

# LRT in Hong Kong's New Suburbs

JONATHAN YU

The first phase of Hong Kong's light rail transit (LRT) system opened in September 1988, providing a fully integrated transport service for the fast growing northwestern region of the New Territories. Designed as a high-capacity carrier yet providing a comprehensive network of services, the system features a large number of stopping points located in commercial, industrial, and residential areas. Many of the stops are directly linked by footbridges to transport interchanges and into the housing developments. The system opened on time and within budget, with very few technical start-up problems. Yet its early days of operation were clouded by controversy, and at one time it was branded as dangerous and trouble-prone by the local media. The LRT system is the only public transport service in Hong Kong that features an open fare system, giving maximum customer convenience without turnstiles on the platforms or in the vehicles. Passengers pay for the number of fare zones they travel through rather than the route they take. The system now regularly operates with 98 percent punctuality and 99.9 percent reliability despite having 18 major and 51 minor road crossings, all at grade and without barriers. Average journey speeds achieved are 20 km/hr including stops. Despite the low fares, the system already covers about 100 percent of its direct operating costs. Three new links have been added and 30 more cars will be delivered starting in late 1992. The operating regime is described, with the line-of-sight driving that achieves this daily performance, the priority request system to obtain signals to proceed over the road junctions, experience to date, as well as plans for the future.

The first phase of Hong Kong's light rail transit (LRT) system commenced operation in September 1988, providing a fully integrated transport service for the fast-growing northwestern region of the New Territories with a target population of 800,000 by the late 1990s. Clouded by a series of controversies initially, including concerns about monopoly and safety, the system has gradually started to gain passenger and public recognition and has become an integral part of Hong Kong's multimodal public transport scene.

Patronage on the 23-km Phase 1 system has increased about 50 percent to average 262,000 daily (including some 37,000 who traveled on bus services feeding the network) in 1991, making it one of the most heavily used LRT systems in the world.

Operated largely on its own right-of-way but entirely at grade with 56 road junctions (73 on the expanded network) where the system meets other road vehicles, the system has consistently been attaining excellent safety, punctuality, and reliability records.

On an average day over 99 percent of the 1,600 light rail vehicle (LRV) trips on the timetable are operated and 98.5 percent arrive at their destinations within 3 min of their scheduled time. The accident rate is the lowest of all road-based

modes of public transport, and no major incident has occurred that caused widespread interruption of service for an extended period of time.

Despite the very low fares charged (which, at the end of 1991, averaged HK\$2.10, more or less the same charged by ordinary Hong Kong buses), fare revenues almost cover 100 percent of the system's direct operating costs (excluding provisions for depreciation) thanks to continued rapid patronage growth and productivity enhancements.

## BACKGROUND ON THE SYSTEM'S CONSTRUCTION

The northwest part of the New Territories of Hong Kong, which includes the new town of Tuen Mun, a developing market town, Yuen Long, and the Castle Peak Road corridor between the two towns, has been developing rapidly since the mid-1970s under the Hong Kong government's new towns development program to cope with rapid population growth.

The idea of introducing an LRT system into the region dated back as far as 1972, when a commercial firm proposed building a circular tram route in Tuen Mun. This triggered a series of studies to determine the most appropriate transport system for the new town. A wide range of modes was initially screened, ranging from minibuses, buses, street trams, a light rail system, a automated guideway system, a conventional metro, and elevated monorail. Finally the government decided to provide an advanced light rail system to the new towns. Apart from such advantages as independence from fuel oil, better quality of service, and greater environmental compatibility, it was thought that a light rail system would help to promote the image of the new towns.

In November 1983 the government invited the Kowloon-Canton Railway Corporation (KCRC), a public corporation running a passenger and freight heavy rail service, to build and operate the LRT, which by that time had developed conceptually from a Tuen Mun town system into a regional system for the whole northwestern New Territories, including a loop for another new town called Tin Shui Wai.

In July 1984 the KCRC accepted the offer to build the LRT system. KCRC was granted an exclusive right to provide the major public transport services (i.e., LRT and its feeder bus services) in the designated transit service area.

