Rail and Bus Committee found little difference in overall costs between electrically powered guided bus systems and light rail.

Examples of Guided Bus Technologies

O-Bahn in Adelaide

TVR (Nancy)

Civis (Rouen)

Phileas

Relative Capital Costs between Light Rail and Guided Bus for Equivalent System

Component	Light Rail	Guided high capacity bus
Stations and guidance systems	20.9	13.0
Rest of System	11.9	11.9
Road redevelopment and property acquisitions	44.3	44.3
Workshops and Garages	9.5	8.5
Rollingstock	13.4	21.2
Total	100	98.9

Source: UITP Committee on Light Rail and Bus. Note that all costs are expressed in relative terms, with the light rail system summing to 100 units, to allow comparison on an equivalent basis.

Affordability and Cost-Effectiveness

The proposed light rail mass transit network has an estimated capital cost of between $1.2 and $1.6 billion, including vehicles. While this is significant, it needs to be seen as a long-term investment, and in the context of other transport investments which are being made in Sydney, for example:

- The Cross-City Tunnel, estimated to cost around $1 billion, and other major road projects totalling well over $10 billion in the last decade.
- Major heavy rail projects such as the Airport Rail Line ($900 million), Epping – Chatswood line ($1.6 billion), and Rail Clearways project ($1 billion).

As shown below, the proposed light rail network for Inner Sydney is affordable and cost-effective.

Light Rail Network and other Major Transport Projects

Project	Light Rail Network	Cross-City Tunnel	Epping – Chatswood Rail Line
Capital Cost	$1.2 - $1.6 billion	$1.0 billion	$1.6 billion
Construc-tion	15 years	3 years	4 years
Annual in-vestment required	$100 million	$330 million	$400 million
Estimated Annual Usage	50 million passengers	33 million vehicles	15 million passengers
Estimated pass-km	200 million	100 million	150 million
$pass-km	$7	$10	$11
Benefits	Increased capacity and amenity, and reduced traffic in CBD and inner suburbs	Travel time savings for motorists; reduction in traffic in CBD	Travel time savings for rail passengers; improved access to Macquarie area
Other effects	Encourage shift to public transport, walking and cycling; health, environmental and land use benefits	Encourages mode shift to cars; health and environ-mental costs	Encourage shift to public transport, walking and cycling; health, environmental and land use benefits

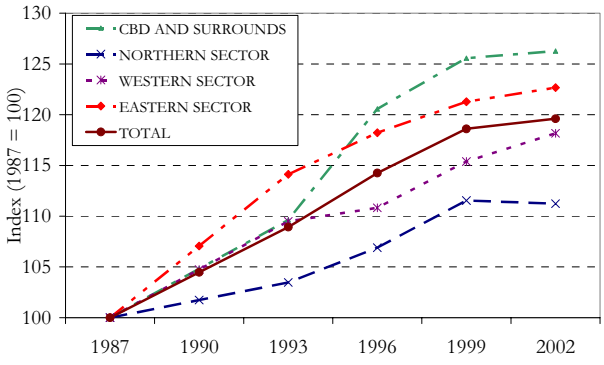
In this context, it is worth noting the trend in the USA both to light rail, and to transit in general, with record ridership for the last few years, and transit ridership growing faster than traffic volumes in the last decade. This has been supported by voters agreeing to fund new light or heavy rail-lines, dial-a-ride and other initiatives from local sales taxes and property taxes.

Some $10 billion has been invested in major road projects in Sydney in the last decade, including the M2, M4, M5 and M5 East, Eastern Distributor, Cross City Tunnel, Lane Cove Tunnel, and the M7. Other projects are planned, including the M4 East, the M2-F3 link, and a new tunnel linking the Ashfield to the airport.

Despite massive investment in motorways, traffic on remaining roads continues to grow, for example by 20% in Inner Sydney.

Sydney needs a more balanced transport investment with more emphasis on public transport to provide better alternatives to driving.

Traffic Growth in Inner Sydney (excluding new roads)



Source: RTA Traffic Count Data

The light rail network is affordable and cost-effective. It will lead to longer term savings in operating costs for buses currently travelling right into the city.

The US trend to transit is set to continue, with 52 ballot initiatives on transit funding to be voted on in US cities this year, worth over US$50 billion. This is in addition to the 22 ballot initiatives already voted on earlier this year (of which 18 were passed), compared with a total of 38 ballots in 2002 and 16 in 2003.

No single mode can handle all of Sydney's public transport needs, and the key is to build a seamless, system enabling passengers to move easily and conveniently between modes as appropriate to their particular transport needs.

Integration of Modes

There are many advantages of moving to light rail to improve Inner Sydney's mass transit systems, including freeing buses from major radial CBD routes to allow more cross-regional and feeder services.

However buses will remain the most practical option for some inner Sydney corridors, as well as for middle and outer suburbs. Similarly heavy rail and ferries will continue to play a key role in Sydney's transport system. Heavy rail provides the backbone for high capacity, longer distance travel, and the system needs upgrading, with a new link between Central and Chatswood required by 2015-2020 to handle increased commuting from the outer south-western and north-western suburbs. There is also need for further growth in ferry services to service the redevelopments along the Parramatta River.

A fully integrated, multimodal system is needed with:

- ***Improvements to interchanges*** to provide better physical facilities (such as shelter, easy-access and services such as coffee shops, newsagents, florists and convenience stores), so that people can utilise the time changing between modes productively.
- ***Integrated ticketing and fares***. Sydney is currently developing a smart card ticketing system which will reduce the need to purchase individual tickets for different modes. This should be taken further to introduce integrated fares as has recently happened in South-East Queensland.
- ***Real time information***. This should be provided at all stops, as well as via the internet and mobile phone. Sydney has done this for some rail stations and the Parramatta – Liverpool transitway, but it needs to be provided throughout the system. For example, London's Countdown system provides real-time information at some 4,000 bus stops.
- ***Public Transport Priority.*** This will need to be extended from the current bus lane system to include separate rights of way where possible, shared transitways with pedestrians and light traffic, and signal priority at intersections.

