Wellington Public Transport Spine Study

RAILWAY STATION TO HOSPITAL
International Review of Public Transport Systems

Appendix C1

Appendix C

Case Study Data Sheets

Case Study: Urban Light Transit (ULTra), London Heathrow Airport Terminal 5

Country: United Kingdom

Mode: Personal Rapid Transit (PRT)

Similarity to Wellington Environment	
Bus based system with capacity problems requiring modal shift	
Relatively constrained and narrow CBD with a strong PT Spine where throughput has been optimised	
A suburban rail line (metro) which stops short of the CBD, which requires journeys to be taken by another mode	
Shuttle service in the CBD area supplementing other transport options	
Other (please describe) Shuttle service providing innovative alternative to linking different modes of transport (point to point)	✓

Modal Characteristics Summary

Vehicle capacity	4
Peak hour capacity (pphpd)	480
Service frequency	On demand
Capital expenditure (per km)	NZ$9-NZ$20M
Total cost	
Operational expenditure (per vehicle per km)	Yet to be disclosed
Operating speed (km/h)	40 km/h (operating and design top speed)
Turning radii (m)	<10 m
Power source	Battery
Typical spacing of stops	3.8 km
Annual patronage	500,000 (Anticipated)
Annual passenger kilometres	1,900,000 (Anticipated)
Hours of operation	22 hours
Rides per day	

Case Study Description

Overview

Personal Rapid Transit (PRT) is a mode of public transport featuring small vehicles that travel along purpose built, automatic guideways. The vehicles are designed for individual or small group travel, up to six passengers, with stations located on sidings that facilitate non-stop, point-to-point travel.

History

BAA Airports Limited aspired to reduce the environmental impact of their land transportation and improve the experience for passengers accessing Heathrow Airport's Terminal Five via the use of a cutting edge, green transport solution. Speed and efficiency were also key factors behind BAA's decision to develop ULTra.

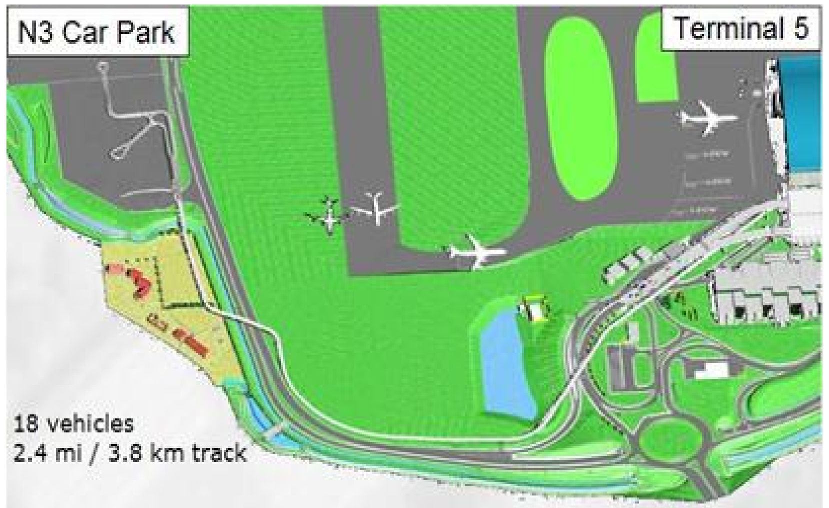
Project details

ULTra is an electric, battery-powered, elevated PRT system that connects Terminal Five business car parks to the terminal. ULTra has successfully replaced bus services by proving a more efficient, cost effective and environmentally friendly means of transporting people between two fixed points.

ULTra began operating in April 2011. The system consists of 21 low energy, battery powered, driverless, zero emission vehicles that can carry four passengers and their luggage along a dedicated 3.8km guideway. The alignment is more direct than the route previously operated by buses which contribute to shorter journey times. On demand frequency means that wait times are greatly reduced (averaging 30 seconds). These factors have resulted in a 60 percent improvement in travel time when compared with the bus service.

Between April 2011 and September 2011, ULTra was used by 100,000 passengers and its operators anticipate annual patronage of 500,000 passengers (*Local Transport Today, issue 580, 23 September 2011*). In comparison with the bus service, it is expected that there will be 40% operational cost savings.

Reference Map



Alignment of Personal Rapid Transit (PRT) for Heathrow Airport's Terminal 5
Source: www.ultraprt.net (2011)

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

ULTra is forecast to eliminate 50,000 bus journeys from roads around Heathrow Airport by providing a faster and more direct alternative.[1]

The elevated system was integrated into the design and layout of infrastructure constructed for the new terminal. The dimensions of the infrastructure have enabled it to be constructed around existing structures, including a section that runs underneath an elevated highway.

The routing of the PRT system within the Airport boundary ensured that planning and land use issues were relatively straight forward.

Key Success Factors

The success of ULTra is that it supplements other transport infrastructure providing fixed point-to-point services. In newly constructed, or redeveloped, environments this can be carried out relatively cheaply and with minimal disruption. Key features include:

- Zero emission vehicles (environmentally friendly);
- Energy efficient;
- Low noise levels;
- Journey time savings over shorter distances;
- Short wait times;
- Flexible infrastructure provided by turning radii and narrow width (2.1 m wide); and
- Relatively cheap construction.

Design Issues

- Elevated structure – completely segregated from traffic although may require additional land take.
- Small vehicles capable of travelling on lightweight guideways – this makes construction cheaper and integration into the existing urban fabric easier than for heavier infrastructure.
- Guideways are approximately 2.1 m wide, including the outer kerbs, and therefore relatively narrow.
- Empty vehicles charge themselves at battery points.

Operational

- Can only travel on a predetermined route (there are also no intermediate stops along the Heathrow alignment).
- Pod cars are activated by passengers using a touch screen interface.
- Larger interchanges require docking areas for multiple PODs.

Constraints

- Capacity of each pod is only four passengers and luggage.
- Unlikely to be suitable for large cities as it is not considered capable of handling large mass transit requirements.
- Top speed of 40 km/h limits its appropriate range.
- In existing and densely developed urban environments, more complex and expensive construction is likely to be required.

Technology

- Twenty-one low energy, battery powered, driverless, zero emission vehicles – vehicles are recharged at battery points.

Interchange

There are two types of interchange. A larger terminal station with multiple berths and smaller two-berth car park stations. The stops are typically attached to host-interchanges and each, fully accessible ULTra bay can dispatch up to 100-120 vehicles per hour with little or no waiting time.

Procurement and Governments

Aiport operators paid for the line, developed by ULTra, on land owned by the airport. As a result of these factors, issues relating to procurement and governance were limited. The development and operation of PRT is likely to be more suitable for operation in campus environments such as Universities, self contained business parks and airports.

Passengers are charged for using the business car park for the terminal but not directly charged for using ULTra.

[1] Local Transport Today, issue 580, 23 September 2011

Visual Images of the City and Passenger Transport Mode/System

Boarding at Heathrow Airport ULTra Hub

Source: www.ultraprt.com

Pod Cars Operating at Heathrow Airport

Images of:

1. Boarding and alighting point. Source: http://www.transportxtra.com/files/10071-l.jpg
2. Elevated section of route beneath highway Source: http://www.transportxtra.com/files/9795-l.jpg
3. PRT vehicle utilising concrete guideway Source: Skybum at en.wikipedia

Case Study: PRT
Country: Masdar City
Mode: Private Rapid Transit (PRT)

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	
Shuttle PT service in the CBD area supplementing other transport options	✓

Modal Characteristics Summary

Vehicle capacity	4-6
Peak hour capacity (pphpd)	500
Service frequency	On demand
Capital expenditure (per km)	-
Total cost	-
Operational expenditure (per vehicle per km)	-
Operating speed (km/h)	40
Turning radii (m)	-
Power source	Lithium-Phosphate batteries
Typical spacing of stops	1.2 km
Annual patronage	310,000
Annual passenger kilometres	372,300 km
Hours of operation	6am-12am
Rides per day	-

Case Study Description

Overview

Masdar City in Abu Dhabi is a planned city that began construction in 2006. Located 17 km to the south-east of Abu Dhabi city, Masdar City is built on the concept of sustainability, particularly in relation to energy use. Upon completion, the city is intended to be home to up to 50,000 people, however, the first stage of the development is not expected to be completed until 2015.

One of the most unique features of this development is a complete ban on motor vehicles. Instead of using cars to get around, residents are expected to rely on public transport and personal rapid transit systems (PRT). The PRT system uses small pod-like vehicles to transport people from the North Car Park to the Masdar Institute of Science and Technology. Up to six passengers (four adults and two children) can travel in each vehicle. There is no charge for using the PRT, it is provided for free to the people of Masdar City.

History

With motor vehicles banned, an alternative form of transport was required for Masdar City. Designed in a manner that would facilitate greater pedestrian movement and access, the city still required a transport option for longer journeys. With this in mind, the fully electric PRT system was selected as it would fulfil this roll while falling in line with the city's sustainability objectives.

The first connection of PRT was completed in late 2009, providing a link between the car park to the north of Masdar City and the Masdar Institute of Science and Technology. The PRT system is seen as an integral part of Masdar City's overall goal of urban sustainability. 2getthere, a company based in the Dutch city of Utrecht, was commissioned to provide the first stage of what will eventually be an exhaustive PRT network.

Masdar PRT

The Masdar PRT system currently consists of a single connection, with only two stations along the network. This, however, is only the first step to creating a comprehensive network comprising of 85 stations serviced by 3,000 PRT vehicles.

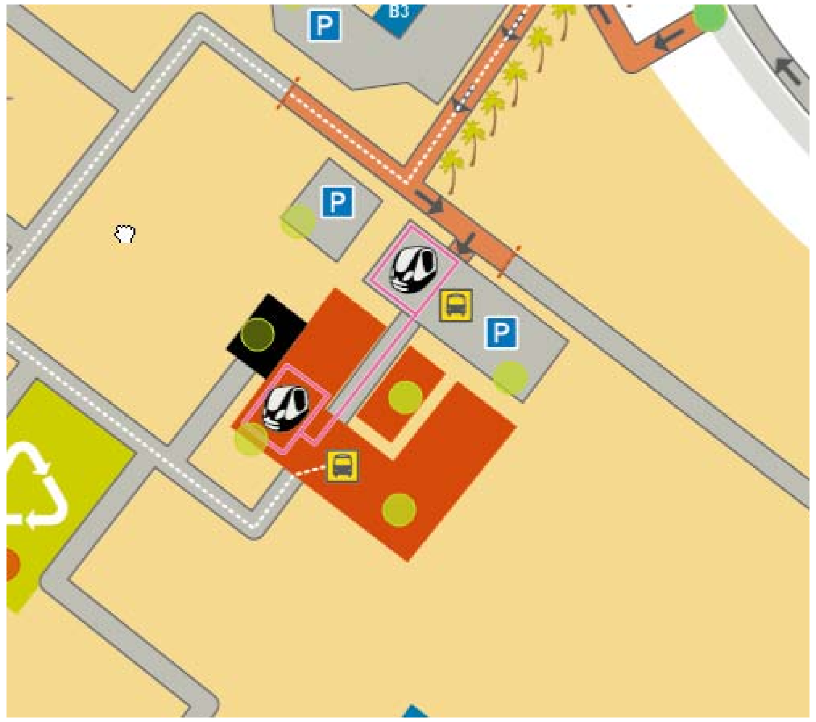
At this stage there are 10 vehicles operating along the 1.2km line, each with the capability to carry four adults and two children. The size of the vehicles dictates their capacity as it is not possible to stand and only four seats are provided.

In a straight line, the PRT vehicles operate at a speed of 40 km/h, however, this slows to around 25 km/h around corners. The two stations currently in use have capacity for six vehicles at one time

Completely automated, the PRT vehicles use magnets installed in the track as reference points for direction.

In the first 10 months of operation, PRT experienced passenger numbers of around 700-1,000 people per day.

Reference Map



Source: http://www.masdarcity.ae/en/109/explore-masdar-city/

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

By removing cars from the transport network, it was necessary for an alternative transport typology to be provided to fill the gap that this left. Although the city has been designed to be pedestrian oriented, PRT provides an option for longer journeys.

PRT removes the need to dedicate large areas of the city to roading, allowing for a greater integration of people and land uses. The relatively small area required for the network and size of the vehicles means that it can be installed between individual buildings, enabling direct connections between differing land uses.

Key Success Factors

- PRT reduces travelling time along this 1.2 km journey to around two minutes, making it an efficient form of transport.
- As vehicles only travel on demand, there are almost always vehicles available for use at both stations. If this is not the case, waiting time is approximately two minutes, the amount of time it takes to travel along the network.
- PRT systems are still in their infancy and therefore there is a certain level of novelty attached to using this transport mode, something which is likely to have contributed to its success.
- There is no charge for using the PRT system, making it accessible to everyone.

Design Issues

- To ensure that Masdar City maintains its objective of being pedestrian oriented, the PRT will be installed underground but will directly connect with the buildings above.
- The network is completely flat with vehicles using magnets imbedded in the track to position them.
- The onboard batteries last for around 60 km (approximately 50 trips) before they need recharging.

Operational

- The PRT system operates seven days a week between 6 am and 12 am.
- During the first six months of operation, the system operated at 99 percent availability.
- The vehicles are operated using the TOMS (Transit Operations Monitoring and Supervision) system.

Constraints

- The development of Masdar has been impacted by the global economic recession, slowing the creation of additional sections of the PRT network.
- Although vehicles can recharge while sitting unused in stations, if this is not possible they must be taken out of the network to recharge.

Technology

- An obstacle detection system allows the vehicles to operate at a minimum of five seconds apart.
- Vehicles feature LCD screens which allow users to monitor journey status.
- Magnets installed within the track are used by the vehicles to judge road position.
- Piping imbedded within the track contains a glycol solution which is heated during the winter to melt snow and ice.

Interchange

The two stations on the PRT network are the North Car Park station and the Masdar Institute of Science and Technology. Eventually the network will see a total of 85 stations.

The necessity to ensure that Masdar is primarily a pedestrian oriented city means that these stations will be subterranean and linked to the buildings above. Up to six vehicles can berth at a station at a time.

Procurement and Governments

- The Masdar City project is administered by the Abu Dhabi Future Energy Company who contracted 2getthere to provide the PRT service.

References

http://www.advancedtransit.org/advanced-transit/applications/masdar-prt/
http://www.masdarcity.ae/en/
http://www.new.2getthere.eu/?page_id=10

Visual Images of the City and Passenger Transport Mode/System

Images from PRT in Masdar City

An example of one of the vehicles operating on the Masdar PRT network
Source: http://www.advancedtransit.org/advanced-transit/applications/masdar-prt/

Residents using the PRT system
Source: http://www.new.2getthere.eu/?page_id=10

Masdar City masterplan concept
Source: http://www.masdarcity.ae/en/48/resource-centre/image-gallery/?gal=4

Case Study: PRT

Country: West Virginia

Mode: Private Rapid Transit (PRT)

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. PRT mode at University campus to provide congestion relief for buses.	✓

Modal Characteristics Summary

Vehicle capacity	20
Peak hour capacity (pphpd)	1,500
Service frequency	No more than 5 minutes
Capital expenditure (per km)	$11.3M
Total cost	-
Operational expenditure (per vehicle per km)	-
Operating speed (km/h)	50 km/h
Turning radii (m)	9.1 m
Power source	575V AC
Typical spacing of stops	2.6 km
Annual patronage	2,250,000
Annual passenger kilometres	-
Hours of operation	-
Rides per day	-

Case Study Description

Overview

Morgantown, West Virginia is home to 30,000 people. However, this number swells to almost double from September to May due to the influx of university students.

An extension to West Virginia University (WVU) in the 1960's resulted in the construction of a second campus 3km away from the original location. As a consequence WVU were forced to look at transport options to connect the two campuses. This led to the construction of the PRT system in the 1970's to cater to the needs of students.

Since its construction the PRT system has been expanded along with the university. Today, the PRT system has a total of five stations and runs for a length of 13.2 km, carrying on average 16,000 people a day in 2007. PRT is free for university staff and students and costs 60 cents for outsiders to use.

History

The expansion of WVU in the 1960's created an issue regarding transporting students and staff between two campuses that were 1.5 km apart. Originally the university operated a free bus service between the two campuses. However, this often got stuck in heavy downtown traffic. At one stage this forced WVU to ban students from taking classes at both campuses.

The PRT solution arose out of the belief that it would provide the most cost-effective solution to Morgantown's problem. Backing from President Nixon ensured that Morgantown would become the test case for PRT systems within the USA. The first phase of PRT was completed in 1975.

Although originally marketed as a cheap form of rapid transit, costs for the PRT system quickly spiralled nearly quadrupling in cost, with the first stage costing $72,000,000. A second phase of PRT was added in 1979, costing around $77,000,000, bringing the total cost of the network to $149,000,000.

Looking forward, there have been proposals to extend the PRT system further. The large costs associated with this ($26,000,000 / km) has prevented any action to date.

Morgantown Personal Rapid Transit PRT

Covering a distance of 13.2 km, the Morgantown PRT is the only privately operated PRT system in the world. The PRT system services five stations along its route, providing connections to different WVU campuses.