In August 1985 the KCRC awarded a turnkey contract of HK\$1.1 billion to an Australian consortium of Leighton Contractors Asia Ltd. and MTA (Metropolitan Transit Authority of Victoria, Melbourne) to build and equip the first phase of the LRT project. Following an intense 3-year construction period, the 23-km Phase 1 system commenced commercial service on September 18, 1988 (see Figure 1), managed and

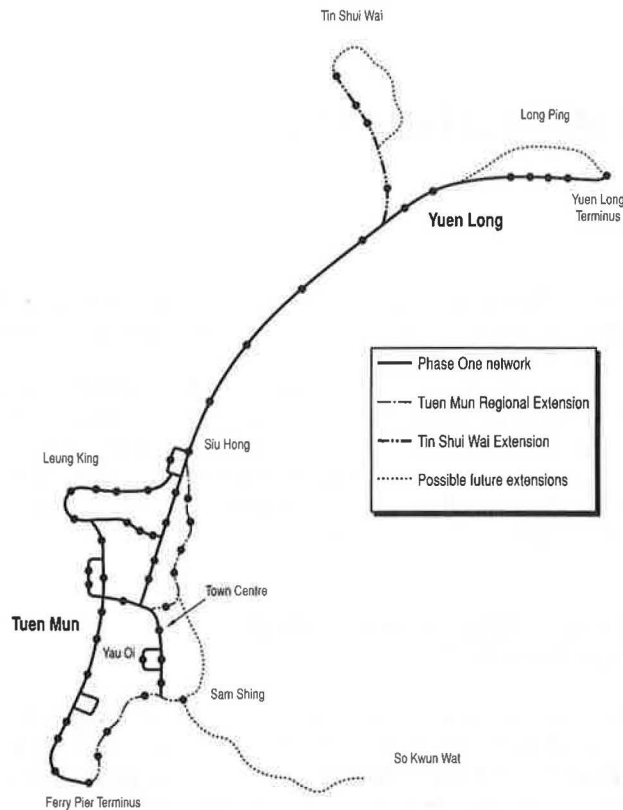


FIGURE 1 LRT network in Hong Kong's New Territories.

operated by the light rail division, one of KCRC's business divisions.

## SYSTEM FEATURES

### Network

The Phase 1 system is 23 km of double track and 41 stops. Three extensions to the system in Tuen Mun, totaling 5 km

TABLE 1 Technical Information, Tuen Mun LRT: Network

	Phase 1	Expanded Network <sup>a</sup>
Route length (km)	23.35	33.05
Roadside reservation (km)	20.00	29.30
Paved, segregated median (km)	2.25	2.25
Paved, street track (km)	1.10	1.50
Length of single track, excluding depot (km)	46.00	71.43
No. of signalized road crossings	56	75
No. of unsignalized road crossings	13	13
No. of stopping places	41	55
Platform height (mm)	910	910
Platform width, usual (m)	3	3/4
Platform width, min/max (m)	2/5	2/5
Minimum design headway (sec)	60	60
Passenger capacity/diwn/hour <sup>b</sup>	22,800	22,800

<sup>a</sup>Early 1993.

<sup>b</sup>Based on two-car trains and standees at 6/m<sup>2</sup>.

of track with 10 stops, opened for service between November 1991 and February 1992 (see Table 1).

The Phase 1 system is entirely at grade but the extensions feature three LRT bridges. Over 90 percent of the system runs on its own right-of-way, which in Tuen Mun was formed as part of the development of the new town. As a result construction work caused the minimum disturbance to the community.

The bulk of the system is fenced off to prevent pedestrian access other than at specified crossing points (largely located adjacent to the stops) and at road junctions.

### Track

Standard gauge (1,435-mm) steel rails are used (see Table 2). The tracks are generally laid on ballast, with the exception of road junctions, the section through Yuen Long town, and three small sections in Tuen Mun, two of which are the only

TABLE 2 Technical Information, Tuen Mun LRT: Trackwork

	Phase 1	Expanded Network <sup>a</sup>
Contractor	Henry Boot (Far East)	Balfour Beatty Ltd./Henryvicy Consortium
Flat-bottomed rail		
Type <sup>b</sup>	UIC 54	UIC 54
Supplier	British Steel	Sydney Steel
Grooved rail		
Type	Ri 60	(not used)
Supplier	Thyssen	(not used)
Track gauge (mm)	1435	1435
Precast concrete sleepers <sup>c</sup>	F27S	F27S
No. of points	128	168 (Total)
Supplier of points (motors/controllers)	Hanning & Kahl	Hanning & Kahl
No. of diamond crossings	29	38 (Total)
Minimum curve radius (m)	23	23
Maximum gradient (%)	6.1	6.1

<sup>a</sup>Early 1993.

