
Wellington Public
Transport Spine Study
RAILWAY STATION TO HOSPITAL
International Review
of Public Transport Systems

Appendix C2

Case Study: Bergen Bybanen
Country: Norway
Mode: Light Rail Network

Similarity to Wellington Environment	
Bus based PT network with capacity problems requiring mode shift in order to resolve them.	
Relatively constrained and/or narrow CBD with a strong PT Spine where throughput has been optimised.	✓
A suburban rail network (or metro) which terminates short of the central CBD requiring a change of mode to complete the journey.	
Other (please describe)	

Modal Characteristics Summary

Vehicle capacity	220 (per train set)
Peak hour capacity (pphpd)	Phase 1 2,000[2]
Service frequency	5 minutes (peak) 10 minutes (off peak) 1 hour at night
Capital expenditure (per km)	NZ$ 46.4[1] (Total - NZ$ 454.8 M)
Operational expenditure (per km)	NZ $1.5m per km per annum (includes staff costs)[2]
Operating speed (km/h)	Average speed: 28km/h (Maximum speed: 70 km/hr)
Turning radii (m)	25 m
Power source	Electric (overhead) 98% from hydro plants
Typical Spacing of stops	800 m
Annual Patronage	Phase 1 8,580,000[3]
Annual Passenger Kilometres	42,805,331[4]

Case Study Description

Overview

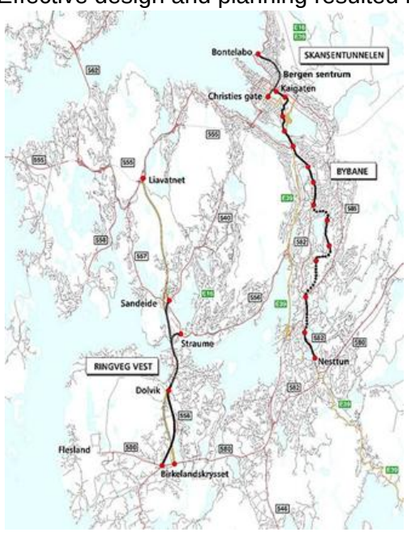
Bergen Light Rail (Bybanen in Norwegian) is a light rail system in Bergen, Norway. The first stage of the network opened over a 9.8 kilometre route in January 2011 with 15 stations between the city centre and Nesttun. Bergen Bybanen has already been recognised as an example of good practice in light rail and was named Light Rail Project of the Year in the 2011 Global Light Rail Awards.

Bergen is well suited to high quality transit systems. The area is mountainous and its population is concentrated in valleys that radiate from the city centre, generally under 2 km wide. The entire line will, upon completion, directly serve about 25% of the region's population. The existing line is considered to have improved the efficiency of the existing transport system by offering additional transport capacity along the city's busiest corridor.

History

Like many cities, Bergen was faced with increasing levels of congestion and adverse environmental conditions associated with escalating traffic volumes. Existing public transport infrastructure, including radial bus services, were not providing sufficient capacity or quality of service to facilitate a shift in travel choice away from private motor vehicles. Significant investment in road infrastructure, including a toll ring in the 1980's and 1990's, did not alleviate traffic congestion and, as a result of these conditions, the need for further transport investment was acknowledged and potential options identified. A planned investment strategy, known as the 'Bergen Program for Transport, Urban Development and the Environment (2002 – 2015)' was subsequently developed which included road investment and pedestrian and cycling schemes alongside a light rail system.

Effective design and planning resulted in fast and efficient delivery, which meant the light rail line was implemented in just two years - within the project deadline and budget. Although the new line has only been open for little over a year, there are already signs that it has established itself as an integral part of the transport system and has become a recognisable symbol of Bergen.



Map showing the light rail scheme in the context of wider Bergen Program.

Phase 1

The first phase of the light rail network developed for Bergen is a 10 km line, with 15 stops between the city centre and Nesttun. Phase 1 opened in 2010 with a proposal to extend the line in two stages as far as the city's airport, subsequently serving the northern and western parts of the city. Passenger numbers have, even at this stage of implementation, surpassed all forecasts and with further transit orientated development planned, and extensions to the line under way, there is potential for further growth.

Overall, the new Light Rail system has provided an environmentally friendly, efficient and direct transport system along a corridor where there was particularly high demand. It has facilitated greater choice for passengers and helped to reduce some of the negative impacts of car travel, including in the city centre.

Reference Map

The map demonstrates the linear form of the route which has been shaped by existing settlements and the area's topography.

Source: www3.bergen.kommune

[1] ETC Papers - LPT03iii (2011)
[2] ETC Papers - LPT03iii (2011)
[3] ETC Papers - LPT03iii (2011)
[4] ETC Papers - LPT03iii (2011)

Source: http://en.wikipedia.org

Success of Scheme in Restructuring and Reshaping Integrated Land Use and Passenger Transport

One of the core aspirations for the new line was to stimulate urban development along the line and around the stations. Therefore, local government permits and encourages high-density commercial and residential development adjacent to stops. As a result of this political will and investment in infrastructure, a number of development projects are now being considered by private developers.

The key aspirations for the new line were to reduce the impact of traffic, improve the environment and promote development. As well as benefitting the corridor, along which the system runs, the impact on traffic volumes is also contributing to reduced traffic volumes and an improved environment in the city centre. The new transport infrastructure provides a positive image for the city and is now integral to its streetscape. The environmental credentials of the schemes are high with zero-emissions. Due to the way electricity is generated in Norway, 98% of energy is supplied from emission free hydroelectric sources.

Key Success Factors

- Ensuring a high quality passenger experience - frequent, reliable services and ease of access have made the network popular with users.
- Passenger number forecasts have exceeded that expected and significant modal shift is thought to have occurred (although this has not yet been measured).
- The line has been designed to integrate with existing bus services throughout the corridor. In addition there has been a deliberate strategy to link high quality pedestrian and cycle routes with the new stops.
- The system responds to existing high levels of demand along a congested corridor where there has been a long-term desire for transport improvements. The network is supported by transit orientated development.

Design Issues

- The network line is served by 12 low-floor vehicles that are 32 metres long and 2.65 metres wide with space for approximately 220 people (seating 84). The system is built without balloon loops, so trams must be bi-directional.
- The trams have five articulated sections and are expandable, with another two modules, to a length of 42 metres should additional capacity be necessary in future. Stations have been constructed to cater for the extended trams.
- Design features have been implemented on tram-only sections of the route to discourage cars from accessing the streets while still enabling emergency access. Along one stretch of the route the track has been laid on maize, which appears inaccessible but allows emergency vehicles to drive safely.
- The whole line is double tracked which is beneficial in terms of journey times as it enables visual signalling and speed adjustment on all ground stretches.
- All stations are step free and fully accessible.

Operational

- Segregation from traffic reduces journey times and an average operating speed of 28 km/h has been achieved through priority at junctions, short station dwell times, limited slow speed operation in the town centre and an average of 800 m between stations. Once the line is extended, however, residents have highlighted that, beyond its current terminus at Nesttun, journey times will be longer than for direct buses not making intermediate stops.

Constraints

- The network takes a linear form as a result of the physical constraints in Bergen, namely the mountainous topography and existing settlements. As a result of this linear form it has been acknowledged that for future extensions journey times may be less favourable.
- The scheme has not been universally popular and opposition has been raised by some residents, in particular those who live in areas not served by tram who consider that users of the toll will have to pay for public transport investment that will not benefit them.

Technology

- To reduce noise, city centre streets have been laid with rubber insulation.
- Advanced signalling solutions have been included to increase efficiency and improve safety. As well as priority at junctions, key features include interlocking, depot management and block signalling for four tunnels with Automatic Train Stops.

Interchange(s)

- Stations have been integrated with bus and rail nodes, including in the city centre. Local transportation infrastructure has been provided for pedestrians and bicyclists and many stations have also included parking spaces for commuters.
- Real time information is provided for waiting passengers.
- Many of the stations are located in primarily residential areas and although the designs are generally low impact, the project has received some opposition from residents concerned it could impact on the character of the local area.

Procurement and Governments

Cooperation between different levels of governance (state/district/municipality) has been necessary to deliver the project. Finance required was developed by local and national governments in a package known as the Bergen Program for transportation, urban development and the environment. Local funding for the program has been raised via a 20 year extension of the city's toll ring that has been collecting tolls from motorists since 1986.

Bergen Light Rail Project Office, an agency that is part of the municipal government of Bergen, was responsible for building the line while the physical infrastructure and trams are owned by Bybanen AS, a limited company (which is wholly owned by Hordaland County Municipality)[5] [6]. The Bybanen infrastructure and rolling stock are owned by the local authority, which has set up a subsidiary, to manage the maintenance of the line. The operation has been contracted on a long-term (7+2 year) basis to a private consortium which facilitated long-term planning for these organisations.

[5] Bergen Light Rail Project Office. "Fjord1 Partner skal køyre Bybanen

[6] Hordaland County Municipality (18 March 2009). "Pressemelding" (in Norwegian)

Visual Images of the City and Passenger Transport Mode/System

Panoramic view of Bergen

Source: http://en.wikipedia.org

City centre alignment

Source: http://en.wikipedia.org

Example of stop

Source: http://en.wikipedia.org

Alignment parallel to highway

Source: http://en.wikipedia.org

Segregated section in suburban Bergen

Source: http://en.wikipedia.org

Case Study: Freiburg
Country: Germany
Mode: Light Rail Network

Similarity to Wellington Environment	
Bus based PT network with capacity problems requiring mode shift in order to resolve them	
Relatively constrained and/or narrow CBD with a strong PT Spine where throughput has been optimised	✓
A suburban rail network (or metro) which terminates short of the central CBD requiring a change of mode to complete the journey	
Other (please describe)	

Modal Characteristics Summary	
Vehicle capacity	205[1]
Peak hour capacity (pphpd)	-
Service frequency	7.5 min
Capital expenditure (per km)	-
Operational expenditure (per km)	-
Operating speed (km/h)	-
Turning radii (m)	-
Power source	Electric
Typical spacing of stops	300 metres
Annual patronage (buses and trams in Freiburg)	65.9million[4] (two thirds light rail)
Annual passenger kilometres	-

Case Study Description

Overview

Investment in transport infrastructure in the city of Freiburg has resulted in a transformational impact on modal choice. In the last three decades, the number of bicycle trips tripled, public transport patronage doubled, and the share of trips by car declined from 38% to 32%.[2] Despite strong economic growth, the city has also seen per-capita CO2 emissions from transport fall. The light rail system is the central component of the city's public transport network and makes up two thirds of the city's annual public transport patronage.

History

In Freiburg there has been a consistent application of policies over the last 30 years promoting more sustainable travel and discouraging private car use. Following a period of decline in public transport infrastructure, which saw just 14 km of street car lines remain, an extensive public transport network was developed made up of tram lines, bus routes, and a gondola lift. Alongside transport investment, the city has consistently applied land use policies that encourage development to occur along public transport corridors and adjacent to public transport stops. A key element of Freiburg's planning for development is proximity to public transport stops. Around 65% of Freiburg's residents and 70% of all jobs are located within easy walking distance (300 metres) of a light rail stop (City of Freiburg 2008f).

As a result of sustained investment in public transport and strategic planning to encourage development that supports public transport use, passenger km of regional rail rose six fold between 1997 and 2006 and total public transport demand in the city of Freiburg and the surrounding region increased by 70% (Regio-Verkehrsverbund (RVC) 2008). Car ownership also grew at a slower rate in comparison with the rest of Germany. Between 1990 and 2006 it remained at 420 cars per 1,000 inhabitants, 23% below the German average. Between 1982 and 2007, the share of trips undertaken by car in Freiburg fell from 38% to 32% during a period in which both the economy and population were growing strongly.

Freiburg VAG tram

The tram lines make up the backbone of the public transport network which carries an average of 200,000 passengers a day[3]. It has a one metre gauge and is able to carry large numbers of passengers through the narrow city centre streets without the requirement to widen streets or demolish buildings. Investment in extending the existing network commenced in 1983 and subsequently a further three lines were added lengthening the network to 36.4 km. Following this period of investment the supply of light rail service almost tripled (from 1.1 to 3.2 million vehicle km). Tram services are provided every seven and a half minutes and co-ordinated with these are 26 bus lines connecting interchange points to surrounding areas. VAG, the municipal transport company of the city, operates a fleet of 62 trams and 104 buses.

Reference Map

Map demonstrating the existing and proposed tram network (Planned Extensions in Yellow)
Source: http://upload.wikimedia.org

[1] http://bc.transport2000.ca/debate/opinions/ad_justification.html
[2] Sustainable Transport in Freiburg: Lessons from Germany's Environmental Capital, Ralph Buehler1 and John Pucher (2011)
3 ^ a b "About the VAG". Freiburger Verkehrs AG. http://www.vag-freiburg.de/index.php?id=98&L=1. Retrieved 2009-04-17
[4] F. Fitzroy and I. Smith, Public transport demand in Freiburg: why did patronage double in a decade (1998)

Success of Scheme in Restructuring and Reshaping Integrated Land Use and Passenger Transport

A coordinated transport and land use policy in the city of Freiburg over the last thirty years has sought to maximise sustainable travel and integrate the LRT system. This strategy is in line with federal policy and regulation which discourages urban sprawl. It also provides strategic leadership to encourage the integration of land use and transport policies across all levels of government.

Freiburg is seen as a leader in land use policy development and patterns that support sustainable development. A carrot and stick approach has been applied where restrictive measures have greater acceptance as a result of providing safe, convenient and affordable public transport. Since the 1980's land-use planning has centred development on public transport stops, including the new light rail lines. More recently land-use planning has promoted high density development around public transport stops. However, these policies have been supported by economic success and widespread political support for sustainability.

Freiburg's most recent land-use and transport plans of 2008[5] were developed simultaneously. The earlier goals of reducing car use are reiterated, but there is greater emphasis on prohibiting car-dependent developments and actively supporting car-free neighbourhoods. There is a focus on compact development along light rail routes, strengthening local neighbourhood commercial and service centres, and mixing housing with stores, restaurants, offices, schools, and other non-residential land uses (City of Freiburg 2008b). Central development is unequivocally favoured over peripheral development.

Key Success Factors

Freiburg and its surrounding region have significantly increased the quantity and quality of public transport services. A higher share of trips by public transport is considered to have increased its financial sustainability and reduced CO2 emissions. Successful design and planning has been complemented by an attractively priced, unified ticketing system, which enables riders to use a single ticket for several trip segments and different types of service.

Other key factors that have supported public transport growth in Freiburg include:

- Implementing controversial/ restrictive policies in stages;
- Incorporating flexibility and adaptability into plans;
- Truly multi-modal planning that includes both incentives and disincentives and is long term;
- Fully integrated transport and land-use planning;
- Public participation in planning; and
- Sustainable transport policies must be long term and sustained.

Design Issues

- Generally trams are segregated from traffic along light rail corridors although there are instances where trams share road space with cars.
- Narrow (1 m) gauge has facilitated flexible routing.
- Low floor vehicles have resulted in a highly accessible tram network.
- Real-time information is provided by digital displays at rail stations, light rail stops, and key bus stops.
- Space previously allocated to general traffic has been reallocated to public transport and restrictions on access and parking have resulted in greater priority for public transport and sustainable travel. This is particularly true of the city centre where many streets are pedestrianised, facilitating access via tram or bus, and the city centre ring road has seen lanes reallocated for use of buses.
- Bus feeder corridors strongly support the rail system.

Operational

Frequent and reliable services (every 7.5 minutes in peak) provide users with greater confidence and certainty.

Both light rail and bus services are faster and more reliable because of traffic signal priority, with lights turning green for oncoming trains and buses at key intersections. Car use restrictions, such as car free zones and traffic calmed neighbourhoods, encourage the use of public transport.

The introduction of Germany's first transferable flat-rate monthly ticket, providing cost savings for users, assisted with increasing patronage.

As well as public transport, Freiburg has invested heavily in cycling. This has resulted in a significant number of trips being undertaken by bike. Integration of cycling and public transport is broadly promoted with widespread provision of cycle parking spaces at public transport stops.

Constraints

- The popularity of the initial tram line resulted in the need for additional vehicles

Technology

- One attractive feature of the Freiburg light rail system, that also has a practical purpose, is the use of dedicated grassed tracks along the rail lines. Grass has replaced the use of tarmac or cobbles along some sections and as well as providing an attractive feature, it also benefits the network in terms of noise reduction and improved drainage.

Interchange(s)

- The light rail system has been developed as a network encouraging onward journeys by public transport. Light rail, regional rail, and bus services and timetables are fully integrated supporting the 'capture' of passengers within the public transport network.
- Fare integration and seasonal ticketing has been a successful attribute of the public transport network in Freiburg – a single regional ticket is purchased and is valid for all transport providers.

Procurement and Governments

The federal system of government has resulted in a tradition of local self-government. This has enabled local government in Freiburg to demonstrate strategic leadership in advancing its sustainable transport ambitions. The public transport network is run by the municipal transport company of the city, which has assisted with co-ordinating development and integration.

Development in Freiburg has been highly inclusive facilitating input from public, private, and community representatives. The city's history of public participation since the 1970's has assisted with developing inclusive processes, and in some instances communities have called for greater restrictions on car use.

Financial Viability

The financial viability of public transport in Freiburg is considered relatively high requiring only 10% of its operating costs to be subsidised through government funds, compared to 30% for Germany as a whole.[6]

Revenue for the light rail network is supplemented by advertising on vehicles, which makes a popular canvas for advertisers as they are highly visible. Advertising provides 5% of the total revenue.[7]

[5] City of Freiburg. 2008f. Verkehrsentwicklungsplan Endbericht 2008 (Transport plan 2008)
[6] Sustainable Transport in Freiburg: Lessons from Germany's Environmental Capital, Ralph Buehler1 and John Pucher (2011)

Visual Images of the City and Passenger Transport Mode/System

Aerial view of Freiberg demonstrating the impact of the topography on its development

Source: http://upload.wikimedia.org

Example of light rail stop

Source: bjoern.f | Björn Freiberg Fotografie
(http://urban-research.blogspot.com/2012/01/lessons-from-freiburg-on-creating.html**)**

Images demonstrating light rail operating within a physically constrained city centre and use of sympathetic street treatment

Source: http://upload.wikimedia.org

Light rail operates within the historic city core

Source: http://upload.wikimedia.org

[7] Scheurer J, Personal Communication, October 2002.

Case Study: Karlsruhe
Country: Germany
Mode: Light Rapid Transit

Similarity to Wellington Environment	
Bus based PT network with capacity problems requiring mode shift in order to resolve them	
Relatively constrained and/or narrow CBD with a strong PT Spine where throughput has been optimised	✓
A suburban rail network (or metro) which terminates short of the central CBD requiring a change of mode to complete the journey	✓
Other (please describe)	

Modal Characteristics Summary	
Vehicle capacity	223 (100 seated)
Peak hour capacity (pphpd)	Up to 40,000 (peak on busiest city centre section)[3]
Service frequency	45 second headways (peak on busiest section)
Capital expenditure (per km)	Conversions from heavy rail - $3.8m[4] (€2.3m) Street running – NZ$$29.4M (€17 million)
Total cost	-
Operational expenditure (per vehicle per km)	-
Operating speed (km/h)	Innercity: 30-70 km/h Outskirts: 60-80 km/h
Turning radii (m)	25 m
Power source	Electric (DC + AC)
Typical spacing of stops	-
Annual patronage	-
Annual passenger kilometres	133 m[1] (network)
Hours of operation	-
Rides per day	-

Case Study Description

Overview

The tram-train network in Karlsruhe is often described as the originator of modern light rapid transit. Following municipal public transport authority and federal state (who operated the regional rail network) agreement, it was agreed that a light rail network could expand beyond its traditional boundaries to serve a much wider area. Enlargement of the local network occurred as a result of technological developments that facilitated transfer between heavy and light rail alignments, including through the city centre. The initiative has demonstrated that technical obstacles relating to light rail's use of heavy rail alignments could be overcome and that vehicles could alternate between current and direct current. The network now serves a relatively large, but dispersed, population of 1.3 million people.

History

The concept behind the Karlsruhe model was to facilitate the seamless transition of regional rail services to inner city tram services. There was a particular need for greater penetration into the city centre as the main rail station is located on its periphery of the centre. The need to reduce the impact of traffic congestion on roads in the city was also an influential factor.

It was understood that cooperation between local agencies and regional bodies would be required for the improvements in Karlsruhe to be realised. Greater integration was required across borders and between towns and this process required gradual implementation and negotiation and establishment of one organisation coordinating local and regional public transport (see procurement and government).