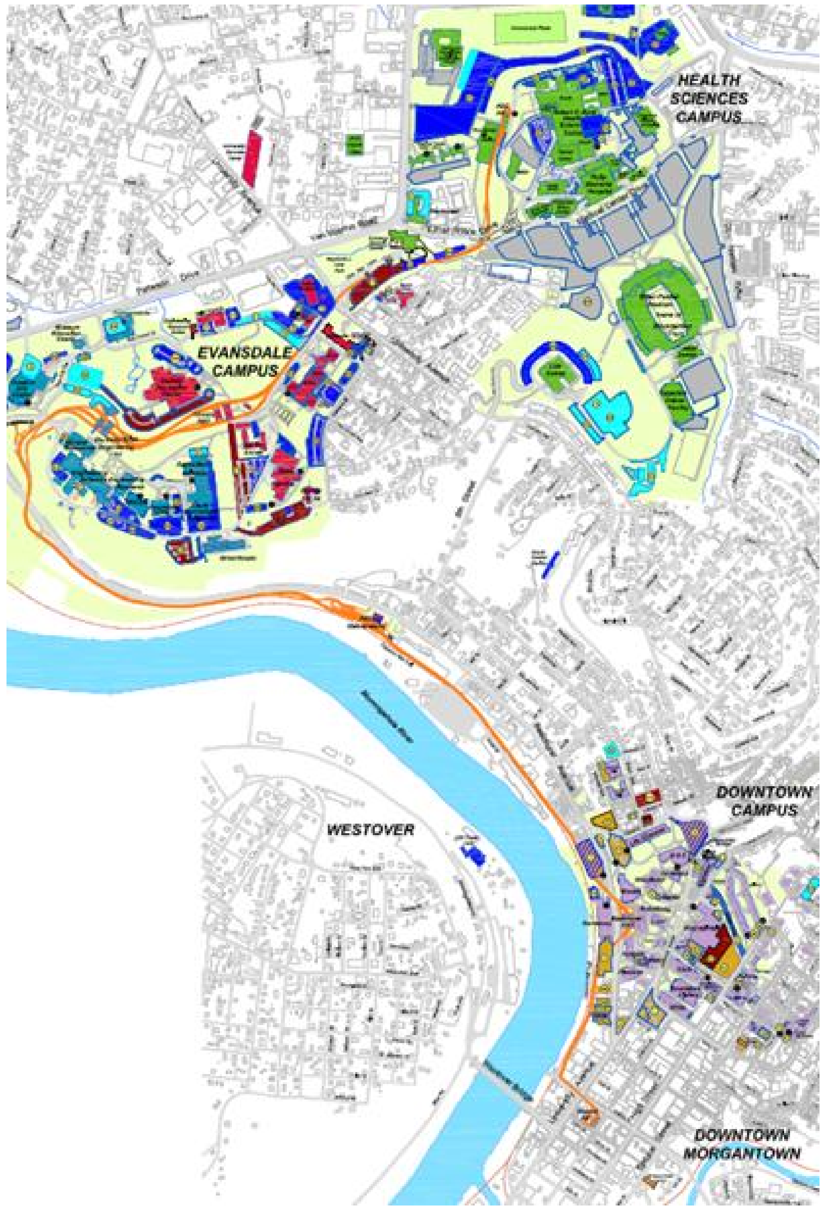
Three different operating modes control the frequency of the service. During peak times the network is available on demand, (demand mode) where waiting time is typically no longer than five minutes and usually closer to one minute, and Schedule Mode where vehicles run along predetermined routes. In these peak times the network can transport around 1,500 people an hour.

In off-peak times, the network operates on Circulation Mode which resembles a more traditional bus service.

The network operates 71 vehicles which can carry 20 passengers, with space for eight people to sit. The PRT service is free to students and staff who use their Mountaineer ID card to travel, while others are charged 60 cents. This charge generates enough income to fund 60 percent of the system's operating costs.

It takes 11.5 minutes to travel along the whole network.

Reference Map



PRT route shown in orange
Source: http://transportation.wvu.edu/r/download/69970

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

- The introduction of PRT removed the reliance of WVU on bus services between its separate campuses. In turn this reduced the severe traffic jams that were building in the central city as a result of these buses.
- By connecting the five campuses with a PRT network, WVU was able to avoid segregation of parts of some faculties and areas and ensure a degree of integration between all campuses. This is something that would not otherwise be possible due to the large geographic distance between them (up to 13 km).

Key Success Factors

- The PRT system is operated free of charge for WVU staff and students, making it a highly viable transport option between university campuses.
- The speed of the network means it is possible to travel from the two most distant campuses in the 20 minute break between classes.
- With services operating on demand and along a schedule during peak times, waiting times are low, making the system a convenient form of travel.

Design Issues

- The PRT system operates mainly above ground, with 65 percent of its route along raised platforms or bridges.
- The climate of Morgantown makes the PRT vulnerable to snowfall in the winter. To combat this, heating elements are placed along the track to melt snow and ice.

Operational

- The PRT system operates at around 98.5 percent reliability, with most problems relating to individual vehicles rather than the system at large.
- As PRT is aimed towards students and WVU staff, it is only operational during semester time. Hours of operation vary depending on the time of year, but in general PRT runs from 6:30 am through to 10:15 pm on weekdays and 9:30 am-5 pm on Saturdays. The service does not operate on Sundays

Constraints

- Future developments to the PRT system have been constrained by the expense of extending the network.
- There was a necessity for much of the network to be above grade.
- Government and national interest saw the project affected by political positioning

Technology

- Staff and students use their Mountaineers ID card to ride the network.
- Magnets imbedded in the track allow the vehicles to position and orientate themselves along the network.
- Piping imbedded within the track contains a glycol solution which is heated during the winter to melt snow and ice.
- The network operates 71 driverless vehicles which are controlled from a central system

Interchange

- There are five stations along the network, connecting different parts of the WVU campuses. The largest stations are at the three middle destinations which can accommodate 22 vehicles at once. All stations feature disable access.
- If PRT is stops working for more than 15 minutes, an indicator light will signal this at affected stations.

Procurement and Governments

- The PRT system is owned and operated by WVU, however, the original development of the system did receive government funding due to the high profile nature of the project and the government's willingness to experiment with this form of rapid transport.
- Additional funding is provided by the Federal Transit Administration,

References:
http://transportation.wvu.edu/prt/facts_about_the_prt
http://www.cities21.org/morgantown_TRB_111504.pdf

Visual Images of the City and Passenger Transport Mode/System

Images from PRT in West Virginia

Station on PRT network
Source: http://www.city-data.com/picfilesv/picv29235.php

Source: http://www.prtconsulting.com/gallery5.html#show

View from Evansdale
Source: http://www.prtconsulting.com/gallery5.html#show

Display at turnstile on PRT network
Source: http://www.prtconsulting.com/gallery5.html#show

Case Study: Xiamen BRT
Country: China
Mode: Bus Rapid Transit – Elevated

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	88
Peak hour capacity (pphpd)	7,900
Service frequency	From 40 seconds
Capital expenditure (per km)	NZ$17.6M[1]
Total cost	-
Operational expenditure (per vehicle per km)	-
Operating speed (km/h)	Ave 27 (Max 60)
Turning radii (m)	~50
Power source	Diesel
Typical spacing of stops	900 m to 1300 m
Annual patronage	11,000,000
Annual passenger kilometres	-
Hours of operation	0550 to 2240
Rides per day	-

Case Study Description

Overview

Xiamen is a city on the south-east coast of China, near Taiwan. It has a population of approximately 3.5 million people. Xiamen has a strong and diverse economy with high quality transport infrastructure.

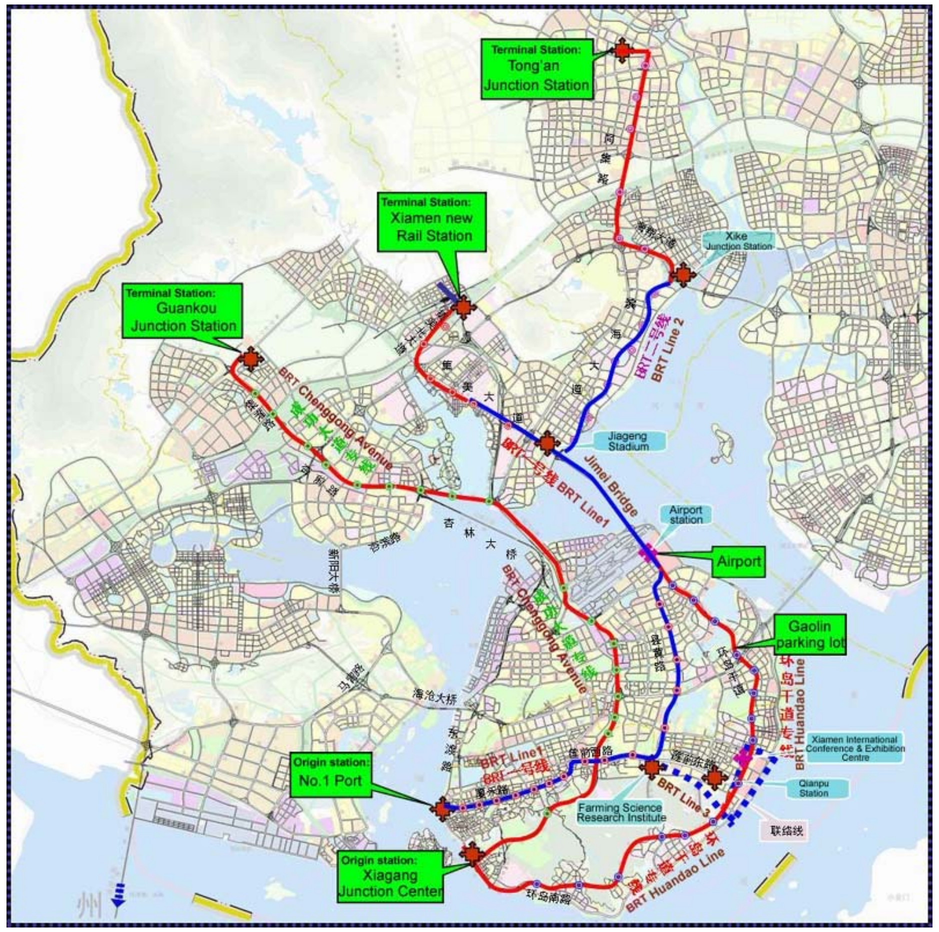
History

The Xiamen BRT network was constructed recently, with significant sections on a network of elevated viaducts, similar to a light rail network. The network began operating in August 2008. There are currently three lines and 47 stops.

Project

An elevated Bus Rapid Transit system was constructed to relieve the effects of heavy traffic on the performance of the bus network. By elevating the busway, the need to use existing road space was avoided. A commuter railway station exists on the edge of the densely urbanised No.1 Port area in the southwest portion of Xiamen Island. Commuters can transfer to the BRT system there, which uses an exclusive, elevated busway above the main road to take passengers to their destinations. The busway serves this area of intense activity, which the existing railway system does not adequately service, as shown in the Google reference map.

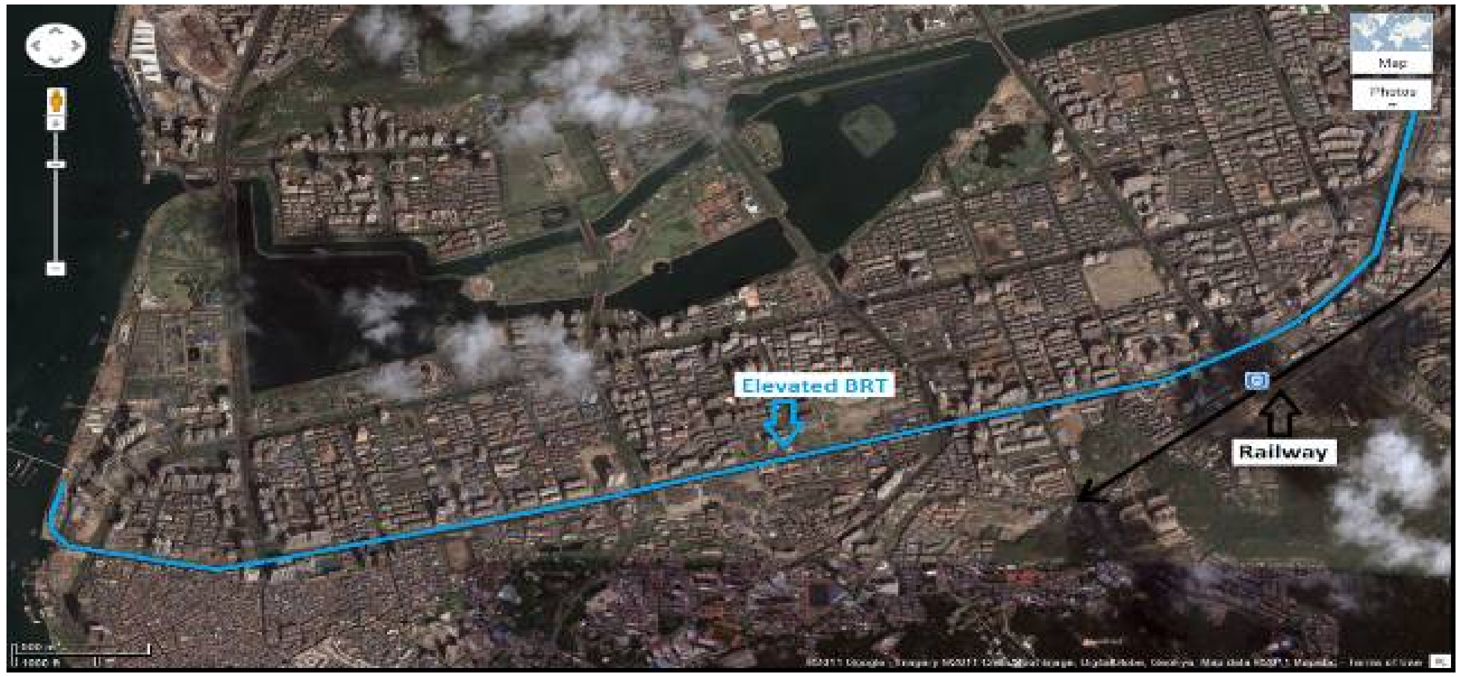
Reference Map



[1] BRT Line 1 only, assuming an investment of 3 billion Yuan over 32.6 km of busway (from a secondary source: http://bbs.xmfish.com/simple/?t3316391.html)

<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="3">- The elevated busway began operating in 2008 to relieve traffic on the roads – therefore, the route selected was in response to identified travel patterns. Patronage on the elevated busway is high and bus travel mode share is also high in Xiamen.</td><td rowspan="3">- Enhanced, sheltered station environments.
- Pedestrians do not need to cross any roads to change service as access to elevated stations passes over the road.
- Buses are completely grade separated and therefore do not interact with general traffic.
- The average speed of vehicles on the busway is significantly greater than the average speed of vehicles on the road network at peak times.</td><td>- The most important design issue is the viaduct system required to support the busway.
- The ability to convert the system to elevated light rail in the future, increasing the throughput capacity of the system.
- Using an elevated solution works well in congested cities where there is sufficient space to accommodate support piers, and street reservations are wide enough to accommodate the elevated structure at an aesthetically acceptable distance from buildings e.g. privacy/visual issues associated with building windows, shading of the street below. Issues regarding noise generated by buses operating at an elevated level may also need to be addressed.</td></tr>
<tr><th>Operational</th></tr>
<tr><td>- The operation runs as a trunk, fully segregated transit network, supported by feeder (non-BRT) routes that run in mixed traffic.
- Current throughput capacity of this system is 8,000 pphpd.
- Full grade separation from other traffic minimises operational problems. As the busway is only one lane per direction, some congestion is likely on the busway during peak times.</td></tr>
<tr><th colspan="2">Constraints</th><th>Procurement and Governments</th></tr>
<tr><td colspan="2">The main constraints to capacity are the width of the road, and the capacity of the vehicles. Capacity could be increased by using bi-articulated or double-decker buses.</td><td rowspan="5">The network is operated by a non-profit, nationally owned Xiamen BRT Corporation.</td></tr>
<tr><th colspan="2">Technology</th></tr>
<tr><td colspan="2">The Xiamen BRT system uses 12 m long buses on the trunk routes and 10 metre long buses on feeder routes. Several 18 metre long buses have recently been introduced on trunk routes. Buses run on diesel fuel and are manufactured by a Chinese company called Kinglong.</td></tr>
<tr><th colspan="2">Interchange</th></tr>
<tr><td colspan="2">The BRT stations are elevated and allow access by stairs and/or elevators. Pedestrian bridges join stations on either side of the road, allowing pedestrians safe and easy access to stations as they do not need to cross the busy road.</td></tr>
</table>

Visual Images of the City and Passenger Transport Mode/System



Source: Google

Source of all photos: ITDP http://www.transportphoto.net/cmtbrt.aspx?l=en&cmtc=Xiamen

Case Study: South East Busway
Country: Brisbane, Australia
Mode: Bus 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: suburban BRT network which extends into the CBD	✓

Modal Characteristics Summary

Vehicle capacity	60-70
Peak hour capacity (pphpd)	6,500 actual 12,000 capacity
Service frequency	From 24 seconds[1]
Capital expenditure (per km)	NZ$74M[2]
Total cost	-
Operational expenditure (per vehicle per km)	NZ$9.80[3] (all buses)
Operating speed (km/h)	29[4]
Turning radii (m)	15-20
Power source	Diesel, some CNG
Typical spacing of stops	1,500 m
Annual patronage	35,000,000[5]
Annual passenger kilometres	~6,000,000,000 place kilometres (all buses 2009-10)
Hours of operation	-
Rides per day	-

Case Study Description

Overview

The South East Busway is a dedicated bus rapid transit corridor which runs from Eight Mile Plains to Brisbane's CBD, a distance of 16.5 kilometres. The busway was opened in 2001, leading to an immediate and rapid rise in bus patronage in Brisbane. The buses are frequent and relatively fast due to grade separation from general traffic.

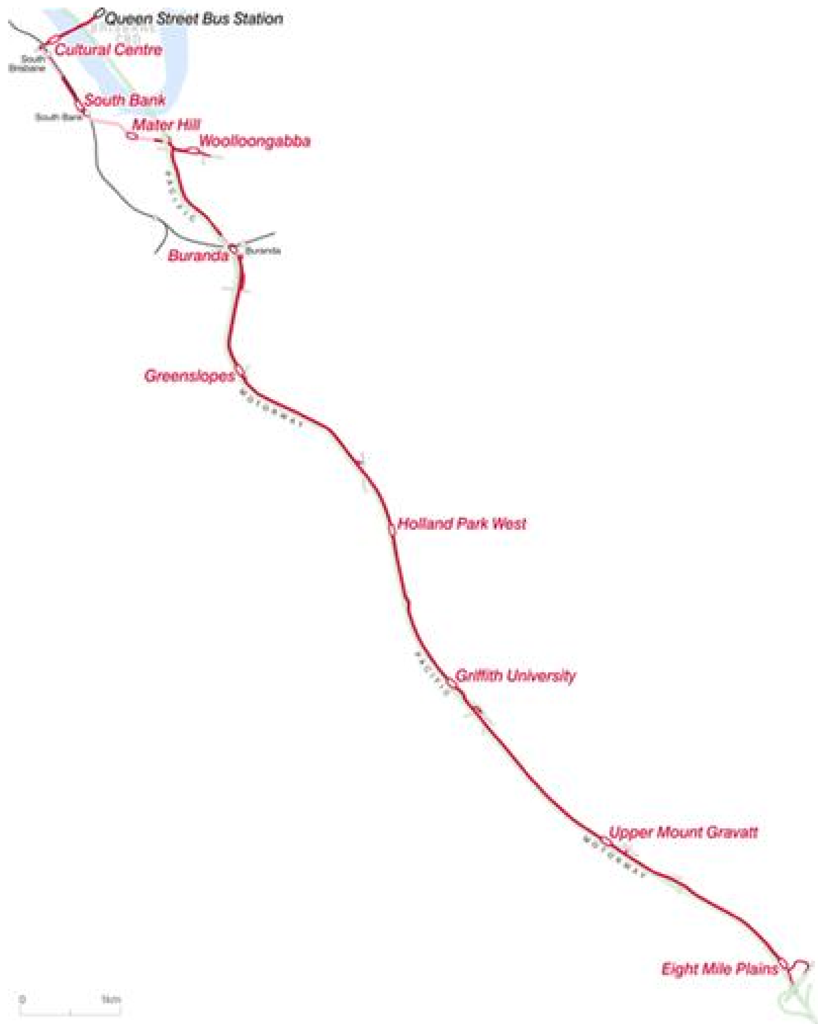
History

After the 25 Year Integrated Regional Transport Plan was released in 1997, The Queensland government undertook to construct a network of dedicated busways to complement the existing suburban rail network. The South East Busway was the first of these busways to open. As shown in Figure 1, bus patronage in Brisbane has gone up remarkably since the South East Busway was opened. Although some of this increase has been 'cannibalised' from the heavy rail network, increase in total public transport patronage has been higher in South East Queensland than anywhere else in Australia or New Zealand. This suggests the busway strategy has been successful in attracting substantial patronage onto the public transport network.