Conclusion

Inner Sydney needs an upgraded mass transit system. The key initiative is to introduce a light rail system on major routes, as indicated both by evaluations undertaken in Sydney and by experience overseas. This network needs to be fully integrated with all other modes including a rationalised bus system.

Interchange between the underground, the surface rail system, light rail, buses and taxis in Vienna, Austria

South-East Queensland achieved an immediate 10% lift in public transport patronage earlier this year when it introduced the world's largest integrated fares network, covering the region between Noosa and the NSW Border.

Light Rail vehicle in Sydney's Hay Street

Light rail vehicles are electrically powered, with no local emissions and low noise, enable fast loading and unloading and have proven passenger appeal. Their full guidance on tracks allows higher capacity vehicles, reducing congestion and improving efficiency. Their characteristics make them more compatible with pedestrians and cyclists and with the needs and environment of the CBD and Inner Sydney, than conventional buses

CHAPTER 3: MASS TRANSIT VISION

The Overall Vision

A light rail mass transit network for Inner Sydney could be developed over a fifteen year period:

- **Light rail** could be used to provide internal north-south circulation within the Central Business District, and to the inner suburbs.
- Initially, five key lines have been identified (see Map):

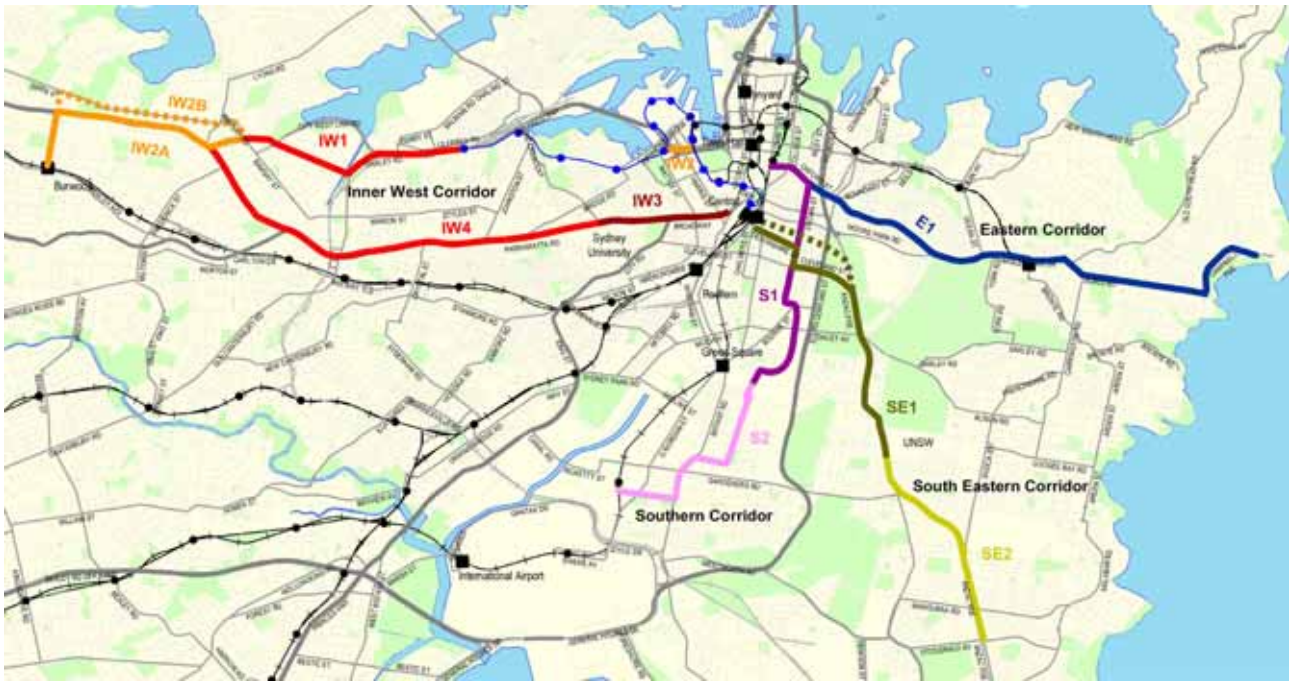
  SE Line: Maroubra Jcn via UNSW
  IW Line: Burwood via Lilyfield
  Sth Line: Mascot via Green Square
  IW Line: Burwood via Parramatta Rd
  E Line: Bondi via Bondi Junction

- These lines could be built in stages from the city outwards, after completion of the first CBD Loop.
- Additional routes, such as on William Street, could also be considered.
- **Interchanges** would be provided in the City (Circular Quay, Park Street and Central) and at key locations in the inner suburbs.
- **Buses** on routes paralleling the light rail lines would be progressively redirected to provide improved feeder services and additional cross-regional services.
- **Integration** of all modes (Trains, buses, ferries, light rail, taxis) would be achieved through these new and improved interchanges, the introduction of integrated fares and ticketing, and the provision of real-time passenger information.
- **Park and Ride** facilities would be developed at selected locations, especially along the light rail routes.

The following sections outline:

- The proposed inner suburb routes, including integration with other services, park and ride opportunities, and potential for future extensions.
- CBD route alternatives.
- Reasons for selecting these routes.
- How bus services could be rationalised, and the benefits in terms of efficiency and amenity.
- How the light rail network can facilitate walking and cycling.

Map of Proposed Inner Suburbs Light Rail Network



Description of the Routes

South-East Line (SE1 and SE2)

Location and Purpose
The route will travel past Central station to Moore Park via Devonshire Street, then on to UNSW and Maroubra Junction via the existing bus lane and Anzac Parade. It will connect the south-eastern suburbs with the CBD, and also provide reverse connections between Central Station and the city with UNSW, Moore Park and the Sydney Boys and Girls High Schools, removing the need for large numbers of special bus services.

Integration
The route will connect with the 390 series of buses, and also with buses to Coogee. Key interconnections with buses will occur at Maroubra Junction, near UNSW and at the Nine Ways Junction.

Potential Extensions
Possible extensions include Coogee and Matraville.