<sup>b</sup>With plating for some street track.

<sup>c</sup>Timber used for special work.

parts of the system where LRVs share the same road space with other road vehicles.

The maximum possible gradient on operational track is 8 percent, though for short distances only. In actual fact the steepest gradient is 6.1 percent. The maximum within the depot and the yard is 0.2 percent.

The grade of the track generally follows that of the adjacent street. So far as reasonably practicable, the track alongside platforms is straight and level.

The tracks are aligned to provide a 150-mm clearance between the kinematic envelope of the vehicle and any fixed object, such as a building or overhead structure, adjacent to the line. Because of geographical constraints, the minimum curve radius was only 20 m.

## Stops

The stops are conveniently located in commercial, industrial, and residential areas, generally 300 m apart in the urban areas and 500 m in the more sparsely populated areas.

All stops are high-level platforms 910 mm above rail level to match the height of the vehicle floorline to facilitate boarding and alighting. One platform is provided for each direction of travel and access is normally by adjacent footpaths or footbridges. Each platform is 40 m long to accommodate two vehicles simultaneously. The width varies but generally is 3 m wide on the Phase 1 system and 4 m on the new stops.

All stops have stairs and ramps, and the system can be used by the disabled, including the wheelchair-bound.

Stop canopies are provided, and each platform is equipped with automatic ticket vending machines, a public address system, and passenger and fare information.

## Vehicles

Of German-Australian design, the light rail vehicles (LRVs) are constructed to provide a high quality of passenger convenience and comfort consistent with operational requirements and proven technology.

The LRVs are rigid frame, stainless steel vehicles, single-decked, 20 m long and 2.65 m wide, with 52 seats and a carrying capacity of 205 passengers (see Table 3). The LRVs are four-axle with a single pantograph and single-ended with a driving cab at one end only, though an auxiliary driving position is at the rear for emergency and shunting purposes.

The LRVs can be operated singly or in pairs, and each has three sets of double doors on one side. They are fully air-conditioned and, with the latest electronic power control system and regenerative braking, are very energy efficient, with up to 40 percent of the traction current recycled within the system. The resilient, cushioned wheel rim and the use of a split-type air-conditioning unit help to reduce vehicle noise.

## Power Supply

The LRVs are electrically powered from a 750-volt (V) direct current (dc) lightweight overhead power supply system provided initially at 11 kV via two primary substations and then

distributed through the LRT's own 12 rectifier stations and workshop substation (see Table 4).

The overhead line system has been designed to withstand typhoon conditions and the whole system can be supplied by either one of the two primary substations in case one fails.

The majority of the rectifier stations are provided with two 11-kV feeders forming a series of ring mains. Cables installed in cable troughs along the track provide the connections between rectifier stations. The capacity of the rectifier transformers and the overhead line equipment is so designed that, if one rectifier station fails, operation can be maintained on the affected section by feeding from neighboring rectifier stations.

The rectifier stations are unmanned and equipped with a supervisory control and data acquisition (SCADA) system for remote control of the power supply network from the operational control center (OCC) at the LRT depot.

A low voltage system, connected to the auxiliary transformer at each rectifier station, provides power supply to each LRT stop.

## Communications and Control

Regulation and supervision of vehicle operations and supervisory control of associated electrical, mechanical, and communication systems are carried out at the OCC to ensure safe and efficient service, whereas the actual operation of the vehicles is under the manual control of the LRV driver.

The LRT system has 73 at-grade junctions where LRVs interface with road traffic. The LRT signals at the junctions are synchronized with road traffic signals to give a degree of priority to LRVs. For minor junctions (largely serving isolated developments) where road traffic rarely interferes with the LRT, 100 percent priority is accorded to LRVs. But at the most complex junctions, for example, where the LRT T-junction is superimposed on a major road T-junction, little priority could be given because of heavy road traffic. The LRT traffic signals are controlled from the adjacent electronic road traffic controller. The LRT point signals are controlled by the presence of the vehicle, although this control may be overridden by driver command. An LRV will cross a road junction by making an automatic request to the road traffic controller and LRT track equipment.

The track is equipped with separate vehicle identification loops between rails to initiate traffic signal and point signal request and cancel commands. There is no interlocking between the track point switching controller and the road traffic signal controller.