Project

The South East Busway was constructed in tandem with the Pacific Motorway. It was constructed in two stages (with the first stage opening in 2000) at a cost of AU $660 million in 2001. The project successfully cut travel times compared with the road network, and its success has ensured continued busway construction in Brisbane.

Reference Map



Source: Wikimedia

[1] http://transporttextbook.com/?p=1136
[2] http://www.atrf11.unisa.edu.au/Assets/Papers/ATRF11_0183_final.pdf $950 M for 16.5km in 2010 AU dollars, AU$57.58 M per km
[3] According to the 2009-10 TransLink annual report, bus operator expenditure was AU$682.7 M over 90,000,000 service kilometres, or AU$7.58 per kilometre source: http://translink.com.au/resources/about-translink/reporting-and-publications/2009-10-annual-report.pdf
[4] http://www.chinabrt.org/en/cities/brisbane.aspx
[5] South East Busway Extension Rochedale to Springwood Concept Design Study Report, Parsons Brinckerhoff. Entire network has an annual patronage of about 60,000,000 according to TransLink Annual Report 2009-10.

<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="3">- The scheme has been very successful in attracting passengers to bus services and onto the public transport network in general</td><td rowspan="3">- The buses are very frequent
- Travel times are reliable due to the segregated roadway
- The corridor serves residential areas with strong demand for CBD accessibility</td><td>- The majority of the route runs alongside the Pacific Motorway on the same road reserve
- There are several tunnels and bridges along the route</td></tr>
<tr><th>Operational</th></tr>
<tr><td>- There is significant congestion in the inner city stations, particularly the Cultural Centre station</td></tr>
<tr><th colspan="2">Constraints</th><th>Procurement and Governments</th></tr>
<tr><td colspan="2">- Parts of the busway (in the inner city area) are on the road and are constrained by general traffic</td><td rowspan="5">The infrastructure was delivered by the Department of Transport and Main Roads, a state government agency.
Various bus operators use the busway under the umbrella of TransLink, a state government transit authority. It was introduced by the Queensland Government in 2003.</td></tr>
<tr><th colspan="2">Technology</th></tr>
<tr><td colspan="2">Brisbane Transport operates 1,179 buses that are currently in service. They are all air conditioned and 85% are wheel-chair accessible (see btbuses.info).</td></tr>
<tr><th colspan="2">Interchange(s)</th></tr>
<tr><td colspan="2">Transfers can be chaotic and confusing due to the extremely high frequency of buses at inner city stations. Staff need to direct passengers to the right platforms.</td></tr>
</table>

Visual Images of the City and Passenger Transport Mode/System

Source: Wikimedia (Cyron Ray Macey)

Source: Wikimedia

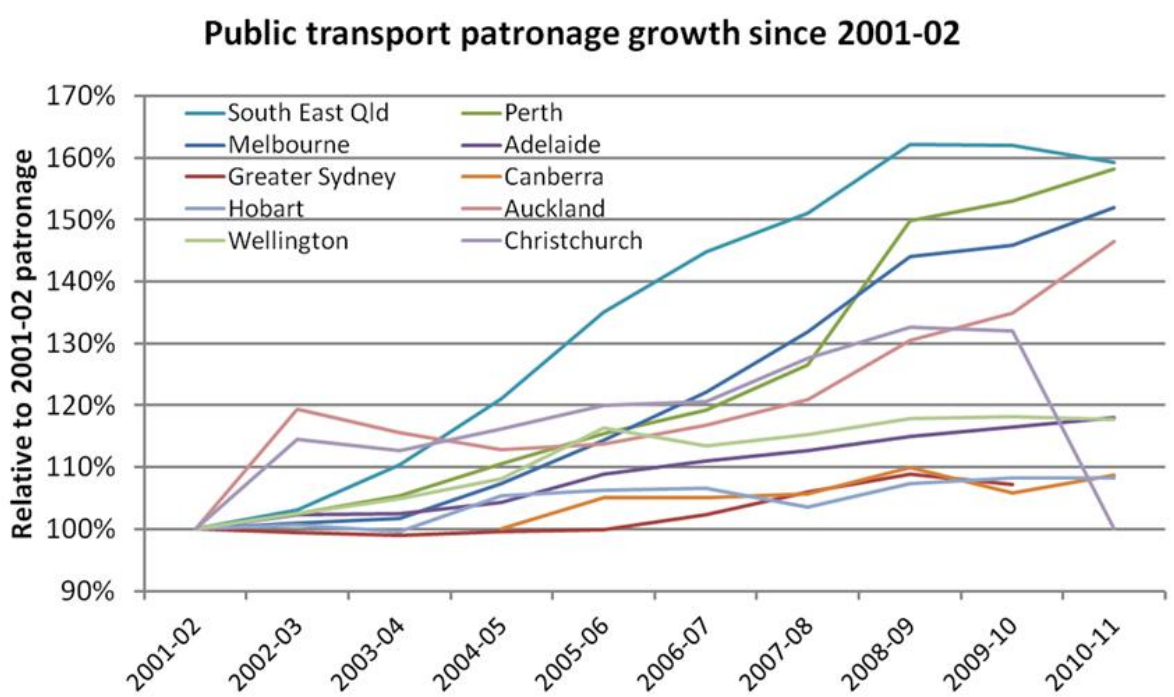


Figure 1

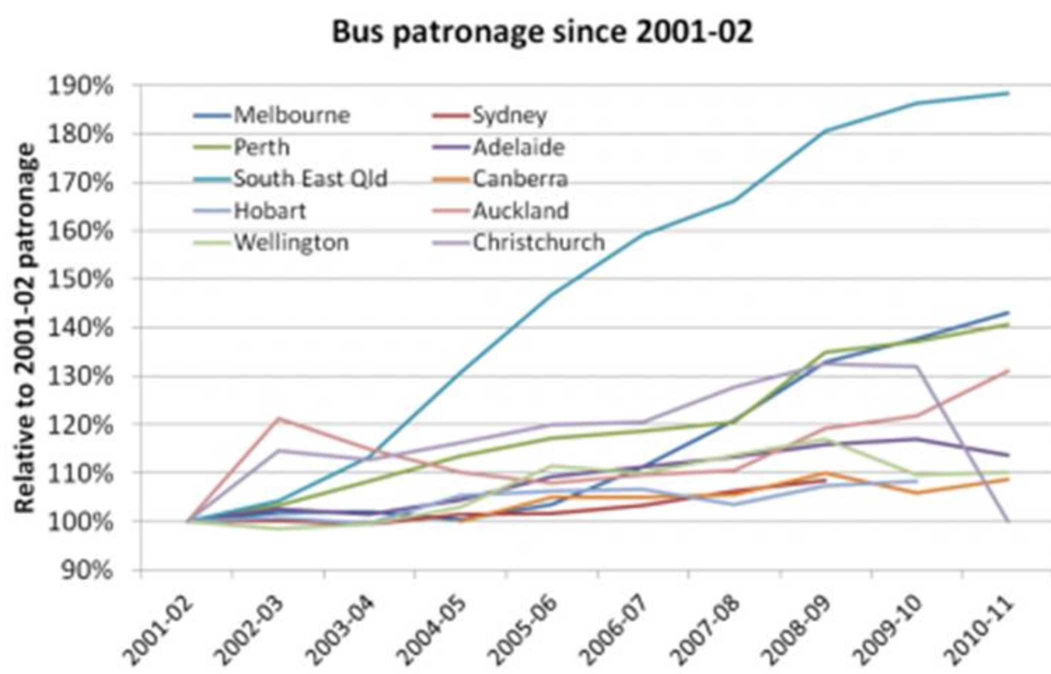


Figure 2

Source: Chris Loader http://chartingtransport.com/2010/11/13/public-transport-patronage-trends/

Case Study: Adelaide O-Bahn
Country: Australia
Mode: Bus Rapid Transit (BRT)

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)	36,000
Service frequency	5-15 minutes
Capital expenditure (per km)	$10.5M
Total cost	-
Operational expenditure (per vehicle per km)	-
Operating speed (km/h)	100 km/h
Turning radii (m)	-
Power source	-
Typical spacing of stops	6 km
Annual patronage	8,000,000
Annual passenger kilometres	-
Hours of operation	-
Rides per day	-

Case Study Description

Overview

The city of Adelaide, South Australia, experienced rapid population growth through the middle of the 20th century. The population of Adelaide currently sits around 1,200,000 people, making it the fifth largest city in Australia.

To provide for growth into the undeveloped north-eastern suburbs, a new system of freeways was proposed in the 1960's. However, this was met with strong opposition, as was a plan to introduce light rail. Aided by a change in government, the O-Bahn system was introduced in the 1980's. The O-Bahn sits somewhere between light rail and traditional bus services, operating buses along a 12km stretch of guided tracks.

Despite other public transit types suffering fluctuating patronage over the last 20 years, the O-Bahn has seen consistent usage, experiencing around 22,000 users on an average weekday.

History

The release of the Metropolitan Adelaide Transport Study in 1968 began the discussion on the best transport typology to service Adelaide's north-eastern suburbs. The study's report recommended the introduction of a network of freeways supported by an inner-city underground railway. There was major public and political opposition to this plan.

Further studies were undertaken and in 1978, the Highways Department concluded that light rail or a busway would be the best option for providing access to the north-eastern suburbs. Initially the government decided to extend the existing light rail network up into the suburbs despite opposition from the Adelaide City Council. To ease concerns about the potential impact of this development it was proposed the light rail extension would be underground.

A further change in government halted the tunnelling work that had begun for the new light rail system. Further research into potential options identified the O-Bahn concept as the superior choice for Adelaide due to its overall better performance in relation to noise, speed, cost and land demands.

Construction of the O-Bahn began in 1983 with the first section opening in 1986. A second phase was completed three years later following the success of the first half. Operation of the O-Bahn was privatised in 1990.

Plans to extend the O-Bahn have surfaced in recent years, however, these have been shelved as funds were shifted to help with recovery from the 2010 Queensland floods.

Adelaide O-Bahn

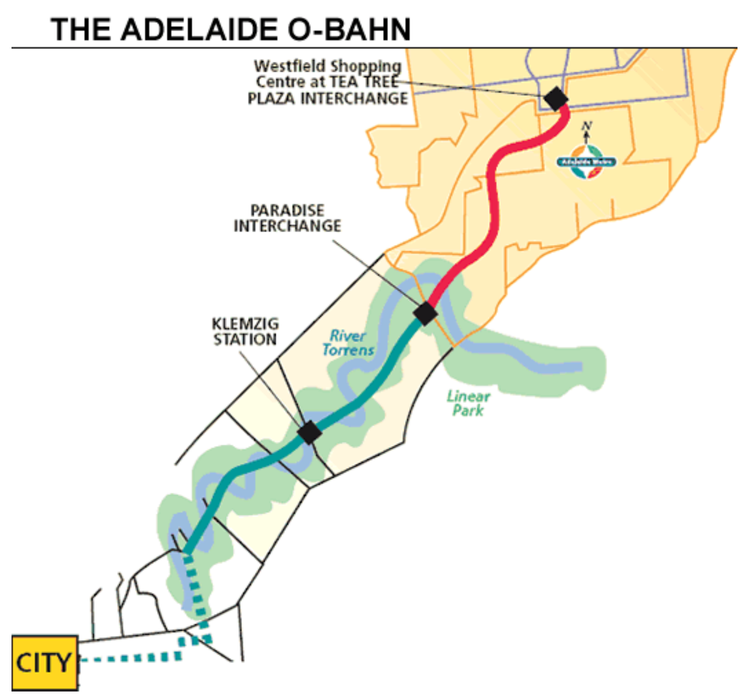
At 12 km long the Adelaide O-Bahn is the longest example of this type of transport worldwide. The O-Bahn operates above grade, allowing minimal interference with the wider transport network and environment in Adelaide.

The concrete tracks, along which the bus operates, means that less space is required when compared with more traditional busways. They also allow the buses to run at much higher speeds more safely. Small rubber wheels extend from busses, parallel to the ground and run along the inside of the concrete tracks to guide them down the O-Bahn.

Busses enter the O-Bahn at either the Klemzig station to the south or Tea Tree Plaza Interchange to the north. Only minor bus modifications are required to allow them to operate along the O-Bahn. This means they are capable of running on standard roads and allows the O-Bahn to connect to the city centre as well as suburbs to the north of the network. Seventy one different routes connect with the O-Bahn or run exclusively along its length.

The O-Bahn uses the Adelaide Metro ticketing system with tickets costing $5.90 in peak times and $3.60 off-peak.

Reference Map



Source: http://www.adelaidemetro.com.au

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

- The O-Bahn provides a passenger transport system that does not intrude heavily into the surrounding environment. This was one of the key factors that influenced the decision to build the O-Bahn with other options requiring much greater land areas and alienating the public and surrounding suburbs.
- The O-Bahn connects the north-eastern suburbs of Adelaide to the city centre and terminates at its northern extent at the Westfield Tea Tree Plaza shopping centre. Public transport links to both of these key destinations.

Key Success Factors

- The O-Bahn is able to travel at higher speeds than regular bus services due to its track system, making it a convenient and fast service.
- In peak times, the O-Bahn has service frequencies of five minutes, with a minimum service frequency of 15 minutes in off peak times.
- By connecting with the Westfield Tea Tree Plaza and Rivers Torrens Linear Park, the O-Bahn provides a link between the central city and these two key attractions.
- Buses require only minor modifications to operate on the O-Bahn, allowing them to leave the O-Bahn and provide an unbroken connection into the suburbs.

Design Issues

- The rubber guide wheels allow the bus to operate in a much narrower lane when compared with standard bus networks.
- To avoid interference with other transport modes the O-Bahn runs above grade, incorporating a number of bridges along its route. This was also necessary due to the poor quality of soils within the river bed that the track sits.

Operational

- There is a 3 km gap in the network between the O-Bahn and the city centre. Increasing congestion has increased the amount of time it takes to travel this part of the route.

Constraints

- Poor quality soil along the O-Bahn route required that it was elevated along its entire route, not just where it intersected with the wider transport network.

Technology

- Innovative aluminium tyres, which form part of the wheels' construction, allow buses to travel at around 50 km/h in the event of a puncture.
- Small rubber tyres are fixed to the front wheels of buses allowing them to be guided by the concrete tracks along the route of the O-Bahn. This enables faster and safer travel along the O-Bahn.
- A rumble strip warns drivers they are entering a station and need to resume control.
- To prevent cars using the O-Bahn network, 'sump busters' are installed along the route, which remove a car's oil pan if it passes over one.

Interchange

- There are three stations along the O-Bahn network. Only two of these, The Paradise Interchange and Tea Tree Plaza Interchange, allow buses to enter or leave the network. Both interchanges feature park-and-ride stations and also connect bus services with surrounding suburbs.

Procurement and Governments

- Government funding was used to construct the O-Bahn and operated by TransAdelaide, a publicly owned corporation.
- Since its inception, the O-Bahn has been managed by a number of different operators. Today it is operated by Light-City Buses.

References:
http://www.pbworld.com/pdfs/regional/australia_nz/Adelaide_O-Bahn.pdf
http://www.gulliver.trb.org/publications/tcrp/tcrp90v1_cs/Adelaide.pdf
http://www.faculty.washington.edu/jbs/itrans/adelaide-o-bahn-paper.doc
http://www.adelaidemetro.com.au/guides/obahn

Visual Images of the City and Passenger Transport Mode/System

Adelaide O-Bahn	

Guide wheel on O-Bahn bus
source: http://www.nbrti.org/media/g

Buses operating along the O-Bahn
source: http://livingtravel.com/australia/southaustralia/adelaide/adelaide_3a.htm

O-Bahn Tea Tree Plaza Interchange station
source: http://www.panaramio.com

Case Study: Northern Busway
Country: Auckland, New Zealand
Mode: Rapid Bus Transit (BRT)

Similarity to Wellington Environment	
Bus based PT network with capacity problems requiring mode shift in order to be resolved	✓
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	60-75
Peak hour capacity (pphpd)	6,000 (future 18,750)
Service frequency	
Capital expenditure (per km)	NZ$34.0M
Total cost	-
Operational expenditure (per vehicle per km)	-
Operating speed (km/h)	100km/h (design), 80km/h (normal)
Turning radii (m)	-
Power source	Diesel
Typical spacing of stops	800 m–1 km
Annual patronage	-
Annual passenger kilometres	-
Hours of operation	-
Rides per day	-

Case Study Description

Overview

The Northern Busway opened in 2008 and is the country's first dedicated busway connecting the North Shore with the CBD. Built adjacent to State Highway One (SH1) it is a physically separated corridor.

History

The Busway is the focus of North Shore City's upgrade of public transport to provide better bus services, give people more travel options, and reduce car numbers and road congestion. Future consideration includes extending the busway to accommodate buses or possible rail in the future.

Northern Busway

As a physically separated busway there are five bus stations located over 6.2 km of the corridor with dual lanes operating adjacent to SH1 from Albany to Akoranga bus station. From Akoranga Station (Esmonde Road) a one-way southbound bus lane extends a further 2.5 km to the start of the Auckland Harbour Bridge. Buses during AM peak periods make use of a dedicated bus lane to bypass traffic on the bridge which continues to Fanshawe Street. Outside of the peak AM period buses re-enter the general traffic stream. The resource consent for the busway includes provision for HOVs to use the facility. To date the facility only permits buses to the use the busway.

A recent investigation concluded that the introduction of HOVs onto the Northern Busway would result in an "unacceptable low level of service for vehicles joining the Northern Busway, including buses in the traffic stream. To control this effect, it is likely that ramp metering would be required at Constellation Station, Esmonde Road and Onewa Road, and this has the potential to restrict buses if they are in the same traffic stream".(NZTA 2010)

The investigation recommended that "HOVs not be introduced on the Northern Busway until the Onewa Road merge issue is resolved, and the provision of an Additional Waitemata Harbour Crossing could also be a catalyst for a review".