The first section of actual 'tram-train' opened in 1992 operating both on tram lines and along regional rail routes. Progress made in developing the Karlsruhe model allowed people to travel into the heart of the city centre when previously they had to transfer between modes. As well as improving the passenger experience, benefits were also realised in terms of journey time savings. These improvements resulted in greater numbers of passengers using public transport, although the impact on modal share is thought to be less significant.

Tram-Train

Overall the network covers 530 km of tracks[1] and is served by more than 260 light-rail vehicles (121 of these are tram-train cars). The hybrid vehicles can operate on both the tram network, using DC and generally inside of the city, and the rail network, using AC and generally outside of the city. Progress made in Karlsruhe demonstrated that trams can operate over longer distances and that they represent a feasible alternative to underground metro and heavy rail.

The network has seen a significant impact on passenger numbers including a doubling of passenger numbers to 133 million[2], between 1985 and 1999. Different rail corridors have been impacted to different extents. In the Karlsruhe-Bretten corridor, where there were higher proportions of former car users, there was a greater increase in public transport patronage growth (+600% between 1992 and 1997) than Karlsruhe-Worth which saw an increase in patronage of 94% (1996 and 1998).

Reference Map

Source: www.humantransit.org

[1] http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rrd_101.pdf
[2] http://www.pteg.net/NR/rdonlyres/F37F7FEB-4756-4705-8185-EEEA79F6287E/0/WhatLightRailCanDoforCitiesAppendices_0105.PDF
[3] ttp://www.railforthevalley.com/news-articles/lrt-and-subway-construction-costs/
[4] http://www.tramtrain.org/en/index.html

Success of Scheme in Restructuring and Reshaping Integrated Land Use and Passenger Transport	Key Success Factors	Design Issues
Public transport has become more competitive as a result of faster and more reliable journey times and greater integration. Greater priority has been provided to light rail vehicles and integration between light rail and feeder buses has provided more direct and seamless journeys by public transport into the city centre. This “pick-up-the-customer-at-his-front-door-approach” to public transport increased the efficiency and user experience along existing transport corridors. Park-and-ride is a key feature of suburban sections of the network and has been encouraged at stops as a means of transferring journeys into the city centre onto public transport.	Key aspects of the infrastructure which are considered to have contributed to its success are as follows: - Reduced journey times (15 minutes of travel time saved); - Reduced need to interchange especially for trips into the city centre; - A consistent tariff system; - High quality vehicles; - Low investment (shared infrastructure); - Good intermodal transport; - Local and regional public transport companies under one umbrella; - Development of light-dual mode vehicles; and - Although there are additional costs associated with coordinating light and heavy rail the overall costs compare favourably to implementing extensions to heavy or light rail. Understanding existing travel patterns was considered to be critical for developing the right scheme. Traffic flows have been investigated in detail when developing schemes.	Design features of the Karlsruhe model include the following[5]: - The wheel profiles have been adapted to be used on different switch types and on both track types: flange rail for heavy rail, and partly grooved rail on tramways; - The vehicles need to manoeuvre on a variety of curve radii; - Adherence to a lower wheelset load on tramway tracks (generally 10t instead of 16t on some heavy rail tracks) ; - Adjustable overhead catenary power mechanisms as the height of the power lines differs for light and heavy rail systems; - The tram-train must be equipped with both types of radio control systems; - The buffer load must be greater than 600 kN, as compared with the standard of 200 kN for trams, and 1500 kN for heavy rail; - The vehicles must comply with the relatively short stopping distances; - The vehicles must be outfitted with an automatic train warning/automatic train stopping inductive system for travel in sections of heavy-rail track; and - To increase travel speed, trams receive the right of way at most crossings.
		Operational
		- Over 200 vehicles are in operation and new vehicles have been designed to contain the range of facilities, such as toilets, that would be expected of long-distance trains. Punctuality and comfort are also been key factors behind the successful implementation of the tram-train vehicles.

Constraints	Procurement and Governments
- Along Karlsruhe’s main street in the city centre, the number of trams using this route has led to congestion. Consideration has been given to introducing a tunnel through the city centre in response to this issue. - High and medium floor vehicles have required level access and therefore ‘heavier' infrastructure in the city centre. - Providing direct access into the city centre increases journey times for those on journeys across the city. - Conversions to LRT have not always resulted in modal shift - the line from Karlsruhe to Bretten caused an increase of passengers from 2,000 in 1992 to 14,000[6] in 1997. This growth in public transport usage did not, however, translate directly into significant modal shift with only 16% of trips overall in 1998 were made by public transport.	Karlsruhe was the first European city to implement track-sharing for light and heavy rail vehicles. In order to achieve this ambition there was a need to coordinate its development between local public transport operators and regional public transport bodies. An umbrella organisation entitled the Karlsruhe’s Transportation Association (Verkehrsverbund / KVV) was therefore founded in 1994 by the five public transport companies which operate different networks. Track ownership has also been split between the local operator (owning more than 260 km of the network track) and Deutsche Bahn (the German national railway company) who own the remainder. The light rail network itself is co-ordinated by the local public transport operator and the regional tram-train operator who work together to support the economic and efficient operation of the light rail network. The scheme was implemented and is operated by Albtal-Verkehrs-Gesellschaft (AVG), which is owned by the city of Karlsruhe and the privately owned railway company. As well as local and regional public transport operators, support was also required from the city’s politicians and administrators, representatives from wider areas, and rail haulage companies.
Technology	
- The German guidelines for heavy rail operation (EBO) are different from German tramway (LRT) specifications (BOStrab). The trams needed power modification, to be able to operate in a AC power environment, as well as with DC power. Overcoming this design issue was critical in facilitating the development of the Karlsruhe model. The regulatory requirements of both needed to be conformed with along with new track sharing guidelines which were specifically developed in response to the plans.	
Interchange(s)	
One of the key aspirations for the public transport improvements was to improve intermodal connections between rail and buses (through provision of feeder services). Interchanges also cater for automobiles and bicycles. At the same time tram-train has reduced the need to interchange in some cases by providing direct access into the city centre.	

[5] http://www.karlsruher-modell.de/en/index.html
[6] [6] http://www.tramtrain.org/en/index.html

Funding

Funding for rail projects in Germany is shared between different levels of Government although the federal government has a significant role to play in contributing to project finance. Since the passage of the Federal Municipal Transportation Finance law (GVFG) in 1967, federal governments have had to provide funds to state and local governments for capital investment. For Karlsruhe the following breakdown of funding has been applied for infrastructure and rolling stock costs.[7]

Infrastructure	Proportion [%]
German Municipal Financing Act (GVFG)	85
Local and Regional Authorities	15

Rolling Stock	Proportion [%]
German Municipal Financing Act (GVFG)	50
Local and Regional Authorities	50

[7] http://www.tramtrain.org/en/index.html

Visual Images of the City and Passenger Transport Mode/System

Tram-train is routed through the heart of Karlsruhe city centre

Source: TransportTechnologie-Consult Karlsruhe GmbH (TTK)
(http://www.tramtrain.org/en/index.html)

Central rail station and city centre stop

Source: TransportTechnologie-Consult Karlsruhe GmbH (TTK) (http://www.tramtrain.org/en/index.html)

City centre alignment

Source: http://en.wikipedia.org

Heavy rail operation:

Source: http://en.wikipedia.org

Source: http://en.wikipedia.org

Case Study: Rouen LRT
Country: France
Mode: Light Rail Network

Similarity to Wellington Environment	
Bus based PT network with capacity problems requiring mode shift in order to resolve them	
Relatively constrained and/or narrow CBD with a strong PT Spine where throughput has been optimised	✓
A suburban rail network (or metro) which terminates short of the central CBD requiring a change of mode to complete the journey	
Other (please describe)	

Modal Characteristics Summary	
Vehicle capacity	178 (per car)
Peak hour capacity (pphpd)	-
Service frequency	Every 3 minutes (peak) and every 20 minutes (off peak)
Capital expenditure (per km)	NZ$50M (€32m)[2]
Total cost	NZ$796M
Operational expenditure (per vehicle per km)	-
Operating speed (km/h)	19 km/h (80km/h maximum)
Turning radii (m)	-
Power source	Electric
Typical spacing of stops	500m
Annual patronage	15 million[1](network)
Annual passenger kilometres	-
Hours of operation	0500 to 2330
Rides per day	-

Case Study Description

Overview

Rouen is a city of 530,000 people located in upper Normandy in the north-west of France, 110 km to the north-west of Paris. As well as an historic and densely developed city core the development of public transport infrastructure and operation in Rouen has been further constrained by several elevated plateaus and the city being dissected by the River Seine.

In addition to physical constraints, further unfavourable conditions impacted on access and movement in the city, including the proliferation of private vehicle ownership, an oversupply of city centre parking and increasing urban sprawl. As a result of these factors the city's authorities decided to develop an integrated public transport network utilising existing public transport facilities. The integrated network currently includes light rail, Transport Est-Ouest Rouennais (TEOR) bus rapid transit and standard buses.

Historic context and overview of scheme

Following 10 years of feasibility work, a decision was made in 1990 to construct a light rail network. The first section of the light rail system opened in 1994, and the tramway was extended in 1997 to the technopôle du Madrillet. It operates on one line with two southern branches to Saint-Étienne-du-Rouvray and Le Grand-Quevilly. The length of the tram network is 18.2 km, including a 1.7 km section city centre route that runs underground, and 31 stops. The remainder of the network operates at street level along highways and on reserved track.

The service benefits from 18 and a half hours of operation (between 5 am and 11.30 pm) and frequent peak services at 3 minute intervals. On a daily basis it is estimated there are at least 4,000 passenger trips per route kilometre.

Reference Map

Source: Wikimedia common

[1] http://www.metrotram.it/index.php?vmcity=ROUEN&vmsys=lrt&ind=0&num=2&lang=eng

Success of Scheme in Restructuring and Reshaping Integrated Land Use and Passenger Transport

In France, one aspect of surface-level fixed rail transit services that is seen to be advantageous is the opportunity to reassign the streetscape. Roadspace previously dedicated to private automobiles has been converted to tramway and adjacent footpaths have been redesigned to better integrate with transit orientated and more pedestrian friendly corridors.

The light rail system has also had a role in 'greening' the city as a result of landscaping in locations where roadspace has been reclaimed. 15,000/m² of green space has been reclaimed with features including landscaping with turf between the tracks[2]. In addition, pedestrian accessibility has been enhanced with wider crossings.

Key Success Factors

Key factors that have made the scheme successful are:

- A favourable public image;
- Trams designed to offer high levels of comfort with a stylish interior design, use of climate control, noise and vibration insulation;
- Reliable and high performance levels with frequent services;
- Zero-emission vehicles;
- Lower capital cost than metro systems;
- Higher capacity than buses; and
- Integration with other forms of public transport.

Fares are provided at a flat rate and are integrated with bus service fares.

Following the opening of the light rail system in 1994, Rouen saw annual public transport trips rise from 25.7 million (1993) to 32.8 million (1995), an increase of 27.7 percent.[3]

Design Issues

The original rolling stock was Tramway Français Standard (TFS), a type of vehicle used on many of France's tramways. There are 28 tramcars with the following specification:

- Low-floor vehicles
- Tramcar capacity: 178
- Length: 29.40m;
- Width: 2.30m;

In 2010 it was announced that new vehicles were going to be ordered to increase capacity by as much as 60 percent. Twenty-seven Citadis 402 trams will replace the current fleet of vehicles. The new trams are 42 m long and 2.4 m wide with space for 300 passengers. It has also been suggested that the trams will consume 10 percent less energy than the original vehicles.

Operational

- There are no sections of the route where the system integrates with general traffic and the majority of the network operates along dedicated right of ways. These dedicated lanes enable trams to operate independently of cars while providing a more reliable service and higher operational speeds. Traffic regulation has also been introduced at junctions to ensure that priority is given to trams.

Constraints

- Due to physical constraints in the city centre a section of the line needed to be diverted underground, significantly adding to the cost of the project. As a result of this infrastructure, Rouen's LRT network has a higher average cost than similar schemes in France.

Technology

- The new light rail vehicles in Rouen will be equipped with electricity saving braking technology which allows electrical braking energy to be recuperated.[5]

Interchange

- The network integrates with both the heavy rail network and bus services, including the TEOR bus rapid transit system. Bus services have been reorganised to support the tram line.

Procurement and Governments

In France the local authority creates and modifies urban transport strategies for the local area. Urban Local Transport Plans are established and local authorities are provided with financial tools to finance their public transport policy. The Clean Air Act (1996) provided added impetus for enhancing public transport as greater emphasis was placed on improving air quality, including through reducing car use.

Funding for public transport is made up of contributions from government (around 35 percent of capital costs only), local authorities, local companies and passengers[4]. Nationally in France, passengers contribute around a quarter of the annual investment and operations financing through fare box revenues. However, the most important source of funding for tramway projects has been 'versement transport', a local tax exclusively dedicated to public transport. In Rouen the rate was set at 1.75 percent, generating a significant contribution towards public transport in the city.

The tramway scheme was implemented through a design, build, operate, and transfer (DBOT) contract, where some of the associated project risks are transferred to the consortium bidding for the work. After a tendering process, the Transport Authority selected a consortium that included financial institutions, an engineering company, infrastructure contractor, suppliers for rolling stock and systems, and an operator TCAR (Transportes en Commun de l'Agglomeration de Rouen). TCAR is a subsidiary of Veolia Transport (a multinational company) and provides public transportation in the form of light rail, TEOR and buses for the 45 communes of the metropolitan area of Rouen.

[2] www.veolia-transport.com
[3] Comparative performance data from French tramways systems, Egis Semaly Linited and Faber Maunsell (2003)
[4] Comparative performance data from French tramways systems, Egis Semaly Linited and Faber Maunsell (2003)
[5] www.veolia-transport.com

Visual Images of the City and Passenger Transport Mode/System

Rouen City Centre

Source: www.frenchconnections.co.uk

Source : http://world.nycsubway.org

Images showing street running and underground sections of the network

Source: http://world.nycsubway.org and http://en.wikipedia.org

Case Study: Phileas (Eindhoven)
Country: Netherlands
Mode: Advanced Guided Bus

Similarity to Wellington Environment	
Bus based PT network with capacity problems requiring mode shift in order to resolve them	
Relatively constrained and/or narrow CBD with a strong PT Spine where throughput has been optimised	
A suburban rail network (or metro) which terminates short of the central CBD requiring a change of mode to complete the journey	
Other. Advanced type guided bus but less expensive than rail	✓

Modal Characteristics Summary

Vehicle capacity	120 and 180 person bus models
Peak hour capacity (pphpd)	1,000
Service frequency	10 min
Capital expenditure (per km)	NZ$11.6M
Total cost	-
Operational expenditure (per vehicle per km)	-
Operating speed (km/h)	25-30 km/h (average speed)
Turning radii (m)	12.5 m
Power source	LPG Fuel/Battery
Typical spacing of stops	300 m
Annual patronage	9,405,000 (network)
Annual passenger kilometres	-
Hours of operation	-
Rides per day	-

Case Study Description

Overview

Phileas is a high quality public transport concept developed and implemented in Eindhoven. The system operates as an advanced guided bus ('rubber tired alternative to tram') intended to deliver tram-like public transport at a lower cost than light rail. It is designed to serve an area of significant mixed-use development between the cities Central Station and Eindhoven Airport. It also passes through a number of residential districts.

History

The concept was originally set up as a demonstration project to highlight expertise in the Eindhoven area and to create jobs. However, as the city sought to increase accessibility to the city centre and halt the trend of growing car ownership, Phileas represented an innovative solution to these transport challenges. Phileas also provided an opportunity to reverse the trend for cuts in local bus services and contribute to improving air quality. Spend on the project has been over one and a half billion NZD (€1 billion) since the late 1990's taking the idea from concept to implementation although construction has represented just 10% of these costs.

Phileas

Phileas provides a more modern and futuristic image than a standard bus and is perceived to overcome some of the issues that have dissuaded people from travelling by bus. For much of the 15 km route the vehicles travel along dedicated traffic lanes and Phileas has also been designed to use electronic guidance.

The cost of fully segregating the route was too high, therefore sections of the network interface with traffic. Although there is greater potential for conflict to arise with general traffic, in particular in the morning and evening peaks, this approach has benefits in terms of flexibility. The ability to provide segregated lanes and requirements for cornering also depend on available land which is especially relevant for town and city centres.

In operation Phileas has many similarities with light rail with comparable journey times. The vehicles and stops offer a similar ride quality and the dedicated lanes and elevated section give a greater feeling of permanence and quality than a standard bus. The vehicles also have strong environmental credentials. Their liquid petroleum gas engine emits on average 90% less combustion gases than a regular bus and fuel consumption is also 20% lower. As a result of having the option of switching to battery power, Phileas can travel short distances (up to three to four km) emission free which is particularly beneficial for town and city centre sections.

Reference Map

Map demonstrating the street pattern of Eindhoven. The central station, where Phileas serves, is highlighted in the centre of the picture and the airport is located on the western outskirts of the city

Source: http://www.google.co.uk/images

Success of Scheme in Restructuring and Reshaping Integrated Land Use and Passenger Transport	Key Success Factors	Design issues
Integrating With Development The transport corridor has been established to connect with development and other transport modes and the changes that have occurred can be seen to be mutually supporting. The system integrates public transport and new residential, leisure and commercial developments located in the city's Westcorridor whilst new links to existing transport infrastructure, including the motorway network, have also occurred. One location where this has occurred is Meerhoven, a residential area that has been designed around connectivity to the new transport system with a uniform layout that maximises visibility and connectivity to the stops. **Enhancing the Built Environment** The quality of design and contribution to the built environment has also been a consideration throughout the network. This has enabled public transport infrastructure to contribute to the attractiveness of its surroundings and a sense of place.	The network provides a frequent (every ten minutes) high quality service and segregated sections of the route contribute to favourable journey times that would be comparable with those provided by a light rail system. The journey between the city's Central Station and Airport takes less than 25 minutes. The delivery of the guided bus system has been supplemented by the following measures to encourage public transport usage: - Parking fees in the town centre. - Connecting public transport facilities in neighbouring areas and to the motorway. - Travel planning management. - Building of bicycle parking facilities.	The following design features exist: - Infrastructure – partially segregated system with sections of route operating on bus lanes which interface with general traffic. - Use of high quality materials for bus stops with provision for cycle parking. - Landscaping along the route and at bus stops enhances the local environment and supports the branding of Phileas. - The vehicles are designed to offer a comfortable ride and climate. They are operated at all times by a driver. - Levels of accessibility are high with raised platforms provided. Stops are approached using an electronic guiding system. - Sections of the route could be converted to light rail at less cost than implementing a full scheme as some of the 'heavy' infrastructure is already in place (such as the flyover on the approach to the airport).
		Operational - The infrastructure is significantly cheaper than light rail to operate because it requires less maintenance and there are no rails and overhead lines. - Electronic passenger information systems enable information to be obtained remotely on timetables, departures and delays. - On board payment system does not require driver interaction. - High demand enables more frequent services. Stopping is on demand. - Although individual vehicles do not have the maximum carrying capacity of light rail vehicles, route capacity is not dissimilar as a result of short headways and operational flexibility (vehicles can overtake and operate in convoys).
Constraints - Although it can carry greater numbers of passengers than most buses it does not have the same peak carrying capacity of some light rail networks. - Phileas is not fully segregated therefore in places it has to interact with general traffic. Where this occurs Phileas assumes right of way although trips can be subject to delay compared to fully segregated modes as a result of congestion or meeting other vehicles. - Stopping on demand can result in longer journey times during peak periods.		**Procurement and Governments** The development of Phileas required a significant amount of planning and investment along with strong partnership to develop the scheme from a concept to a working transport system. Other features of the procurement process included: - Co-ordination between regional government and the municipalities of Eindhoven and Veldhovens. - Construction by a consortium of predominantly regional companies with funding coming from a range of sources including the Dutch national government, the participating municipalities, Stimulus (European subsidies), the province of Noord-Brabant and local companies[1].
Technology Although externally it looks similar to a bus it has a number of technological features that distinguish the vehicle: - Vehicles can operate flexibly either using LPG fuel or by battery. Batteries are recharged by means of electromagnetic induction – this feature enables the battery to be much smaller, and thus lighter and with less environmental impact. - Magnetic docking allows drivers and vehicles to accurately stop alongside low floor platforms. - A pre-programme route guided system (FROG) has been installed that uses magnets to allow a driverless system to operate. However, Phileas operates with drivers as the system is not fully segregated and Dutch law requires the presence of a driver.		
Interchange - Interchange with other modes is a key feature of the network with Phileas providing connections to the railway network, the motorway network and the airport. Ticketing and pricing for the new system has also been co-ordinated with standard buses. - All bus stops have a modern design with shelters, seating and real time information. Some of the bus stops in Meerhoven have separate bicycle parking facilities.		