South Line (S1, S2)

Location and Purpose
The route will follow Oxford, Crown and Bourke Street to the Victoria Park area and on to Mascot Station via Dacey Avenue. It will connect the rapidly growing areas in the vicinity of Green Square with the city.

Integration
Intersects the SE line at the junction of Devonshire and Crown Streets, allowing flexibility in operations and staging of the routes. Also connects with the 303, 352, 355, 357 and 370 bus routes as well as the airport line.

Possible further extensions
Possible long term extensions to the F6 corridor south.

East Line (E1)

Location and Purpose
The route follows Oxford and Bondi Roads to Bondi Beach, connecting Bondi, Paddington and neighbouring areas with Bondi Junction and the city.

Integration
Integrates with wide variety of bus routes as well as heavy rail at Bondi Junction. Limited opportunities for park and ride.

Inner West Line via Lilyfield (IW1, IW2)

Location and Purpose
The route will follow the existing freight line west of Catherine Street for approximately 1.7km, then cross to Parramatta Road via Haberfield, with an extension to Burwood Station via Parramatta Road and Burwood Road. It will link parts of Leichhardt, Haberfield, Five Dock and Ashfield to both the city and to Burwood. A short tunnel under Pyrmont will cut 5 minutes travel time and provide a direct and fast route to the city.

Integration
Connections with buses will be made at several points including James Street (route 445, 440, L40), Boomerang Street (routes 471, 472), and Ramsey Street (routes 437, 438, L38), while Burwood Station interchange will allow connection with heavy rail as well as the many buses serving this important centre.

Possible Further Extensions
There is potential to extend to Abbotsford and to the Concord peninsula in the longer term.

Inner West Line via Parramatta Rd. (IW3, 4)

Location and Purpose
The route will follow Broadway and Parramatta Road, and will connect parts of Chippendale, Glebe, Camperdown, Leichhardt and Petersham with the city, as well as with key activity generators such as the University of Sydney and the University of Technology, Sydney.

Integration
The route will join route IW1/IW2 at the corner of Henley Marine Drive and Parramatta Road. It will connect with a wide range of bus routes including the 420 series from City Road and the 430 series from Glebe at Broadway; routes 470 and 412 at Sydney University; and routes 445, 438, L38, 440, L40, 480 and 483 in Leichhardt. Key interchange points will be established at Sydney University and at Norton Street.

Possible Further Extensions
There is potential to extend to Abbotsford and to the Concord peninsula in the longer term.

Central Business District Links

Light rail will provide for north-south circulation in the CBD, linking with key interchanges at Circular Quay, Park Street and Central Station (Martin Walsh and Associates, 2004). This will also provide a basis for the extensions to the inner suburbs.

A large number of potential CBD links have been examined (GHD 2004), and the three which are considered to have the most merit by the City of Sydney are shown below.

Eventually both the George Street Route and one of the two other routes will be needed to handle both internal travel and to provide capacity for the five routes to the inner suburbs.

The choice of the first route to be built will be made following consultation with the community and business interests, particularly those in the city. Note that any of the five extensions described previously can be connected to any of the three CBD links.

Potential CBD Links

George Street Route

Castlereagh St Route

Pitt / Castlereagh (Figure 8) Route

Note: Connections to extensions not shown

Selecting the Proposed Routes

The five routes in the inner suburbs proposed for light rail were selected on a number of criteria, including:

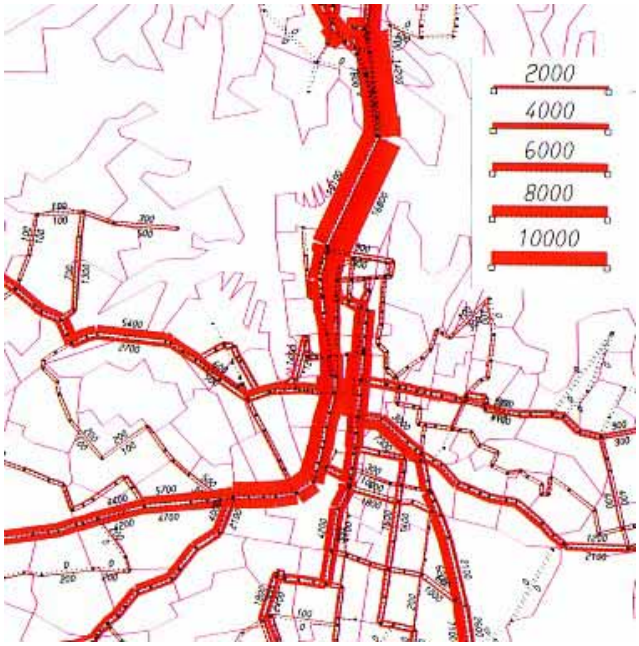
- Current passenger volumes and route structure
- Potential for future growth
- Ease of implementing light rail technology
- Presence of other rail modes

As shown in the map and table at left, there are seven key bus corridors into the CBD: the Harbour Bridge, the Western Distributor, Broadway, Elizabeth Street, Oxford Street and William Street., as well as more minor flows on streets such as Foveaux St, Campbell Street and Bent Street. Altogether there were 1100 State Transit buses entering the CBD on a typical weekday peak in 2001, and 3,500 between 7:00am and 7:00pm. In addition, the current light rail route via Lilyfield provides a further transit corridor from the inner suburbs.

The table below right shows the characteristics of these corridors in relation to these criteria. On this basis:

- The Northern corridor across the Harbour and the Victoria Road (Western Distributor) corridor are considered as more suitable for metro rail than light rail, given the volume of passengers using the routes, and the topographical and other factors which would make implementation difficult or expensive (extensive tunnelling).
- The Broadway / Parramatta Road corridor is considered suitable for light rail but with some implementation difficulties given current traffic volumes.
- The Anzac Parade (Oxford Street) corridor is considered highly suitable for light rail given the patronage volumes, growth potential and ease of implementation.
- The Oxford Street corridor to Bondi is considered suitable for light rail given the patronage volumes and other characteristics.
- The South corridor is considered suitable for light rail given its growth potential and relative ease of implementation. A route via Crown and Bourke Streets was favoured as it complements the existing airport rail line rather than competes with it.
- The William Street corridor is considered suitable for light rail, but a low priority given the existence of a heavy rail link in the corridor already and relatively low volume of patronage and growth potential.
- The Lilyfield corridor is considered highly suitable for extending the light rail given its growth potential and ease of implementation.