Future extension of the busway to Orewa in the north is being considered with no firm decision made. Studies have estimated the cost to extend the busway to Sliverdale at around NZ$500 million to NZ$1.2 billion.

Reference Map

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

- The busway route follows the existing major transport corridor (SH1 North) with potential future expansion to Owera.
- A pedestrian air bridge over SH1 improves linkages between the local educational institute (AUT) situated on the opposite side of SH1 (northern side) with Akoranga bus station (southern side).
- Albany busway station has been integrated and located within the future Albany Centre, a new sub-regional centre that when completed will support a variety of mixed use activities which includes North Harbour stadium.
- The majority of spectators to North Harbour Stadium arrive by bus with tickets incorporating return bus fares. This has been most successful in the management of traffic in and around the site during events.
- Demand for park-and-ride at Albany is a reflection of the area wide catchment with commuters arriving from Sliverdale and/or Owera to park and ride buses into Auckland's CBD.
- The Auckland Regional Growth Strategy 1999 provided support to compact cities and development of sub regional growth centres. The RGS was supported by a number of planning documents and strategies which supported the increased use of buses as an alternative to single occupancy car travel.

Key Success Factors

- Improved travel time savings for commuters during peak.
- It is estimated that the busway has removed about 5,100 cars in the morning peak from the route, with 80 buses per hour being used during peak times.
- The busway is designed to accommodate up to 250 buses per hour. by 2016.
- Improved facilities for cyclists and pedestrians at busway stations.
- State of the art technology provides 24-hour security for passengers.
- Quicker bus access to the southbound motorway at the Onewa Road Interchange.

Design Issues

- The busway design is a combination of at-grade and elevated structures.
- Buses enter and exit the busway predominantly from local street networks. The exception is Albany Bus Station where buses travelling north on SH1 may leave the motorway via a dedicated off-ramp.

Operational

- The speed limit posted is 80 km with a 5 0km speed limit on approach to the bus stations.
- New bus services and routes integrate with the busway to improve coverage for passengers accessing bus stations.
- Only permitted scheduled bus services are allowed to use the busway. Currently three bus operators are permitted to use the facility. However, only two of the three operators are permitted to use this facility between Akoranga to Esmonde Road (6.2 km section).
- Ridership has increased by 20% (March 2010) as the result of increased traffic congestion on SH1 South and increased fuel prices.
- Ticketing - a zone based ticket known as the "Northern Pass" allows passengers to ride any bus around the North Shore (as far as Albany and Long Bay in the north, and Greenhithe in the west) and/or into Auckland City, using the one ticket for as long as it is valid and within the zones it is valid for. As a single ticket the pass is transferable across different bus operators and can be used on local train services between Britomart and Glen Innes, Britomart and Ellerslie (via Newmarket), or Britomart and Kingsland (via Newmarket).

Constraints

- Overtaking on the busway is not permitted. However, with the provision of bus bays at stations, buses have the opportunity to overtake buses experiencing longer boarding/alighting times.
- The bus station design allows for passengers to wait on platforms (refer to images below). With no physical segregation between buses and passengers, there is the potential for passengers to wander across busway lanes e.g. there are no automatic screening controls at platforms to control/direct passenger movements.
- If HOVs are permitted to use the facility in the future, there is likely spatial and safety issues around bus stations/access onto/from the busway.
- Park-and-ride demand, multi-storey facilities are likely to be required in future due to limited land available around stations.
- Ticketing is onboard with ticketing if required purchased from bus drivers. Could add unnecessary delay to the commuters.

Technology

The busway operates standard buses with real time information systems and CCTV coverage and security persons on site. Future integrated ticketing will assist with faster boarding times.

Procurement and Governments

The busway cost was around NZ$290–294 million: $210 million for the busway and $84 million for the stations. NZTA built the two-way road Busway's 'spine' while the construction of the five Busway stations was locally funded by the North Shore City Council ($35 million) with the remaining funding from Auckland Regional Transport Authority (ARTA) and Auckland Infrastructure (AI).

Interchange(s)	
Five Busway Stations have been built over 6.2 km of corridor. The five stations north to south are: - Albany Station - Constellation Drive Station - Sunnynook Station - Smales Fram Station - Akoranga Station Park-and-ride facilities are only available at Albany and Constellation stations. Located immediately adjacent to the station the catchment demand for park-and-ride resulted in 550 additional parking spaces at Albany Station(currently being constructer). Albany Station currently provides 500 free car parking spaces while Constellation has 370 free spaces available. In future, multi-storey parking or other alternative measures may be required to accommodate demand. Stations are contemporary steel glass structures with CCTV cameras operating 24 hours, seven days a week and safety points installed. Facilities at stations also include electronic signage and cafes/kiosks, cycle lockers (with the exception of Sunnynock Station), cycle racks as well as drop-off zones, including taxi stands and local feeder bus services stops. While cycle lockers are free, a refundable $2 coin is required to operate the bike lockers, and use is on a day-to-day basis with the authority entitled to remove bikes not collected within 24hrs of use. Security Patrols also monitor and patrol the park-and-ride facilities. In future, should the busway be extended to at least Silverdale, three new stations are proposed at Rosedale, Redvale and Silverdale.	

Visual Images of the City and Passenger Transport Mode/System

Northern Busway Corridor and Station Locations

Source: http://www.nzta.govt.nz/network/projects/sh1-northern-busway/docs/sh1%20northern%20busway.pd

Images from Northeast Line

Albany Busway Station
Source: http://www.nzta.govt.nz/network/projects/project.html?ID=15

http://buswatchnz.blogspot.co.nz/2010/05/aucklands-northern-busway-ridership.html

http://buswatchnz.blogspot.co.nz/2010/05/aucklands-northern-busway-ridership.html

References:
http://www.nzta.govt.nz/network/projects/sh1-northern-busway/docs/sh1%20northern%20busway.pdf;http://en.wikipedia.org/wiki/Northern_Busway,_Auckland; http://www.aucklandtransport.govt.nz/improving-transport/completed-projects/RapidTransit/Pages/TheNorthernBusway.aspx; http://buswatchnz.blogspot.co.nz/2010/05/aucklands-northern-busway-ridership.html; http://www.maxx.co.nz/info/how-to-travel/take-the-bus/faqs.aspx; http://www.aktnz.co.nz/2011/08/11/busway-stays-a-busway/

Case Study: Rouen TEOR
Country: France
Mode: Bus 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	110-115
Peak hour capacity (pphpd)	1,770[2]
Service frequency	Between five and eight minutes in the peak (depending on line)
Capital expenditure (per km)	NZ$8M
Total cost	NZ$188.9M
Operational expenditure (per vehicle per km)	NZ$7.50 (2006)[1]
Operating speed (km/h)	Average speed 18-20 km/h
Turning radii (m)	25 m when optical guidance is in operation. (12 m otherwise)[3]
Power source	Diesel
Typical spacing of stops	500 m
Annual patronage	11,966,000[4]
Annual passenger kilometres	31,654,059
Hours of operation	06:00 to 02:00

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 a historic and densely developed city core the development of public transport infrastructure and operation in Rouen has been further constrained by the existence of several elevated plateaus and the dissection of the city by the River Seine.

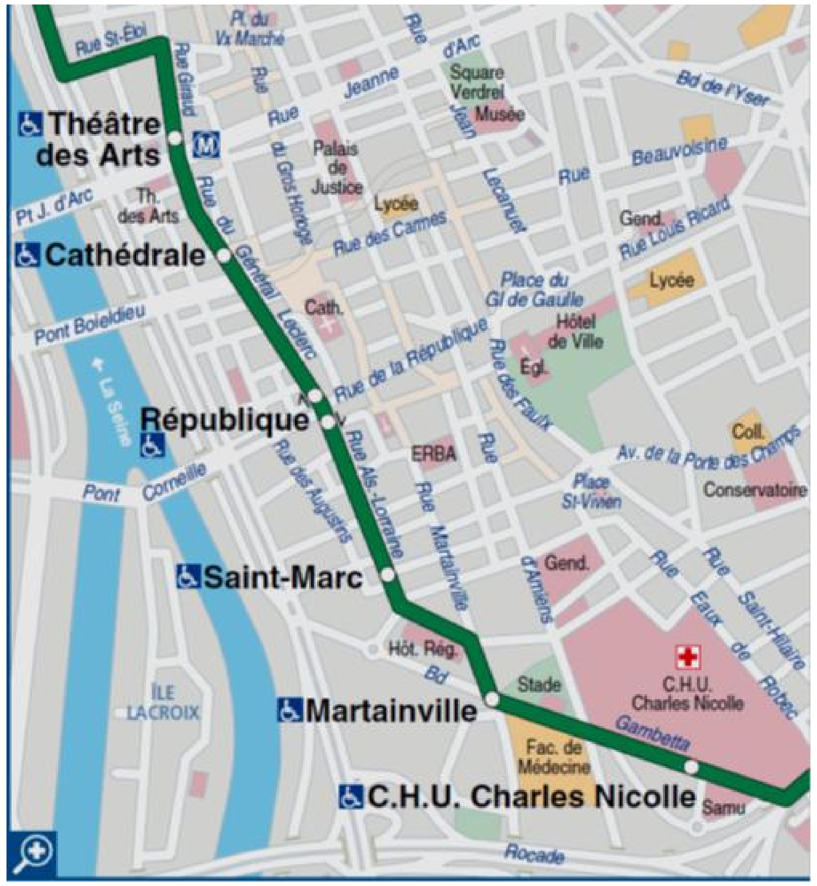
In addition to physical constraints, further unfavourable conditions impacted on access and movement in the city, including the proliferation of private vehicle ownership, an oversupply of city centre parking and increasing urban sprawl. As a result of these factors the city's authorities decided to 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 of TEOR and Scheme

Originally Rouen sought to expand its light rail network but the cost of doing so was found to exceed available funding, therefore bus rapid transit (BRT) was considered to be a more cost efficient alternative. TEOR was the second BRT system to be introduced in France and part of a national programme to develop a high quality bus concept (BHLS[1]). The BHLS model (buses with a high level of service) is not intended to compete with other forms of public transport systems. Instead it demonstrates an alternative option with particular benefits in terms of flexibility as a concept and in operation.

The network in Rouen was opened in February 2001 and there are three east-west TEOR lines, named T1, T2 and T3. The lines serve heavily populated valleys and plateaus outside the city centre and also provide access to educational campuses and a regional hospital. All three lines operate along segregated lanes which provide considerable time savings for users by circumventing traffic congestion. The bus lines were designed to cater for high passenger volumes and include optical guidance to improve efficiency at stops.

Reference Map



City centre alignment of TEOR Line 2which connects residential suburbs with key destinations in the city centre and beyond, including the city's main hospital
TCAR - 2011 (www.tcar.fr)

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[1] http://ctcqyjs.cqjtu.com/upload/2010-06/10062311509554.pdf (English translation of case study on the BHLS concept)
[2] ETC Papers - LPT03iii (2011)
[3] http://ctcqyjs.cqjtu.com/upload/2010-06/10062311509554.pdf
[4] ETC Papers - LPT03iii (2011)

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

- A key factor behind the success of TEOR and public transport in Rouen has been the integration of the network under a single controller.
- As well as incorporating different modes of public transport the public transport network connects to a flexible bike rental scheme.
- Passenger surveys demonstrated comparable levels of satisfaction between the TEOR bus lines and the LRT system.[5]

Key Success Factors

- TEOR's development was based on providing an enhanced image for bus travel and an improved quality of services in order to attract new passengers to the service. Key features include:
  - Dedicated running lanes
  - Station style stops
  - Distinctive vehicles
  - ITS (priority at junctions) and
  - Frequent all-day service.
- Journey time reliability has been by using priority (using pre-emption) at most traffic signals. Bus priority is available at all intersections, except where routes cross national roads. Dedicated bus-only lanes have also been used and estimated to save 6% of overall travel time. Precision docking is estimated to save a further 4% of travel time.[6]

Design Issues

- TCAR, Rouen's public transport agency, operates a fleet of articulated buses. The 28 Irisbus Citelis 18 can seat 43 and are able to accommodate 67 more standing. The vehicles run on a diesel motor system that meets Euro 3 standards. The Renault Agora L has a seating capacity of 40 and can accommodate 75 more standing. These vehicles have a diesel engine that meets Euro 2 standards.
- Each vehicle has a GPS locator on board, enabling traffic signals to give TEOR buses priority at busy intersections, reducing the likelihood of delays along the route. Vehicles have four doors on each side of the vehicle allowing for fast and easy boarding and alighting and flexible operation.
- Vehicles are also fitted with optical guidance systems. Rouen pioneered the development of one type of precision docking at stops, however, the system has not been extended to automatic steering between stations. Overall, bus only lanes and traffic signal pre-emption have greater significance in terms of route performance than precision docking.

Operational

- The TEOR system was designed to simulate LRT as much as possible. Stations were designed, with high levels of accessibility, and similar spacing between stops (around 500m). Also, vehicles were internally designed to offer a similar level of service to light rail, including the use of bell-like alerts to warn passengers about imminent door closure.
- Operation at stops is similar to light rail with all doors opening at each stop (except for on limited stop services along arterial routes). The service also operates on similar headways to light rail. Precision docking has reduced dwelling times, however, drivers need to approach at appropriate speeds because of the infrastructure layout. This has resulted in driver training being a key element of delivering the network.
- Bottlenecks associated with fare collection and validations remain, adversely impacting on journey times.
- Construction of the TEOR network was implemented on a curb-to-curb basis, with the entire street reconstructed. This allows one or two bus-only lanes in most places. The infrastructure is supported by a distinctive pavement colour based on the use of red aggregate to discourage general traffic from driving in bus lanes.

Constraints

- Gradients were required to reach the Rouen Plateau (at an elevation of 150 metres).
- Serves areas of contrasting population densities.

Technology

- Each vehicle has a GPS locator and is fitted with optical guidance systems (see Design issues).

Interchange

- TEOR stations are easily accessible for all users, including those with reduced mobility.
- Stops are equipped with maps, shelters, and fare collection facilities.
- A thousand free parking spaces for bus users have been provided at the Pôle D'Échanges where three bus routes converge.

Procurement and Governments

The restructuring of public transport financing has influenced funding of local projects in France. Previously the French Government provided up to a third of the capital costs. Subsequent decentralisation resulted in national assistance being removed and greater responsibility being placed on local governments. Local taxes rose to compensate for a reduction in national taxes and local government became more focused on efficient budgeting. As a result of this restructuring local governments gave greater consideration to bus rapid transit. The national government also had a role in developing guided bus systems developed under the Prédit 2 program, although the principal motivation behind this feature was a law requiring buses to be accessible for those with disabilities.

TCAR is Rouen's public transport agency covering the 45 communes of the metropolitan area of Rouen. TCAR is a subsidiary of Veolia Transport (a multinational company) and provides public transportation in the form of light rail, TEOR and buses.

The capital costs of the TEOR system were funded by multiple government agencies. Operations are the responsibility of a private concession operator, who is paid on the basis of delivering a high quality transit service as specified by the public sector sponsors.7

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[5] http://www.path.berkeley.edu/PATH/Publications/PDF/PRR/2007/PRR-2007-21.pdf

[6] Lane Assist Systems for Bus Rapid Transit, Volume I: Technology Assessment, Steven E. Shladover, et al. (2007) http://www.path.berkeley.edu/PATH/Publications/PDF/PRR/2007/PRR-2007-21.pdf

Visual Images of the City and Passenger Transport Mode/System

Rouen City Centre – historic and densely developed city core	Images of TEOR buses: Irisbus Citelis 18 and Renault Agora L (utilising segregated running)
	 
Source: france-for-visitors.com	Source: Travail personnel (15.12.12) and Magnum-76 at fr.wikipedia (15.12.12)

Case Study: Nantes Ligne 4, City of Nantes
Country: France
Mode: Bus 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) Bus with high level of service to meet demand along public transport corridor. Supplements existing public transport systems.	✓

Modal Characteristics Summary

Vehicle capacity	150
Peak hour capacity (pphpd)	2,200
Service frequency	4 mins
Capital expenditure (per km)	NZ$12.7M
Total cost	NZ$88M[2]
Operational expenditure (per vehicle per km)	NZ$6.6[3]
Operating speed (km/h)	21–23 km (design average speed - 23km/h)
Turning radii (m)	12 m
Power source	Hybrid (LPG, Diesel)
Typical spacing of stops	500 m
Annual patronage	9,240,000[4]
Annual passenger kilometres	20,050,800
Hours of operation	05:00 to 00:30 (02:30 on Saturdays)
Rides per day	-

Case Study Description

Overview

Nantes is the capital of the north-western region of Pays de la Loire in France, and located on the River Loire. It has a metropolitan population of 580,000. In response to the city's strategic aspiration for public transport to match journeys by private car, BusWay has been added to a public transport network that consisted of three existing tram lines, standard bus lines, and several Navibus (public boat) lines.

History

The implementation of the Ligne 4 'BusWay' project emanated from the city's aspiration to extend its public transport network between the centre of Nantes and a suburban residential area. Originally, a tram-link was proposed for the route. However, this was subsequently discounted due to costs associated with developing the route. Since 2005, France had been developing its own high quality bus concept known as BHLS (*Buses with a High Level of Service*) designed to offer similar capacity to rail based systems at a lower cost – the Metropolitan authorities for Nantes selected BHLS as a suitable mode of transport for this particular corridor.

Project Details

Ligne 4 'BusWay' was launched in 2006 and serves a 7km corridor with 15 stations between the city's ring road and the centre of Nantes. It responds to travel demand between a suburban residential area and the centre. It is also considered to have played a role in shaping people's travel behaviour as it provides an attractive service. To entice motorists onto the public transport network, the BusWay system has been designed to provide a similar quality of service to tram/light rail. This has been achieved by providing high quality vehicles, well designed 'stations' and dedicated infrastructure, including segregated lanes, to improve journey times and reliability.

"The aim was to develop a high level of service (speed, reliability, comfort, frequency, accessibility, visibility, urban integration) with costs adapted to the expected demand. In comparison with a tram project, there are advantages of costs and the easier implementation (shorter duration of works, simpler traffic management during the works...). With a strong political support, it is possible to reach a good level of quality and use the bus system as a tool to limit car traffic and thus obtain a strong modal shift."