[1] http://connectedcities.eu/downloads/3rdparty/brt_phileas_folder.pdf

Visual Images of the City and Passenger Transport Mode/System

Eindhoven Cityscape, Phileas Using Designated Lane and Phileas Vehicles

Source: experience040 at nl.wikipedia

Source: http://connectedcities.eu/showcases/phileas.html, http://upload.wikimedia.org and /www.transportxtra.com

Images of Stop (Including Real Time Information) and Barrier Free Access

Source: http://connectedcities.eu/showcases/phileas.html

Case Study: Hiawatha Line
Country: Minneapolis, MN, USA
Mode: Light Rail Network

Similarity to Wellington Environment	
Bus based PT network with capacity problems requiring mode shift in order to resolve them	✓
Relatively constrained and/or narrow CBD with a strong PT Spine where throughput has been optimised	
A suburban rail network (or metro) which terminates short of the central CBD requiring a change of mode to complete the journey	✓
Other (please describe)	

Modal Characteristics Summary	
Vehicle capacity	186 (per car)
Peak hour capacity (pphpd)	4,800
Service frequency	7-9 peak/p 10 mins headway 15 mins Sat/Sun
Capital expenditure (per km)	NZ$44.8M
Total cost	-
Operational expenditure (per vehicle per km)	NZ$1.6M
Operating speed (km/h)	25 km/h
Turning radii (m)	-
Power source	
Typical spacing of stops	400 m
Annual patronage	10.5 million
Annual passenger kilometres	-
Hours of operation	-
Rides per day	-

Case Study Description

Overview

The city of Minneapolis, Minnesota has a population of over 380,000 while the urbanised area contains nearly 2,700,000 people. Downtown Minneapolis, which borders the Mississippi River, has about 105,000 jobs. The primary commercial area is about 2.5 square km with a traditional street grid.

Minneapolis is served by Metro Transit, which operates a fleet of over 800 buses and 27 light rail vehicles. The transit system serves over 250,000 daily passengers, including about 30,000 daily passengers on the light rail line. The system carries nearly 30% of work trips to the downtown area.

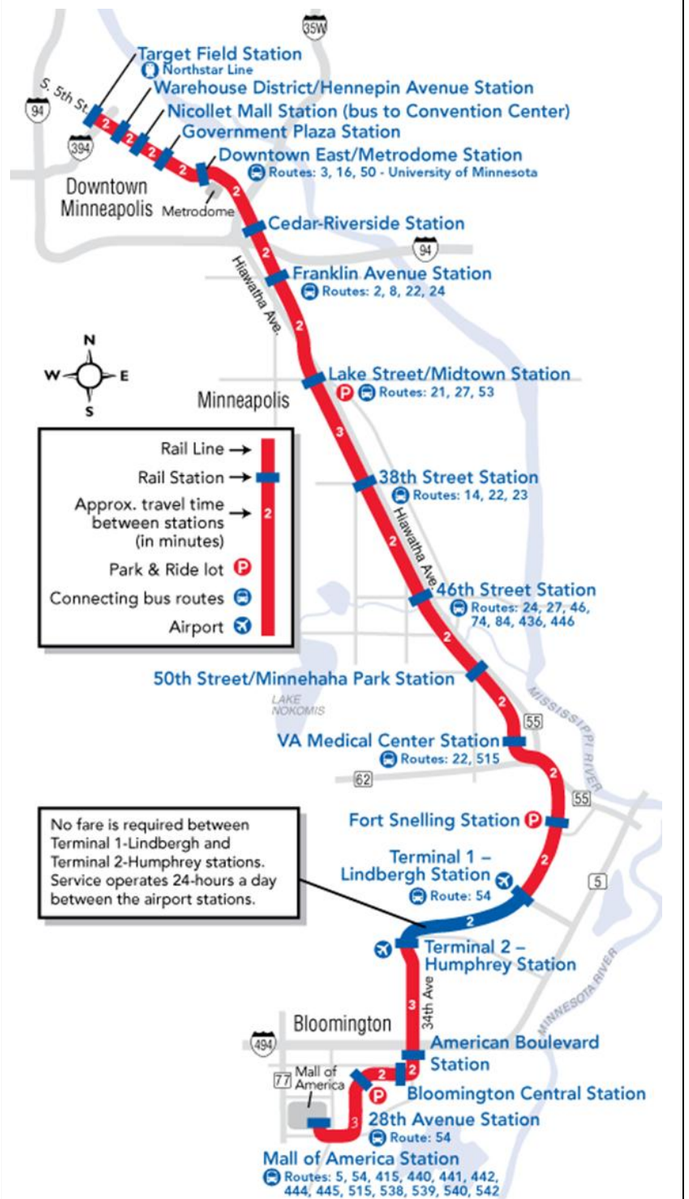
History

Nicollet Mall was created in 1968 to compete for retail with emerging suburban shopping malls. Several blocks on Nicollet Avenue were closed to automobile traffic and pedestrian amenities were greatly improved by introducing wide sidewalks, vegetation, and outdoor seating. Recently, the Minneapolis MARQ2 project (see below) moved all express buses off Nicollet Mall and, in turn, permitted cyclists to use the street at any time of day. Previously, cyclists were not allowed on Nicollet Mall between 6 am and 6 pm. Some local bus routes remaining on Nicollet Mall offer free rides and serve destinations such as the Convention Centre and the Nicollet Mall LRT station. All Nicollet Mall buses are hybrid-electric vehicles, providing quieter and “greener” public transportation service.

The Hiawatha LRT line concept was introduced in 1980, when the LRT line was selected as a preferred alternative in the Hiawatha Avenue Draft Environmental Impact Statement (DEIS). Over the years, the Hiawatha line alignment was refined and 5th Street was selected for the alignment in the Minneapolis CBD. The alignment allowed a limited amount of traffic to operate next to the LRT alignment, primarily to allow access to existing parking garages and other facilities. One block along the downtown alignment would be completely closed to accommodate one of the stations. The line was expected to extend past 3rd Avenue North to connect with the downtown Minneapolis commuter rail line. However, the commuter line was delayed and the Hiawatha LRT extension was included as a part of the commuter line project. The line opened for passenger service in 2004 and, in 2009, the line was extended to Target Field realising a connection with the Northstar Commuter Rail line.

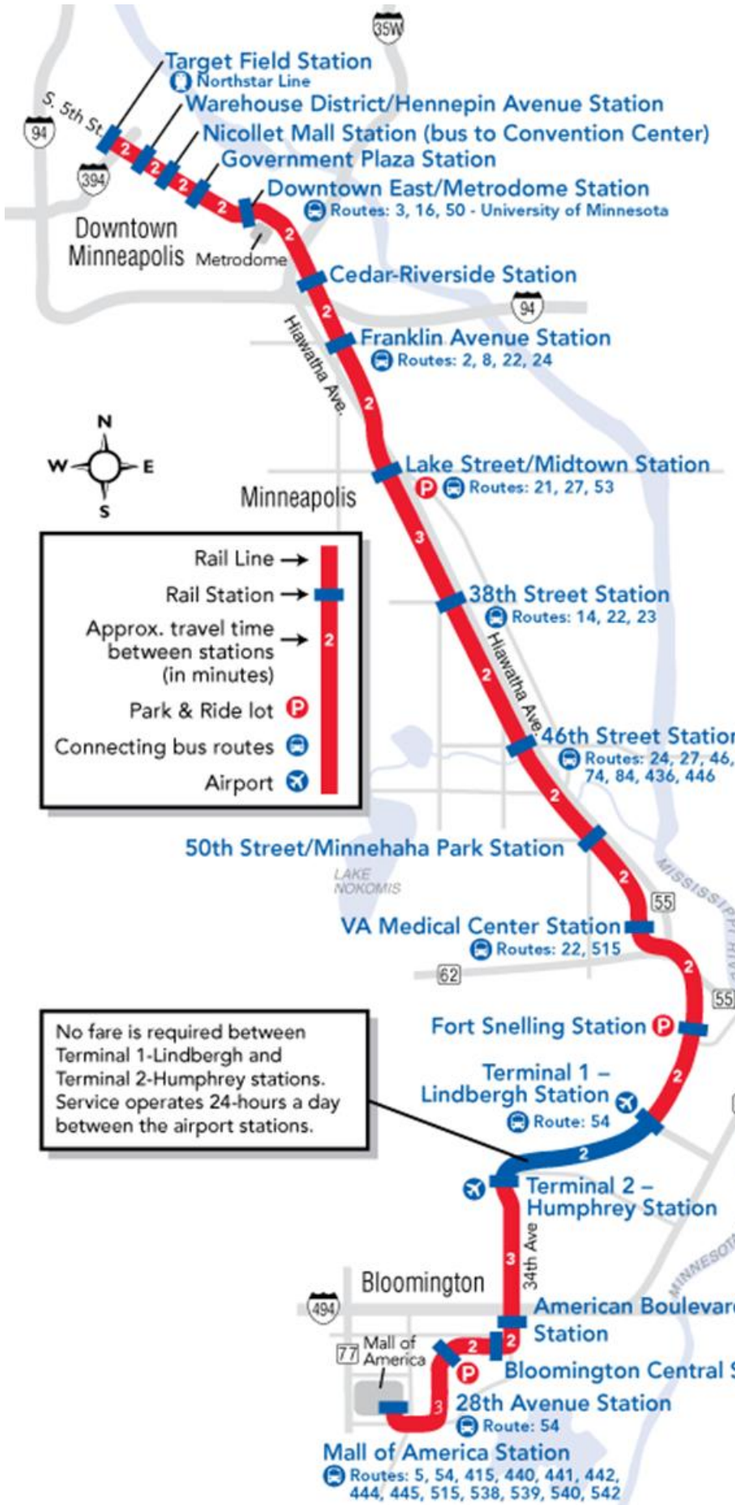
The Hiawatha Line is the first light rail line in Minnesota. Opened in 2004, the 19.2-kilometre Hiawatha Line connects several popular destinations, including downtown Minneapolis, Metrodome, Minneapolis/St. Paul International Airport, and Mall of America. The light rail line has 19 stations with patronage in 2010 reaching 10.5 million. The maximum service speed in the CBD area is around 25 km/h. Each car has four luggage racks and four bicycle hangers. The light rail line operates with seven to nine-minute headways during commute peak periods, ten minute headways during midday periods, and 15 minute headways in the evenings. The Saturday and Sunday headways vary between 10 and 15 minutes.

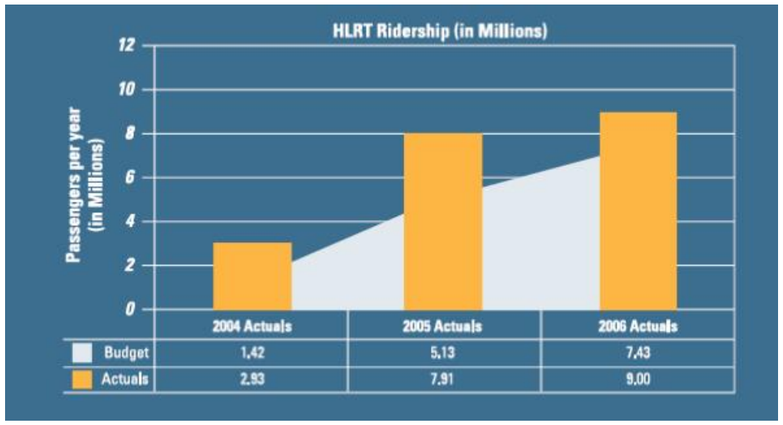
Reference Map

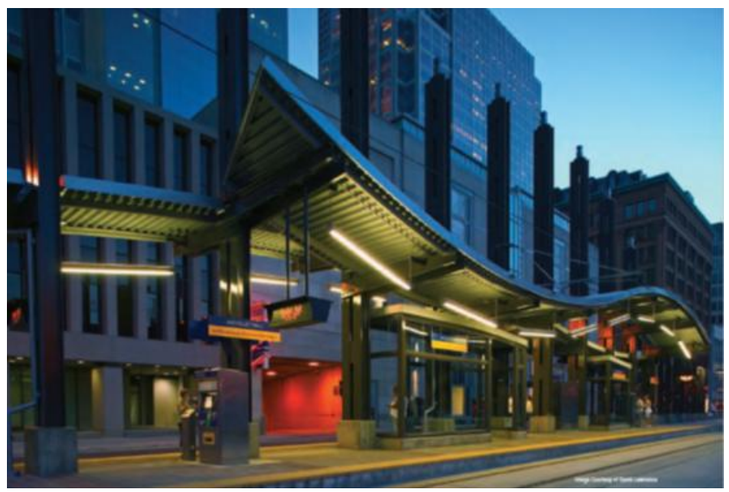


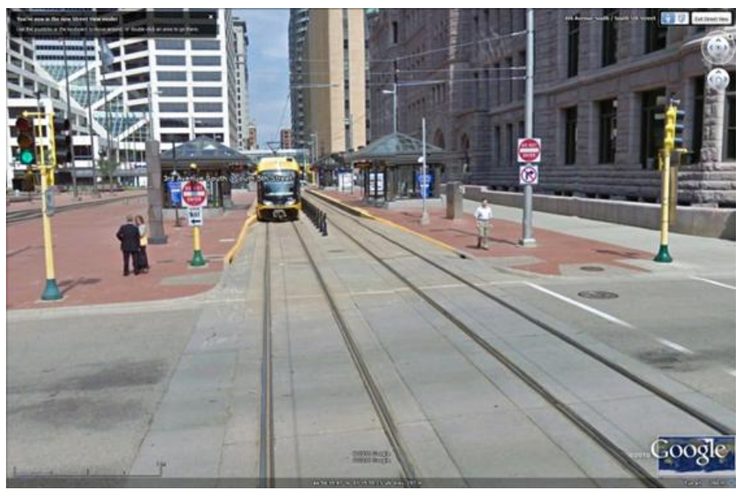
Success of Scheme in Restructuring and Reshaping Integrated Land Use and Passenger Transport	Key Success Factors	Design Issues
The Metropolitan Council adopted framework specifically advocates planning and investing in multimodal transportation choices. It stipulates medium and high density housing and mixed-use development should be promoted. The local street system should also be designed to easily connect housing to transit services and have provide for improved pedestrian and bicycle facilities. Several stations in the light rail corridor are designated as "catalyst" stations to focus initial investments and transit-oriented development actions. Before construction, planners had predicted the areas surrounding Hiawatha LRT would draw 7,000 new housing units by 2020. By December 2010, 8,100 new housing units were open or under construction along the line, with another 7,700 proposed by developers. Bus services have been redesigned to coordinate with light rail. Even with the light rail line, the number of buses is expected to increase in the Minneapolis CBD. Several streets are being reconstructed to improve bus service and multimodal access for cyclists and pedestrians. The main concept is to improve speed and reliability of bus service through the downtown core, add significant bus capacity, provide a more “legible” system for downtown commuters by consolidating express transit service into one north-south corridor, provide improved passenger waiting facilities, passenger security, passenger information systems, and passenger amenities.	- In the first year of operations, patronage of the light rail line exceeded projections by 65 percent. - Around 50 percent of light rail users are new to transit service since the light rail line started. Among new users who started using transit, 71 percent were influenced to do so by the introduction the light rail line. - Transfers are valid between light rail and buses for 2.5 hours. Bus transit routes connect to light rail using timed transfers. Passenger transfer from commuter rail to light rail is free. An additional fare is required for transfer from light rail to commuter rail. Forty-three percent of light rail passengers said they transfer to a bus to complete their trip.	- In the CBD, design issues included retaining access to loading docks, parking garages, and other facilities, a complete closure of one block to vehicle traffic to accommodate a station (see image above) and constructing a parking structure under one of the CBD stations. - Generally, the light rail line operates at-grade through intersections, using transit signal priority and pre-emption. Some crossing locations have automatic gates installed to improve crossing safety. At-grade operations avoid constructing costly grade separations but have greater effect on automobile traffic (especially pre-emption). In the CBD, trains operate only at-grade and frequently stop at signalised intersections. Transit signal priority substantially increased automobile delays at some intersections, especially in the initial phases of operations. - Fare collection is based on a barrier-free proof of payment system.
		Operational
		- The light rail service encountered loading problems during peak hours when using 12 train sets with a mix of one and two-car consists. Revising the schedule to provide 11 two-car consists on a seven to eight minute headway during peak periods improved quality of service. Compared with the original operating plan developed before start-up, savings were achieved by varying the number of cars to better match passenger demand. Signal pre-emption problems caused auto traffic backups at several locations.
Constraints		**Procurement and Governments**
- Initially, most station platforms could only accommodate two-car trains and that was one of the key capacity constraints. The station platforms have since been extended to accommodate three-car trains.		No information available
Technology		
No information available		
Interchange(s)		
The majority of light rail stations provide timed transfer connections to bus service. One of the terminal locations provides access to commuter rail service.		

Visual Images of the City and Passenger Transport Mode/System









Case Study: Portland Transit Mall
Country: Portland Oregon, USA
Mode: Light Rail Network

Similarity to Wellington Environment	
Bus based PT network with capacity problems requiring mode shift in order to resolve them	✓
Relatively constrained and/or narrow CBD with a strong PT Spine where throughput has been optimised	✓
A suburban rail network (or metro) which terminates short of the central CBD requiring a change of mode to complete the journey	
Other (please describe)	

Modal Characteristics Summary	
Vehicle capacity	532 (2 cars)
Peak hour capacity (pphpd)	-
Service frequency	-
Capital expenditure (per km)	-
Total cost	-
Operational expenditure (per vehicle per km)	NZ$1.6 M
Operating speed (km/h)	-
Turning radii (m)	-
Power source	-
Typical spacing of stops	300 - 450 m
Annual patronage	-
Annual passenger kilometres	-
Hours of operation	-
Rides per day	-

Case Study Description

Overview

The city of Portland, Oregon is located in northern Oregon near the Willamette and Columbia Rivers. The city has a population of over 580,000 while the urbanised area contains nearly 1,600,000 people. Downtown Portland caters for about 80,000 jobs and is also a major retail and visitor centre. The downtown area is concentrated along a narrow, 1.6 km long corridor, fronting the Willamette River, with hills rising to the west. The primary commercial area has a regular street grid, with only a few primary north-south streets. The Portland rail station (Union Station), with intercity Amtrak service, is located at the north end of downtown.

Portland is served by TriMet, which operates a fleet of over 600 buses and 140 light rail vehicles. The light rail system covers about 89 route kilometres with the transit system serving over 330,000 daily passengers, including about 133,000 daily light rail line passengers. The system carries nearly 30 percent of work trips to the downtown area. Portland has historically had a high level of transit service on a per capita basis, due, in part, to a solid payroll tax funding base.

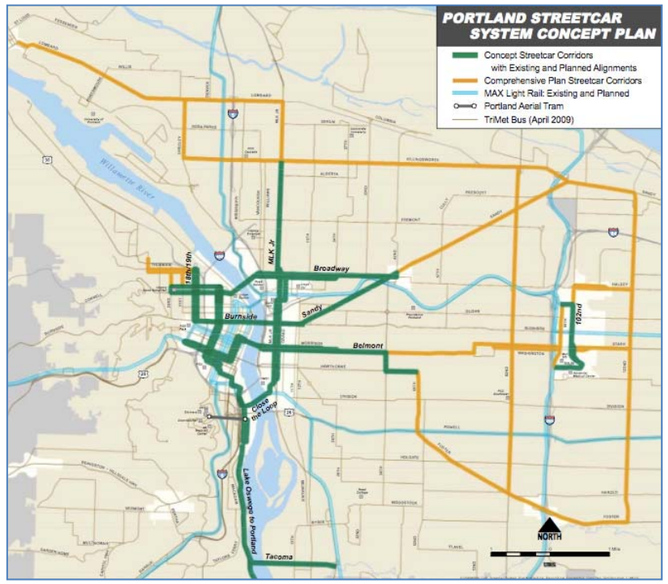
History

Portland's focus on transit stems from a public vote in 1973 to reject the proposed Mt Hood Freeway. Following that decision, new policies, including parking limits, were enacted which supported transit. A key issue at the time was better facilities for bus transit in the downtown. Planning focused on the concept of a bus mall on two primary north-south streets. The Portland Transit Mall opened in 1978, spanning 11 blocks on each of the two streets, 5th and 6th Avenues. The mall provided both a quality design and a well thought out operating strategy for efficient bus movement through the city centre. The mall was subsequently extended in 1994 by seven blocks to connect with Portland Union Station.