Current bus patronage (2001) in morning peak



STA Buses Entering CBD on a weekday in 2001

Entry point to CBD	12 Hours 7am-7pm	AM Peak 7-9am
Harbour Bridge	906	363
Western Distributor	284	118
Broadway	807	209
Elizabeth Street	401	95
Foveaux Street	190	52
Campbell Street	58	18
Oxford Street	557	123
William Street	262	57
Bent Street	66	65
TOTAL STA	**3531**	**1100**

Source: STA 2002

Characteristics of Corridors

Corridor	Current Volume*	Ease of Implemen-tation	Growth Potential	Other Rail
H. Bridge	V High	Low	Med	Yes
Victoria Rd	Med	Low	Med	No
Parramatta Rd	High	Med	High	No
Anzac Parade	Med	Very High	Med	No
Oxford St	Med	High	Low	Part
South	Med	High	High	Part
William Street	Low	High	Low	Yes
LRT Lilyfield	Low	Very High	High	No

In considering routes, current and potential demand, ease of implementation and competition from other rail corridors need to be considered.

Rationalising Buses

The proposed light rail network will allow the bus network to be rationalised over time. This will have a number of benefits, including:

- reducing the number of buses travelling through the CBD and using major arterials
- allowing the buses and bus resources saved to be re-allocated to improve the frequency of feeder services and to establish new cross-regional routes

The table shows how this could be achieved over time as the light rail network is built up. The principles adopted in rationalising buses ars as follows:

- bus routes which are completely replaced by an equivalent light rail route will be dropped, and the buses saved re-allocated
- bus routes which parallel a light rail route for much of their length will be shortened to act as a feeder service, with connection made at an appropriate interchange point
- limited stop or express bus routes will in general be retained. Some of these use different routes to access the city, such as the "X" series utilising the Eastern Distributor.
- Bus routes in the city centre will be restructured to connect with the light rail network so as to reduce their impact on the CBD where possible.

Benefits from these changes include:

- Reduction of 1669 buses needing to travel northbound through the CBD every weekday, based on current timetables.
- Saving of 167 buses required to operate the current peak timetable (including spare vehicles for maintenance). These can be used to improve cross-regional routes and feeder services
- Substantial savings in bus operating costs.
- Substantial improvement in amenity in the city.
- Reduction in the amount of space required for bus layovers in sensitive areas such as Circular Quay.

As shown, assuming bus volumes were to grow to accommodate increased demand plus a small mode shift (27% increase by 2021 assumed), then there would be an estimated 9,420 State Transit buses travelling through the city centre on a typical weekday. The introduction of the light rail network would cut this to 6,000 per day, a reduction of 36%.

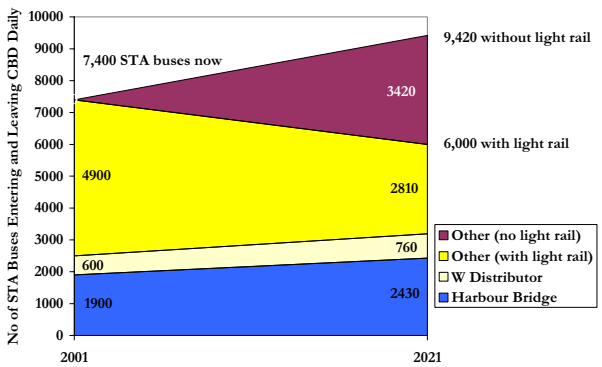
Re-organisation of bus services

Route	Re-organisation
CBD Loop	City Road all-stops buses (422, 423, 426, 428) terminated at Eddy Avenue interchange. Victoria Road buses for Circular Quay redirected to Park Street Interchange and Eastern Layover. William Street Buses for Circular Quay redirected to Park Street Interchange and Western layover.
Inner West Stage 1	Routes 436 and 437 redesigned as feeders, terminating at Norton Street. 50% of route 438 and 440 services terminated at Norton Street
Inner West Stage 2	Route 461 terminated at Burwood
Inner West Stages 3 and 4	Remaining route 440 and 438 services, and route 480 and 483 buses terminated at Norton Street.
South	Routes 301, 302, 303 of route 343 services re-organised as feeders to Green Square
South-East	Routes 391, 392, 393, 394, 395, 396, 397 and 399 re-organised as feeders, interchanging near UNSW (later Maroubra Junction and the five-ways).
East	Routes 378 terminated at Bondi Jcn. Route 380 replaced by light rail.

Benefits from Bus Restructuring (Based on current timetables)

Light Rail Route	Reduction in weekday north-bound buses in CBD	Reduction in number of peak buses required
CBD	608	21
Inner West	327	43
South East	332	50
South	120	16
East	282	37
Total	1669	167

Trends in STA buses travelling through City Centre with and without the light rail network



Facilitating Walking and Cycling

Walking is the most important mode in the CBD now in terms of the number of trips taken. However with further residential, tourism and employment growth the existing footpath space will come under increased pressure.

Cycling, however, is currently a minor travel choice in Sydney, especially compared with the situation in many European cities. The lack of safe cycle routes is a key inhibitor to people using bicycles more.

Cities such as Copenhagen, which introduced a network of cycle-lanes, have shown how important this mode can become if properly catered for.

The proposed light rail network in the CBD will allow more space to be dedicated to pedestrians and cyclists. For example the Pitt / Castlereagh (Figure 8) option would allow sections of both Pitt and Castlereagh streets to be redesigned to carry:

- One dedicated light rail line
- One lane for general traffic
- One lane for parking
- A bicycle route
- Wider footpaths

This would also allow more street trees to be planted, and a much improved urban streetscape, with more space for outdoor cafés etc.