Each LRV is equipped with a transponder. When it passes over the traffic request loop and point request loop, the LRV sends its identification to the trackside computer at the nearest stop. The computer then makes the request for LRV right-of-way to the road traffic controller, switching the point switch to the right position and sending the LRV identification back to the central computer at the OCC for location identification and further processing.

After a safety period the road traffic controller will give the right-of-way to the LRT vehicle.

When the LRV passes, the cancel loop resets the previous request. The traffic controller will then restore the service and the request loop will wait for the next LRV instruction.

**TABLE 3 Technical Information, Tuen Mun LRT: LRVs (Phase 1)**

Specification	70 cars delivered between October 1987 and August 1988
Drive and braking systems	Monomotor bogies with quill shaft axle drive; regenerative/pneumatic service braking, with emergency battery-fed magnetic track brakes, sand assisted; bogie centers offset 24 mm to compensate for externally hung doors
Lighting systems	Exterior: dual front, rear, brake and direction indicators Interior: fluorescent
Control systems	GTO thyristor chopper controls capable of multiple operation up to three cars; rear-end backup shunting control
Suppliers	
Main contractor	Comeng, Australia
Body	Comeng
Bogies	Duewag
Propulsion equipment	AEG
Control equipment	Siemens
Brakes	Knorr
Interior fittings	Comeng
Seats (fiberglass)	Duewag
Doors	Stone Peters
Air-conditioning (split type)	Sigma
Pantograph (type DR-23LA)	SMC
Couplers	Scharfenberg
Body specification	
Frame	Steel
Exterior walls	Stainless-steel ribbed panels
Interior walls	Aluminum alloy
Insulation	"Tuff-skin" fiberglass
Floor	Stainless steel
Floor overlay	Plywood and "Treadmaster"
Doors (externally hung)	Sliding
Windows	Beclawat Design 14, with hopper vents
Heating	None
Flange lubricators	Fitted to 14 cars
Vehicle performance	
Maximum velocity (km/hr)	80
Steepest gradient capability (%)	8
Service acceleration (m/sec <sup>2</sup> )	1.3
Service braking (m/sec <sup>2</sup> )	1.3
Emergency braking (m/sec <sup>2</sup> )	>2.6
Emergency brake reaction time (sec)	1.0
Max. jerk rate (m/sec <sup>3</sup> )	3.0
Min. curve radius capability (m)	
Horizontal	20
Vertical (crest/sag)	300
Passenger capacity:	
Seats	52
Standees (6/m <sup>2</sup> )	153
Noise (inside), on level, clean ballasted track	Li 70 dB(A) at 60 km/hr
Noise (outside), tare load on level, clean ballasted track, 7.5 m from car	La 75 dB(A) at 60 km/hr
Dimensions	
Length over fenders (m)	19.400
Length over couplers (m)	20.200
Height of floor over rail (m)	0.948
Height of roof over rail (m)	3.415
Height of lowered pantograph over rail (m)	3.785
Inside width (m)	2.588
Headroom in center aisle (m)	2.187
Width of center aisle (m)	1.078
Doorway width, minimum (m)	1.500
Doorway height (m)	1.900
Weight, empty (t)	27.032
Weight, fully loaded (t)	37.862
Propulsion and braking	
Track gauge (mm)	1435
Bogie centers (m)	11.0
Bogie wheelbase (m)	1.9
Motors (monomotor drive), type	ABS 3322.2
Motor rating, per car (kW)	2 × 195 (cont)
Motor voltage (V dc)	750
Gear ratio	5.556:1

**TABLE 4 Technical Information, Tuen Mun LRT: Electrification**

	Phase 1	Expanded Network <sup>a</sup>
Contractors		
Overhead	Balfour Beatty	Balfour Beatty
Power	Hawker-Siddeley	Balfour Beatty
No. of infeed substations	2	2
No. of rectifier substations	11	13
Voltage (V dc)	750	750
Contact wire height (m)		
Normal	5.6	5.6
Max/min	6.0/5.4	6.0/5.4
Wire type		
Catenary and trolley (at triangle junctions and termini)	Hard-drawn copper	Hard-drawn copper
Span wires	Synthetic rope	Synthetic rope

<sup>a</sup>Early 1993.

If a number of LRVs are following closely, or approaching the junction in opposite directions, the situation could arise in which LRV demands continue for long periods. To prevent the LRV phase staying green for too long, with unacceptable delay to road traffic, it has a "maximum green" timer similar to a normal vehicle actuation phase. This timer is set so that two fairly closely following LRVs could pass through the junction before the stage change.