Following the success of the Transit Mall, Portland focused on developing light rail. The first line, known then as the Banfield Project, was opened in 1986. Downtown, the line intersected the mall in an east-west direction, providing added downtown transit capacity. Several extensions have expanded the light rail system (now known as MAX) to its current 89 km length. Additional extensions are being developed. The city also invested in a downtown modern streetcar line that serves new areas of development north and south of downtown. The streetcar line is credited as a catalyst for much of the new growth in those areas.

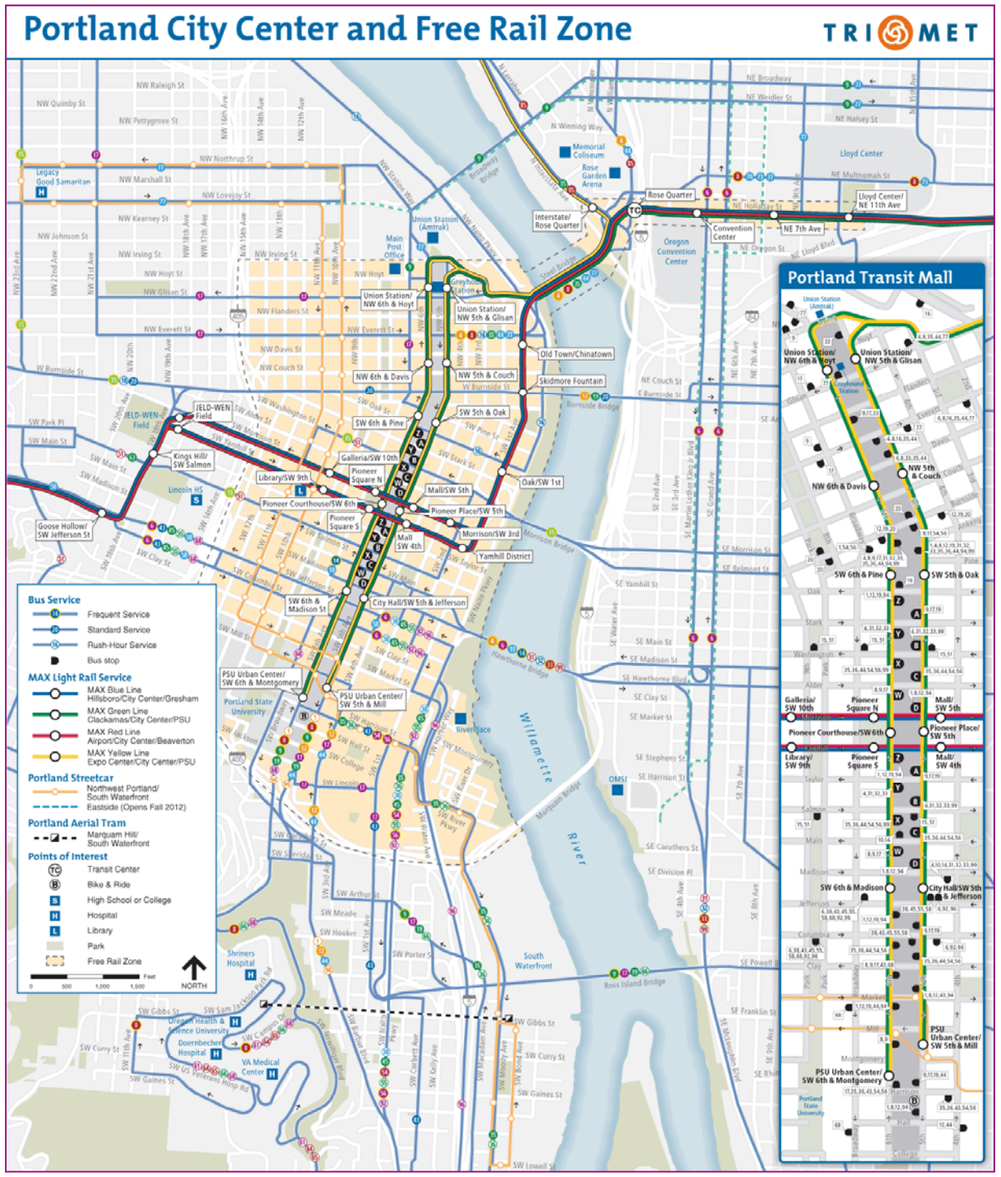
The most recent Portland transit project was the reconstruction of the Portland Mall. Nearly 30 years in age, the mall had suffered from deferred maintenance. Additionally, the continuing light rail expansion demanded new downtown rail capacity. The resulting project, completed in 2009, converted the two-street mall into a bus and light rail mall, with a single continuous auto lane. The pavement and street furniture were upgraded and the mall now functions efficiently with bus and rail intermingled, stopping at alternate blocks.

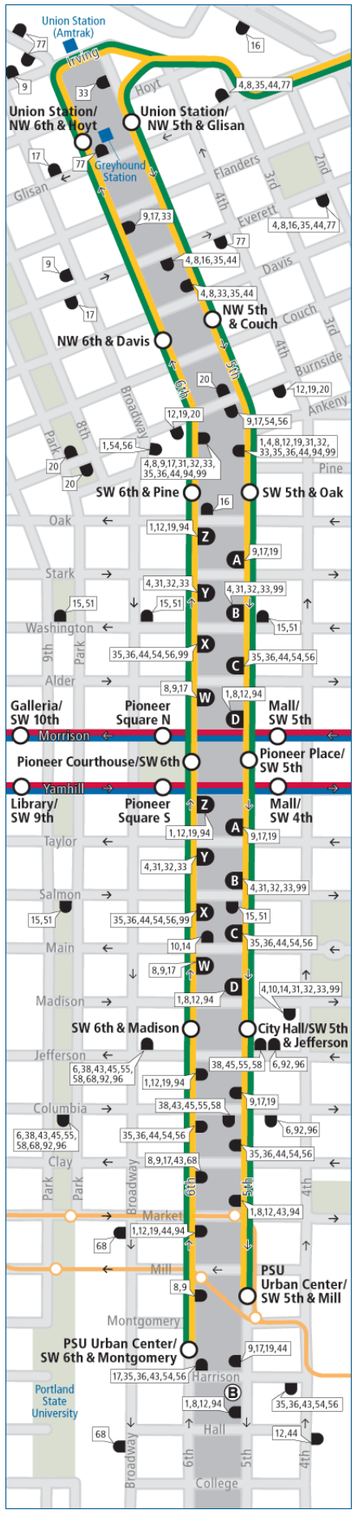
Reference Map

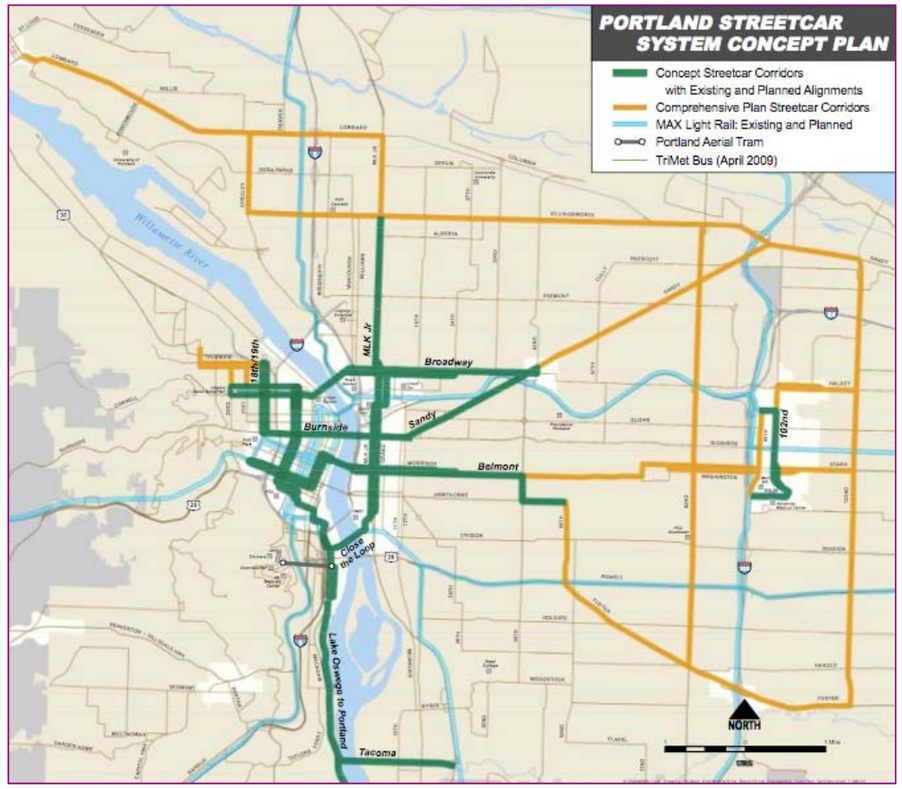


Success of Scheme in Restructuring and Reshaping Integrated Land Use and Passenger Transport	Key Success Factors	Design Issues
A key early city policy that has proved very successful was an action restricting the amount of downtown parking for new development. Downtown, many streets have been converted for bus and rail use, although at least some have usually been retained at capacity. Outside downtown, the rail lines generally have their own separate right-of-way, although there are examples where lanes have been reduced to accommodate rail.	- Success of the Transit mall has been attributed to its location in the heart of downtown, its high design quality and public art, the supportive city policies and the unique approach to bus operations and customer information. - Mode share downtown and through the region is high for comparable cities, growing over time. The high per capita funding commitment to transit, the continued investment in transit projects and the supportive city policies have all contributed to this success. - While Portland does not have any major transfer stations, and is largely operated with surface lines, the high service frequency and a quality pedestrian environment have helped make transfers convenient. A downtown free-fare zone has also helped. - Commitment to, and incremental expansion of downtown transit has been an important element in the growth of the downtown area. Outside downtown, transit has been less successful in focusing growth, but there are some examples of transit-oriented communities that have developed near MAX stations.	- The mall design had to be carefully integrated with adjacent street fronts and historic plazas. Attention to detail and quality were essential. - The city's strategy is to limit and disperse traffic to the edge of downtown. Transit streets are given priority, but auto access is retained (for deliveries and access to parking garages, for example). **Operational** - The key operational issue for the mall was the efficient movement of high volumes of buses and passengers. A unique, leapfrog approach was used with each station reserved for a set of routes. The original mall design also placed a high priority on customer information, providing colour and theme designations for bus groupings. It was one of the first to use video display units.
Constraints		**Procurement and Governments**
- Small blocks in the downtown have restricted light rail trains to 2 cars. While a high frequency of buses and light rail trains is operated, there are limitations due to the need to maintain cross-street traffic.		The Transit mall was developed through a partnership with the city. No other information was available.
Technology		
No information available		
Interchange(s)		
Interchange locations are at the surface and usually involve street crossings to adjacent stations. Good pedestrian provisions and limits on auto movements facilitate the transfers.		

Visual Images of the City and Passenger Transport Mode/System







Case Study: C Street Mall
Country: San Diego, California, USA
Mode: Light Rail Network

Similarity to Wellington Environment	
Bus based PT network with capacity problems requiring mode shift in order to resolve them	✓
Relatively constrained and/or narrow CBD with a strong PT Spine where throughput has been optimised	✓
A suburban rail network (or metro) which terminates short of the central CBD requiring a change of mode to complete the journey	✓
Other (please describe)	

Modal Characteristics Summary	
Vehicle capacity	532 (2 cars)
Peak hour capacity (pphpd)	15 trains, 4,000 riders
Service frequency	-
Capital expenditure (per km)	NZ$25 M
Total cost	-
Operational expenditure (per vehicle per km)	NZ$1.6 M
Operating speed (km/h)	-
Turning radii (m)	-
Power source	-
Typical spacing of stops	0.5 km
Annual patronage	-
Annual passenger kilometres	-
Hours of operation	-
Rides per day	-

Case Study Description

Overview

The city of San Diego, California is located in southern California along San Diego Bay. The city has a population of over 1.3 million while the urbanised area contains nearly 2,700,000 people. Downtown San Diego has about 62,000 jobs and is also a major convention and visitor centre. The downtown area borders on the harbor, with a steep hill on the north side. The primary commercial area is about 2.5 square kilometres and has a tight street grid. The Santa Fe Depot, with intercity and commuter rail service, is located at the west end of downtown, near the harbor.

San Diego is served by the Metropolitan Transit System (MTS), which operates a fleet of over 500 buses and 130 light rail vehicles. The light rail system covers about 90 route km. The transit system serves over 250,000 daily passengers, including about 97,000 daily passengers on the light rail line. The system carries nearly 12 percent of work trips to the downtown area.

History

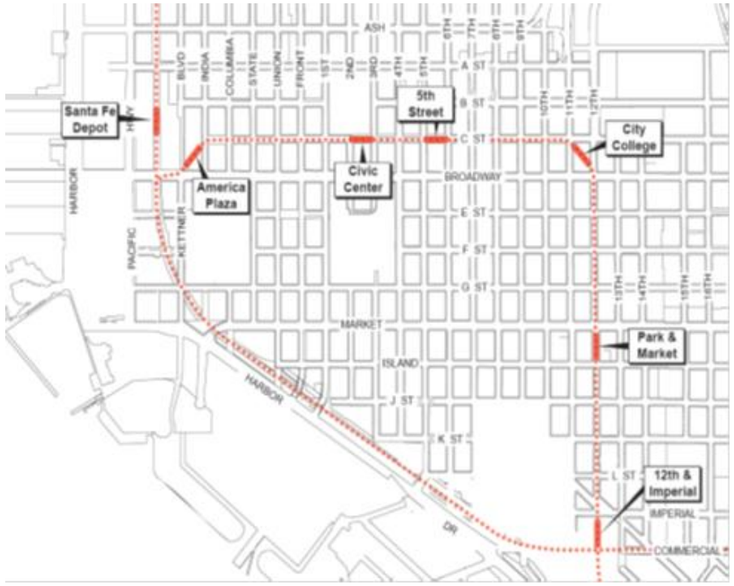
Prior to 1980, San Diego had a traditional bus system focused on downtown. Various studies had proposed modern transit systems, but the real impetus came with the opportunity to buy a private rail line. A tropical storm had destroyed much of the line, so the owners agreed to sell the line, extending from the Mexican border into downtown, to the Metropolitan Transit Development Board (MTDB).

MTDB proceeded to develop light rail in the corridor. Known as the San Diego Trolley, the line opened in 1981. The initial construction cost at the time was NZ$114 million, with mainly single track that had to be later converted to double track. Several extensions were built in the years following and others continue to be developed.

C Street Transit Mall (LRT)

In the downtown area, the Trolley operates on a two-way mall (C Street). Limited general traffic access is provided within some sections of the route. With three-car trains and frequent service on multiple lines, the C Street operation is close to capacity. The main downtown route on C Street was also supplemented by a second line along the bay-side, providing additional transit capacity. All of the lines connect at the Santa Fe Depot and provide convenient transfers with the commuter and intercity rail service.

Reference Map



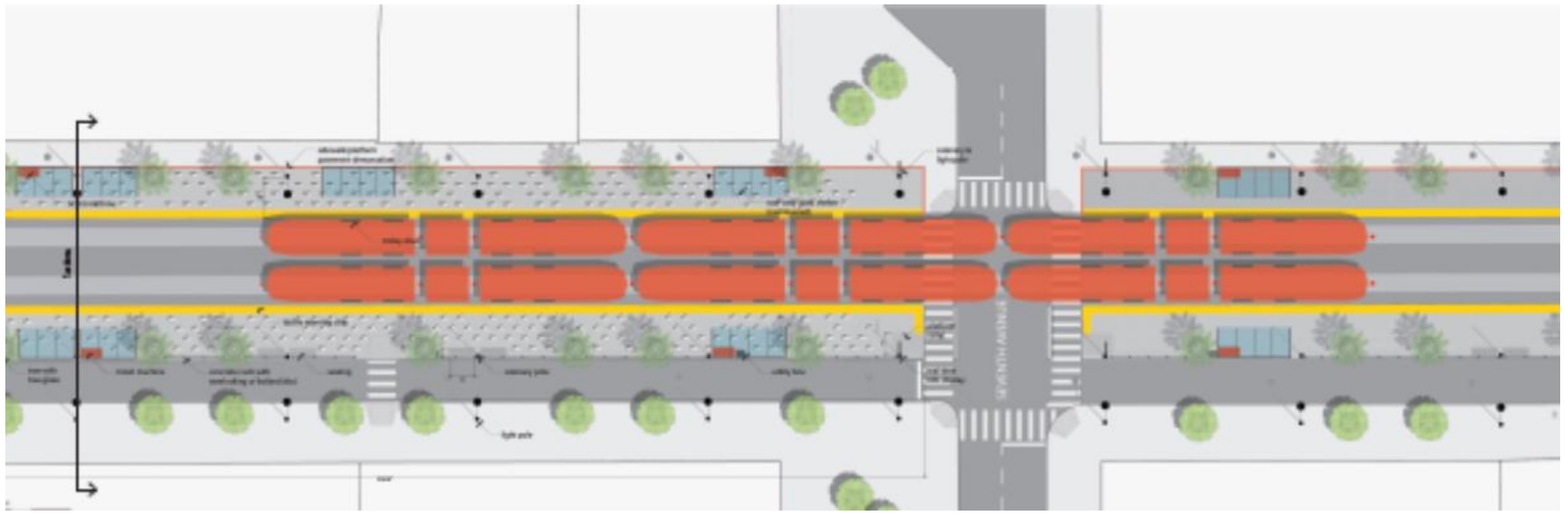
Success of Scheme in Restructuring and Reshaping Integrated Land Use and Passenger Transport	Key Success Factors	Design Issues
San Diego has a city centre plan which calls for a significant increase in transit use to support downtown growth. Outside downtown, city policies support concentrated, higher density growth along the Trolley lines. Separate from the Trolley service, San Diego has also developed a major freeway reconstruction project including dedicated median lanes for carpools and transit (and toll paying vehicles when capacity allows). This project, on Interstate 15 from San Diego to Escondido, is nearly complete and will allow the initiation of the first high capacity Bus Rapid Transit service in the region.	- The San Diego Trolley has been successful by providing a fast and convenient service to the downtown and other key destinations. The line loops through downtown allowing short walks to most destinations. - The passenger transport system serves 12 percent of downtown workers, which is good, but lower than other peer cities. Most passengers use the Trolley; the bus system is not as well developed as others. - Transfers between Trolley, bus and commuter rail lines are concentrated at two locations at each end of downtown – the Santa Fe Depot and the 12th and Imperial Station. Both have attractive facilities with cross-platform connections. - Historically, San Diego was developed more around private vehicle access rather than passenger transport. There is an extensive freeway system that serves most of the major employment centres. As passenger transport has developed in the last 25+ years, there have been efforts to locate new growth along the passenger transport corridors. Several new residential communities have been developed at outlying stations. Downtown, there has been extensive new residential development, based in part on the availability of passenger transport.	- The Trolley was initially developed at a low cost in order to quickly get service in place. As a result, many components have not had a long life, but significant upgrades and rehabilitation have been needed. Newer extensions have been designed to higher standards, at higher cost. - Outside downtown, the Trolley has its own right-of-way and gated crossing protection is provided at cross-streets. Downtown, the Trolley must operate within the coordinated traffic signal system. This restricts the speed of the Trolley and other delays can also affect on-time performance. On the other hand, the Trolleys operate fairly effectively on surface streets in combination with significant peak traffic flows. **- Operational** - In the downtown area, there have been issues with traffic signal priority for the Trolleys and problems with the short blocks at stations, where trains block pedestrian movement. - There are also frequent delays when wheelchair lifts are used, but this problem will be eliminated when a conversion to low-floor light rail vehicles is completed.

Constraints	Procurement and Governments
- Current Trolley capacity is constrained by the limits of operating on C Street. Two-way operation and frequent cross-streets constrain maximum frequency to three-four minutes. Short (60-metre) blocks limit the size of trains to three cars. - The condition of the Transit Mall has deteriorated and, unlike the Denver experience of 16th Street Transit Mall (Refer to Case Study), C Street Mall has not been the catalyst for development as other parts of downtown. Several concepts for upgrades have been considered, but nothing is currently planned	No information available
Technology	
No information available	
Interchange(s)	
Key downtown interchange locations are at the Santa Fe Depot and the 12th and Imperial Station. Both have convenient, cross-platform transfers. The 12th and Imperial Station was specifically designed to be integrated into the transport (passenger) agency offices, which are built over the station.	