The reduction in traffic in the city centre from the Cross-City Tunnel will also allow some streets such as Druitt Street to be closed to general traffic. In time, as the balance shifts to more walking, cycling and public transport, new streets can become fully pedestrianised, adding to Martin Place, Pitt Street Mall and Circular Quay, reclaiming the city for pedestrians rather than cars.

Beyond the CBD, the development of light rail routes can also facilitate key cycle routes linking the regional cycleway network to the CBD. For example, Devonshire Street can be redesigned to carry two light rail lines plus a cycleway, which can connect the CBD with the Moore Park area and with cycleways to the Green Square area. These opportunities will be further developed in the cycle strategy currently being developed by the City of Sydney.

Cycles outside Main Station in Karlsruhe, Germany

Pedestrianisation in Munich

Light Rail and Pedestrians mix in San Jose

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ATTACHMENT 1

NEW OR EXPANDED LIGHT RAIL SYSTEMS SINCE 1994

Country	City	New*/Extension	Country	City	New*/Extension
Australia	Melbourne	2002-2004	Great Britain	Birmingham	1999*
	Sydney	1996*		London	2000*
China	Beijing	2002		Manchester	1999,2000
	Changchun	2002		Nottingham	2003*
	Hong Kong	2002		Sheffield	1994*, 1996
Iran	Mashad	2002*	Ireland	Dublin	2004*
Japan	Kochi	1997	Italy	Milan	1994-2004
	Osaka	1997		Naples	2002-2004
	Tokyo	1995/6		Rome	2001
Philippines	Manila	1999,2000,2003		Turin	2005
Russia	Novosibirsk	2004	Netherlands	Amsterdam	1997-2002
	St Petersburg	2005		Rotterdam	2002
	Moscow	2004		Utrecht	2000
Singapore	Singapore	1999*	Poland	Poznau	1997, 1999
Turkey	Adana	2003*		Warsaw	1998,2001
	Ankara	1996*	Portugal	Lisbon	2005
	Bursa	2002*		Porto	2003*
	Istanbul	1995, 1998	Spain	Barcelona	2003*
	Izmir	2000*		Valencia	1994-2005
	Konya	1996	Sweden	Stockholm	2000*
Austria	Linz	2002	Switzerland	Geneva	1997-2004
	Vienna	2003		Zurich	2005
Belgium	Antwerpen	1996	Tunisia	Tunis	1995, 2005
France	Bordeaux	2003*	Argentina	Buenos Aires	2006
	Grenoble	1996-2001	Brazil	Rio de Janeiro	2002
	Lyon	2005	Mexico	Guadalajara	1994
	Montpellier	2000*		Mexico City	1999
	Orleans	2000*		Monterrey	1994
	Nantes	1994-2004	Venezuela	Valencia	2002*
	Paris	2005	Canada	Calgary	2001
	Rouen	1994-97		Edmonton	2004
	St Etienne	2005		Toronto	2005
	Strasbourg	1994*, 2000	United States	Baltimore	1997
Germany	Augsburg	1996-2001		Boston	2001
	Berlin	2001		Cleveland	1996
	Bremen	2003		Dallas	1996*, 2001
	Cologne	1994-2002		Denver	1994*, 2002
	Erfurt	2000		Houston	2004*
	Freiburg	1995-2002		Jersey City	2000*, 2003
	Gotha	2004		Los Angeles	1996-2000
	Hannover	2002		Minneapolis	2003*
	Karlsruhe	1995-2004		Newark	2000
	Kassell	2005		Pittsburg	2004
	Muelheim	1996		Portland	1998, 2001-4
	Munich	1998		Sacramento	1998,2003
	Neurberg	2004		Salt Lake City	1999*, 2001
	Rostock	2000/1		San Diego	1996, 2004
	Saarbruecken	1997*,2002		San Francisco	1999
	Stuttgart	2002		St Louis	2001-5
Greece	Athens	2004*		San Jose	2001

CITIES WITH GUIDED BUSES (INCLUDES SYSTEMS INSTALLED BEFORE 1994)

Country	**City**	**Type**	**Country**	**City**	**Type**
Australia	Adelaide	O-Bahn	France	Clermont-Ferrand	Translohr (2005)
Germany	Essen	O-bahn		Nancy	TVR (2000)
	Mannheim	O-bahn		Caen	TVR (2002)
United Kingdom	Leeds	O-bahn		Rouen	TVR (2000), Civis
			United States	Las Vegas	Civis

