Development of Singapore's Rapid Transit System and The Environment

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Introduction

Singapore has 3.6 million people living in a total land area of just 646 km^2, making it one of the most densely populated and urbanized countries in the world. Rapid industrialization and intensive development have required a corresponding growth in transport infrastructure. Roads currently take up about 12% of the total land area, and further major expansion to cope with growing transportation needs is not practical. At the end of 1997, 10% of people in Singapore owned a car. From 1981 to 1997, daily trips by car grew from 2.6 million to about 9 million while the vehicle population grew from 402,000 to about 681,000 in the same period. In September 1995, the government of Singapore set up the Land Transport Authority (LTA), which merged all the public sector agencies in charge of land transport, previously under different ministries, to spearhead improvements in the land transport system.

The LTA's mission is to establish a sustainable land transport system providing commuters with efficient, comfortable, safe, and convenient rides at affordable prices. A key component is an effective public transport system. The strategic thrust is to shift commuters towards public transport modes, such as the urban Rapid Transit System (RTS) network and buses. Given the scarcity of land, the push factor is to develop a comprehensive rapid transit network with dedicated rights of way, transporting large numbers of people to their destinations quickly and reliably. This article highlights current developments in Singapore on rail transit projects, which aim to meet the medium-term objectives. It also discusses the key environmental considerations in development of transit systems.

Figure 1 Singapore's Rapid Transit System (RTS) Network

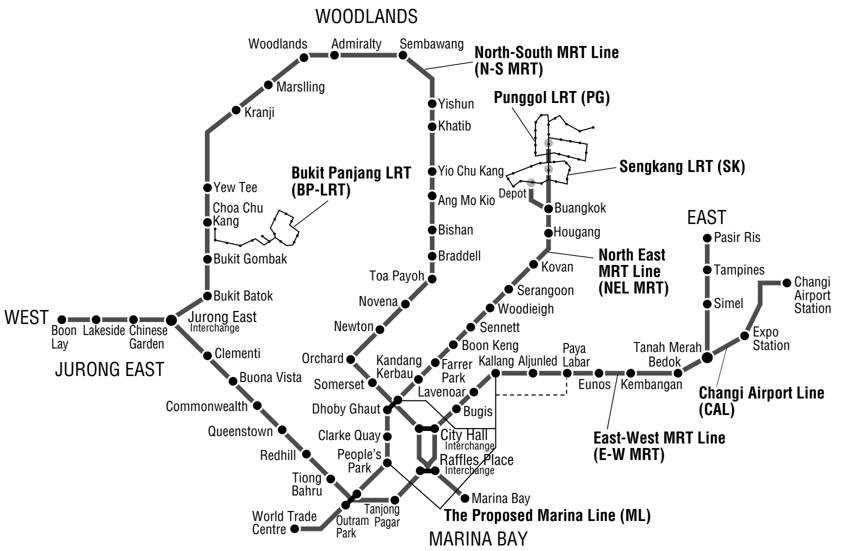


Table 1 Summary of Singapore's Current and Planned Transit Systems

	MRT in Operation	In progress						Total
		BP-LRT	CAL	NEL-MRT	ML	SK	PG	
Route	83 km	8 km	6 km	20 km	13 km	11 km	13 km	154 km
No. of stations	48	14	2	16	20	14	19	133
Cost (S$)	6.3 bn	285 m	850 m	5 bn	1.75 bn	656 m		14.8 bn
To be completed		end 1999	end 2001	end 2002	end 2004	end 2002	end 2004	

Singapore's Rapid Transit System

Figure 1 shows an overview of the existing transit systems and those under development.