Damien Garrigue,
Vice General-Director
Nantes Métropole, Nantes, France[1]

Reference Map

Map demonstrating the public transport network in the centre of Nantes including BusWay (dark green), trams and local buses www.tan.fr (2011)

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[1] *Guidelines for implementers of innovative Bus Systems, TRANSMAN Transport System Management Ltd. on behalf of the European Commission (2010)*
[2] ETC Papers - LPT03iii (2011)
[3] http://www.sputnicproject.eu/docs/equipment/Nantes%20Busway.pdf
[4] ETC Papers - LPT03iii (2011)

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

- Two central lanes of a highly trafficked, four-lane highway were converted to dedicated bus lanes.
- Tramway signalisation has been introduced along the busway to maintain a high level of safety.
- In the first two years 37% of motorists along the route switched to the new service. Monitoring demonstrated that cars travelling along the Line 4 route reduced from 25,000 to 18,000 in 2006 (although reduction in highway capacity would have impacted upon this).[5]

Key Success Factors

The BusWay concept was built around six fundamental principles:

1) A compelling service offer (high-frequency services, good evening and Sunday provision).
2) Full accessibility for everyone both on buses and at stations.
3) Dedicated, high quality vehicles with a unique and striking visual identity.
4) Well-equipped stations with above-standard facilities such as real-time information, excellent lighting and clear signage.
5) Priority at traffic lights and, where possible, a dedicated right of way and segregated lanes.
6) Integrated, easy to use ticketing alongside complementary bus and tram services.

User Surveys

Research was conducted among BusWay users to compare the desirability of the service in comparison to trams, which found equal levels of acceptance.[6]

Design Issues

- As the system does not have an automatic docking system in place, a 25 m straight approach is required leading up to the stops to ensure docking is accurate.
- To ensure high levels of accessibility, wheelchair and pushchair accessible 'platforms' were designed. A ramp, level with the second and third doors of the bus, slides out to cover a gap of several centimetres between the bus and platform.
- Attractive landscaping alongside the segregated lanes ensures the new bus route is contributing to the visual amenity of its surroundings.
- Physical constraints mean providing segregated lanes has not been possible throughout the network.

Operational

- BusWay provides levels of operational flexibility that rail-based solutions would not have been able to provide. In the suburbs, the vehicles merge with general traffic for sections of the route. Where this occurs specific road signs yield the right of way to the busway when it leaves its own lane – this is also the case when the vehicles approach junctions. This system is reliant on motorists giving way to BusWay vehicles, therefore the system does not provide the level of safety of segregated systems.
- On sections of the route where a two-lane busway has not been feasible, vehicles alternate priority driving one way in each direction, passing each other at stops.

Constraints

- Although served by 20 vehicles that operate at frequent intervals, the capacity of the system is limited by the capacity of individual vehicles (150 passengers). Crowding occurs at peak times, therefore, further capacity increases would require larger vehicles or, in the longer term, an upgrade to light rail.

Technology

- Unlike some BRT systems, the vehicles do not use guidance for docking at stops. Instead the vehicles are driver controlled and interface with specific granite curbstones.
- Real time information provides connection times with the other lines.
- Vehicles have tram-like sliding doors

Interchange

- The 15 stops were designed to offer the same quality of provision and shelter as tram stops. Eight of the stops provide links to other bus and tram lines.
- There are four park-and-ride facilities that encourage motorists to transfer to the public transport network – these facilities have had to be expanded as they were consistently operating at capacity.

Procurement and Governments

BusWay is operated by Semitan, a mixed private and public sector company (with Nantes Métropole as the principal shareholder).

Strategic influence came from a national programme to develop a high quality bus concept (BHLS[7]) and local political will to provide high quality public transport in the city. Following the introduction of a new rail link, the BusWay concept was the second phase of a strategy to improve access to the south east of the city.

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[5] http://www.busandcoach.travel/download/Bus_rapid_transit_EN.pdf
[6] International Road Federation (2010) http://www.irfnet.org/files-upload/pdf-files/irf_urbanmobility_web.pdf
[7] http://ctcqyjs.cqjtu.com/upload/2010-06/10062311509554.pdf (English translation of case study on the BHLS concept)

Visual Images of the City and Passenger Transport Mode/System

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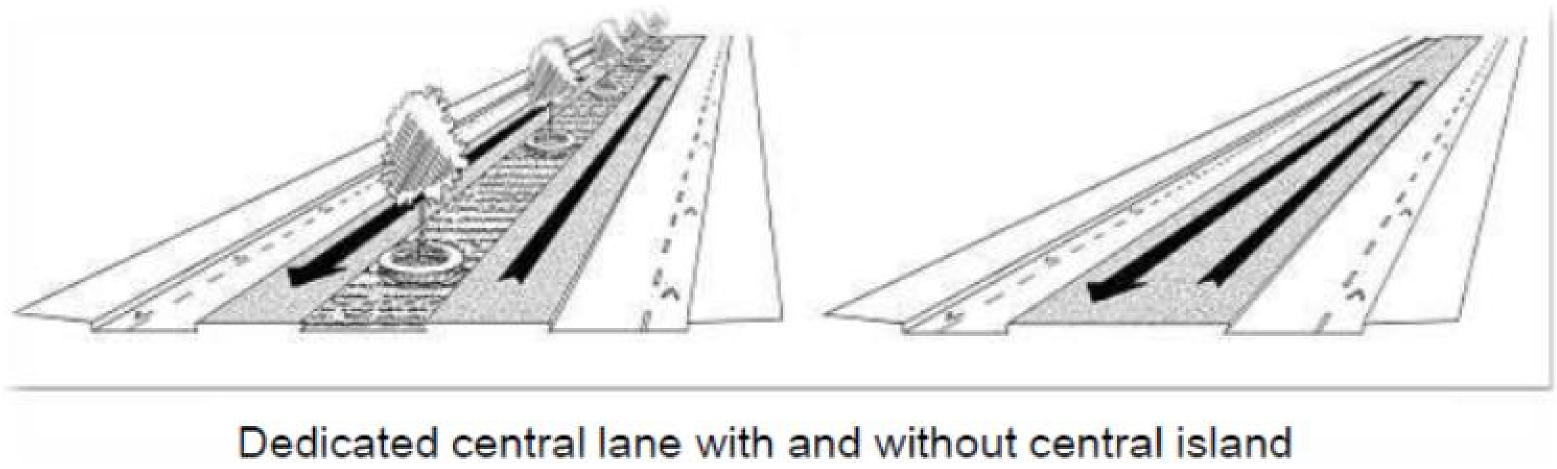

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[8] http://en.wikipedia.org/wiki/File:Ile_de_Nantes.JPG
[9] http://www.nantes.fr/bd-du-gal-de-gaulle
[10] http://www.transportxtra.com/files/6906-l.jpg
[11] http://fr.wikipedia.org/wiki/Fichier:Busway_nantes_01.JPG
[12] http://www.polisnetwork.eu/uploads/Modules/PublicDocuments/nantes-a-new-network-conpept---new.pdf

Case Study: Cleveland, Ohio
Country: USA
Mode: Bus 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	47 seated and 53 standing
Peak hour capacity (pphpd)	~1,000
Service frequency	5 min
Capital expenditure (per km)	NZ$23.87M
Total cost	-
Operational expenditure (per vehicle per km)	-
Operating speed (km/h)	40 km
Turning radii (m)	-
Power source	Diesel-Electric Hybrid
Typical spacing of stops	400 m
Annual patronage	~3,800,000
Annual passenger kilometres	-
Hours of operation	24 hours, daily
Rides per day	12,000

Case Study Description

Overview

The city of Cleveland, Ohio is located on the south shore of Lake Erie. The city itself has a population of nearly 400,000 while the urbanised area contains about 1,800,000 people. The city has two important employment areas (dual hubs) in the city centre - the Cleveland Central Business District (CBD), which has 100,000 jobs, and the University Circle Area, located about 5 km to the east along Euclid Avenue. University Circle is the region's second largest employment centre with about 40,000 jobs.

Cleveland is served by the Greater Cleveland Regional Transit Authority (GCRTA), which operates a fleet of more than 500 buses on 98 routes and over 100 rail vehicles on the Red (heavy rail), Blue and Green (light rail) lines. The system serves more than 140,000 passengers daily, with more than 25,000 on the rail lines and the rest on the bus network. A high percentage of daily passengers use the corridor from downtown to University Circle and East Cleveland. The system provides for 19% of work trips to the downtown area.

History

The Euclid Avenue Corridor is one of the oldest areas of Cleveland, while Euclid Avenue itself has been an important transit street since the beginning of the 20th century. Served by streetcars for many years, it remains a heavy transit corridor with peak-hour, one-way bus volumes of 40 buses in the downtown area. The corridor has redeveloped a number of times as the city expanded. Today, Downtown is noted for the legal and financial sectors, while major medical and educational/constitutional activities are on the east end of the corridor.

When the Red Line rapid transit was built in the 1950s, it utilised rights-of-way along existing railroad lines to reduce costs, rather than directly serving the Euclid Corridor. In addition, the single CBD rail station (at Tower City) limited its ability to conveniently serve much of the CBD. As a result, various planning studies were conducted from the 1950's to the 1980's to identify potential corridor transit improvements. These rapid transit proposals were never realised, mostly due to cost concerns. By the early 1980's, local studies continued to identify the Euclid Corridor as the priority corridor for transit investment.

Around 1985, the city initiated the Dual Hub Corridor Alternatives Analysis, which was complete in 1993. This proposed a Light Rail Transit option with a short subway segment. The cost (US$750 million at the time) again precluded development of this plan. A subsequent study led to a decision in 1995 by GCRTA and other study partners to implement Bus Rapid Transit (BRT) in the corridor.

The BRT Project

Development of the BRT project began in 1996, construction in 2005 and completion in July 2008. From the beginning, it had two basic goals:

- Improve transit system efficiency
- Promote economic and community development and growth in the corridor.

As a result, the project includes both dedicated bus lanes and a reconstruction and upgrade of the full 30 metre Euclid Avenue right-of-way. The cities of Cleveland and East Cleveland both agreed to contribute to the utility upgrades by giving up one travel lane. Key features of the plan include:

- Dedicated bus lanes for most of the 10.6 km corridor
- Traffic signal priority for buses
- Specialised, articulated BRT vehicles with doors on both sides
- Improved (i.e. off-board) fare collection to reduce delay and
- Attractively designed stations with good weather protection
- Streetscape improvements, including pedestrian provisions, landscaping and public art.

The service is marketed as the HealthLine, based on financial contributions from the medical institutions in the corridor. It is treated as a rapid transit service, similar to the rail lines.

Reference Map

Location Map
Source: GCRTA, 2011

<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="3">The City of Cleveland supported the economic revitalisation of the corridor through an economic development plan, a zoning overlay district, design guidelines and various financial incentives.

The core design of the HealthLine project involved the full reconstruction of Euclid Avenue into a transit street.</td><td rowspan="3">- Key factors for Cleveland were identifying a project that could be realistically funded from available sources and combining the BRT project with joint efforts for corridor revitalisation and economic development. The unique branding of the vehicles and stations has also been identified as a key success factor.

- The BRT service has increased patronage due to the faster and higher quality service, but some of the shift may be from other transit services in the broader corridor. Future evaluations are planned to better understand the project impacts.

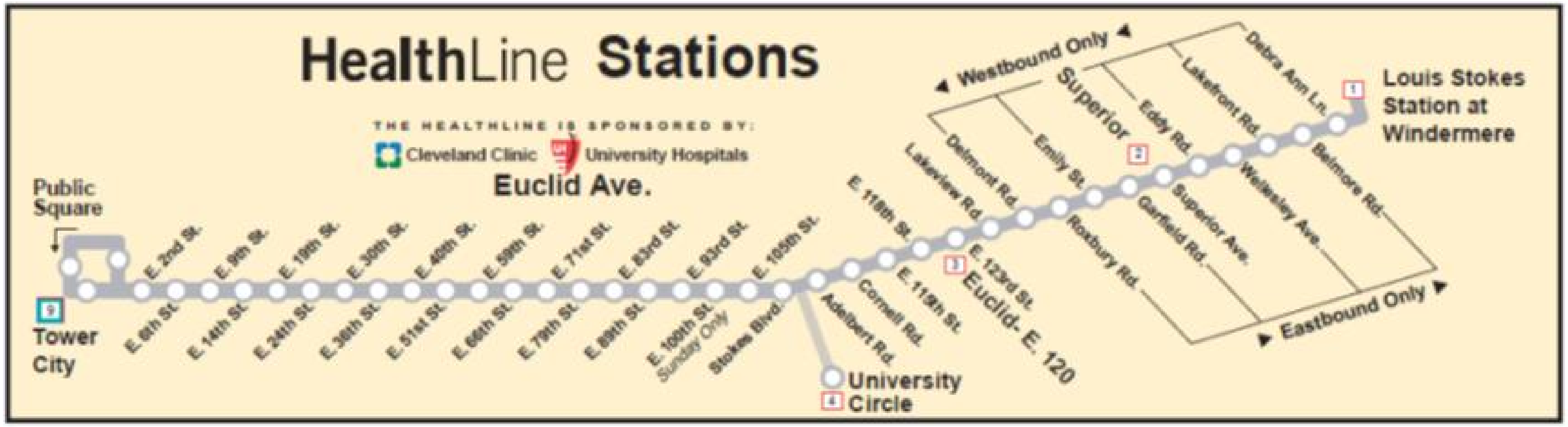
- The project is largely intended to serve existing transit demand from current development, but is also linked to plans for development in the corridor.

- Quality stations and frequent service</td><td>Key design issues involved reducing the number of general traffic lanes to provide BRT lanes and designing the full streetscape to support the project as well as adjacent businesses.

BRT vehicles operate in dedicated lanes for about 2/3 of the corridor. Transit signal priority is provided, but the benefit is somewhat reduced by the high pedestrian movements and frequent number of cross streets. As a result, the time savings were not as great as had been hoped. BRT vehicles are allowed to travel at slightly higher speeds than the posted 40 km/h speed limit, which compensates somewhat. Turning movements across the BRT lanes is not allowed in most locations, which also helps BRT performance.</td></tr>
<tr><td>Operational</td></tr>
<tr><td>No information available</td></tr>
<tr><td colspan="2">Constraints</td><td>Procurement and Governments</td></tr>
<tr><td colspan="2">Capacity is constrained by the size of individual vehicles (articulated buses) and by traffic signal operations along the corridor.</td><td rowspan="5">No information available.</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 project does not include specific interchange stations, but BRT stations are located at the surface near the underground rail stations at each end of the line.</td></tr>
</table>

Visual Images of the City and Passenger Transport Mode/System

Euclid Avenue Corridor, About 1930
Source: APTA BRT Presentation, Michael York, Deputy General Manager



Source: GCRTA, 2011

BRT Lanes on Euclid Avenue
Source: James Lightbody, 2010

BRT HealthLine Vehicle
Source: Transportation Research Board Presentation: Joe Calabrese, General Manager, July 2008

Case Study: 16th Street Mall, Denver
Country: Colorado, USA
Mode: Buses - Transit Mall

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 (future commuter rail service)	✓
Other.	

Modal Characteristics Summary

Vehicle capacity	115
Peak hour capacity (pphpd)	5,500
Service frequency	
Capital expenditure (per km)	NZ$62.1 M (Mall) NZ$2.5 M (LRT)
Operational expenditure (per km)	
Operating speed (km/h)	
Turning radii (m)	40
Power source	Hybrid gas-electric
Typical spacing of stops	
Annual patronage	120 million
Annual passenger kilometres	~17,500,000

Case Study Description

Overview

The city of Denver is located on the Colorado Front Range along the South Platte River. The city has a population of 600,000 while the urbanised area contains about 2,000,000 people. Downtown Denver is a primary employment and retail centre with over 126,000 jobs.

Denver is served by the Regional Transportation District (RTD), which operates a multi-county bus and light rail system. The system serves over 320,000 daily passengers, with over 65,000 on the light rail lines and the rest on the bus network. Downtown transit services carry over 21% of commuter trips.

History

Downtown Denver is spread along a street grid a few blocks wide, extending from Denver Union Station to the State Capitol, a distance of 16 blocks and a little over 1.6 km. Offices, retail and hotels are clustered along this corridor.

Following a period of growth and rising concerns about air quality and traffic congestion, the Denver area began planning for improved transit in the 1970's. To address local and express bus service in the downtown area, a concept emerged for a transitway on 16th Street, the primary downtown spine. This project, subsequently known as the 16th Street Mall, was first developed in 1977 with three objectives: reducing congestion, improving transit efficiency and creating a new pedestrian environment.

The mall was completed and opened in 1982. It has subsequently been extended slightly to serve new development north of Union Station. As the Denver area continued to grow, there was support for additional transit improvements. An initial light rail segment serving the downtown are (perpendicular to the mall) was opened in 1994. Several extensions have been completed and the light rail system now has nearly 64 route km. One extension provides an alternative route into the downtown area, connecting to the transit mall.

In 2004, voters approved FasTracks, a plan to significantly expand Denver's public transportation system. As a result, several additional rail and bus projects are under development. This plan includes the introduction of commuter rail services at Union Station, currently only served by Amtrak.

16th Street Mall

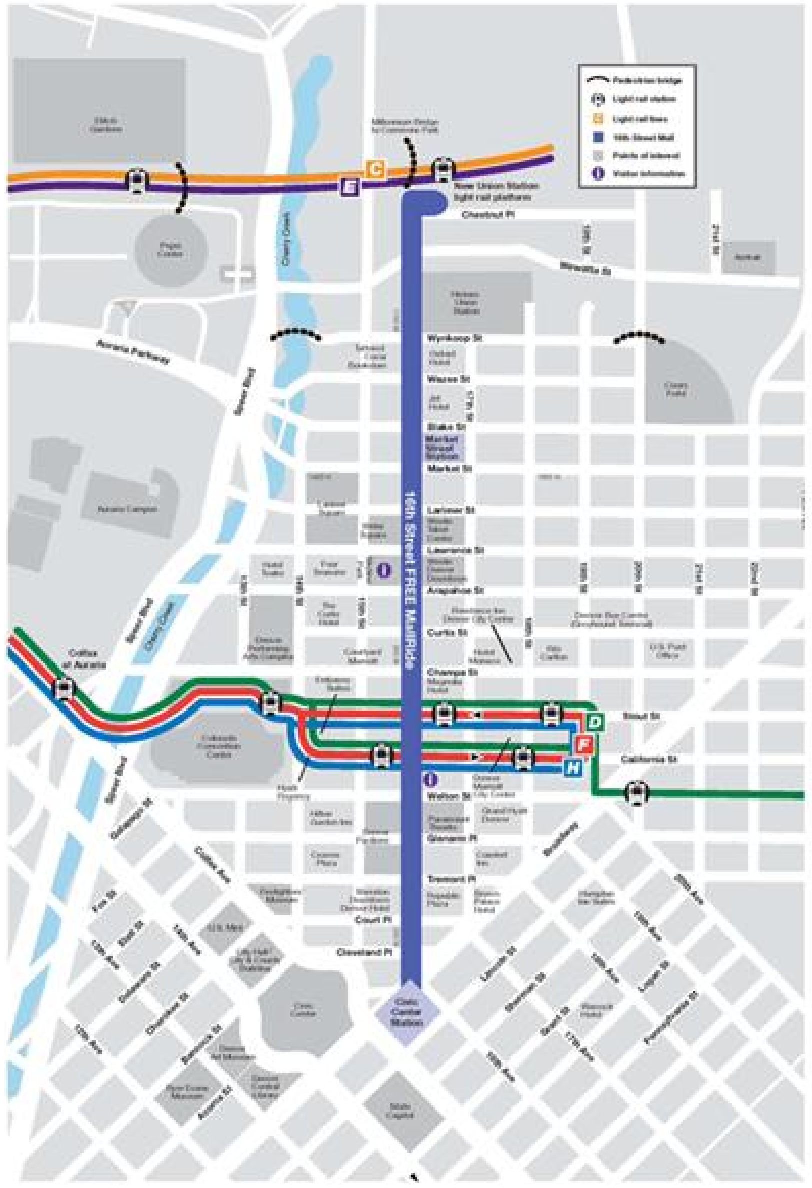
The concept for the 16th Street Mall was to conveniently transport workers and visitors through the downtown area. Commuter express buses entering downtown are intercepted at below-street transfer facilities where they can transfer to the mall vehicles.