ATTACHMENT 2

URBAN DENSITY AND MASS TRANSIT SYSTEMS

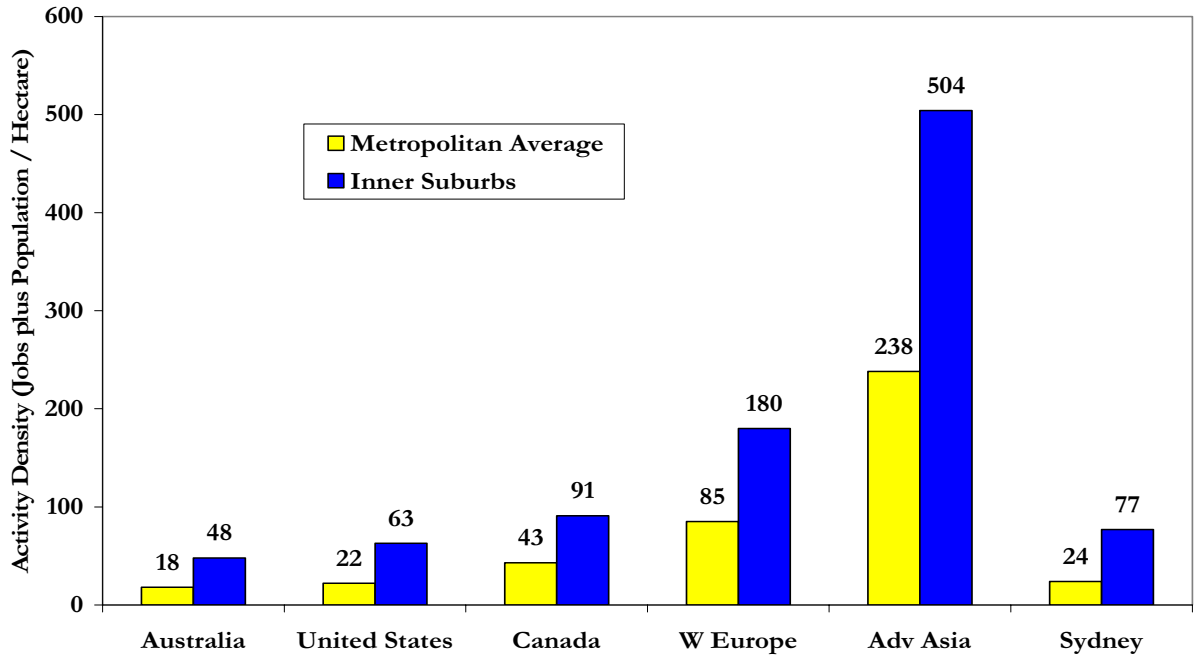
Density Variations in Cities

There are significant differences in the density, both between different cities, and within a given city. Kenworthy and Laube (2000) undertook a detailed analysis of some 40 major cities in economically advanced countries, including in:

- Australia (Adelaide, Brisbane, Canberra, Melbourne, Perth and Sydney)
- The United States (Boston, Chicago, Denver, Detroit, Houston, Los Angeles, New York, Phoenix, Portland, Sacramento, San Diego, San Francisco and Washington)
- Canada (Calgary, Montreal, Ottawa, Toronto, Vancouver and Winnipeg)
- Western Europe (Amsterdam, Brussels, Copenhagen, Frankfurt, Hamburg, London, Munich, Paris, Stockholm, Vienna and Zurich)
- Asia (Hong Kong, Singapore, Tokyo)

They developed the measure of activity density (jobs plus population per hectare), since both population and jobs tend to be key determinants of travel patterns, and examined how this varied across and within cities. Australian cities had an overall activity density of 18 across the metropolitan area, lower than the average for the US cities (22), and well below that in Canada (43), Western Europe (85) and the Advanced Asian cities (239) in the sample. Sydney's activity density was significantly higher than other Australian cities (24), broadly comparable to the US cities, but still low on a world scale. Activity densities in the inner suburbs were generally two to three times higher than the metropolitan averages (see fig. 1).

Figure 1: Activity Density in Selected Major Cities by Geographic Region



Relationship between Transit Systems and Density

The size and density of cities is closely linked with the sort of mass transit systems which tend to be adopted.

All cities have bus-based public transport at a minimum since this is the cheapest and most flexible mode. A relatively small number of cities (eg Ottawa, Brisbane) have built bus transitways to provide higher capacity and speed on key corridors.

However nearly all large cities, as well as many smaller cities, also have some form of rail-based public transport, and in many cases more than one form. The type of rail system(s) used tends to depend on the characteristics of the city:

- Larger cities tend to have **surface rail** systems, possibly with parts of the system underground in the central business district. This is the case for all the Australian cities (except Canberra) and most other cities above one million population.
- Higher density cities such as Tokyo, Paris, New York and Vienna also have extensive **underground (metro) systems** with dense networks of lines and large numbers of stations, to handle the high volumes of passenger movement. However there appears to be an effective density thresh-hold for such systems. For example, virtually all the cities in the sample with overall metropolitan densities above 50, and inner suburb densities above 100, had extensive underground metro type systems, while very few cities with densities below these thresholds had such systems (See Figure 2A and 2B).
- Both large cities (Like Paris) and small cities (like Zurich) often have **light rail systems** (See figures 3A and 3B). However the density thresh-hold is much lower than for metro style rail systems, with many cities having a metropolitan-wide activity density of less than 25, or an inner suburbs density of less than 50, having light rail systems.

This follows from the capital cost of building surface based versus underground systems, and the capacity of the different types of systems. As shown in the table below, underground rail systems typically cost three to ten times as much to build as surface light rail systems, but typically provide around four times the capacity. Where the capacity is required, they are justified and are the most efficient solution to mass transit, however where the capacity is not required, it is difficult to justify them.

Table 1: Capacity and Cost for Underground versus Light Rail

Type of System	Typical Capital Cost A$ / km, double track including stations / stops	Typical maximum capacity (passengers per hour per direction in peaks, including standees)
Light Rail	$10 - $40 million	4,000 – 8,000
Underground Rail	$100 - $150 million	15,000 – 30,000