The computerized vehicle information system enables the traffic controllers at the OCC to see all LRV positions and deviations from scheduled running times so that corrective action can be taken whenever required. Required changes in service can be communicated to LRV drivers through a radio link. The OCC can also make public address announcements to passengers on vehicles or stops, singly, by route, or systemwide.

### Fare Collection

The LRT adopts an open fare system, which is the first of its kind in Hong Kong. It has a zonal fare structure with full integration between LRV and feeder bus fares, allowing free transfer within the same fare zone. Passengers pay for the number of fare zones they travel through rather than the route they take. Currently five fare zones are employed with three fare steps (see Table 5).

Without turnstiles or gates at stops, the open fare system, which is also an honor fare system, enables passengers to travel conveniently by holding a valid ticket. Infrequent travelers can purchase a single-ride ticket from the automatic ticket machine at LRT stops and travel within a 2-hr limit in one direction within the fare zone(s). The ticket vending machines provide change and issue tickets stamped with the origin and destination zone numbers, machine number, time, and date. All ticket machines are linked to a computer terminal in the OCC, and malfunctioning and vandalism trigger alarms.

Various multiride passes are offered for frequent travelers and are sold at substantial discounts. Both monthly passes

**TABLE 5 Technical Information, Tuen Mun LRT: Fare Collection**

	Phase 1	Expanded Network <sup>a</sup>
Ticket vending machine		
Autelca	215	
Cubic Western Data		148
Total		363
Zonal fares issued		Yes
Monthly seasons issued		Yes
Stored value tickets accepted		Not yet
Free transfers		to LRT buses
Fares (adult/child)		
1-2 zones		HKD2.40/1.20 <sup>b</sup>
3 zones		HKD3.00/1.50 <sup>b</sup>
4-5 zones		HKD3.50/1.80 <sup>b</sup>
Monthly		
3 zones (Adult)		HKD117 <sup>b</sup>
All zones (Adult/Child)		HKD172/60 <sup>b</sup>
Student season (quarterly)		
3 zones		HKD268 <sup>b</sup>
All zones		HKD390 <sup>b</sup>
Surcharge/no ticket		HKD175 <sup>b</sup>

<sup>a</sup>Early 1993.<sup>b</sup>Fares as of early 1992.

and student season passes allow unlimited rides and free transfers within the zone or zones specified on the ticket. Adult and student multiride passes are divided into four zonal types: Tuen Mun pass, Central pass, Yuen Long pass, and all-zone pass. The first three zone passes can be used as all-zone passes on Sundays and public holidays. Passengers can purchase multiride passes at LRT passenger services counters at major stops and termini, as well as local convenience stores.

To protect the interest of honest passengers and LRT revenue, teams of passenger services assistants conduct random ticket inspections at LRT stops and on LRVs in addition to their regular duties of providing assistance to passengers. A heavy penalty equal to 50 times the maximum single journey fare is imposed on passengers found without a valid ticket.

### Depot and Workshops

The depot and workshops together with the LRT administration building (which houses the OCC) occupy a site of about 5 hectares. The depot, when developed to its full capacity, can be used for the stabling, cleaning, and maintenance of a fleet of 143 LRVs and a number of auxiliary vehicles used for maintenance purposes.

There will be 17 tracks for stabling purposes and three more with 1.5-m-deep pits for LRV servicing and inspection.

Vehicles due for major inspection and overhaul will be brought into the workshops by a traverser. Facilities include a bogie repair shop, wheelset repair shop, motor repair shop, shop for couplers, brakes and compressed air system, battery shop, machine shop, air-conditioning equipment shop, and electronic workshop where electronic equipment on LRVs, the signaling system, and automatic ticket vending machines are tested and repaired. A body workshop has an underfloor wheel lathe, door repair shop, and area for scheduled and unscheduled repair of car bodies. The workshops are also equipped with two sets of overhead traveling cranes, two sets



of vehicle-lifting screw jacks, and all necessary jigs, tools, and testing instruments. The permanent way and overhead line equipment are repaired in a separate workshop accessible from a special siding.

## EARLY PROBLEMS AND SOLUTIONS

### Safety

A series of road accidents at road/LRT junctions involving LRVs during the trial running and early stages of passenger service in mid- to late-1988 resulted in a lot of adverse publicity for the system. People questioned whether something was wrong with system design in terms of safety.