Visual Images of the City and Passenger Transport Mode/System

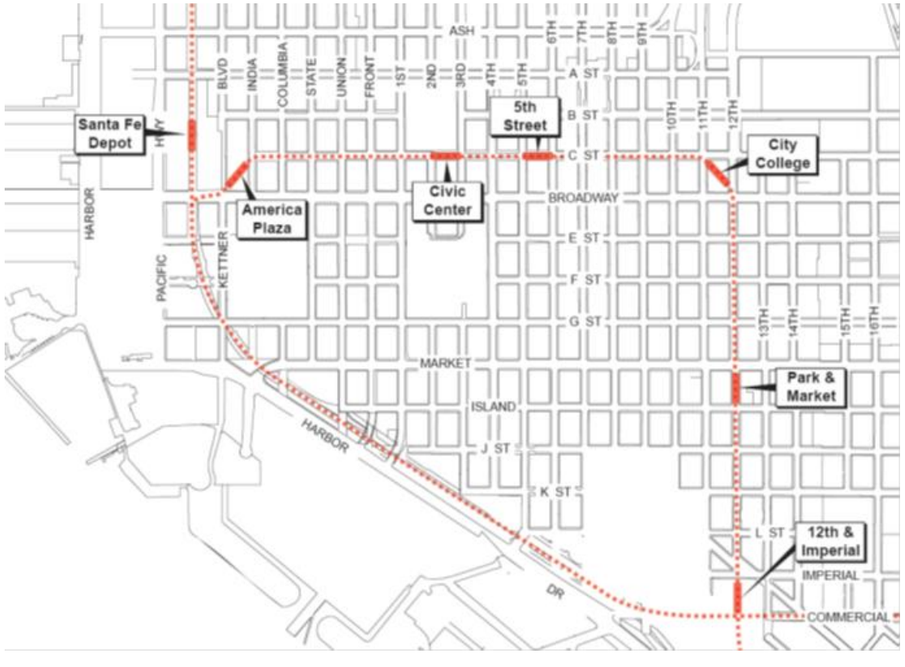
Santa Fe Depot

C Street Cross Section

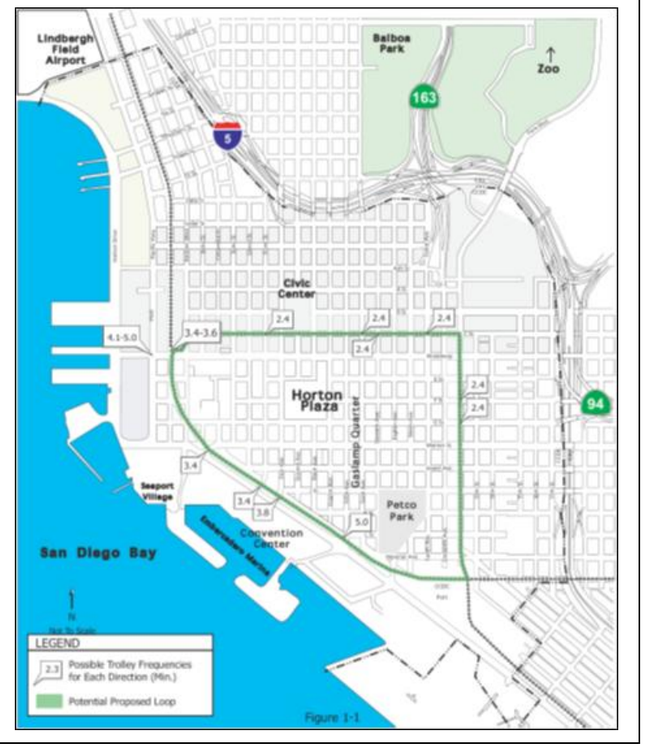


C Street

Maximum Trolley



Maximum Trolley



Case Study: San Francisco, California
Country: USA
Mode: Light Rail Network

Similarity to Wellington Environment	
Bus based PT network with capacity problems requiring mode shift in order to resolve them	
Relatively constrained and/or narrow CBD with a strong PT Spine where throughput has been optimised	
A suburban rail network (or metro) which terminates short of the central CBD requiring a change of mode to complete the journey	✓
Other (please describe)	

Modal Characteristics Summary	
Vehicle capacity	220
Peak hour capacity (pphpd)	9,500
Service frequency	-
Capital expenditure (per km)	NZ$28.6M (Embarcadero extension)
Total cost	-
Operational expenditure (per vehicle per km)	NZ$3.4M
Operating speed (km/h)	-
Turning radii (m)	600 m
Power source	
Typical spacing of stops	47.4 m (all lines)
Annual patronage	-
Annual passenger kilometres	-
Hours of operation	-
Rides per day	-

Case Study Description

Overview

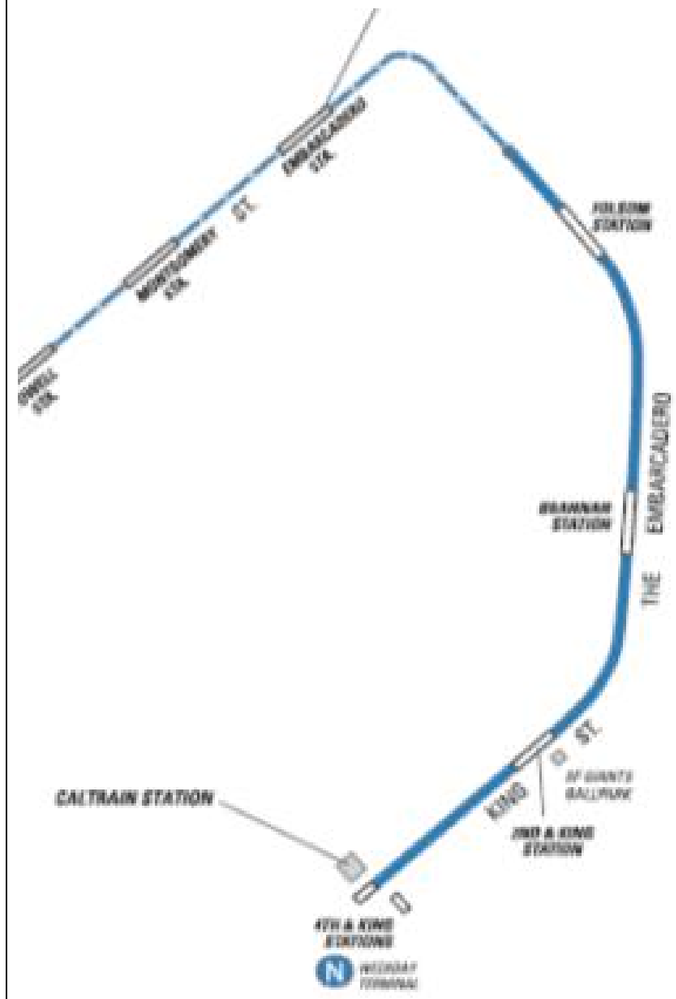
The city of San Francisco has a population of over 800,000 while the urbanised area contains over 3,200,000 people. Downtown San Francisco caters for about 300,000 jobs and is also a major retail and visitor centre. The downtown area is concentrated along the Market Street corridor, extending a little more than 1.5 km from San Francisco Bay to the Civic Centre area. A rail station, with heavy commuter rail service, is located at downtown's south end.

San Francisco is served by the Municipal Transportation Authority (Muni), which operates a fleet of over 700 buses and 190 light rail vehicles. The light rail system covers over 65 route km. Muni serves over 670,000 daily riders, including the light rail line (Muni Metro). San Francisco is also served by the Bay Area Rapid Transit (BART) system and other bus and rail service from adjacent counties. This includes commuter rail service on the San Francisco peninsula, with over 90 daily trains. The combined system carries nearly 50 percent of work trips to the downtown area.

Muni Metro service operates light rail on surface streets both in semi-exclusive alignment and in mixed traffic and subways. The subway section, travelling under Market Street, opened in 1980. Fare collection is based on a barrier-free proof of payment system. In 1999, the percentage of commuters using transit was around 15 percent in the San Francisco-Oakland area. LRT can be an affordable mode choice to a variety of users for example; twenty-five percent of all light rail passengers had annual household earnings of less than NZ$30,000, while twenty-two percent of all light rail passengers had annual household earnings of more than NZ$120,000.

The Muni Metro 2.4 km extension, from the underground Embarcadero Station to a station situated next to the northern terminus of the Caltrain commuter lane line at Fourth Street and King Street, was opened in 1998. The extension has four new stations with platforms designed to be accessible for people with limited mobility. The cost of the new line was NZ$62.2 million. Passengers transferring from Caltrain pay separately to ride the LRT. The LRTs operate at-grade through intersections using transit signal priority. The Fourth and King Street station is separated from the Caltrain station by the southbound lanes on King Street, often forcing transferring passengers to wait for an appropriate signal indication to cross the road. Original passenger boarding estimates were not met (2007 data), with approximately 4,500 daily boardings and alightings compared with projected boardings and alightings of 15,000 daily.

Reference Map



<table>
<tr><th>Success of Scheme in Restructuring and Reshaping Integrated Land Use and Passenger Transport</th><th>Key Success Factors</th><th>Design Issues</th></tr>
<tr><td rowspan="2">The “Transit First” policy is one of the City’s governing policies. The policy prioritises development of public transit, walking, bicycling, and other alternative modes. Parking policies in areas well served by public transit are designed to encourage public transit use and alternative transportation modes.

The Muni Caltrain extension is in the median of King Street along the Embarcadero, which was reconstructed following the 1989 earthquake. The design and landscaping was created to help revitalise the area – and has been very effective.</td><td rowspan="2">Higher density development, a large number of CBD jobs, limited parking availability and high cost parking in the CBD area all contribute to success.

San Francisco has always had a high modal transit share and the improvements and additions have been designed to maintain this share as the city has grown.

Seventy percent of commuter rail users transfer to or from light rail or bus transit.</td><td>- Light rail generally receives preferential treatment at intersections (when operating at-grade).
- LRT operates on surface streets both in semi-exclusive alignment mixed traffic and in subways.</td></tr>
<tr><td>Operational

- FARE collection based on Darer-free proof of payment system.</td></tr>
<tr><td colspan="2">Constraints</td><td rowspan="5">Procurement and Governments

No information available</td></tr>
<tr><td colspan="2">On at-grade sections, intersections and pedestrian traffic negatively affect light rail capacity.</td></tr>
<tr><td colspan="2">Technology</td></tr>
<tr><td colspan="2">No information available</td></tr>
<tr><td colspan="2">Interchange</td></tr>
<tr><td colspan="2">The Caltrain Muni station is located in the median of an adjacent six-lane arterial road. Pedestrian access to the station from the rail depot is limited to one at grade crossing of the arterial.</td><td></td></tr>
</table>

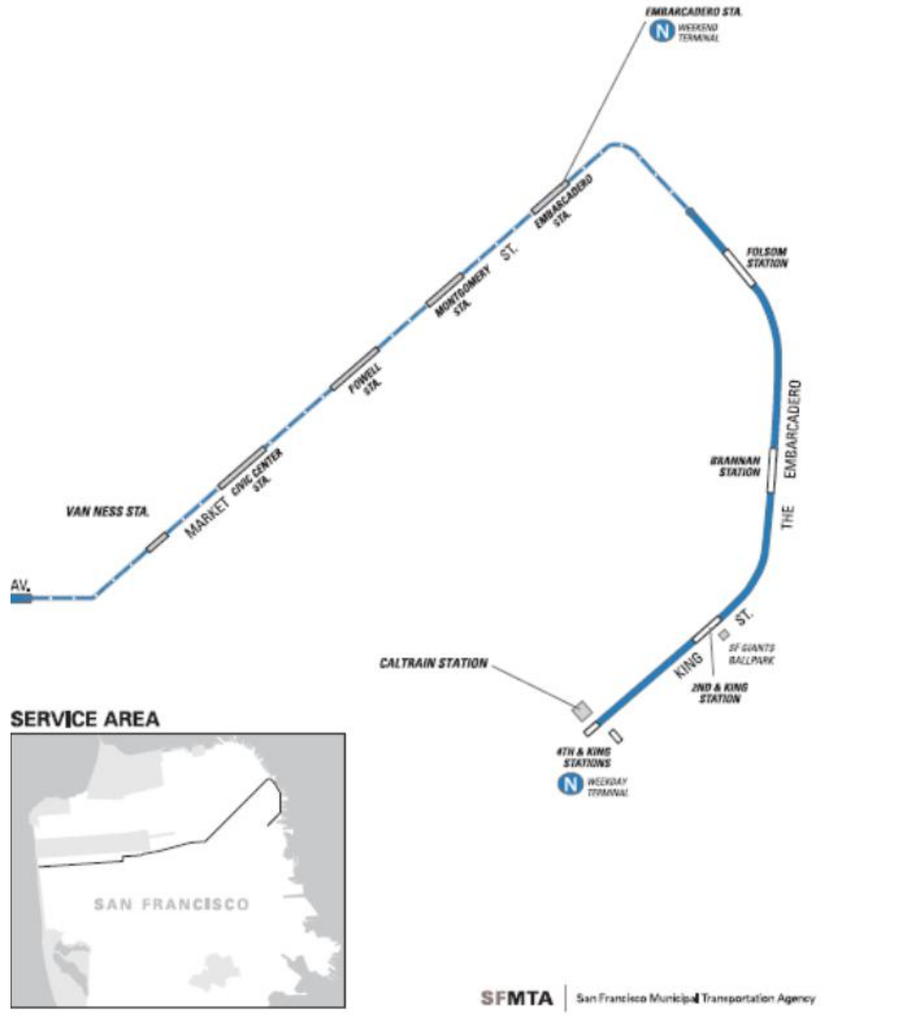
Visual Images of the City and Passenger Transport Mode/System

Route Map

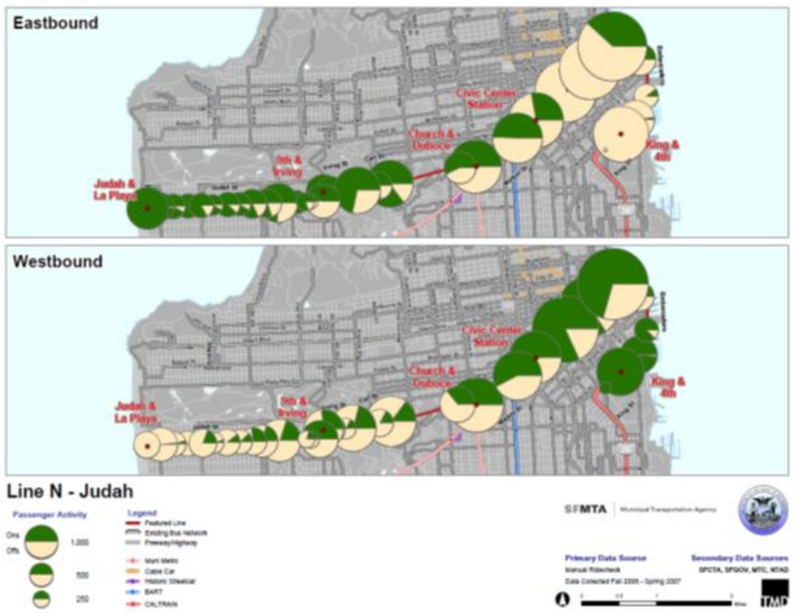
Rail Stop Example

Rail Carriageway

Route Diagram



Passenger Activity



Caltrain Station

Case Study: Downtown Seattle Transit Tunnel
Country: Seattle, WA, USA
Mode: Light Rail Network

Similarity to Wellington Environment	
Bus based PT network with capacity problems requiring mode shift in order to resolve them	✓
Relatively constrained and/or narrow CBD with a strong PT Spine where throughput has been optimised	✓
A suburban rail network (or metro) which terminates short of the central CBD requiring a change of mode to complete the journey	
Other (please describe)	

Modal Characteristics Summary	
Vehicle capacity	200
Peak hour capacity (pphpd)	3,600
Service frequency	7.5 M peak 10-15 M off peak/weekend
Capital expenditure (per km)	NZ$275 M (for Bus Tunnel)
Total cost	-
Operational expenditure (per vehicle per km)	NZ$1.9 M
Operating speed (km/h)	-
Turning radii (m)	-
Power source	-
Typical spacing of stops	500 m
Annual patronage	-
Annual passenger kilometres	-
Hours of operation	-
Rides per day	-

Case Study Description

Overview

The city of Seattle, Washington is located on the shore of Puget Sound. The city has a population of over 600,000 while the urbanised area contains over 2,700,000 people. Downtown Seattle has over 155,000 jobs and is also a major retail and visitor centre. The downtown area is geographically constrained by the Sound and surrounding steep terrain. The primary commercial area is just a few blocks wide and extends little more than 1.6 km from north to south. A rail station (King Street Station) is located at the south end, with commuter rail and Amtrak service.

Seattle is served by King County Metro, which operates a fleet of over 1,000 buses. Transit is also provided by Sound Transit, which runs express bus and commuter rail services. Transit developed the recently established light rail system and is responsible for developing additional rail services. The transit system, which carries nearly 35% of work trips to the downtown area, serves nearly 400,000 daily bus passengers and about 27,000 passengers on the light rail line.

History

Downtown Seattle's narrowness prompted a long search for ways to speed up the flow of transit vehicles, especially buses travelling through downtown from suburban communities. In the early 1980's, transit planners proposed terminals north and south of downtown linked by an electric transit mall down Third Avenue. This proposal would have reduced downtown bus traffic and pollution, but it would also have forced suburban passengers to change vehicle, even if they were just passing through. This proposal created political opposition. In the fall of 1983, then transit director Neil Peterson proposed a compromise: run "dual-mode" electric-diesel buses through a downtown tunnel from Ninth Avenue at Pike Street to Union Station at Fifth Avenue and S Jackson Street. This plan moved diesel buses off downtown streets and didn't require suburban passengers to transfer, but it also created a very expensive and technically challenging project.

The Seattle Bus Tunnel project involved boring two parallel tubes beneath the city's streets, constructing five distinct transit stations, and relocating existing utilities. Planners also added rails for future light rail operation (these would later prove inadequate). Construction on the tunnel began in 1987, with completion, and the start of service, in 1990.

Seattle area voters subsequently approved a plan to develop a light rail system. As a result, the Bus Tunnel was converted to a bus and rail tunnel during a two year closure from 2005 to 2007. The conversion included lowering the running way and installing new tracks. At the same time, the buses using the tunnel were converted from dual mode electric buses to hybrid-electric vehicles. The first light rail line (which connects downtown and the SeaTac Airport) began operating in 2009 and other extensions are being developed.

Downtown Seattle Transit Tunnel

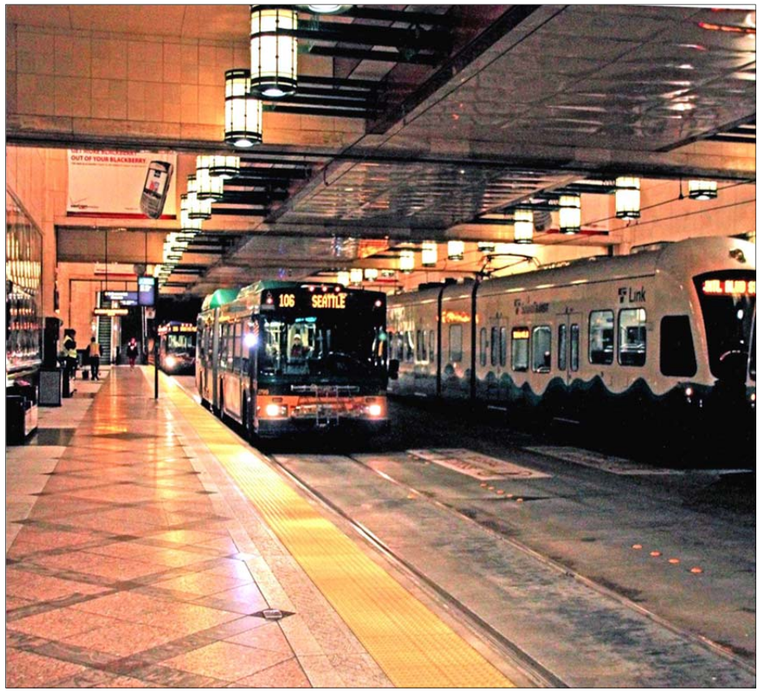
The 2 km Downtown Seattle Transit Tunnel was completed in 1990 at a cost of NZ$550 million. The tunnel has four light rail stations and five bus transit stations (four of the bus stations are shared with light rail). The tunnel is open between 5 am and 1 am, Monday to Saturday and from 6 am to midnight on Sundays. Bus routes that operate when the tunnel is closed use surface street stops. The stations in the tunnel are functional, safe, and attractive, and each station features distinctive art and architecture, which represents the neighbourhood the station serves. Passengers travelling in the tunnel can transfer to Seattle Centre Monorail at Westlake Station and to commuter rail at the International District/Chinatown Station. The International District/Chinatown Station is also near Amtrak King Street Station and Jackson Street Waterfront Streetcar station (the Waterfront Streetcar operations have currently been suspended). Patronage in 2010 was around seven million.