Figure 2A: Metropolitan Density for Cities with and without Metro Systems

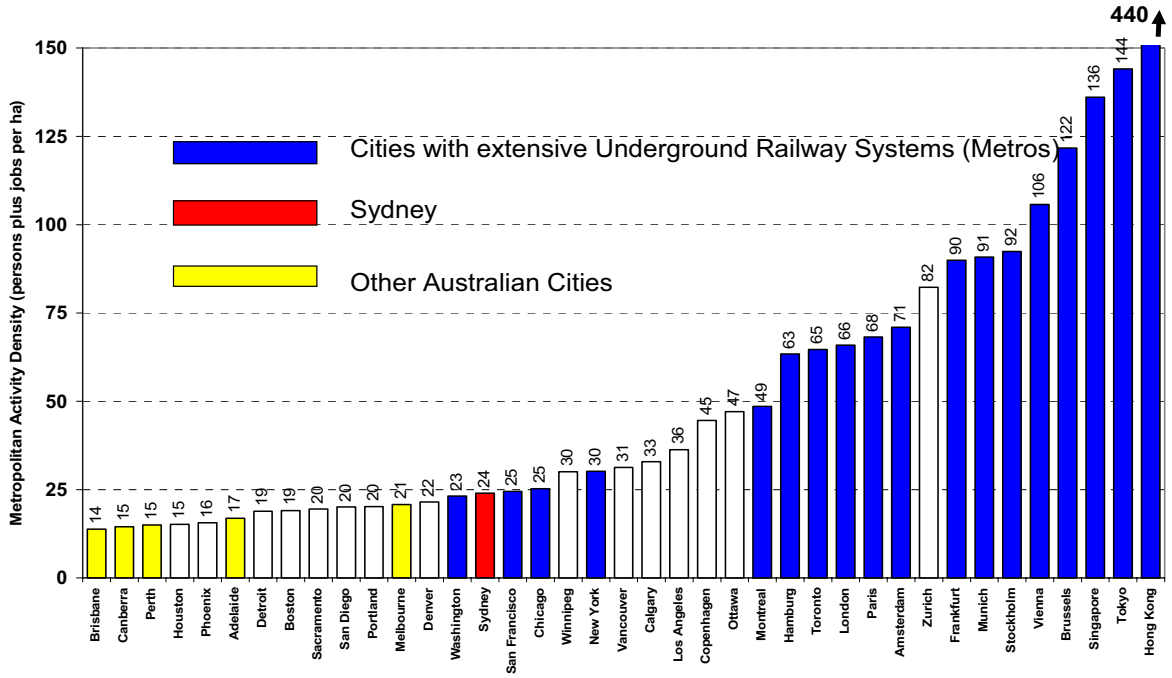


Figure 2B: Inner Suburbs Density for Cities with and without Metro Systems

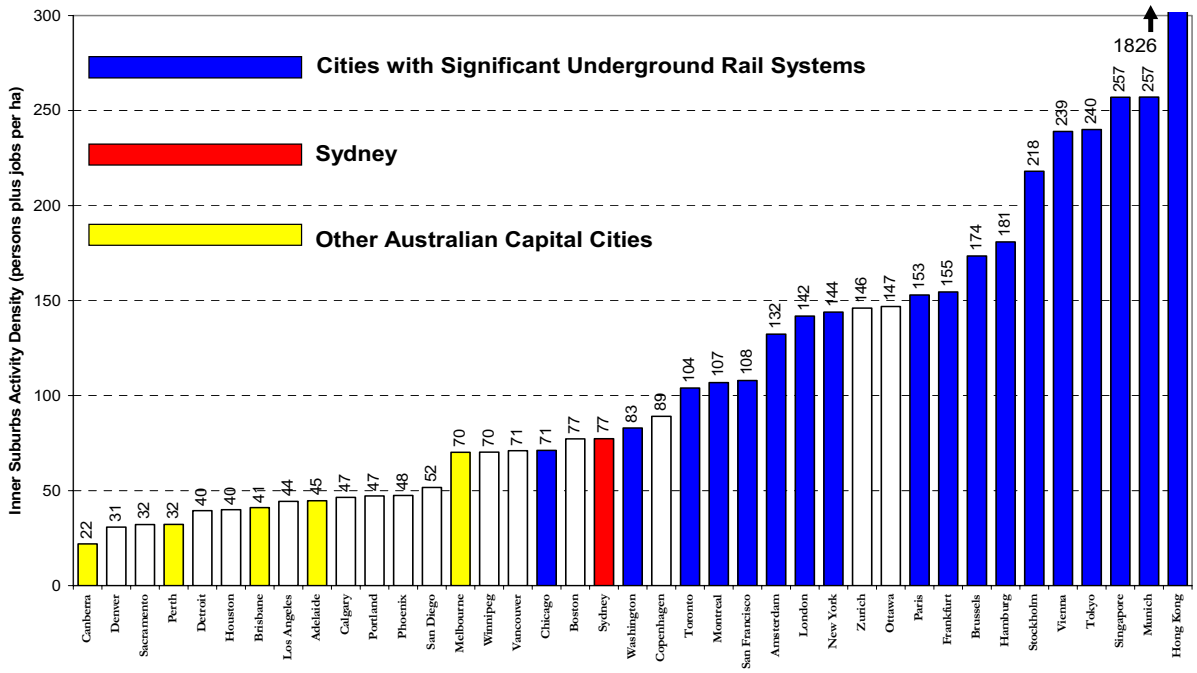


Figure 3A: Metropolitan Density for Cities with and without Light Rail Systems

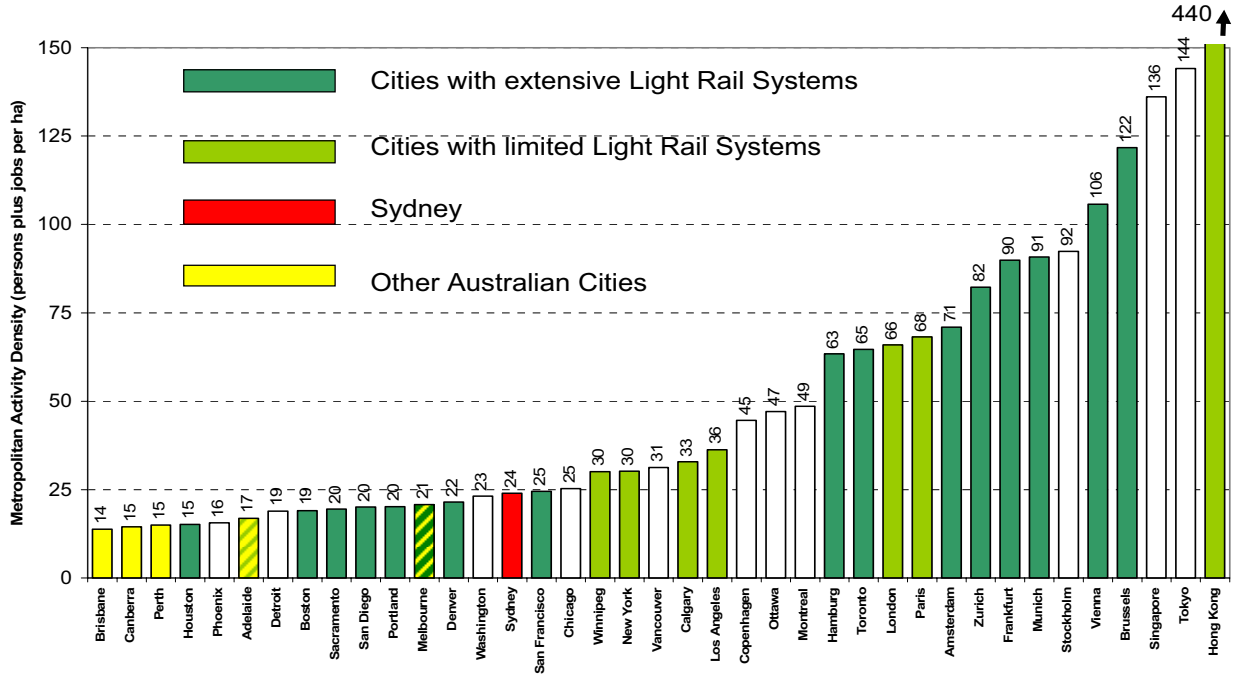
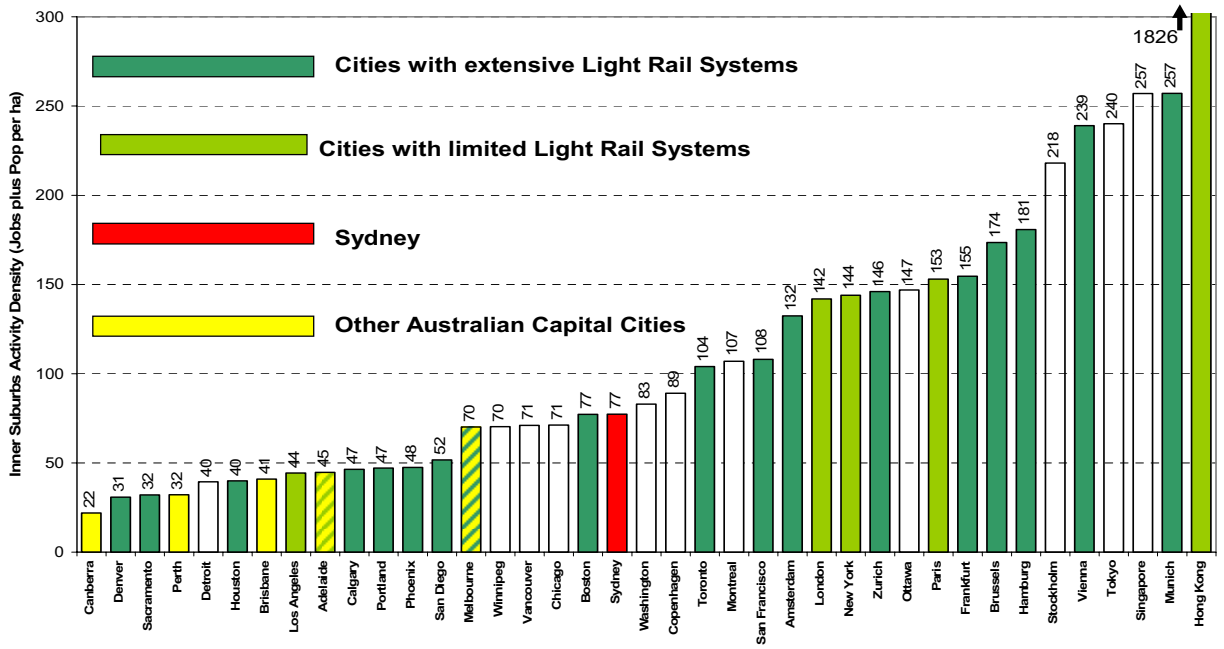


Figure 3B: Inner Suburb Density for Cities with and without Light Rail Systems



Implications for Sydney

The comparison with other cities indicates that Sydney is at the lower limit of where extensive underground metro rail style systems are likely to be viable, even in the future with 30% growth in population and employment density. On the other hand, Inner Sydney in particular already exceeds the densities where light rail is common overseas.

The actual choice of mode for particular applications depends on many factors, including patronage potential; density; the length of the corridor; topography, heritage or other constraints; and urban form and potential for development. For example:

- The total potential patronage on a mass transit system will depend on the length and density of a corridor, the extent to which the corridor serves key desire lines (such as to a Central Business District), and competition from other alternative routes or corridors. Because of their high cost, fully underground metro rail systems are generally only justified where very high patronage can be developed (15,000 passengers per hour per direction in the peak hour or above). Partially underground or surface heavy rail systems can be viable at somewhat lower patronage levels.