Part of the problem was associated with the fact that many new traffic signals were not installed prior to commencement of trial operations, leaving very little time for motorists and pedestrians to become familiar with new traffic conditions after installation was completed and the LRT started full-scale commercial operation. Both the government (which has overall responsibility for road safety in Hong Kong) and the KCRC were unaware of the extent of the perception problems about what an LRT system is. Many road users might have equated LRT with the slow-moving trams on Hong Kong Island, while the general public might, on the other hand, equate the LRT with other fully segregated heavy railways in Hong Kong that do not conflict in any way with road traffic.

Through large-scale safety public education campaigns, improvements in signage, road markings, and modifications to traffic signal positioning as well as junction layouts, the early concern on safety has largely died down. Even in 1988, the LRT had the lowest accident record among all road-based public transport and recent statistics have indicated that LRT traffic junctions are safer than non-LRT junctions.

### Political Problems

#### *A White Elephant?*

The decision to go ahead with building an LRT system to serve the internal public transport needs of the northwestern New Territories was most controversial. Hong Kong's other rail-based transport systems all serve the built-up urban area or link the urban area with the new towns of the New Territories. Government's housing and new town development policy successfully brought more and more people to live in the New Territories. However, most of the people still work in the urban areas where the major employment activities, especially for the commercial services sectors, are concentrated. Hence many of the residents believed that the priority for a rail system in the northwestern New Territories was for a rail link to the urban heavy rail networks instead of an internal system, which, it was thought, could adequately be provided for by a bus service. It was extremely difficult for people to look at the requirement for an LRT to cope with long-term growth and development of the region with additional benefits such as environmental advantages.

Though this has changed somewhat as internal travel has built up with the new towns maturing and as more educa-

tional, community, and other infrastructure projects are completed in the region, the demand for a rail link to the urban areas remains.

### *The Monopoly Issue*

It had been established since the days when the LRT was first conceived for the region that transport demands there could not support both a bus system and the LRT, hence the government decided that the LRT would replace the internal bus network that was operating (and this was one of the conditions for KCRC to undertake the project). However, it was perceived that KCRC acted in a high-handed manner in forcing people in the area to use LRT service by ending bus service. This requirement for the creation of a transit service area (TSA) is, of course, a new concept as far as new transport facilities in free enterprise Hong Kong is concerned, and it has remained an issue of contention to this day. Although in terms of actual choice, residents in the TSA have no less choice now with the LRT than with the previous partial monopoly enjoyed by the buses.

It has to be pointed out that though the TSA franchise confers a degree of monopoly for the KCRC, on the other hand, the LRT has the responsibility to provide an adequate level of service for the entire region, including the money-losing feeder bus services.

### *Political Battlefield*

Tuen Mun is a special new town in Hong Kong because it is farther away from the urban area with relatively few community facilities (including no rail service) and a younger and generally less affluent population. About 70 percent of the residents live in subsidized government housing. All these factors have caused a mushrooming of quasipolitical pressure groups that vie for influence and support at a time when Hong Kong is developing a more representative form of government, including district-based consultative District Boards and elected representatives to Hong Kong's law making Legislative Council. Added to this is the clash of ideas and, at times, interests between these new, public housing-based young groups with a more radical outlook and the traditional rural elements who had previously enjoyed tremendous influence in affairs in the New Territories. Hence Tuen Mun is the most politically active area in Hong Kong and, as could be expected, public transport (including the LRT) is always an issue and an easy target for political debate.

### Community Relations Initiatives

To address the many political and communications issues, the LRT has carried out a very comprehensive community relations program to ensure effective communication channels are maintained with passengers, community organizations, political forces, and the media. The program includes a telephone enquiry and complaint hotline service, passenger services counters at the major stops, the publication of a monthly newsletter, participation in the District Board traffic and

transport committees, school talks and visits, exhibitions and briefing sessions, courtesy and safety campaigns, as well as the establishment in 1991 of passenger liaison groups through which regular two-way dialogue is maintained with users of the system.

A "Get to Know the LRT" project was launched in 1989 and is still popular. This program is targeted at students, community organizations, and the general public outside the region (who would have little opportunity or need to use the LRT), inviting them to visit and experience the system firsthand.

### Teething Problems

Like other new transport systems, the LRT in 1988 also suffered from teething problems such as passengers' lack of knowledge about the new ticketing system, the learning curve of operators resulting in slower journey times as well as slower handling in incidents. These problems have all now been overcome.