Peak hour headway for Central Link light rail line is 7.5 minutes. During off peak hours, weekends, and holidays the LRT headways vary between 10 and 15 minutes. Central Link passenger throughput capacity is around 3,600 passengers per hour per direction (based on planning capacity). Nineteen bus routes also use the tunnel simultaneously with the LRT. The tunnel serves around 70 buses per hour in the peak direction, corresponding to a bus transit capacity of about 6,200 passengers per hour per direction (88 passengers per articulated bus).

Reference Map

Success of Scheme in Restructuring and Reshaping Integrated Land Use and Passenger Transport	Key Success Factors	Design Issues
Sound Transit owns multiple properties that were acquired for construction staging and easements. The redevelopment of these properties includes active promotion of transit-oriented development (TOD). Sound Transit's TOD strategic plan aligns with the Federal Transit Administration (FTA) and the US Department of Housing and Urban Development's (HUD) joint development and sustainable community's initiatives. However, it is noted that in some areas outside Sound Transit's control, local policies related to land use planning and general taxation are not optimal for transit. The City of Seattle supports mixed use and higher density development. Walking and using public transit to access light rail stations are encouraged. Initially, the city policy prohibited parking facilities at light rail stations to encourage walking and using transit. However, this policy has since been waived to allow all-day parking near the station. Bus feeder services are being redesigned to coordinate with light rail. Service planning is an ongoing process. Route performance is evaluated and route structure is modified to respond to changes in demand. Most recently, parking at a remote lot and feeder service has been added at Puyallup Station in Pierce County and a shuttle has been added to serve Lakeland Hills near Auburn Station in south King County.	- Separating transit from surface streets made downtown work better and subsequently allowed the efficient development of light rail. - Mode share to downtown is one of the higher rates in the US for a city of Seattle' size. - When using ORCA cards (One Regional Card for All), transfers between commuter rail, light rail, and buses are automatically calculated. Paper transfers are no longer needed.	- Conversion of the tunnel to bus and rail operation was a significant challenge, requiring the tunnel to be shut for two years. - The light rail line is generally separate from traffic (elevated or tunnel). However, some segments run at surface and are noticeably slower, in part due to less than optimum signal priority. **Operational** - The joint bus/rail tunnel operation requires careful coordination and quick response to emergencies and breakdowns.
Constraints		**Procurement and Governments**
Stub tunnel crossover length limits the number of cars.		The light rail transit service is operated by the Central Puget Sound Regional Transit Authority (Sound Transit). Metro Transit operates buses and other various public transportation services in King County.
Technology		
No information available.		
Interchange		
The King Street Station is directly connected to the first bus tunnel station, providing convenient connections.		

Visual Images of the City and Passenger Transport Mode/System



Case Study: Canada Line (SkyTrain)
Country: Vancouver, BC Canada
Mode: Light Rail Network

Similarity to Wellington Environment	
Bus based PT network with capacity problems requiring mode shift in order to resolve them	
Relatively constrained and/or narrow CBD with a strong PT Spine where throughput has been optimised	✓
A suburban rail network (or metro) which terminates short of the central CBD requiring a change of mode to complete the journey	
Other (please describe)	

Modal Characteristics Summary	
Vehicle capacity	200 (per car)
Peak hour capacity (pphpd)	10,000–15,000
Service frequency	<2 mins
Capital expenditure (per km)	NZ$100 M (for Canada Line)
Total cost	-
Operational expenditure (per vehicle per km)	-
Operating speed (km/h)	-
Turning radii (m)	-
Power source	-
Typical spacing of stops	500 m
Annual patronage	290,000
Annual passenger kilometres	-
Hours of operation	-
Rides per day	-
	-

Case Study Description

Overview

The City of Vancouver, British Columbia has a population of 578,000 (2006) while the Metro Vancouver area contains over two million people. Downtown Vancouver has more than 162,000 jobs and is considered the business, cultural, and entertainment centre of the city. The downtown area is geographically constrained by water on three sides, somewhat limiting transportation access. An intermodal public transportation station is located at the north end. The station (Waterfront Station) serves as a terminus for the area's commuter rail, urban rapid transit system, buses, and passenger ferry service.

Vancouver and the Metro Vancouver area are served by TransLink (South Coast British Columbia Transportation Authority), which is responsible for the regional transportation network, including public transportation services. In the downtown Vancouver area, TransLink operates bus transit, two of the three SkyTrain's urban rapid transit lines, the West Coast Express commuter rail line, and the SeaBus passenger ferry service. SkyTrain operates fully automated trains on three lines that are completely grade separated (elevated track or underground for most of their length). The lines are the Expo Line, the Millennium Line, and the Canada Line. All three lines have a terminus at Waterfront Station, however, the Canada Line is operationally independent from the Expo and Millennium lines. While it is considered part of the SkyTrain network, the Canada Line does not share track with the other two lines nor is it operated by the same agency. The Canada Line is run by InTransit BC under a 35-year concession agreement with TransLink.

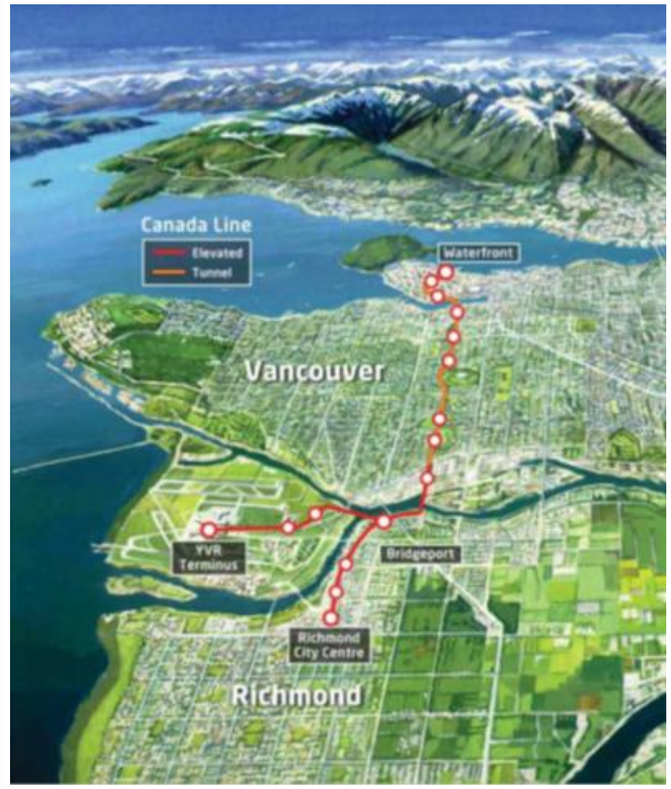
As of 2011, the regional transit system serves nearly 760,000 daily bus riders and about 425,000 daily riders on SkyTrain. At the end of 2010, TransLink operated 1,525 buses, 278 rapid transit vehicles, 44 commuter rail passenger cars, and three passenger ferries. Public transportation carries nearly 41 percent of work trips to the downtown area.

History

The Expo line started in 1983 as a demonstration project to showcase new technology and at the time only had one station and one kilometre of track. In 1986, a 21.4 km extended line with 15 stations opened for revenue service, in conjunction with the Expo '86 World Exposition. Subsequent extensions increased the number of stations to 20 and the line length to 28.9 km. The Millennium Line opened in 2002 and is currently 20.3 km long with 13 stations. Patronage in 2011 on the Expo and Millennium lines combined approached 290,000. The 19.2 km Canada Line opened in 2009 and has 16 stations. The line connects downtown Vancouver with Vancouver International Airport and services more than 135,000 daily passengers.

Currently, SkyTrain can run two or four-car trains (two-car trains for the Canada Line) with 108 second operating headways. The Expo and Millennium lines can run longer trains at 75 second headways to meet rising patronage.

Reference Map



<table>
<tr><th>Success of Scheme in Restructuring and Reshaping Integrated Land Use and Passenger Transport</th><th>Key Success Factors</th><th>Design Issues</th></tr>
<tr><td>Vancouver encourages high-density residential development around SkyTrain stations. TransLink is required by law to support the Livable Region Strategic Plan, which promotes complete, sustainable, and compact communities with diverse transportation choice. Since opening the Expo Line, the areas around many SkyTrain stations have been redeveloped to increase densities.

TransLink ran rapid-transit buses in the future rail corridors to cultivate transit supportive markets. In particular, the Canada Line used a median that had been previously reserved for a BRT route.

Service planning is an ongoing process. Route performance is evaluated and route structure is modified to respond to changes in demand and changing community needs.</td><td>- In 2010, 75 percent of surveyed SkyTrain customers gave the service good or excellent evaluations. In particular, the system is fast and reliable. The main concern among surveyed users was overcrowding. The 2009 SkyTrain's reliability was 95.3 percent.

- During the 2010 Olympic Games, parking and driving restrictions in downtown Vancouver pushed many commuters to consider public transit options. Recent patronage data show that many commuters continued using public transit a year after the Olympics concluded.

- Patrons holding valid tickets have unlimited transfer privileges for 1.5 hours.</td><td>- As a fully automated system, SkyTrain lines must be fully grade-separated. Therefore, its design required adequate surface or elevated alignments, or be prepared to invest in costly subway designs.

- The SkyTrain stations are conveniently located near rail stations, but there are no integrated station features other than pedestrian connectors.

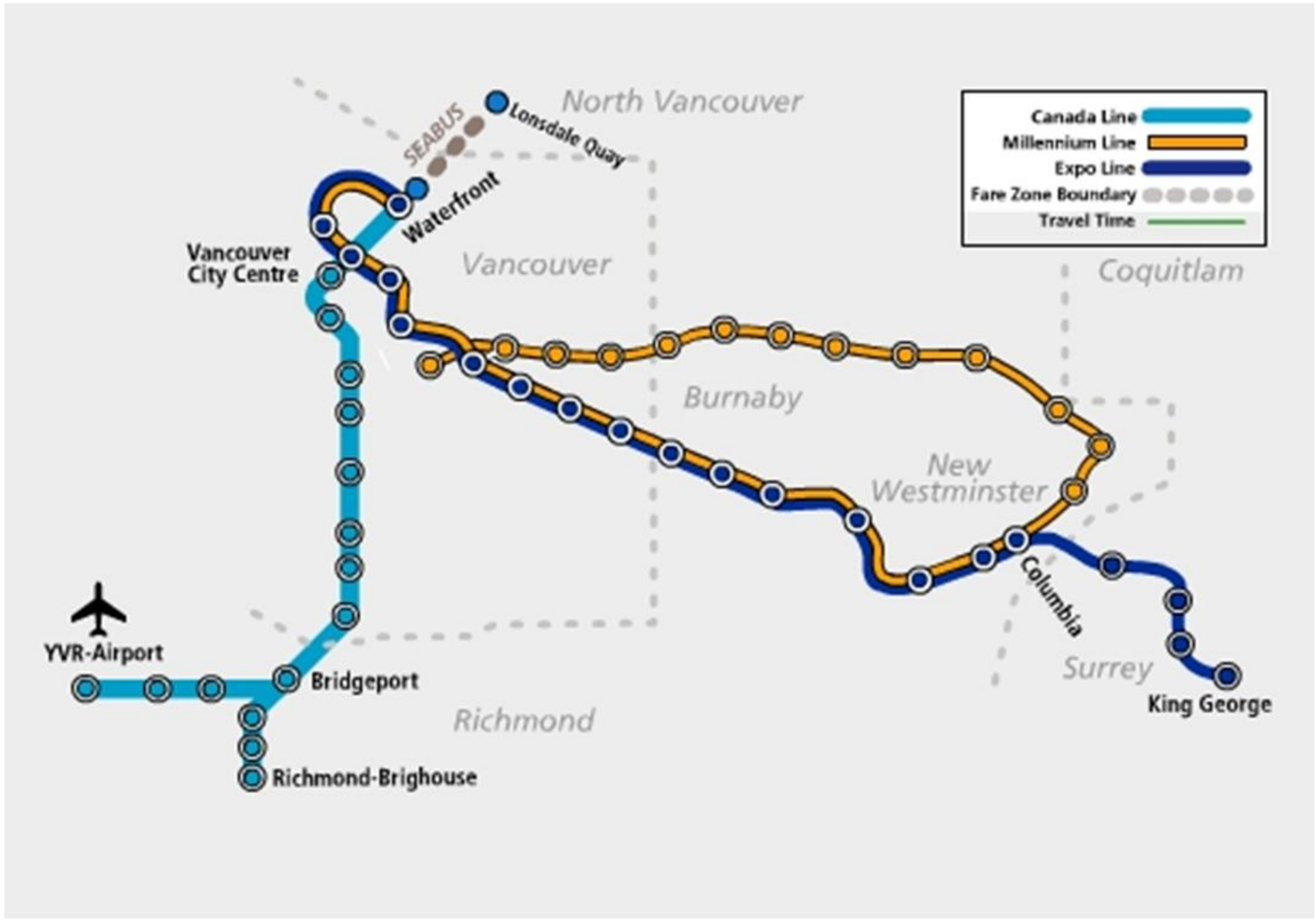
- All SkyTrain lines are grade-separated from vehicular traffic.</td></tr>
<tr><td colspan="2">Constraints</td><td>Operational</td></tr>
<tr><td colspan="2">The Canada Line can only run two-car trains, but can run a very frequent service (with automated service to lower operating costs) in order to partially offset that constraint.</td><td>No information available</td></tr>
<tr><td colspan="2">Technology</td><td rowspan="4">Procurement and Governments

The Canada Line was designed and built through a public-private partnership structure. While this structure allowed construction costs to be contained to some extent, some feel it limited public involvement.

The Millennium Line's route was selected by the provincial government and not by the transportation authority or the local municipalities in the region. This route was selected by the province to enable faster construction.</td></tr>
<tr><td colspan="2">No information available</td></tr>
<tr><td colspan="2">Interchange</td></tr>
<tr><td colspan="2">SkyTrain stations are conveniently located near rail stations, but there are no integrated station features other than pedestrian connectors.</td></tr>
</table>

Visual Images of the City and Passenger Transport Mode/System

LRT Lines



Map of Vancouver (Canada Line)

Station Platform

LRT Station

Patron Feedback

What the world had to say

"The public transit is scarily efficient" **Time Magazine**

"This well-planned city seemed more than able to handle the crowds. That's mostly thanks to the transit system that seems futuristic to U.S. residents" **The Bellingham Herald**

"Trains and buses steal gold for Vancouver – Vancouver's driverless trains have been steady winners at the Winter Olympics" **Reuters**

Case Study: Mumbai Metro Lines I , II and III
Country: Mumbai, India
Mode: Metro

Similarity to Wellington Environment	
Bus based PT network with capacity problems requiring mode shift in order to resolve them	
Relatively constrained and/or narrow CBD with a strong PT Spine where throughput has been optimised	
A suburban rail network (or metro) which terminates short of the central CBD requiring a change of mode to complete the journey	✓
Other (please describe) Strong bus spine which commuters use to connect to employment locations from the rail network	✓

Modal Characteristics Summary	
Vehicle capacity	1100 (based on a four car unit)
Peak hour capacity (pphpd)	15,000-25,000
Service frequency	3–5 mins
Capital expenditure (per km)	NZ$65M[1]
Total cost	-
Operational expenditure (per vehicle per km)	33 average[2] 80 top speed
Operating speed (km/h)	100
Turning radii (m)	-
Power source	25 kV, 50 Hz AC through overhead catenary
Typical spacing of stops	1 km
Annual patronage	-
Annual passenger kilometres	-
Hours of operation	-
Rides per day	-

Case Study Description

Overview

The Mumbai Metro Lines system is currently under construction. Metro Line III will extend into the CBD areas of Nariman Point and Cuffe Parade down to Colaba, where heavy rail services do not currently reach. Traffic congestion is heavy in the CBD area and the decision has been made to provide metro services to this area by tunnelling underneath the CBD. Demand for public transport services in Mumbai is very high, and the capacity of the metro systems is likely to reach upwards of 35,000 pphpd within the next 20 years. Due to severe traffic congestion in Mumbai, the completely grade separated metro lines will deliver substantial time savings to commuters compared to using buses or private vehicles.

History

Mumbai has an extensive suburban railway network, founded in 1867, as well as many buses. Despite this, the rail network and bus networks struggle to serve the extremely high demand for mobility in the extremely densely populated city – greater Mumbai has a population of 20 million. It is common to see people hanging out of open doors or clinging to the exterior body of trains on rail services in Mumbai due to the lack of capacity on the trains. In addition, the road network is extremely congested and therefore travel speed on the road network is very low.

Mumbai Metro Lines

The Mumbai Metro Lines plan is an attempt to partially alleviate some of the congestion problems in Mumbai as well as provide the possibility of shorter travel times across the heavily congested city. The plan is expected to be implemented in three phases – Mumbai Metro Lines I, II and II represent the first phase of the plan. Eventually, there is expected to be 8 metro lines of total length of approximately 146 kilometres, opening in 2021.

For more information, see http://www.mmrdamumbai.org/showProject.jsp?srv=U5S35v4b58d03r.