The present Mass Rapid Transit (MRT) system has a route length of 83 km and 48 stations. Operations started in 1987 and the daily ridership has risen from 300,000 to about 1 million. The MRT runs through Singapore's heavily populated corridors, linking the various residential estates to the Central Business District (CBD). Near and within the city, it runs underground for 19 km, and the remaining 64 km is elevated. During peak hours, the system operates at a 2-minute headway and a scheduled speed of 40 km/h, providing efficient transport for commuters. The Woodlands Line, which opened for revenue service in 1996, highlights the importance of integration between different modes of transport. Woodlands Station, in particular, is a model of such integration. The MRT system is located at the elevated viaduct level, the taxi stands and car drop-off points at ground level, while a bus interchange is located at one level below ground. This allows commuters to change modes easily. This level of integration has been specified for all subsequent rapid transit projects, including the North East MRT Line (NEL) presently under construction.

The NEL is a conventional rail system that will run completely underground from the World Trade Centre in the south of Singapore to Punggol, a soon-to-be-developed residential town in the north-east. The NEL will be 20-km long with 16 stations. When completed in 2002, it will link the heavily populated North East corridor to the CBD. Two interchanges with the existing MRT system are planned: at Outram Park Station on the East-West Line, and at Dhoby Ghaut Station on the North-South Line. Great emphasis has been placed on integration, and the design incorporates integrated interchanges with future Light Rapid Transit (LRT) systems. In addition, the interchange at Dhoby Ghaut Station is designed with an integrated above-ground commercial development. This concept optimizes the development potential of sites above and near MRT stations. Similarly, to optimize land usage, the NEL depot will have an over-the-track deck to facilitate development of industrial units.

The Changi Airport Line (CAL) is a 6-km branch of the existing MRT network, with two additional stations. The elevated Expo Station will serve the soon-to-be-completed mega exhibition centre, while the second station will be underground at Changi Airport, serving Terminal 2 and future Terminal 3.

The Bukit Panjang Light Rapid Transit system is Singapore's first LRT. It is fully automated and links the relatively new Bukit Panjang and Choa Chu Kang residential estates to the Choa Chu Kang Station on the existing MRT. It has a route length of 8 km with 14 stations. To optimize land usage, the depot will be integrated with a commercial-cum-residential development. The system is expected to be completed by 1999. Stations will be located within 400 m of most apartment blocks, making the system very accessible to residents.

Other LRTs shortly to commence construction are the fully automated Sengkang and Punggol LRT lines. Both will serve as feeders to the NEL and will have a total length of 24 km with 33 stations. They will serve two new towns with relatively few physical constraints, so the stations will be well integrated with the neighbourhood facilities. They are expected to be completed at the same time as the NEL.

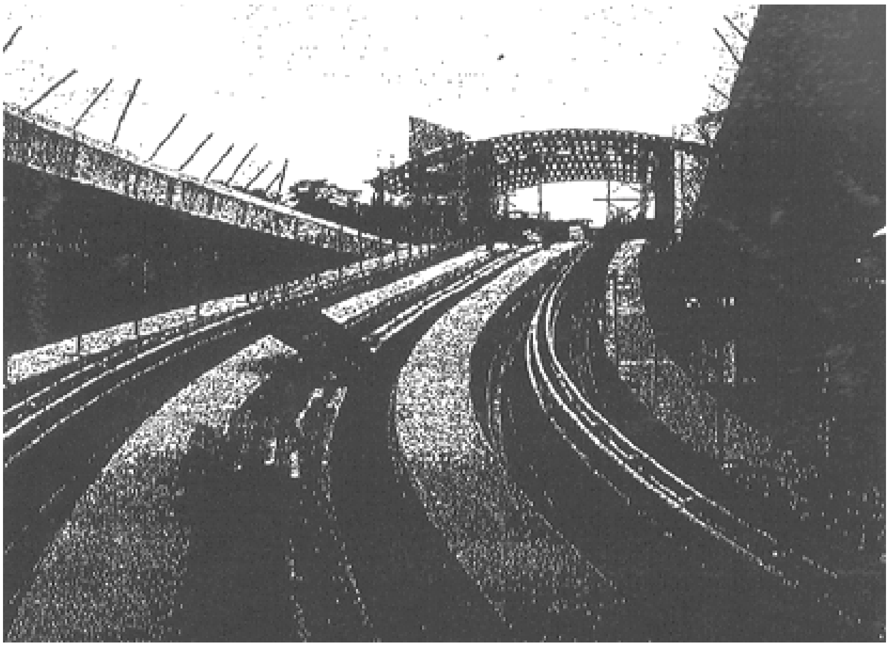
In addition to the MRT/LRT systems now under construction, feasibility studies are presently being undertaken for the Marina Line intended to serve the New Downtown in Marina South. It will also provide better links to other areas within the CBD and to the existing MRT. It will form part of a larger orbital system around the city.