The cost for the mall, when built, including the transfer stations, was US$76 million (16th Street Urban Design Plan, November 2010). Today, over 55,000 people use the mall shuttles every weekday (Downtown Denver Partnership: 16th Street Plan, http://www.downtowndenver.com/Business/DevelopmentandPlanning/16thStreetPlan/tabid/174/Default.aspx, accessed December 20, 2011). The peak hour capacity of the system is over 5,500 passengers in each direction. With future light rail and commuter rail plans to add service into Union Station, there is a projected need for additional capacity. This would increase the number of mall vehicles from 48 to 72 per hour and the capacity to 8,000 passengers per hour in future. Additionally, a new downtown circulator would operate parallel to the mall.

This case study focuses on the current bus operations within the mall.

Reference Map

16th Street FREE MallRide



Source: RTD, 2011

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

16th Street has been designed specifically to support the transit mall operation and other corridors have been reworked to help the success of the mall (e.g. parallel auto corridors). Other streets have been modified through parking restrictions or light rail travel lanes.

For the downtown area, transit has largely responded to travel patterns, supporting downtown growth. The convenience and quality of the mall has played a role in downtown's success. Outside the downtown area, RTD has been working with local communities to locate growth along light rail corridors.

Downtown land use policies have focused growth on the 16th Street Mall, especially retail. Other policies restrict additional downtown parking and encourage transit.

Denver's downtown transit strategy has two basic elements. The first was creating the 16th Street Mall, providing a strong and sustainable transit spine. The second was the incremental addition of light rail service to increase capacity, while maintaining the effectiveness of the core mall operation. The mall has been successful both as a high capacity transit solution, but also as a catalyst for downtown development.

5 AM to 1:35 AM on weekdays

- The transit system, a dedicated transit/pedestrian wall operated by RTD, serves over 25,000 peak period transit passengers into the downtown area on a system of bus and light rail lines. A substantial portion (perhaps 40%) transfer to the 16th Street Mall vehicles to complete their trip.
- Unlike other transit malls, the 16th Street Mall has been highly successful. Key factors include:1) a well-designed transit concept with convenient transfer provisions, frequent service and easily accessible vehicles, 2) high quality design of the mall, integration with adjacent development and a high level of maintenance, and 3) the availability of parallel streets providing auto access, circulation and freight delivery. Denver has also had a sustained level of support for transit improvements.
- The key design issue, which the mall has successfully addressed, was creating an attractive pedestrian environment while maintaining an efficient transitway for MallRide vehicles.
- Over time, transit has played a larger role in serving downtown trips. The development of the 16th Street Mall provided a transit foundation that supported subsequent (and planned) rail extensions.
- No traffic interference.

Design Issues

- Over time, transit has played a larger role in serving downtown trips. The development of the 16th Street Mall provided a transit foundation that supported subsequent (and planned) rail extensions.
- Another key element of the original plan was the streetscape design. Sidewalks were widened, a tree-lined centre promenade was created, unique paving was installed and special benches, shelters and lighting were provided. Over time, as downtown has thrived, the mall has become a centrepiece and the focus of retail development.
- Seventeen stops in each direction, stopping in each block.

Operational

- Operational issues include the use of specially designed mall vehicles (with unique maintenance issues), the need to maintain proper spacing of vehicles and the safety issues related to heavy pedestrian activity.
- Auto traffic does not operate on the mall, but can access 16th Street businesses from cross-streets and parallel streets. The design of the mall makes it clear it is a pedestrian and transit environment. Cross-street traffic does affect the mall's operation, but the large number of cross-streets helps spread out traffic and keep signal cycles short.
- Non polluting vehicles.

Constraints

- The mall now operates close to capacity, although there are plans to provide some increase above current conditions. The primary constraints are the cross-streets and the high level of pedestrian activity.
- A customer drawback is the need for many riders to transfer, but the high frequency and convenience of the mall service offsets that concern to a large degree. The 16th Street Mall is also an example of how quality pays off. While more expensive than others to build and maintain, the mall quality has attracted transit riders and downtown developers alike.

Technology

No information available.

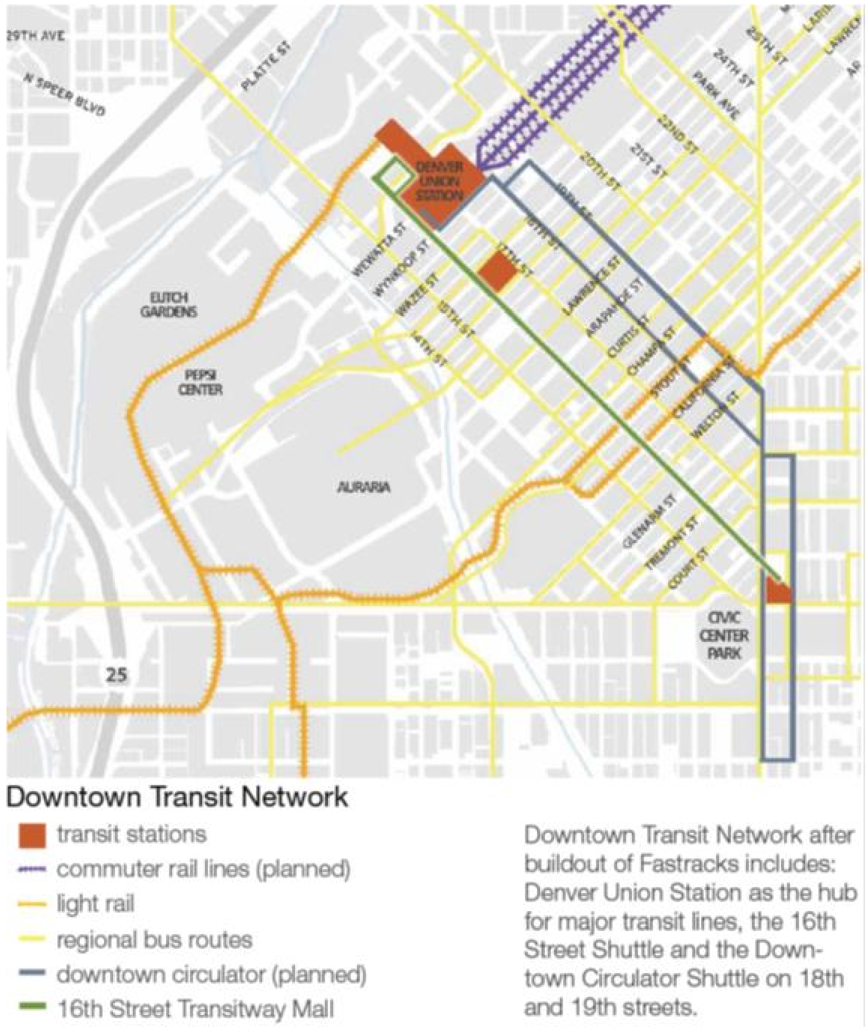
Interchange

The transfer stations are below-street and weather protected. They provide a waiting area and good passenger information. Buses and MallRide vehicles can quickly enter and exit the facility. While more expensive than most surface transfer centres, the stations have proven successful over time and are a key element in the success of the 16th Street Mall.

Procurement and Governments

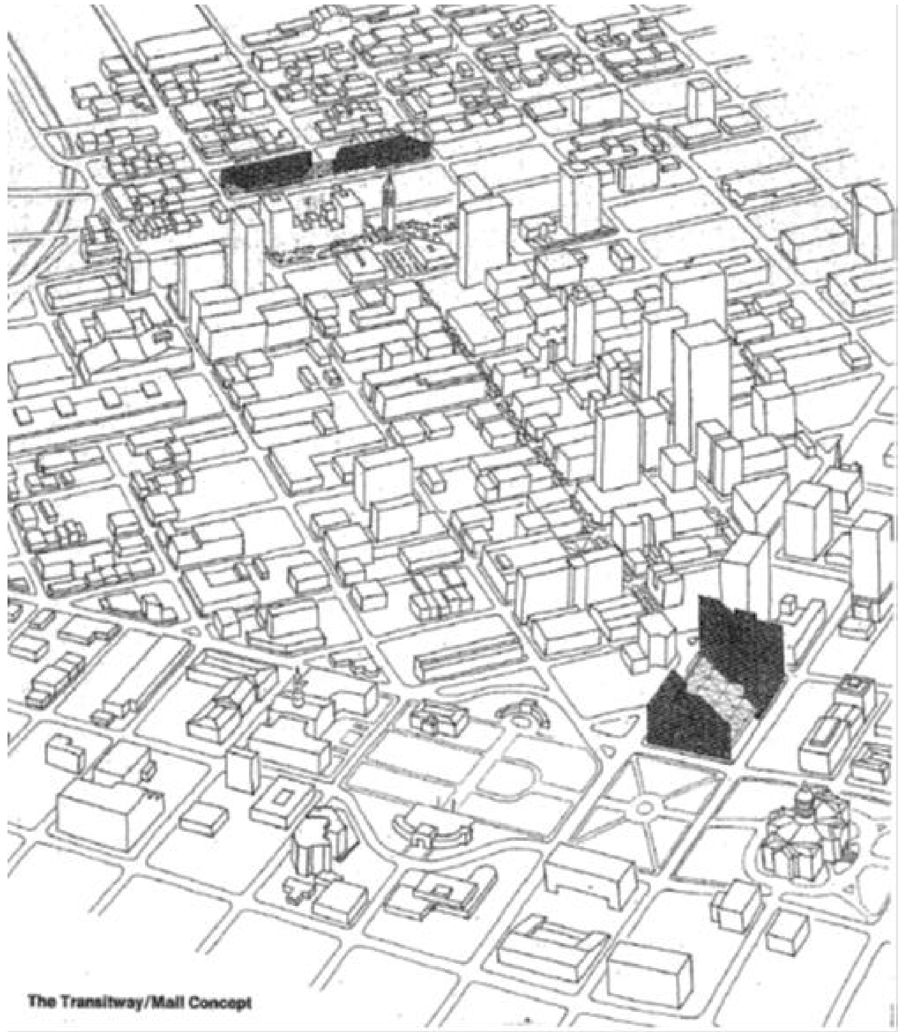
No information available.

Visual Images of the City and Passenger Transport Mode/System



Existing and Planned Downtown Transit Network
Source: 16th Street Urban Design Plan, November 2010

Greater Downtown Area, 1986
Source: 16th Street Urban Design Plan, November 2010



Original Mall Concept, 1977
Source: 16th Street Urban Design Plan, November 2010

Corridor View (Source: 16th Street Urban Design Plan, November 2010)

Corridor View (Source: James Lightbody, 2010)

Case Study: Gold Coast Rapid Transit, Queensland
Country: Australia
Mode: Light Rail Network, Under Construction

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	Up to 309
Peak hour capacity (pphpd)	2,000
Service frequency	7.5 minutes
Capital expenditure (per km)	NZD$31M[1] per km (estimated)
Total cost	-
Operational expenditure (per vehicle per km)	N/A
Operating speed (km/h)	Up to 70 km/hr (vehicle maximum)
Turning radii (m)	25m (vehicle minimum)
Power source	Overhead electric DC600V
Typical spacing of stops	400 metres
Annual patronage	18,250,000[2] (projected)
Annual passenger kilometres	N/A
Hours of operation	-
Rides per day	-

Case Study Description

Overview

The narrow coastal urban strip called the Gold Coast has a population of approximately 500,000 people. The Gold Coast Rapid Transit (GCRT) project will link the activity centres of Griffith University, Broadbeach, Southport and Surfers Paradise. In future, a light rail system will link with the heavy rail system at Helensvale railway station. Stage 1 is 13 kilometres of track, with the light rail network expected to eventually expand to a 40 kilometre network.

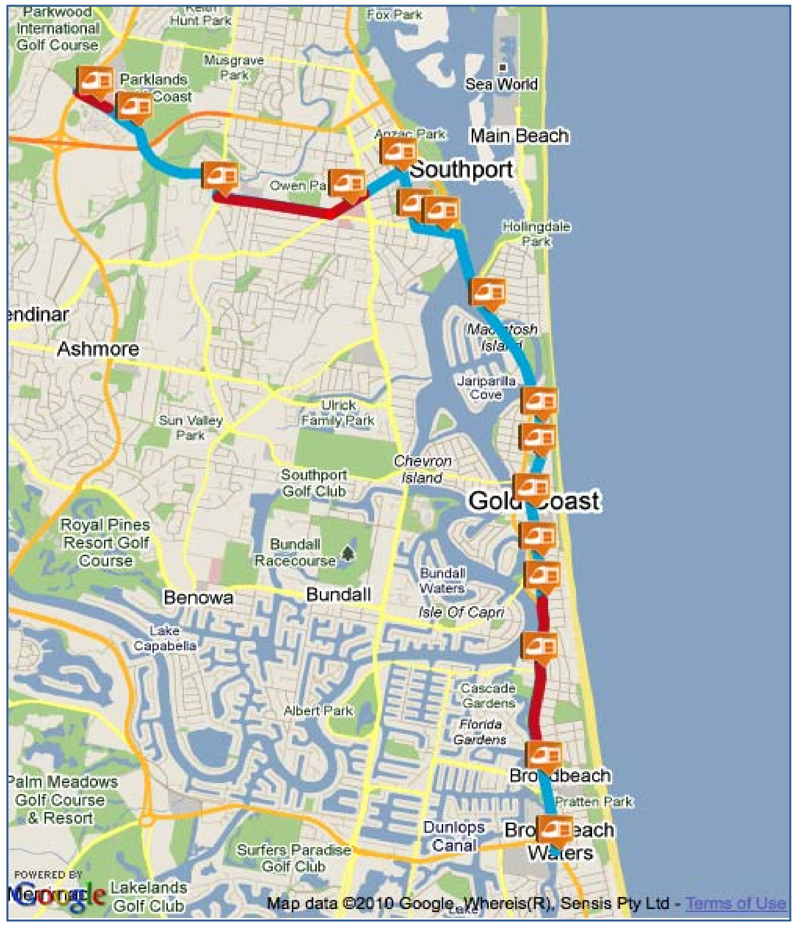
History

The Gold Coast is a car dependent area. According to the Australian Bureau of Statistics, over 70% of journey to work trips were by private car in 2007. The heavy rail network does not connect with busy tourist locations in the Gold Coast strip as development precluded a cost-effective surface corridor. Therefore, people travelling to the Gold Coast by train are reliant on transferring to buses to reach their destinations. Problems with traffic congestion and high transport emissions have seen the Gold Coast implement measures to promote sustainable transport, including investing in pedestrian and cycling infrastructure and public transport.

Project

The GCRT project Stage 1 is currently under construction. Stage 1 is 13 kilometres of track connecting a hospital and university with the activity centres of Southport, Surfers Paradise and Broadbeach. As of January 2012, construction is underway and the route is expected to open in 2014.

Reference Map

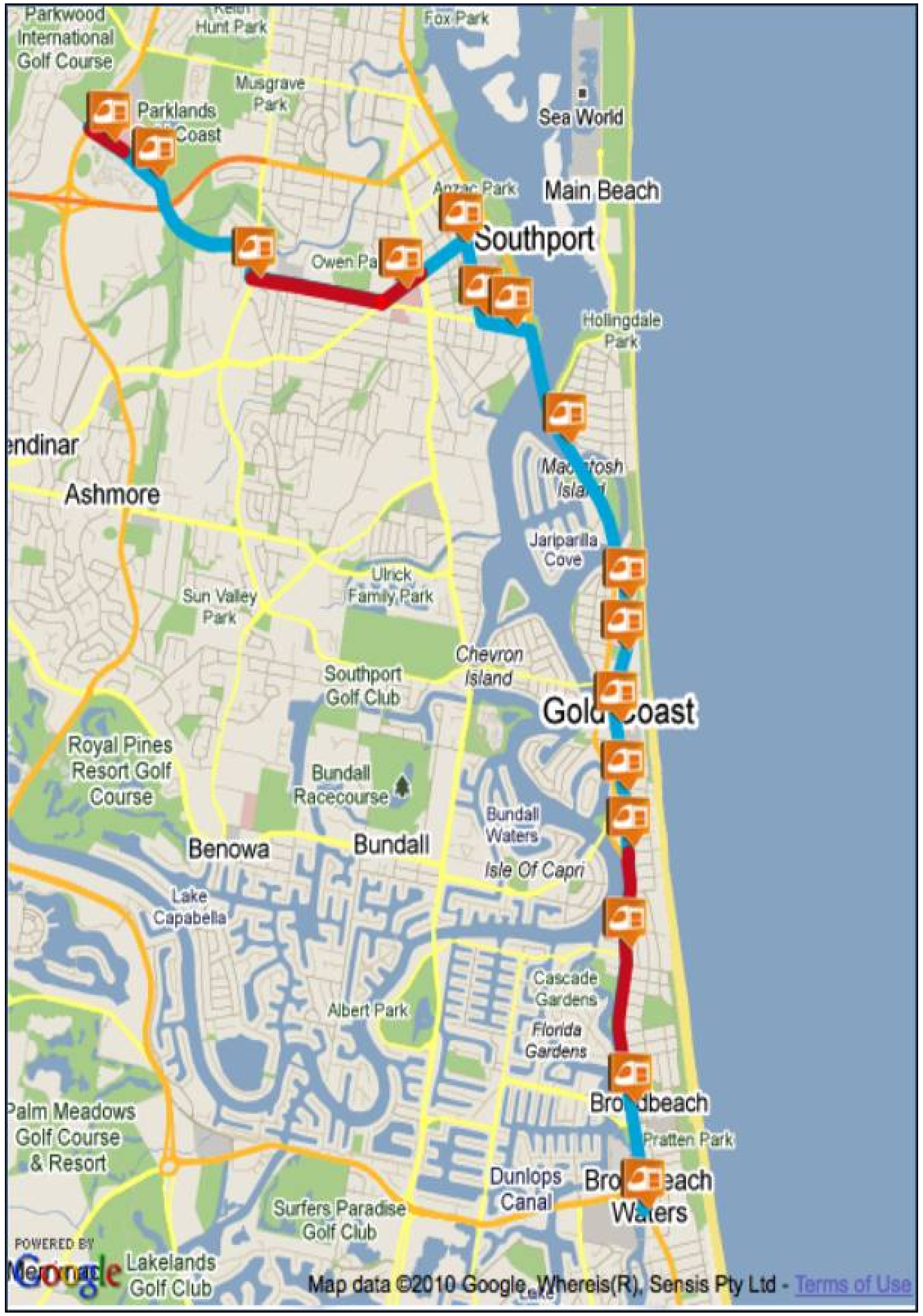


[1] Assuming a cost of AU$949 million and 40 kilometres of route
[2] The patronage is expected to reach 50,000 passengers per day (source: http://www.railexpress.com.au/archive/2011/may/may-11th-2011/top-stories/goldlinq-win-gold-coast-rapid-transit-bid)

<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="3">Currently under development, the Gold Coast City Transport Strategy 2031, identifies the key issues facing the Gold Coast as:: “population growth, congestion, car dependence, connecting our centres, funding limitations, rising obesity levels, energy vulnerability and climate change.”