Reference Map

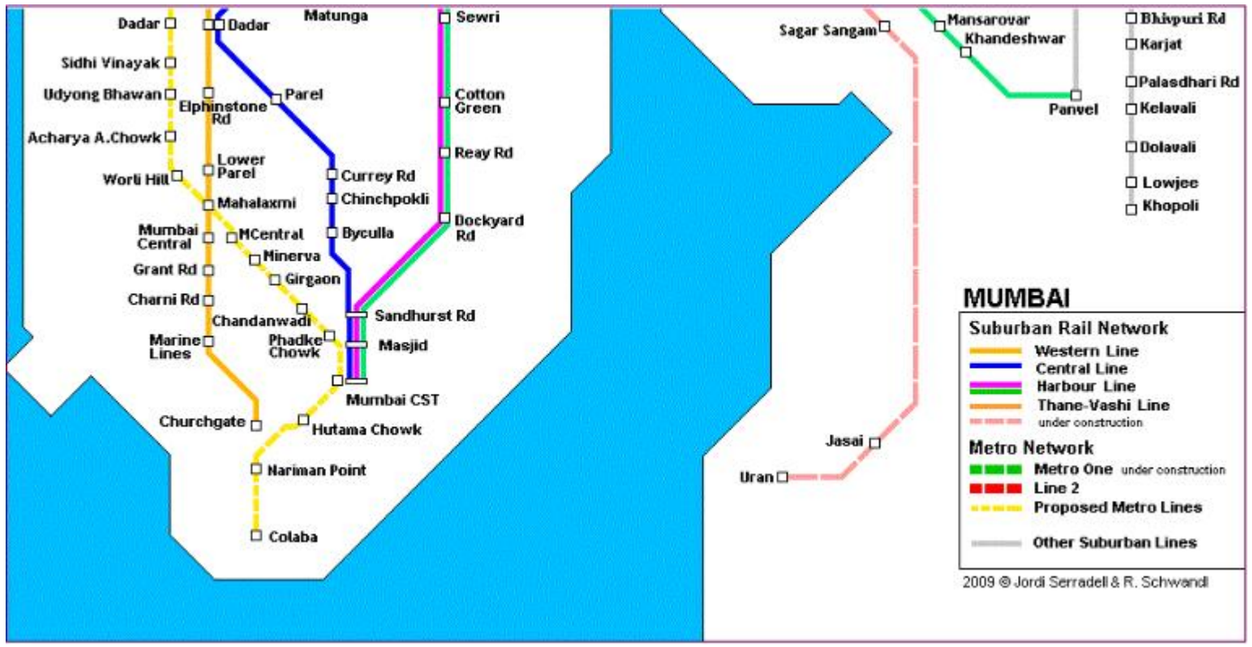
Source: http://www.urbanrail.net/as/mumb/mumbai.htm

[1] http://articles.economictimes.indiatimes.com/2010-05-18/news/28491695_1_mmrda-projects-versova-andheri-ghatkopar-line
[2] http://www.mmrdamumbai.org/

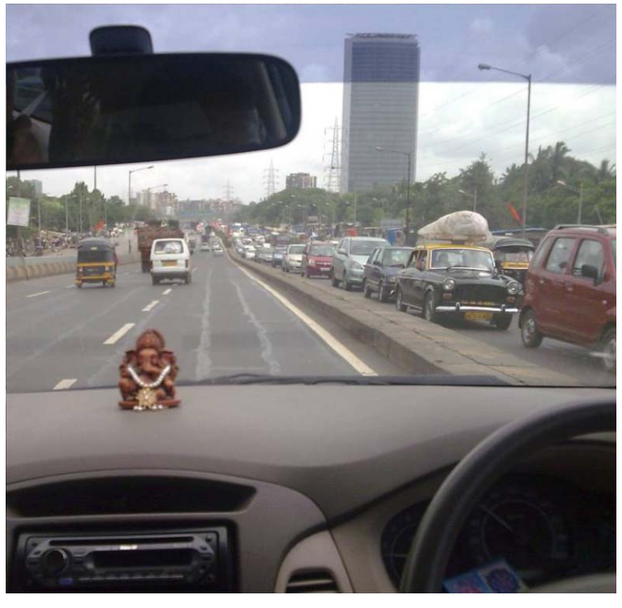
Success of Scheme in Restructuring and Reshaping Integrated Land Use and Passenger Transport	Key Success Factors	Design Issues
For densely populated cities like Mumbai passenger transport is essential to maintaining a well-connected and accessible place. The proposed metro lines respond to existing and future travel patterns. - Metro can and has helped shape the existing and redeveloped urban form around corridors. - The range of demand experience is a reflection of urban growth form, population, car ownership levels and person carrying capacity of rolling stock on metro systems.	- Fares are cheap, competitive and integrated with other modes of travel (ferry, metro, buses). - Travel time savings; for example Metro Line I is expected to cut passenger travelling time by one hour making it an attractive alternative to car travel. While the system will support a large demand, the system alone is unlikely to sufficiently meet the city's growing demand for mobility.	- Fully segregated e.g. underground and/or grade-separated from general traffic/pedestrians. - Metro stops and interchange facilities are positioned for quick transfers and access to significant buildings, open spaces.
		Operational
		- Passenger carrying capacity of existing metro in some instances is well over capacity and imposes safety issues on operators.

Constraints	Procurement and Governments
The following have been identified as existing / potential constraints on capacity: - High crush loading restricts users' ability to freely enter and exit at stops. - Rolling Stock – capacity of vehicle types. - Headway – delays resulting from capacity of vehicles, circulation on platforms.	- The development of the Metro Network is a mix of government and private operator funding. Agreements may include obligations to extend and modernise networks, through the purchase of new and refurbished rolling stock. - Mumbai Metro Line II – Japanese funding through International cooperation. - Mumbai Metro Line I and III funding will be via PPP model. Due to huge capital costs associated with the construction of Metro III, this line is not seen as a viable PPP model
Technology	
Chinese company CSR Nanjing supplied the rolling stock. The coaches will be air conditioned and fitted out with LCD screens and 3D route maps. There will also be black boxes on board for accident investigation.	
Interchange(s)	
Easy interchange between metro lines will be possible via some underground metro stations which are shared between lines. Interchange between the metro network and the suburban rail network will also be possible at some stations.	

Visual Images of the City and Passenger Transport Mode/System



Source: http://www.urbanrail.net/as/mumb/mumbai.htm



Case Study: Airport Express
Country: Hong Kong
Mode: Mass Rapid Transit (MRT)

Similarity to Wellington Environment	
Bus based PT network with capacity problems requiring mode shift in order to resolve them	
Relatively constrained and/or narrow CBD with a strong PT Spine where throughput has been optimised	✓
A suburban rail network (or metro) which terminates short of the central CBD requiring a change of mode to complete the journey	
Other (please describe)	

Modal Characteristics Summary	
Vehicle capacity	-
Peak hour capacity (pphpd)	80,000
Service frequency	2-3 minutes on main lines
Capital expenditure (per km)	-
Total cost	-
Operational expenditure (per vehicle per km)	-
Operating speed (km/h)	80-130 km/h
Turning radii (m)	-
Power source	1500V DC
Typical spacing of stops	-
Annual patronage	1,298,700,000
Annual passenger kilometres	-
Hours of operation	-
Rides per day	-

Case Study Description

Overview

Located to the south of mainland China, the city state of Hong Kong is home to over 7,000,000 people within its 1,104km^2 area. Hong Kong itself is made of three major areas, the New Territories to the north, Kowloon and Hong Kong Island.

Hong Kong's Mass Transit Railway (MTR) has been popular since its inception in 1979. A government led project, the MTR holds 45% of the market share of franchised public transport with over 4,000,000 trips made on an average weekday, making it the most popular transport system in Hong Kong. The MTR covers a distance of 211.6km, and runs between mainland Hong Kong and Hong Kong Island, crossing Victoria Harbour through a series of three tunnels.

History

The first stages of the Hong Kong MTR were opened in 1979, the result of the *Hong Kong Mass Transit Study* a decade earlier. The study had been commissioned by the Hong Kong Government in response to growing concerns in relation to traffic congestion, a result of the territory's expanding economy.

Since the completion of the first section of the MTR, the network has been expanded greatly and now includes three harbour crossings and the world's first dedicated airport rail line. In total, the MTR now encompasses 10 lines, following the merger of the MTR with the former KCR network in 2007. The majority of the length of the MTR is underground, including all three harbour crossings, there are however sections which emerge above ground. There are a total of 103 stations along the network which are supported by a series of feeder bus networks that take in housing estates and local attractions. The MTR runs for 211.6 km and has the highest capacity of any dual track metro line worldwide. The MTR connects Hong Kong Island to Kowloon and the rest of mainland Hong Kong, as well as providing a direct link to the airport.

Airport Express

The decision in 1989 of the Hong Kong Government to construct a new international airport created the opportunity for the installation of a MTR link to service the new airport. The Airport Express line was completed in 1998 and provides a linkage from the Hong Kong Island and Kowloon through to the Hong Kong International Airport on Chek Lap Kok island in the west. At an average speed of 130 km/h, it takes approximately 24 minutes to travel the extent of the 35.3 km line.

In 2005 an extension to the line was added, taking the Airport Express past the airport to the Asia World-Expo exhibition centre.

Cost of travel on the Airport Express is significantly greater than on other lines on the MTR network, with a one-way ticket from Hong Kong Island through to the airport costing around $15. However, the rolling stock operating along the line provides a better passenger experience than other parts of the MTR network. Carriages are designed to reflect the needs of airline passengers and include baggage holds and LCD screens providing news and announcements. It is also possible to check-in for flights at Kowloon and Hong Kong Stations, making the Airport Express more convenient for travellers.

The Airport Express operates every 10 minutes during the day and every 12 minutes after midnight. The world's first dedicated airport line, the Airport Express accounted for 32% of all airport traffic in 1999, although this has dropped to around 23% today.

Reference Map

Map of Airport Express line (shown in green), detailing connections to other lines in the MRT network

Source: http://www.mtr.com.hk/eng/getting_around/system_map.html

Success of Scheme in Restructuring and Reshaping Integrated Land Use and Passenger Transport

Prior to the introduction of the MTR, Hong Kong's transit system was heavily reliant on the traditional road network. The MTR moved transit underground, lessening the pressure on the territory's road network. This is crucial in a place as densely populated as Hong Kong where above ground space is at a premium.

The feeder bus service that complements the MTR allows for a more integrated transport system that reaches a greater area of the city.

With 103 stations along the network, including a dedicated airport line, the MTR integrates effectively with the urban form of Hong Kong, providing access to and from key features.

Key Success Factors

- The MTR provides a fast, safe and clean connection across Hong Kong at a relatively cheap price. Tickets range from around $0.50 to $7 for an adult, with concession fares around half price.
- The introduction of the Octopus Card ticketing system in 1997 has made it easier to travel on the MTR as it allows travel across all public transport providers using one ticketing system. The smart card system is contactless and therefore is more convenient to use and a small discount is generated when compared with cash fares.
- The addition of feeder bus networks allows the MTR to reach a wider catchment, with access now provided to large housing estates and attractions.
- Despite much of the network being underground, it is still possible to receive a mobile phone signal, making the MTR as convenient as above ground travel modes.

Design Issues

- The MRT operates both automated and non-automated rolling stock. The automated stock is controlled from four different control centres.
- For most of the MRT's extent it runs underground, however there are some above ground sections.
- As the lines approach the harbour, stations become deeper in anticipation of the harbour crossing.

Operational

- There have been issues in regards to the environment during the construction phase of parts of the network. The MTR Corporation has been criticised on two occasions where work has led to the felling of trees that has been deemed unacceptable.
- Safety, cleanliness, ease of use and reliability are all features of the MTR which have led it to being held in high regard.

Constraints

- In order to connect to Hong Kong Island, there was the need to build a harbour crossing. Although on one occasion this has been combined with a road tunnel, there is a large economic cost involved with tunnelling across the harbour.

Technology

- The Octopus Card smart ticketing system allows users to use one card for all public transport service providers in Hong Kong and is an easier and more efficient ticketing system compared with traditional ticketing.
- Platform screen doors have been installed on some sections of the MTR and this will be expanded, providing increased safety for service users.

Interchange

- There are 103 stations along the MTR network, most of which are below ground. Extensive retrofitting has been undertaken with the intention of making the MTR more disabled-friendly with the introduction of larger gates and doors for wheelchair access and tactile flooring for the visually impaired. The design of the stations is focussed more towards durability and accessibility rather than architectural grandeur.

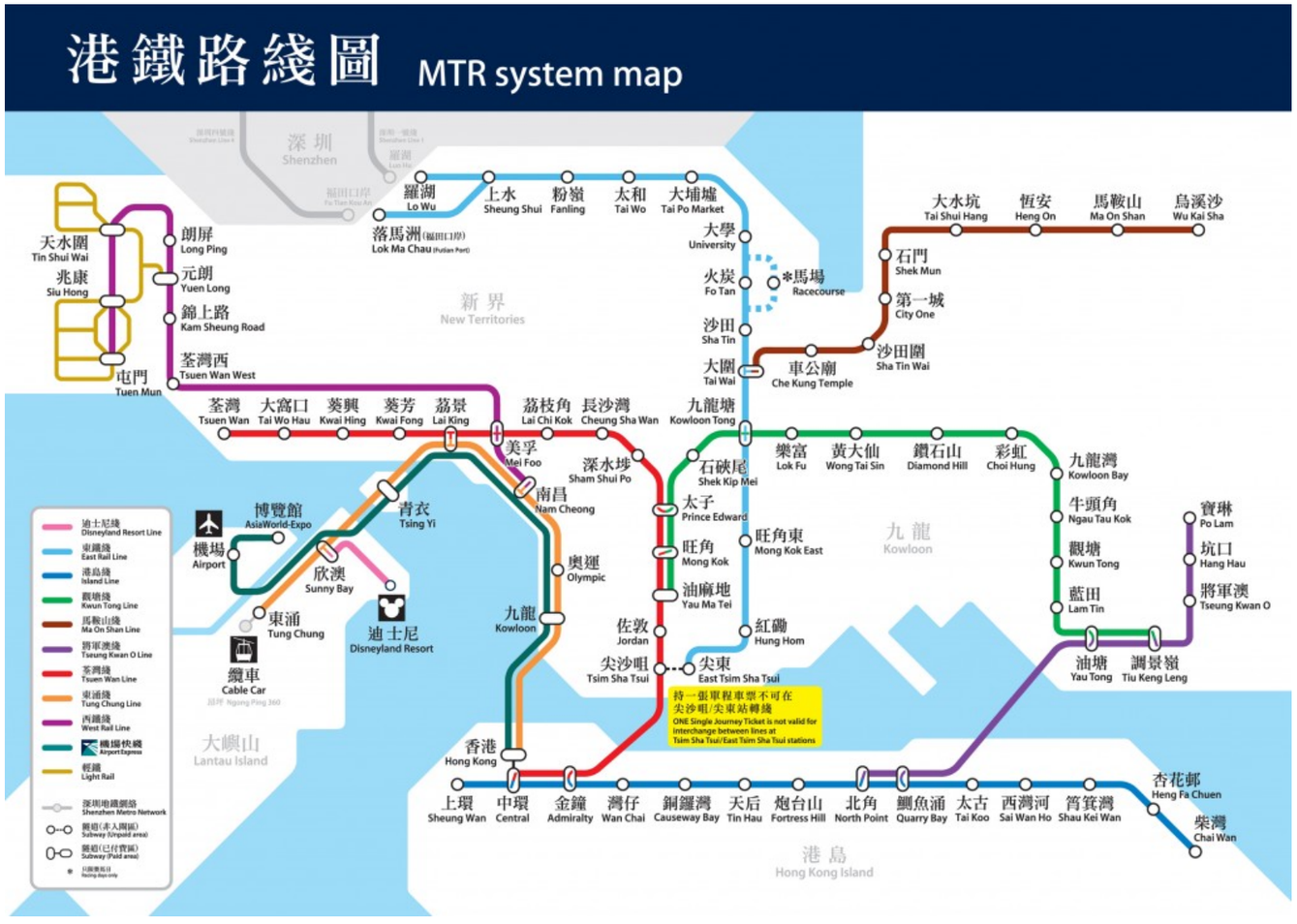
Procurement and Governments

The Mass Transit Railway is owned and operated by the MTR Corporation Ltd. The MTR Corporation was established by the Hong Kong government in 1975 as a state-owned enterprise with the purpose of setting up the MTR system. The MTR Corporation was privatised in 2000 and became the MTR Corporation Ltd; however the government still retains the majority shareholding.

References:
http://www.urbanrail.net/as/hong/hong-kong.htm
http://www.mtr.com.hk/eng/investrelation/2006frpt_e/F110.pdf
http://www.mtr.com.hk/eng/investrelation/2010srpt_e/E207.pdf

Visual Images of the City and Passenger Transport Mode/System

MRT Network – Hong Kong



Source: http://www.mtr.com.hk/eng/getting_around/system_map.html

Images from MTR

Airport Station

Tsang Yi station on the Airport Express Line

Photos: http://www.urbanrail.net/as/hong/hk-photos.htm

Case Study: North East Line (NEL)
Country: The Republic of Singapore
Mode: Mass Rapid Transit (MRT)

Similarity to Wellington Environment	
Bus based PT network with capacity problems requiring mode shift in order to resolve them	✓
Relatively constrained and/or narrow CBD with a strong PT Spine where throughput has been optimised	✓
A suburban rail network (or metro) which terminates short of the central CBD requiring a change of mode to complete the journey	
Other (please describe)	

Modal Characteristics Summary

Vehicle capacity	1,920 based on six train set (six passenger/m^2)
Peak hour capacity (pphpd)	-
Service frequency	90 seconds
Capital expenditure (per km)	NZD$2.2M
Total cost	-
Operational expenditure (per vehicle per km)	-
Operating speed (km/h)	100 km/h (design), 90 km/h (normal)
Turning radii (m)	-
Power source	1,500V from the DC overhead line
Typical spacing of stops	-
Annual patronage	137,970,000 trips
Annual passenger kilometres	2,759,400,000 km
Hours of operation	-
Rides per day	-

Case Study Description

Overview

Singapore's land transport system and network of MRT lines date back to the 1967 jointed study for land use planning by the Singapore Government and United Nations Development Programme. The result was the conceptualisation of a long-term concept plan that would guide the country's future spatial development. The study concluded that an MRT would be required by 1992. Given the spatial constraints of the island, providing more roads to meet the rising transportation demands, was not possible or a viable solution. By 1982 construction of the first North South Line began linking the CBD with the north and southern parts of Singapore. Today there are currently six lines, the North South, East West and NorthEast lines, Bukit Panjang, Sengkang (East), and Sengkang (West) constructed. The long-term plan is to have 540 km of passenger railway by 2020 via the completion of planned or current new lines e.g., Circle Line or new extensions to existing lines e.g., Taus Extension.

History

The North South and East West routes of the MRT were completed in 1987 and have been expanded at various times since. However, the last 20 years has seen a rapid growth in Singapore and this soon translated into the need for an improved transport system. Established by the Singapore Government in 1995, the Land Transport Agency (LTA) was tasked with providing a transit system that reflected the new Singapore. The response needed to be efficient, comfortable, safe and convenient whilst also operating at a cost that was accessible for most people.

With the opening of the Circle line in 2009, Singapore now has four MRT lines providing access across the country, with a fifth currently under construction. The total distance covered by the network currently totals 149 km, and upon the completion of the new Downtown line this will reach 191 km.

North East Line (NEL)

NEL is 20 km in length and is a fully automated underground train operated and controlled system. Construction began in 1997 and completed five and half years later costing a total of $NZ 4.7 billion. It was the second major MRT line to be built, since the completion of the main MRT network in 1990.

Delays in the construction process saw the NEL open in June 2003, having originally been scheduled to open in late 2002. It currently operates as the highest capacity MRT within Singapore, catering to over 378,000 people daily. It is intended that the NEL will eventually form part of a greater MRT network running throughout Singapore.

One depot and 16 stations link existing and new residential estates in the North-east of the island e.g., Sengkang and Punggol, to Singapore's commercial and retail city centres. Of the 16 stations identified, 14 stations where opened in the first phase of development and nine stations where fully integrated into surrounding developments. 13 of the stations are civil defence shelters. The depot can service 25 trains (six car sets).

Reference Map

Source:
http://www.tsd.org/cbtc/projects/SIG_Singapore_AutomaticMetro_en.pdf

This map shows the North East Line (NEL) linking Punggol Station to Harbour Front Station, the gateway entrance to Senstoa Island. Key interchanges include Serangoon (Little India), Harbour Front with the future Circle Line (CCL); and existing MRT Interchanges at Dhoby Ghaut (located on Orchard Road) and Outram Park (China Town).

Success of Scheme in Restructuring and Reshaping Integrated Land Use and Passenger Transport

NEL has been successful in connecting existing and new residential communities in the north east of Singapore with the central city and new Harbour Front development. The delivery of the successes include:

- Land Transport White Paper, 2006 sets the vision for all transport modes.
- Co-ordination between government agencies e.g., LTA and Urban Redevelopment Authority (URA) on staging and timing of land use and transport infrastructure.

  The NEL route follows existing major transport corridors along Serangoon Road and Upper Serangoon Road allowing the MRT to fit within the existing transport system and provide alternatives to private transport.

  The 16 stations along the NEL integrate with existing towns as well as new towns such as Hougang, Sengkang and Punggol. The MRT integrates these into the wider transport network and ensures a connection to the downtown area of Singapore and the popular Harbour Front Centre (the main gateway to Sentosa Island).

Key Success Factors

- Increasing ridership, since the completion of the project, saw the number of daily users increase to over 250,000 by 2006. This was the benchmark necessary for the project to become profitable, something that it has been since reaching this target in 2006.
- The NEL was the first completely underground line in Singapore .
- The NEL was the first to feature all 16 of its stations in the Art in Transit programme; this led to the installation of art works within the stations along the length of the line.
- A full scale prototype of the train was presented to the public in 1999 to receive feedback on the design and layout of the carriages. The resulting questionnaire led to some changes in the final interior design to better fit the needs of the community.
- The service operates every two minutes in peak times, and between five and six minutes at other times of day.

Design Issues

- The NEL is a fully automated, underground MRT Line.
- In the early days of the NEL's operation there were issues related to the design of the trains, namely people leaning on the automatic stop buttons. This was remedied by the installation of plastic covers being placed over the buttons to prevent this.

Operational

- The NEL has also been criticised for charging higher fares than the rest of the system. Despite that, it had been operating at a loss until late 2006. After half a year of operation, ridership remained below expectations at an average of 170,000 passengers per day, short of the 250,000 per day needed to break even. At that time, SBS Transit estimated its losses for 2003 at NZ$37.9 million and was even rumoured to be considering selling the line to competitor SMRT Corporation, although both operators dismissed such speculation. However, the ridership has been slowly increasing and broke the break-even mark of 250,000 in late 2006. The NEL operations have been turning in profits since.
- Signalling faults have been the cause of disruption and delays over the past few years, with three occurrences of this issue since April 2010.