These systems represent the LTA's efforts to build an RTS network in the short-to-medium term. Table 1 gives an overview of the current network as well as the network envisaged in 2004. A long-term Strategic RTS plan is being developed. Currently, in addition to being the builder and owner of the various systems, LTA is also the regulator, ensuring that the systems are operated and maintained safely and efficiently.


Woodlands MRT Station *(LTA)*

Environmental Issues

Apart from solving transportation needs, an RTS network can offer considerable improvements in the quality of the environment and the quality of life, particularly in a densely populated area like Singapore. Social costs due to air pollution, excessive noise, exploitation of land, and traffic accidents are



Guideway bifurcation at Station A6 on the Bukit Panjang LRT (LTA)

much lower with such networks.

In planning Singapore's RTS, the LTA works closely with the Urban Redevelopment Authority (URA) and Housing Development Board (HDB) to ensure integration with land usage and to identify and safeguard corridors for future construction.

For the existing MRT and those systems under construction, much effort has been taken to ensure that the stations and infrastructure are not visually obtrusive and that the architecture blends with the environment. This is important to preserve the character of the area served by each station. To this end, eminent local and international architects either design or review the station architecture. To ensure that the cityscape is not compromised, in the early 1970s, the government decided to stop all overhead cabling. This has caused high costs for burying power and telecommunications cables. Apart from increasing the complexity and cost of constructing roads and transit systems, this decision means that overhead catenary systems are not allowed for elevated transit systems. The present MRT uses a 750-V dc third rail to power the trains, while the Bukit Panjang LRT has 600-V ac side conductors.

Protection of the environment is a primary consideration as Singapore proceeds with plans to expand the RTS network, and it is imperative that environmental issues are considered both in operations and construction.

Operations

Reducing energy consumption is an important contribution to protecting the environment as well as reducing operational costs. Major design efforts for the various subsystems of the RTS have been implemented as follows based on developments in the railway industry and advancement in technology:

Rolling stock

- Reduction of vehicle weight by using aluminium bodies
- Use of efficient electronic switching devices such as Gate Turn-Off (GTO) thyristors and Insulated Gate Bipolar Transistors (IGBT)
- Optimization of the train running profile between stations to maximize coasting using the Automatic Train Operation system

Platform screen doors (LTA)

- Use of regenerative braking to minimize loss of train braking energy as heat. For the existing MRT, the regenerated power is fed to other trains nearby and the excess is returned to the 22-kV power network through inverters along the line. The returned power is used for station lighting and air conditioning, etc.

Stations

- Use of hump profiles when feasible, to reduce energy requirements for braking and accelerating by slowing trains when entering the station on the upgrade and facilitating acceleration when departing on the downgrade
- Reduction of air conditioning levels through correct location and orientation of heat-reflecting glass
- Design of elevated stations for good cross ventilation, thereby reducing the need for air conditioning
- Installation of platform screen doors in underground stations to minimize loss of cooled air into tunnels. These doors also help prevent blasts of air (caused by the piston effect of trains running through tunnels) affecting commuters standing on platforms: they also enhance passenger safety.
- Use of energy-saving lighting and separate group control in areas with good ambient light
- Use of direct lighting when possible to improve brightness and cut power consumption
- Use of high-efficiency air conditioning with load demand control in underground stations

  To cut energy demand as much as possible, the MRT uses high-efficiency filters, air conditioners with high Coefficients of Performance (COP), insulation of chilled water pipes/air ducts, and variable-speed motors in cooling towers.
- Design of escalators switching automatically to low-power consumption under low passenger load

  All escalators on NEL and CAL will have energy-saving devices to slow them down when nobody is on them.