As the GCRT project will link existing activity centres, it responds to travel patterns. However, the intention is that the light rail corridor will create economic stimulus and transit oriented development will occur due to the presence of new infrastructure.</td><td rowspan="3">- The route is yet to be constructed.</td><td>- The road will be widened and some new corridors will be constructed to provide exclusive right of way to light rail vehicles.
- Gas, water and telecommunications services located underneath the road will need to be relocated.
- Light rail vehicles will share road space with vehicles in some parts of the route, and have dedicated right of way in other parts of the route on an elevated median strip. Where the route mixes with general traffic, tram lanes will be clearly marked.</td></tr>
<tr><th>Operational</th></tr>
<tr><td>- Conflict with traffic and signalised intersections will be key operational issues, as well as pedestrian access to light rail stops in the median strip of roads.
- The light rail network will be connected to high frequency bus services. Eventually, the network will connect to the heavy rail network at Helensvale station.</td></tr>
<tr><th colspan="2">Constraints</th><th>Procurement and Governments</th></tr>
<tr><td colspan="2">No information available</td><td rowspan="5">No information available</td></tr>
<tr><th colspan="2">Technology</th></tr>
<tr><td colspan="2">- The Gold Coast Light Rail system will use air conditioned Bombardier Flexity two light rail vehicles. There will be room for 80 seated passengers and up to 229 standing.</td></tr>
<tr><th colspan="2">Interchange(s)</th></tr>
<tr><td colspan="2">The principles used to plan GCRT stations and interchanges are
- The GCRT system should be recognisable and easy to locate in the streetscape;
- Interchanges between buses and GCRT should be legible and easily accessible, within line of sight where possible;
- Station and interchange locations should be appropriately designed for the location, safe and accessible.</td></tr>
</table>

Visual Images of the City and Passenger Transport Mode/System



Source for all images: http://goldcoastrapidtransit.qld.gov.au

Case Study: St Kilda Road Trams

Country: Melbourne, Australia

Mode: Tram

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) A strong tram spine which commuters use to connect to employment locations from the rail network.	✓

Modal Characteristics Summary

Vehicle capacity	85 (per tram car)
Peak hour capacity (pphpd)	10,000
Service frequency	30 seconds
Capital expenditure (per km)	NZ$13–19 M[1]
Total cost	-
Operational expenditure (per vehicle per km)	NZ$13.50
Operating speed (km/h)	11 km/h (CBD) 14 km/h (St Kilda Rd)
Turning radii (m)	16.8
Power source	Overhead electric DC600V
Typical spacing of stops	200 – 300 m
Annual patronage	182,700,000[2] (all trams)
Annual passenger kilometres	24,600,000[2] service kilometres
Hours of operation	-
Rides per day	-

Case Study Description

Overview

The tram spine, which extends from Swanston Street down St Kilda Road in Melbourne, performs an important role in transporting commuters to office buildings on St Kilda Road, whether they travel entirely on the tram network (e.g. from the inner northern suburbs), or transfer from the heavy rail network (e.g. at Flinders Street Station). The trams are very high frequency during peak times, and maintain short headways outside of peak times as well. Peak capacity is close to 10,000 pphpd which is very high for a surface tram system. The system benefits from exclusive right of way down much of St Kilda Road which minimises conflict with general traffic. However, traffic causes tram speeds to be relatively low within the CBD area, as trams do not have priority at intersections. The tram system is a strong part of Melbourne's heritage and is very popular with residents.

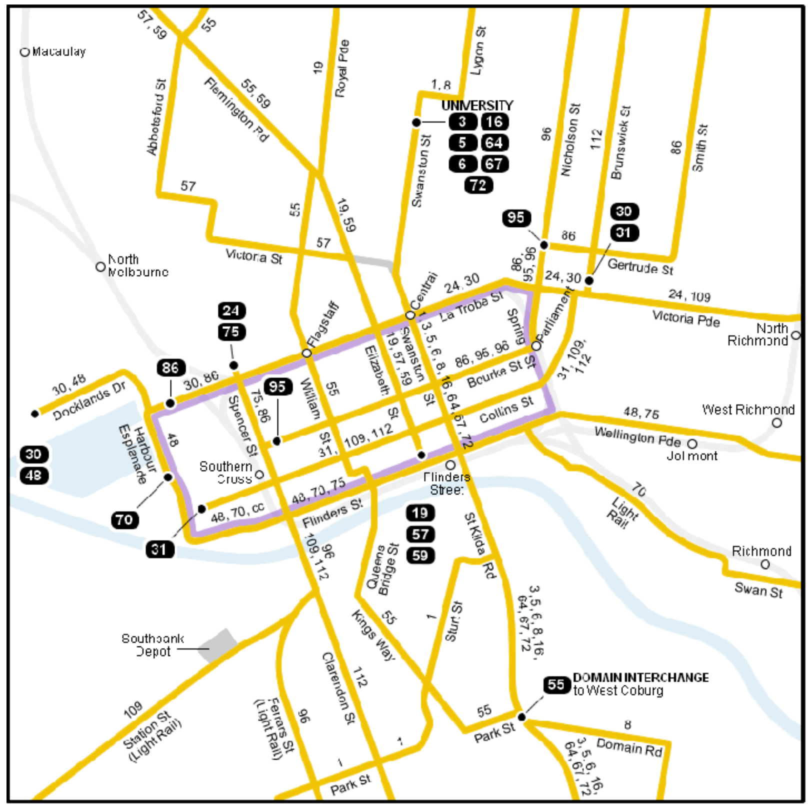
History

Melbourne's tramway network dates back to 1885 when the first cable tram lines began operation. The present day Melbourne tram network has 250 kilometres of double track, making it the largest operating tram network in the world[2]. The network has 1763 stops and 487 trams. Melbourne trams are an iconic part of Melbourne culture as well as being a vital part of the movement network in inner city Melbourne.

Project

The Melbourne tram network has been in place for well over a hundred years. A few recent extensions have been made, allowing the infrastructure capital cost estimates in the table to the left. Some recent network upgrades include modification of older stops to allow at grade boarding and alighting.

Reference Map

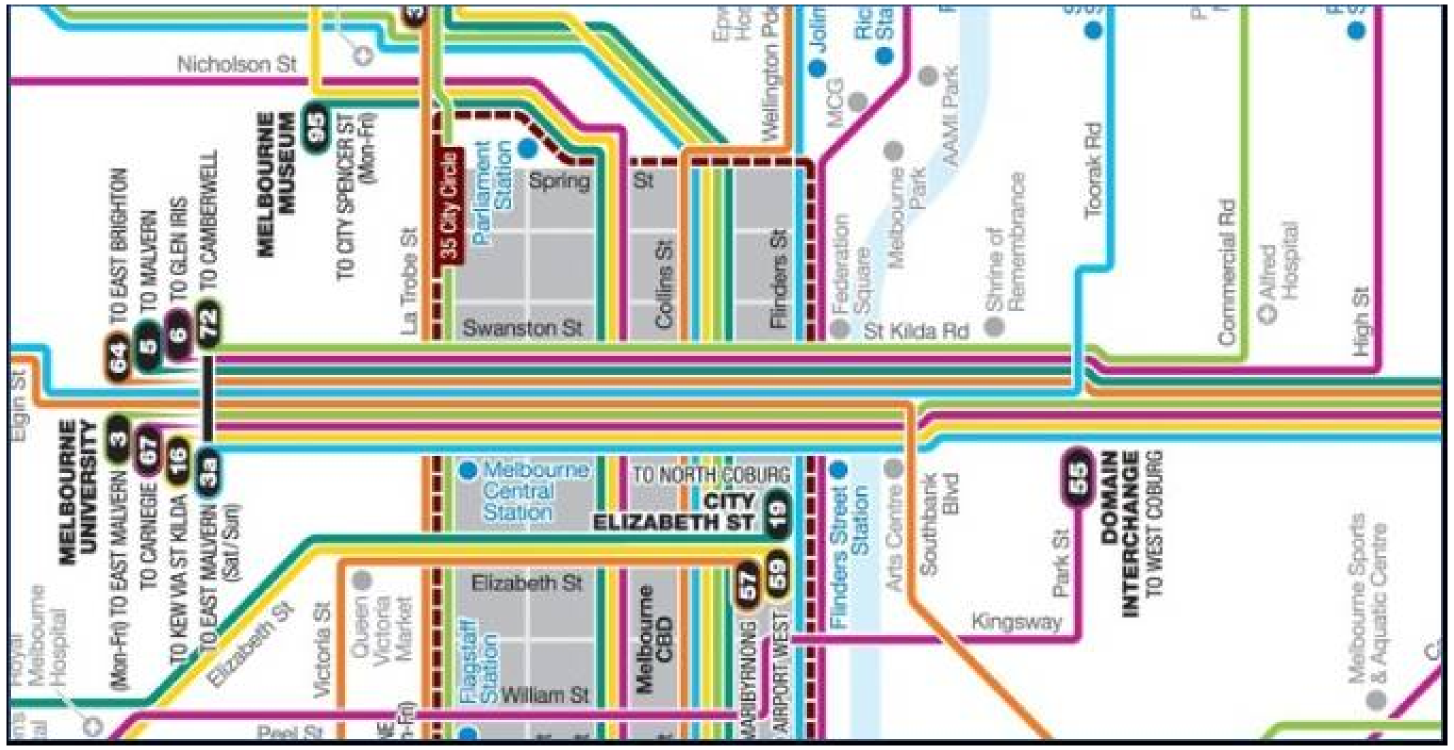


Source: Wikimedia (JohnnoShadbolt)

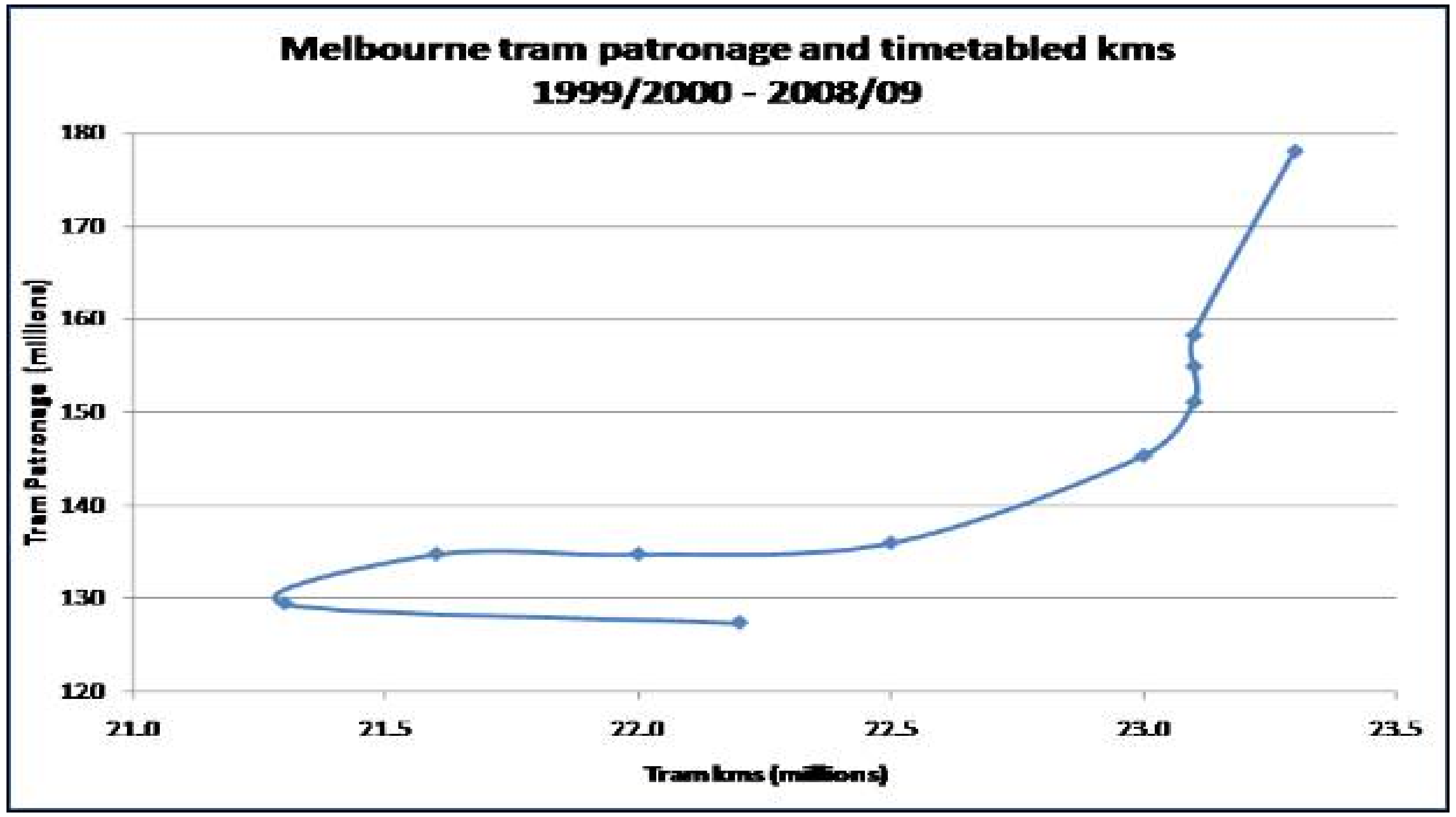
[1] The tram tracks on St Kilda Road have been in place for so long that it would not be useful to report the capital costs of building that part of the network. However, recent extensions on other parts of the Melbourne tram network allow an approximate capital cost for tram infrastructure to be estimated based on three recent extensions (see http://transporttextbook.com/?p=21). Adjusted for 2010 dollars, three extensions cost between AU$10 million and AU$15 million per kilometre.
[2] http://yarratrams.com/about-us/who-we-are/facts-figures/

<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="3">- Melbourne’s transport strategy is called Moving People and Freight 2006 – 2020. The policy goal is to achieve a well integrated public transport system of rail, bus and tram services, allowing it to be possible to live or operate in Melbourne without needing a car.
- The tram system in Melbourne has been in operation for well over a hundred years and is still very well patronised.
- The tram system has been a major influence on the overall urban form and density of inner Melbourne.</td><td rowspan="3">- Melbourne trams are an iconic part of Melbourne culture.
- The tram system has good coverage, being one of the largest tram networks in the world. It serves the CBD and inner suburbs of Melbourne.
- Trams on Swanston Street are very frequent, especially during peak hours.</td><td>- Tram tracks are constructed down the middle of roads, sharing road space with cars in the suburbs (but not in the CBD).
- Tram stops are in the middle of roads.</td></tr>
<tr><th>Operational</th></tr>
<tr><td>- Trams are quite slow due to sharing road space with cars, close stop spacing and the lack of traffic light priority.
- Stops in the middle of roads means users have to cross lanes of traffic to access the trams.
- In the CBD, cars make hook turns (turning right from the left lane) to avoid holding up trams running in the centre of the road.</td></tr>
<tr><th colspan="2">Constraints</th><th>Procurement and Governments</th></tr>
<tr><td colspan="2">Trams are slow due to sharing road space with cars. Trams also do not have absolute traffic light priority.</td><td rowspan="5">The tram network is operated by Yarra Trams, a franchise operating under contract to the Victorian State Government, the ultimate owner of the assets. Planning and development is undertaken in partnership between Yarra Trams and the State Government. The current Yarra Trams franchisee is a consortium named KDR Melbourne, a partnership between French company Keolis and Australian company Downer EDI Rail.</td></tr>
<tr><th colspan="2">Technology</th></tr>
<tr><td colspan="2">Yarra Trams has a relatively modern fleet of 487 trams powered by overhead electrical wires. One hundred new low floor trams have been introduced into the network, and 50 new Bombardier low floor trams will be introduced in late 2012 with capacity for 210 passengers, CCTV and full accessibility.</td></tr>
<tr><th colspan="2">Interchange(s)</th></tr>
<tr><td colspan="2">There are several tram-tram interchange locations on the tram network, and also several locations where passengers can interchange from the heavy rail network. Interchanges generally require users to cross lanes of traffic.</td></tr>
</table>

Visual Images of the City and Passenger Transport Mode/System

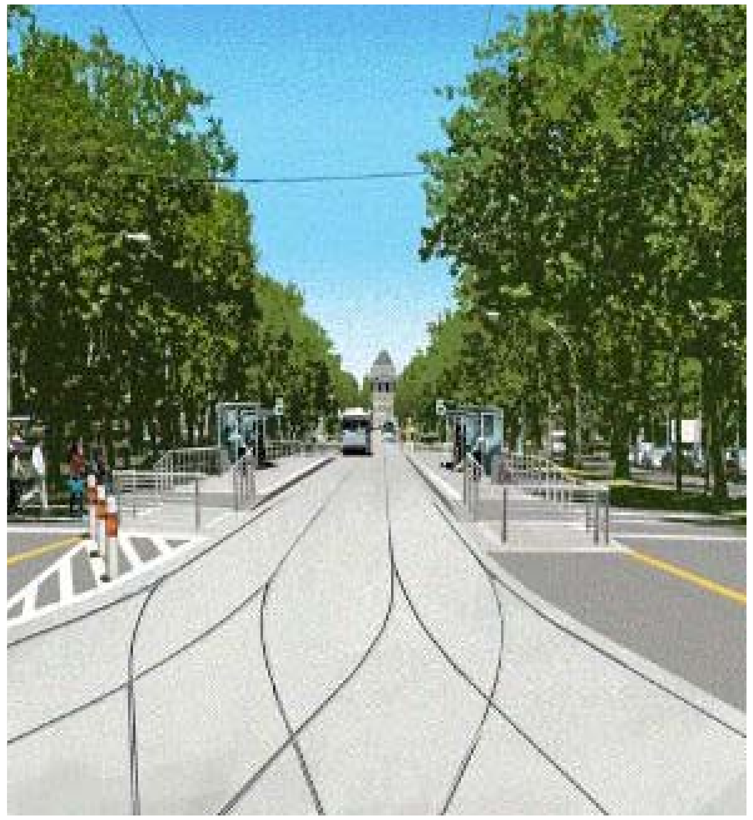


Source: Metlink



Source: http://chartingtransport.files.wordpress.com/2010/01/melbourne-tram-kms-and-pax2.png

Source: Google Street View



Source: www.yarratrams.com.au

Case Study: Hong Kong Trams

Country: Hong Kong Island, Hong Kong

Mode: Tram

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	

Modal Characteristics Summary

Vehicle capacity	115 (per tram car)
Peak hour capacity (pphpd)	4,600
Service frequency	90 seconds
Capital expenditure (per km)	-
Total cost	-
Operational expenditure (per vehicle per km)	NZ$4.23 per service kilometre
Operating speed (km/h)	~9 average 50 maximum
Turning radii (m)	20–25 m
Power source	Overhead electric 550V DC
Typical spacing of stops	250 m
Annual patronage	83,950,000
Annual passenger kilometres	-
Hours of operation	05:30 to 00:30
Rides per day	-

Case Study Description

Overview

This case study focuses on public transport provision on the narrow, densely urbanised strip at the northern end of Hong Kong island. The strong public transport spine is serviced by both an underground mass transit railway (MTR) with an exceptionally high passenger throughput capacity, as well as a surface tram spine served by double decker trams. Public transport on the constrained coastal strip at the north of Hong Kong Island is an example of world class public transport infrastructure and operations. The MTR system has an extremely high capacity of close to 70,000 pphpd in part, and the tram system has a capacity of close to 5,000 pphpd along the coastal strip. The trams achieve relatively high capacity despite competing with car and bus traffic on most parts of the heavily congested route. This is due to the short headways (90 seconds during peak times) and the relatively high capacity double decker trams (115 passengers per vehicle). The tram system is popular among tourists and residents, and trams are an important part of the streetscape on Hong Kong island. However, the MTR system is more effective in moving large numbers of people and the Island line is well integrated with the remainder of the MTR network.