Constraints

- The dense nature of Singapore's urban form required that the new MRT system would need to be underground.
- Spatial underground challenges for alignments, with respect to services, sea levels, building pilings and existing and future MRT lines and stations.

Technology

- A call for international tenders was sent out in February of 1997 with Alstom's METROPOLIS fully automatic metro being the leading bid. Alstom offered a product that fulfilled all of LTA's requirements in regard to efficiency, comfort and safety and provided it at the most attractive price. The agreement reached ensured the provision of 25 six-car trains as well as the necessary support services such as signalling and automatic train control systems.

Interchange(s)

For the NEL there are 16 underground stations along the line, two of which have opened as demand dictated. Passengers are protected from falling onto the tracks by the train's innovative sliding platform screen doors. Lift access, tactile flooring, wide fare gates, a communications system and a quality passenger information system are featured in all stations ensuring that they are accessible. Nine stations were fully integrated into the surrounding area and 13 also act as civil defence shelters.

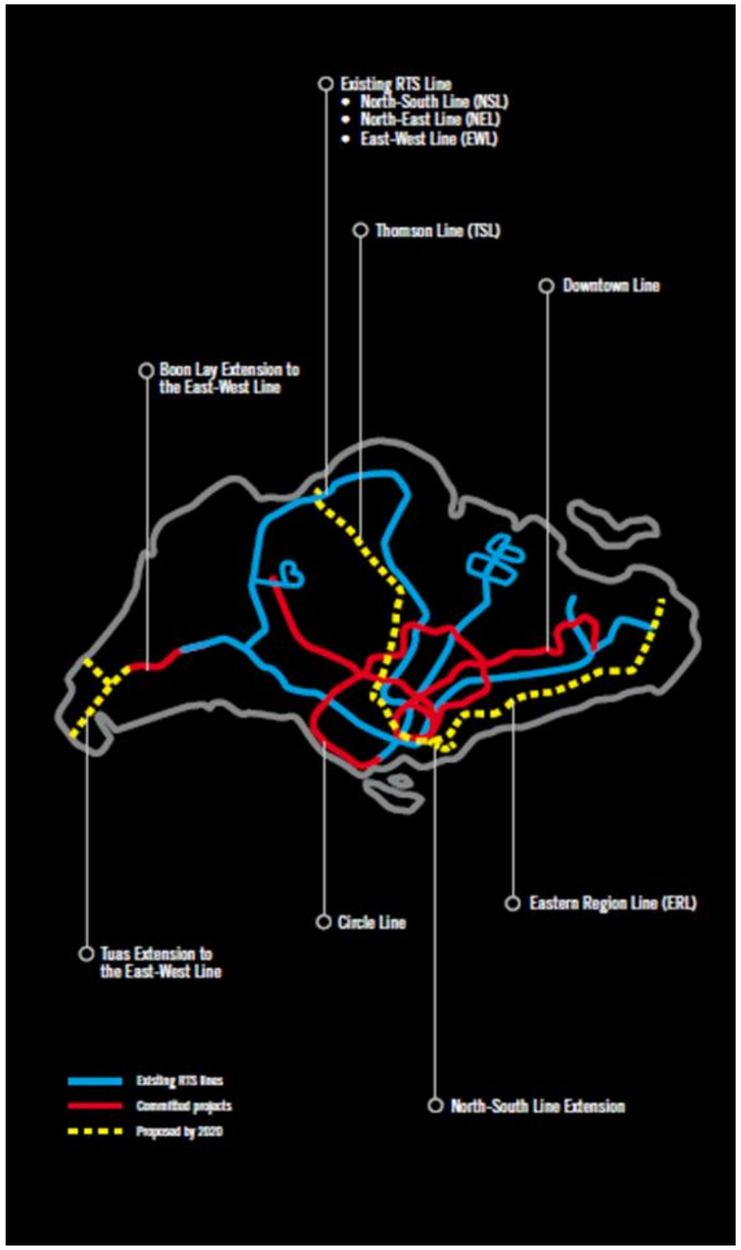
Key MRT interchanges interfacing NEL include the Serangoon Station (Little India), Harbour front Station with the future Circle Line; and existing MRT Interchanges at Dhoby Ghaut (located on Orchard Road) and Outram Park (China Town).

Procurement and Governments

The Land Transport Authority (LTA) was created in light of Singapore's need for a quality solution to its transit issues. They received approval for the construction of the NEL in 1996 and awarded the contract to Alstom as the main contractor. In order to foster competition, the license to operate along the NEL was given to the newly established Singapore Bus Services (SBS).

Visual Images of the City and Passenger Transport Mode/System

MRT Network – Singapore



Future and Existing MRT Networks
Source: http://www.lta.gov.sg/content/lta/pdf/LTMP_Report.pdf

Images from North East Line

Station Layout

L2	Overhead Bridge	
L1	Street Level	Telok Blangah Road, VivoCity, Harbourfront Centre, HarbourFront Bus Interchange
B1	Concourse	Faregates, Ticketing Machines, Station Control, Transitlink Counter
B2 Platforms	Platform A	North East Line towards NE17 Punggol (←)
		Island platform, Doors will open on the left at Platform A and doors will open on the right at Platform B
	Platform B	North East Line towards NE17 Punggol (←)
	Platform A	Circle Line No train service
		Island platform, Doors will open on the left at Platform B
	Platform B *Alternate Services for peak hours only*	Circle Line towards CC1 NS24 NE6 Dhoby Ghaut and CE2 NS27 Marina Bay via CC15 NS17 Bishan (←)

NEL - Harbour Front Station Layout
Source: http://en.wikipedia.org/wiki/HarbourFront_MRT_Station#Station_Layout

NEL Harbour Front Station Platform – looking from B2 up to B1 Concourse Level
Source: http://en.wikipedia.org/wiki/HarbourFront_MRT_Station

NEL – Interior of Trains
Source: http://en.wikipedia.org/wiki/File:North_East_Line,_Singapore,_Train,_Aug_06.JPG

References:
http://www.tsd.org/cbtc/projects/SIG_Singapore_AutomaticMetro_en.pdf;
http://www.railway-technology.com/projects/sing-ne/;
http://www.sbstransit.com.sg/transport/trpt_nel_overview.aspx;
http://www.singstat.gov.sg/pubn/reference/yos11/statsT-transport.pdf

Case Study: Line D, Metro de Lyon
Country: France
Mode: Mass Rapid Transit (MRT)

Similarity to Wellington Environment	
Bus based PT network with capacity problems requiring mode shift in order to resolve them	
Relatively constrained and/or narrow CBD with a strong PT Spine where throughput has been optimised	
A suburban rail network (or metro) which terminates short of the central CBD requiring a change of mode to complete the journey	✓
Other (please describe)	

Modal Characteristics Summary	
Vehicle capacity	500 (2 car) – 250 per car
Peak hour capacity (pphpd)	24,000
Service frequency	2- minutes
Capital expenditure (per km)	-
Total cost	-
Operational expenditure (per vehicle per km)	-
Operating speed (km/h)	75 km/h
Turning radii (m)	100 m
Power source	750V DC Third Rail
Typical spacing of stops	750 m
Annual patronage	258,504,680 (Total network)
Annual passenger kilometres	-
Hours of operation	5am- 12:20am
Rides per day	-

Case Study Description

Overview

Located in the centre of the country, Lyon is the third biggest city in France behind Paris and Marseille. The city itself is home to over 480,000 people, with over 2,100,000 people living in the wider metropolitan area. Lyon's geography is dominated by the Rhone and Saone, two major rivers that fork through the city and intersect to the south.

The wider Lyon transport system is built up of the Metro, Tram, Trolleybus and Bus networks. These four pillars of public transport are integrated to create a comprehensive system that provides a greater range of services. All of these services are operated by TCL (Transport en Commun Lyonnais) allowing a single ticketing service across all four modes.

The Metro is the most popular of the four mode types, accounting for approximately 50% of all daily transit trips in Lyon, a patronage of around 700,000 trips every week day.

History

The first steps towards a metro system in Lyon were taken in 1963 when discussions were held in relation to such a project; however, it was not until 1968 that more concrete actions started to take place. Work began on the new metro system in 1973, but it would be five years before the network was operational.

The Lyon Metro was opened in 1978, incorporating existing rail links with new purpose built routes. The new lines were named A and B and utilised a third rail power system, an unusual feature being that the trains ran on rubber tyres in comparison to steel wheels.

The existing line from Hotel de Ville to Cuire was refurbished in 1974 before its insertion into the new Metro system in 1978 as Line C. A further Line (D) was added in 1991, effectively adding an east west link across the city.

The Lyon Metro was based upon the Montreal Metro system which was completed a decade prior to the completion of work in Lyon.

The Metro stretches 30 km through central Lyon and sits underground for the majority of its length, with just a small section of Line C being above ground. Commuters access the Metro through one of the 42 stations, most of which sit just below the street level.

Today over 700,000 trips are made on the Metro on a typical weekday, with the trains being modified in recent years to increase capacity. Although Line D is fully automated and Lines A and B feature semi-automation, this is to be extended so that Lines A and B will be fully automated by 2013. The Metro has undergone regular development over the past 30 years as demand has dictated.

Line D

Of the four lines on the Metro, Line D is the most modern having opened in 1991. Line D is the longest of the four lines, running for around 13km east to west across the city. The line features 15 stations which sit approximately 930 m apart.

Although originally controlled by an on-board driver, Line D became famous globally as the first high-profile automated line. Unlike the other lines on the Metro, Line D does not operate protective screen doors, relying instead on infrared sensors to detect passengers.

Currently only two-carriage trains (carrying capacity of 500) operate along Line D however, stations have the capacity to cater for four car trains. Two funiculars connect with the main line at the Vieux Lyon station. Services operate every two minutes during peak times, carrying on average around 300,000 people a day, making Line D the busiest of the four Metro lines.

Reference Map

Source: http://www.urbanrail.net/eu/fr/lyon/lyon.htm

Success of Scheme in Restructuring and Reshaping Integrated Land Use and Passenger Transport

Integrating the Metro into the TCL system has created a passenger transport system that provides a comprehensive network across the city. The Metro itself serves the inner city area, allowing mass transit along key routes at high speeds, while tram and bus services create additional links between stations and out into the suburbs.

As part of the TCL, the Metro has contributed to providing a high quality sustainable transport system.

Key Success Factors

- The use of an all-four transport approach has ensured that the Metro de Lyon forms part of an integrated public transport system that allows seamless transition between transport modes.
- However, the Metro remains the key mass transit system in Lyon, accounting for up to 50% of all daily trips.
- The high frequency of the Metro at peak times (two minutes) and off-peak times (up to seven minutes) makes it a convenient and viable option at all times of day.
- Line D features two interchanges with other lines on the Metro system; this allows commuters to access the northern and southern areas of Lyon's city centre through Lines A and B.
- Although Line D does not directly connect with the city's airport, there are direct bus links from stations on the eastern extent of the line (Grange-Blanche and Mermoz-Pinnel).

Design Issues

- The Metro is an almost entirely underground system.
- Currently only one of the lines is fully automated, with Lines A and B to be automated by 2013.
- It was not possible to use the same train type throughout the network. Line C runs on steel wheels, whilst Lines A and B runs on rubber tyres.

Operational

- Services run from 5 am through to 12:20 am all days of the week, ranging from a frequency of two minutes in peak times to six minutes in the evenings.
- A single ticketing system is used across the entire public transport network in Lyon, making it easy to change between modes. This is made possible by all typologies being operated by the same company.

Constraints

- The presence of the Rhône and Saône rivers required the use of a boring machine during the construction of Line D

Technology

- All of the stations along the Metro de Lyon feature automated gates and turnstiles.
- The trains along Line D were the first tyred metro trains to feature automatic control in the world, the control system manages the speed, braking, doors, ventilation and intercoms on the trains. Although the trains are automated, there are manual controls available for emergencies.

Interchange

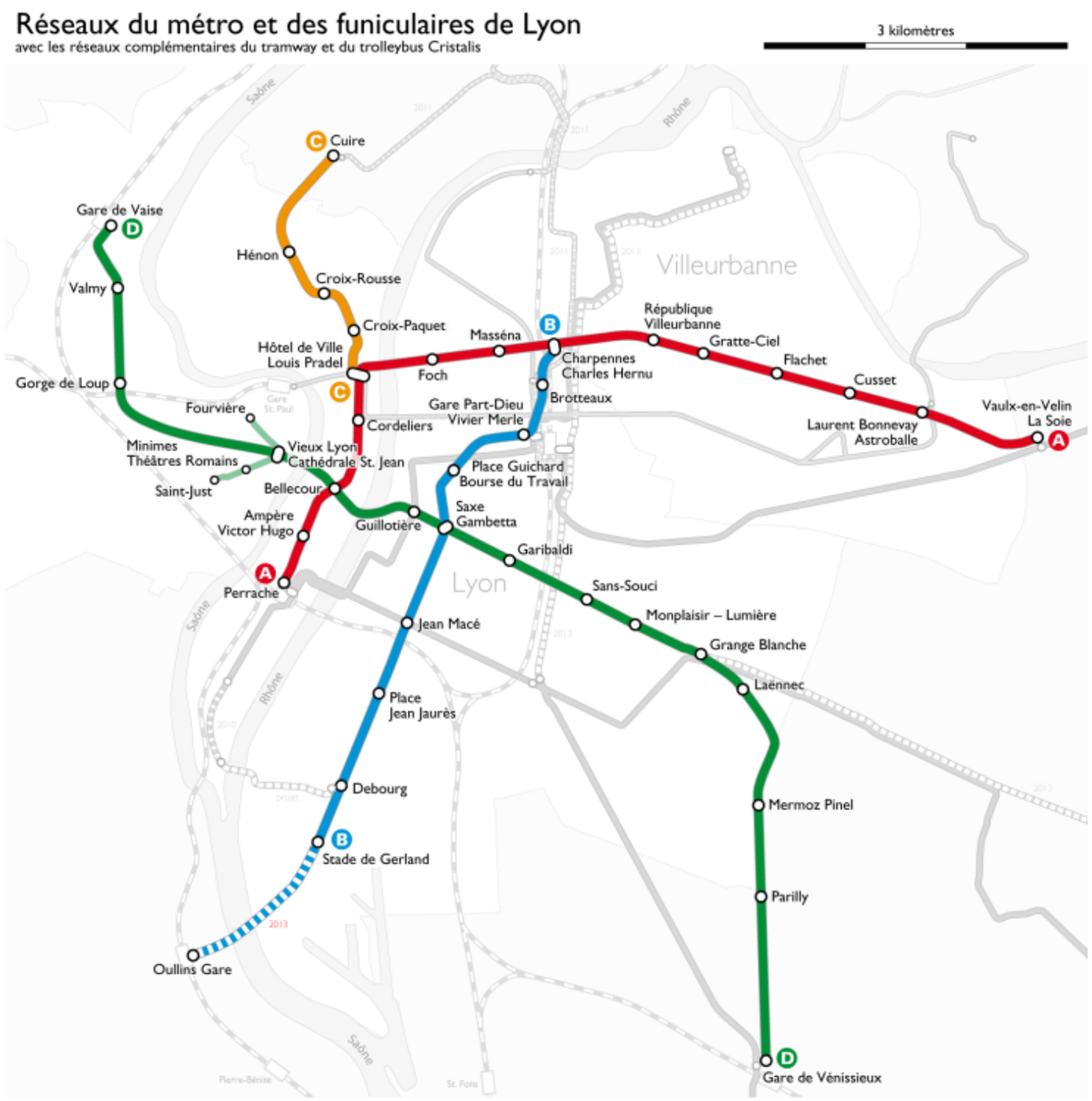
There are 42 interchanges along the route of the Metro, with an approximate distance of 750 m between stations. All of the stations are below ground, with most having entrances on either side. Recent upgrades have added elevators and ticket barriers to the mainly functional stations. A few of the stations on Line D are more interesting in their design, a result of their more recent construction.

Procurement and Governments

The Metro was constructed by the Transport en Commun Lyonnais in the 1970's, the public transport agency in Lyon. Today the Metro is administered by Sytral who set policies and finance the infrastructure of the system. Keolis Lyon operates the network on a day to day basis.

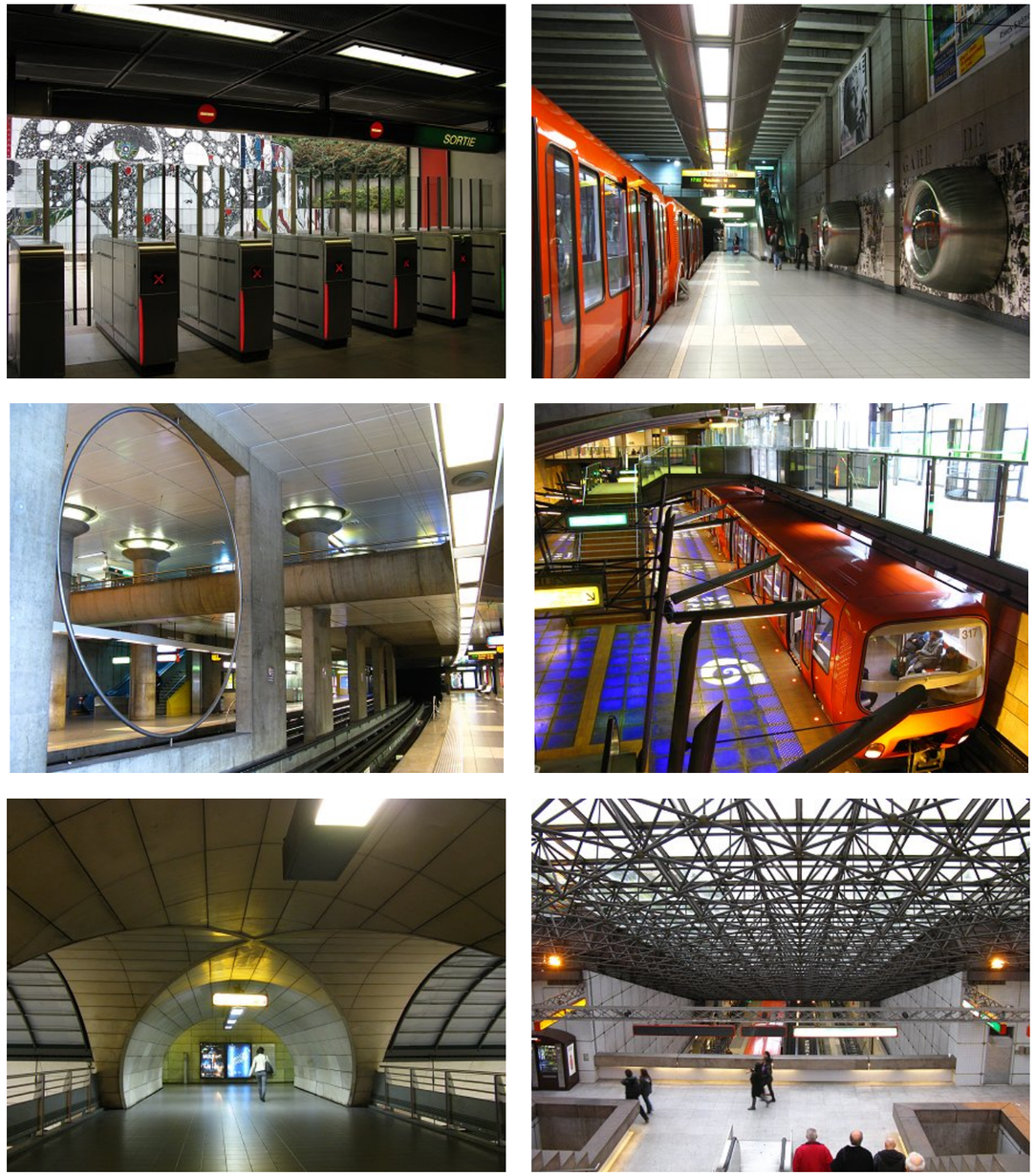
Visual Images of the City and Passenger Transport Mode/System

MRT Network – Lyon



Source: Maximilian Dorrbecker

Images from Line D



Clockwise from top left: Automated turnstiles at Monplaisir- Lumière; train at the Gare de Vaise; Gorge de Loup station; Valmy station; Vieux Lyon station; passengers at Gare de Vénissieux

Source: http://www.urbanrail.net/eu/fr/lyon/lyon.htm

Source: http://www.urbanrail.net/eu/fr/lyon/lyon.htm