- In addition, the longer the corridor the more important it is that higher speeds are achieved in order to keep travel times competitive. Thus for a 5-10 km corridor, on-street based systems such as light rail or buses which tend to achieve average speeds around 20 kph can be appropriate, while for a 20 – 40 km length corridor, some form of grade separation (either dedicated guideway, or above ground or underground installation) is necessary to achieve higher average speeds (30 kph or above).

- Where topography is undulating, partial use of tunnels or above ground installation may be necessary because of gradients. In other cases, heritage constraints may make above ground installations undesirable, so that systems requiring grade separation will need to be underground.

- Urban form is also important. Heavy rail and metro rail systems with stations 1- 2 km apart (or more) tend to be associated with intense development around a relatively small number of nodes – examples such as Bondi Junction and Chatswood in Sydney illustrate this. By contrast light rail systems tend to have more frequent stops (typically every 400-800metres), which support linear development along the whole corridor, as evidenced in Sydney with strip shopping centres and medium density housing along the original tram routes.

Consideration of all the above factors, together with analysis of current travel patterns suggests that, for Sydney:

- the inner suburbs south of the harbour are highly suited to a light rail network, which would complement the existing land use pattern, provide appropriate capacity, and support transit oriented development.

- Extension / upgrading of the suburban heavy rail system is likely to be more appropriate to the much longer corridors linking the CBD to the outer suburbs (eg north-west and south-west sectors, Central Coast and Warringah peninsula. This could however involve some tunnelling and use of metro style rollingstock.

- For the secondary corridors linking lower density areas to secondary CBD's (eg NW sector – Parramatta) busways may be the most appropriate and cost-effective mode.