A problem that has yet to be fully rectified is the air-conditioning system on the LRVs. The 42 kw of cooling capacity proved to be inadequate in the hot summer with temperatures rising to as high as 35°C, the frequent opening and closing of doors given the short distance between stops, and the problem of dust and dirt that affects air flow and performance of the condenser units underframe. A HK\$21 million scheme to upgrade the system to provide more than 60 kw of cooling capacity is now being implemented to be completed by spring 1993.

### Patronage Estimates and Marketing Information

A passenger transport system like the LRT relies on patronage for financial viability. Patronage derives in turn from population and its distribution, trip rate factors, and trip distribution. As opposed to the urban metro system, which serves densely populated corridors with very high travel demand, the LRT's service area is developing new towns with rapidly changing infrastructure, population, and very different demographic characteristics, traveling requirements and patterns.

In Hong Kong demographic prediction is hazardous, and forecasting population distribution is even more difficult. Population in the TSA has grown at a slower pace than original estimates predicted, its distribution has changed, and patronage estimates have to be constantly revised. With 3 years of operating experience on board, patronage projections have, in the last 2 years, become quite reliable.

The open fare system and the unique competitive environment present special challenges to the LRT's marketing team. Unlike the "closed" ticketing systems of the heavy rail system that have very accurate computer records of how a single ticket is used and hence very accurate passenger movement statistics, the LRT's machines selling single-journey tickets can record only the origin stop but not the destination stop of the passengers. And with the growing popularity of the monthly and season tickets, now accounting for 50 percent of total journeys, the traveling characteristics of these passengers

holding tickets cannot be captured at all and have to be ascertained by extensive market surveys.

The LRT's major competitors are taxis, public light buses and special purpose buses (factory and school coaches), and the private car. Information on the use of these modes is at best sketchy and sometimes nonexistent.

Hence extensive use of market surveys has been developed and fine-tuned in the past few years to obtain the necessary market information for planning services and future development plans. These include regular telephone surveys of multiride ticket holders to quantify monthly and season ticket usage; boarding and alighting surveys to gather statistics by time period, platform, and route from which peak-hour factors and vehicle occupancy ratios are ascertained; customer travel profile surveys designed to obtain passengers' traveling pattern, demographic profile, and use of tickets; trip rate and market share surveys; and usage and attitude surveys to obtain passengers' views on such issues as waiting times, cleanliness, safety, staff attitude, comfort levels, fares, and overall image of LRT services.

### SERVICE PROVIDED

The LRT system now operates 19 hours every day from 5:30 a.m. to 12:30 a.m.

The fleet of 70 LRVs operates more than 1,600 trips daily on six routes, three within Tuen Mun and three between Tuen Mun and Yuen Long. The peak-hour headways range from 5 to 8 min on individual routes and from 8 to 10 min in between peaks. The combined headway in the peak periods on busy sections is between 1½ to 2 min against a theoretical design minimum headway of 1 min. Five coupled-sets are timetabled.

An average operating speed, including stops, of about 22 km/hr is achieved in the peak hours, and the longest route from end to end takes about 38 min to complete a 14-km journey.

Forty-two feeder buses, operated by the Bus Division of KCRC, feed the LRT on nine routes, covering more remote areas or areas where LRT extensions are not yet built.

### OPERATING AND MAINTENANCE PHILOSOPHY AND PRACTICES

#### General Principles

The heavy reliance of the traveling public on Hong Kong's public transport system and growing customer expectations mean that the LRT is always expected to provide a highly reliable standard of service that can meet growing demands of the new towns. Hence very high operating standards are set and all equipment maintained to very high standards of availability and reliability.

A policy of preventive servicing and modular replacement of components is adopted in maintenance, whereby failures or faults are anticipated by servicing or replacement sufficiently in advance of possible breakdown or damage, both in system design as well as in the preparation of maintenance and service manuals. This ensures that availability of the system is as high as possible.

Great emphasis has been placed on operator training, not only on rules and regulations and the basic techniques for carrying out the normal duties expected of the job, but also in dealing with incidents and emergencies. Refresher courses are conducted incorporating experience learned from actual recent incidents.

### Productivity Improvements

Productivity improvements are achieved firstly by carefully controlling headcount increases with better staff deployment and multiskilling to cope with expansion in network. Secondly, productivity improvements are achieved through cost savings in the maintenance areas. This includes constant review of maintenance schedules, design modifications, building up internal repair capability to minimize requirements for external repair, using cheaper contractual labor for low-skill and nonroutine jobs, closely monitoring and extending maintenance limits for wear and tear components, and sourcing of alternative and local material supplies.