Noise pollution is another area that has to be carefully managed. The present MRT has steel wheels running on steel rails. Much effort has been made to reduce the high pitch squealing of trains on tight curves as well as the level of low-frequency rumble using noise-damped wheels. In addition, the rails are reground regularly to remove noise-generating irregularities and to maintain the rail profile. The train wheels are also ground to remove noisy 'wheel flats' and to maintain the tolerance. A host of design and maintenance measures have helped ensure that the noise level meets the specification of 67 dBA Leq (1 h) at a distance of 15 m. To ensure a quieter ride, rubber tyres will be used on the Bukit Panjang and other planned LRTs. All on-train auxiliary equipment on all lines must also meet the stringent noise standards specified by LTA.

Apart from energy-conservation and noise-reduction measures, Singapore also closely follows international developments to protect the environment. One example is the use of environment-friendly inert gases such as Inergen to protect critical equipment rooms against fire. Similarly, train and station air-conditioning systems use R134A refrigerant, as recommended by the Montreal Protocol.

Construction

The extensive RTS construction work, such as for the NEL, inevitably has an impact on nearby communities and land. Environmental protection and pollution control measures are required during construction, along with measures to alleviate any environmental consequences.

Cut-and-cover construction at Sengkang Station (left) and View of Clarke Quay Station (right) on North East Line *(LTA)*

Before construction, LTA undertakes a survey to identify the condition of structures and foundations along the construction corridor. Where necessary, monitoring equipment is installed to track any possible impact of construction so countermeasures can be taken if needed. Special attention is given to sites of historical significance.

The two most common concerns during construction are noise and dust. Noise control measures include careful scheduling of noisy work, use of appropriate equipment such as vibro hammers for piling, and controlled movement of heavy vehicles. However, when safety is the primary concern, the mitigating measures may involve use of noisy equipment although the time needed for such work is minimized as much as possible. In this respect, LTA works within the guidelines laid down by the Ministry of Environment and Ministry of Manpower.

For dust control, proper hoardings are always used. In addition to compulsory washing of muddy vehicles with recycled water, before allowing them to leave the site, vehicles carrying spoil must have covers to prevent dust pollution. Contractors are also required to wash the roads used by vehicles leaving the site regularly.

During construction, maintenance of road capacity and safety have high priority. In principle, the LTA maintains the lane capacity before the start of construction, except where it is physically not possible. Road diversions and traffic control schemes are developed in close consultation with experts to ensure the safety of road users while construction is in progress.

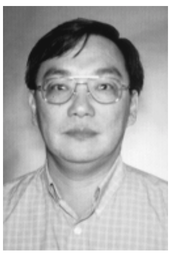
The LTA also works closely with the Ministry of Environment and the National Parks Board during any RTS construction. Cooperation is required to ensure that any impact on water quality is identified and suitable control measures are implemented. The materials and waste management aspect is also examined closely. Since the land and streetscape are inevitably affected during construction, reinstatement is usually required and this is normally undertaken in conjunction with the National Parks Board.

Conclusion

The LTA vision of a world-class land transport system requires a world-class public transport system. The RTS is one key to achieve this vision, because it is the most efficient means of transporting large numbers of people. Consequently, it will form the backbone of Singapore's public transport system. The present MRT network will be expanded into a comprehensive system that will attract commuters in terms of access convenience.

The growth of Singapore's RTS, has the potential for major impact on the environment. The LTA is sparing no effort to ensure that the planning, design, construction, and operation of the RTS gives due recognition to any potential environmental impact and that appropriate countermeasures are taken.

Singapore recognizes that its transport system must not be provided at the expense of the environment. The LTA believes it is on the right track! ■



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