History

The Hong Kong tramway system was built at the beginning of the 20th century. Once an important part of the movement network on Hong Kong Island, its relative importance has declined since the extremely high capacity underground MTR Island Line was constructed in the 1980s. Despite this, the tramway is still an important part of the movement network for short trips in the downtown area, and remains very popular with tourists and sightseers.

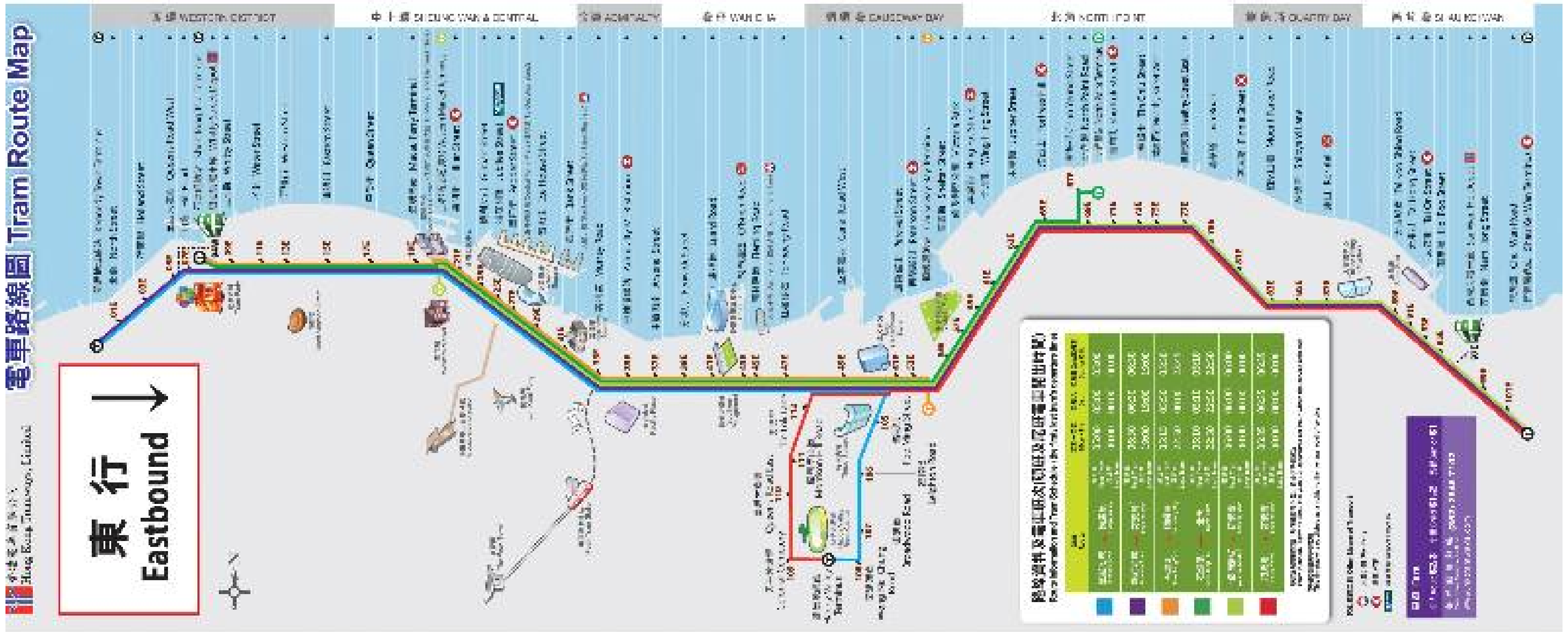
Project

The 30 kilometres of track was constructed at the beginning of the 20th century in the centre of downtown roads.

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="3">- Hong Kong 2030: Planning Vision and Strategy. The strategy emphasises improving transport links with mainland China. (http://www.gov.hk/en/about/abouthk/factsheets/docs/town_planning.pdf)
- Hong Kong trams are iconic, and their presence for over a hundred years has helped to shape the urban form of the densely urbanised northern strip of Hong Kong Island.
- Trams operate on street, with some exclusive tram only lanes. Trams connect with the underground MRT.</td><td rowspan="3">- Public transport is clean, reliable and extremely efficient as well as being very cheap.
- Public transport is the dominant mode in Hong Kong, as reflected in the high ridership
- High frequency of service on all lines and high quality, well located interchange facilities ensure passengers remain in the public transport system.
- Very high population density makes alternative modes difficult to use and ensures high public transport ridership.</td><td>- Trams share street space with traffic on the heavily congested Hong Kong streets. In some areas, the trams have dedicated right-of-way. MTR services are completely grade separated.
- Tunnelling to provide underground infrastructure for the MTR was a key design challenge when the Island line was designed and constructed in the early 1980s. Construction of pedestrian footbridges to provide access to tram stops is another key design issue.</td></tr>
<tr><th>Operational</th></tr>
<tr><td>- Daily tram ridership is about 227,000 (only operates on Hong Kong island) and daily MTR ridership is about 4 million (source: http://www.gov.hk/en/about/abouthk/factsheets/docs/transport.pdf).
- The Octopus stored value card is used to pay for MTR fares and may also be used on any other public transport service, allowing ease of transfer without having to queue for tickets. Additionally, the Octopus card may also be used to pay for goods at many stores and restaurants.</td></tr>
<tr><th colspan="2">Constraints</th><th>Procurement and Governments</th></tr>
<tr><td colspan="2">The tram system capacity is limited by the heavy traffic on Hong Kong island, as the trams share street space with general traffic on many parts of the routes, although there are dedicated tram lines in some areas.</td><td rowspan="5">- The MTR system was initially funded by the Hong Kong Government. In 2000, 23% of the shares in MTR Corporation Limited were sold to private investors (http://www.mtr.com.hk/eng/overview/profile_index.html).
- The Hong Kong tramway is wholly owned by the private French transport operator Veolia.</td></tr>
<tr><th colspan="2">Technology</th></tr>
<tr><td colspan="2">The tram fleet is made up entirely of double decker electric trams.</td></tr>
<tr><th colspan="2">Interchange</th></tr>
<tr><td colspan="2">Most tram stops are located in the middle of the road reserve and are connected to the footpaths by pedestrian footbridges. MTR stops are clean and well designed, passenger information is good and busy transfer points are constructed at grade for ease of transfers.</td></tr>
</table>

Visual Images of the City and Passenger Transport Mode/System



Source: http://www.hktramways.com/en/service/routemap.html

Source: Wikimedia

Source: Wikimedia

Source: Wikimedia

Source: Wikimedia

Source: Wikimedia

Case Study: Kagoshima Trams
Country: Kagoshima, Japan
Mode: Tram

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	✓
Bus based PT network with capacity problems requiring mode shift in order to resolve them	

Modal Characteristics Summary

Vehicle capacity	80 (per tram car)
Peak hour capacity (pphpd)	3,200
Service frequency	5–6 minutes
Capital expenditure (per km)	-
Total cost	-
Operational expenditure (per vehicle per km)	NZ$15/service km[1]
Operating speed (km/h)	14–18
Turning radii (m)	15–20
Power source	Overhead electric DC600V
Typical spacing of stops	200–400 m
Annual patronage	10,200,000
Annual passenger kilometres	1,600,000 service km
Hours of operation	6 am – 10.30 pm (7 days)
Rides per day	-

Case Study Description

Overview

Kagoshima is a southern Japanese city with a population of approximately 600,000. The city is served by three suburban railway lines as well as the Kyushu Shinkansen (bullet train). The railway network only serves the edges of the CBD, with a two line tram system used to service the CBD area (refer to reference map). The interchange facilities from Kagoshima Chuo Station (train) to Kagoshima-chuo-ekimae (tram) and Kagoshima Station (train) to Kagoshima-ekimae (tram) are very good.

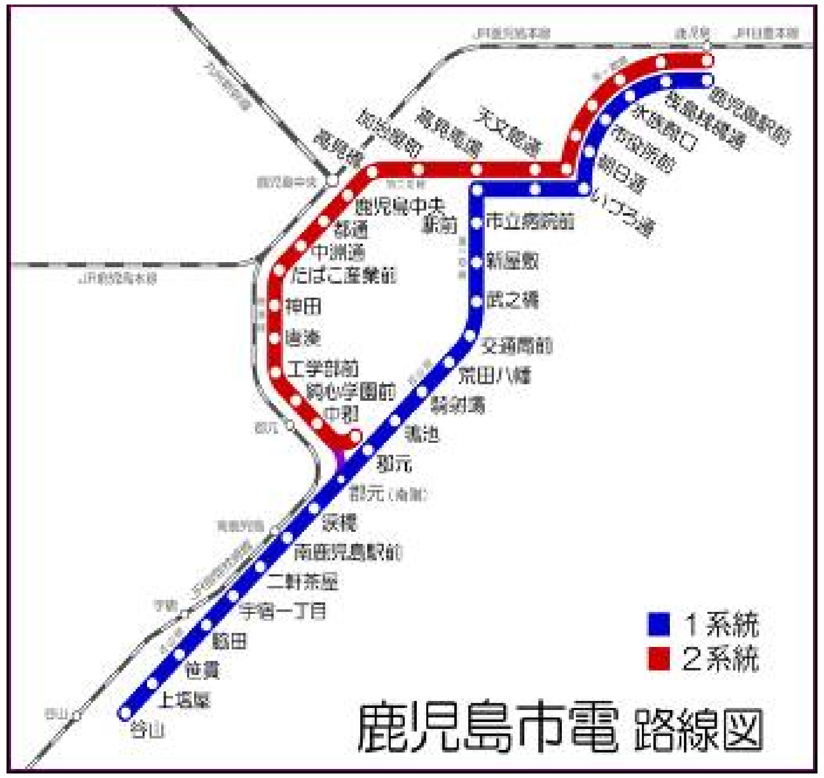
History

The first railway serving Kagoshima was opened in 1889. In 1912, the tramway was constructed, joining the CBD area to the railway network. The Shinkansen high speed railway line opened in 2004, serving the existing Kagoshima Chuo Station.

Project

The Kagoshima tramway was completed in 1912.There are two lines in the CBD over a total of 13.1 km with 35 stops. The tramway was constructed in the median strip of wide roads in the central city.

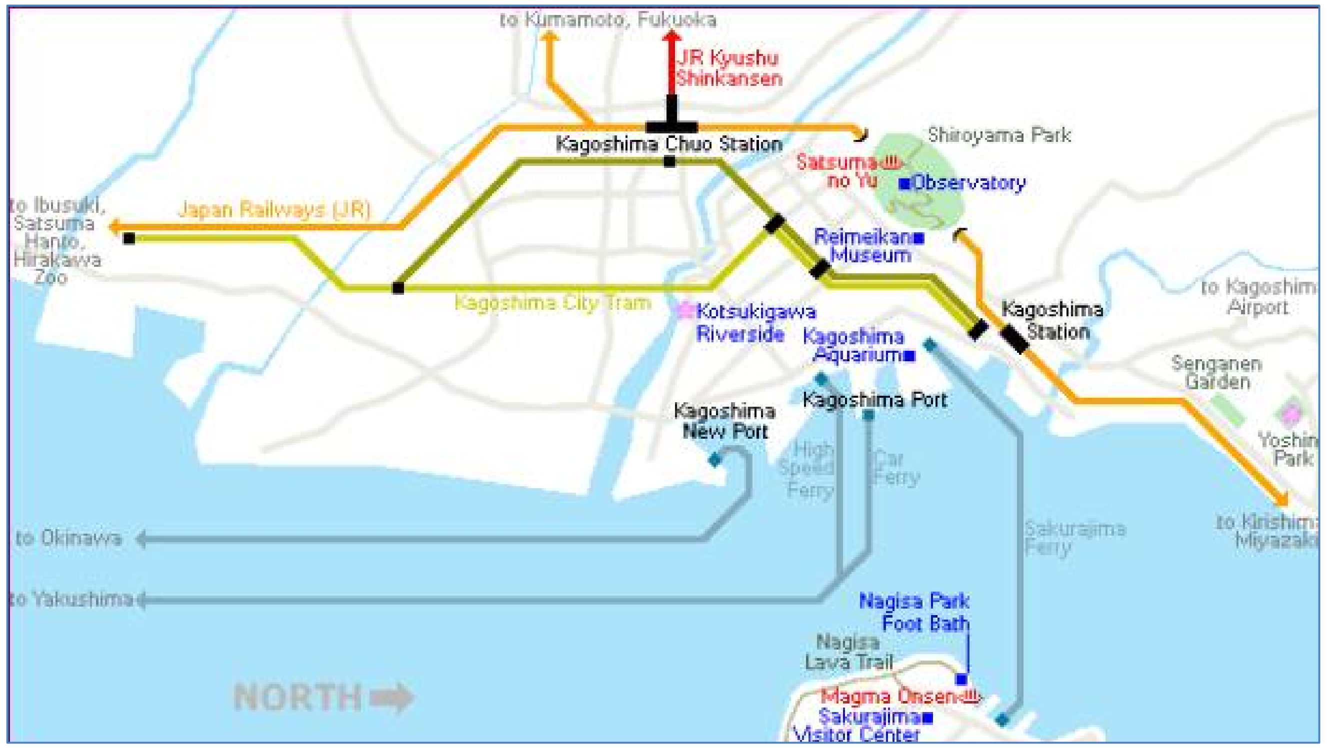
Reference Map



[1] Operational cost is 1,560,000,000 yen per year, excluding capital costs for infrastructure renewal. This converts to NZ$24.3 million per year, over an estimated 1,600,000 service kilometres per year. This translates to an operating cost of approximately NZ$15.20 per service kilometre.

<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="3">- The tramway has been in operation since 1912, so development in Kagoshima has been partly shaped by the tram routes.</td><td rowspan="3">- The tram is the dominant mode used in the CBD, with people transferring from the train system onto trams.
- The tram lines are well routed, frequent and reliable throughout the day and the evening, seven days a week.
- Interchange facilities between the trains and the trams are excellent. The trams are comfortable, clean and spacious. (see http://www.youtube.com/watch?feature=player_embedded&v=eWqAlPlsxHs).</td><td>- Tramways run down the median strip of wide roads.
- The Kagoshima tram system uses dedicated right of ways, however, there is conflict with turning general traffic and trams must stop at signalised intersections. The trams make a positive contribution to the urban design in central Kagoshima where they operate on a grassed median.
- Low floor trams mean that high platforms are not required. Customers can board the train at kerb height.</td></tr>
<tr><th>Operational</th></tr>
<tr><td>- Services run from 6 am to 10:30 pm seven days a week, with headways of about five to six minutes during the day, and ten minutes in the very early morning or late evening.
- Tram stops are located in the middle of roads so patrons must cross busy roads to access the tram stops.
- The Kagoshima tram system is one of the few tram systems in Japan which makes a steady profit (of about NZ$3 million per year). (source: http://www.kotsu-city-kagoshima.jp/modules/pico/index.php?content_id=43).</td></tr>
<tr><th colspan="2">Constraints</th><th>Procurement and Governments</th></tr>
<tr><td colspan="2">The tram vehicles are relatively low capacity.</td><td rowspan="5">The tramways are operated by the Kagoshima City Transportation Bureau, an agency of city government.</td></tr>
<tr><th colspan="2">Technology</th></tr>
<tr><td colspan="2">Kagoshima City Trams use low-floor trams called “Little Dancer”, manufactured by Japanese company Alna Sharyo. They are powered with overhead electrical wires.</td></tr>
<tr><th colspan="2">Interchange</th></tr>
<tr><td colspan="2">The two main interchange facilities are at the Kagoshima Station, where commuter trains stop, and Kagoshima Chuo Station, where both commuter trains and Shinkansen (bullet trains) stop. Both corresponding tram stops (Kagoshima-ekimae and Kagoshima-chuo-ekimae) are located adjacent to the railway stations. There are no busy roads to cross, as the facilities are located in the same precinct. A sheltered walkway is available between the train station and the sheltered tram stop.</td></tr>
</table>

Visual Images of the City and Passenger Transport Mode/System



Source: http://www.japan-guide.com/e/e4604.html

Source: http://en.akihabaranews.com/

Source: Wikimedia

Source: http://www.pref.kagoshima.jp/__image__/rep/1544-115953-608.JPG

Source: Wikimedia

Source: http://saitoshika.blog119.fc2.com/blog-entry-1058.html