### Driver Training and Performance

LRV driver performance is closely monitored to ensure safety and efficiency. New recruits undergo a 6-week training program to be fully qualified as an LRV driver.

Drivers are trained to use defensive driving techniques that emphasize alertness during driving and quick response to anticipated irregularities. During driving practice, a commentary driving technique is also adopted that requires drivers to speak out what they are observing en route. Refresher courses are organized for each driver every 6 months.

### Service Standards

High quality of service relies on the setting of high and measurable standards. Half-yearly as well as annual targets are set to guide and direct operational and maintenance activities. Those targets define the required achievements for the period in punctuality and reliability of service, the peak-hour availability of LRVs, the reliability of LRVs (interpreted as the number of kilometres operated per failure), the reliability of signaling system and fixed infrastructure, and the availability of ticket vending machines. Detailed passenger and operation safety standards are devised requiring continuous improvement efforts to meet these standards. Railway operational safety is monitored by the Railway Inspectorate appointed by the government.

### PATRONAGE PROMOTION

With low fares charged and political constraints on fare increases, apart from productivity enhancements, the LRT has

to rely on patronage growth to improve its financial performance. A variety of patronage promotion programs are regularly carried out to build up a core group of LRT users and stimulate off-peak optional travel.

Increased usage of multiride passes not only has the advantage of cementing customer habit and loyalty, but also can reduce platform congestion and relieve the pressure on the automatic ticket machines. The LRT has been organizing various promotional activities to encourage the use of multiride tickets, which, together with the fare strategies of offering more discount to the multiride pass users, have successfully increased the usage of monthly and season passes from some 30 percent in 1988 to 43 percent in 1991. These promotional activities include giveaway souvenirs, a joint promotion coupon book with local retail shops, cash redemption for domestic appliances, lucky draw, and bonus pack promotions.

### SYSTEM PERFORMANCE AT A GLANCE

Table 6 gives an overall view of how the LRT system has performed and progressed in the past 3 years.

### FINANCING AND PROPERTY DEVELOPMENT

The LRT has been built and operated without any government subsidy, apart from the fact that the KCRC does not have to pay for the formation and structures necessary for the way-leaves that have been provided from the government's public works program. The costs of forming the reserves amounted to about HK\$570 million for the Phase 1 system and HK\$700 million for the extensions. The rationale for this is that the formation constituted part of the region's transport infrastructure without which greater investment in roads would have been necessary.

KCRC financed the construction of the LRT and the operating deficit from its own resources—profits generated from its other businesses as well as commercial loans. The Light Rail Division is a business division of the corporation and a profit center. The LRT is expected in the longer term to be self-supporting financially and to generate a return on investment.

As with other rail companies in Hong Kong, KCRC has been allowed to develop property over its rail stations and depots. Residential and commercial development projects have been completed above the stabling yard in the depot and Tuen Mun terminus. One development above the Yuen Long terminus and one above the Sam Shing interchange are in progress. The two completed developments have generated a cash profit of about HK\$700 million for KCRC and a recurrent commercial income of HK\$11 million per annum. These profits have not been incorporated into the LRT's operating account and are used to finance KCRC's capital expenditure program (including the LRT) and reduce total borrowing required.



TABLE 6 Overview of LRT Service in Hong Kong's New Territories

	1988 <sup>a</sup>	1989	1990	1991
TSA population	507,000	526,000	568,000	600,000
Average daily patronage				
LRV	151,000	171,000	201,000	225,000
Bus feeders	30,000	37,000	34,000	37,000
Total	181,000	208,000	235,000	262,000
Total passengers carried (millions)	19.2	76.0	85.8	95.7
LRT routes (no.)	5	6	6	6
LRV trips per day (year end)	1,227	1,617	1,599	1,626
LRV-km operated (millions)	1.32	4.96	5.84	5.83
LRVs in morning peak-hour service (no.)	53	59	61	64
LRV peak-hour availability (%)	78	87	91	90
LRV reliability (km run per casualty causing delay to service of more than 3 min)	22,600	23,000	35,400	29,400
Service reliability (LRV trips run to trips timetabled) (%)	99	99	99	99
Service punctuality (LRV trips running within 3 min of timetable) (%)	99	99	99	99
Ticketing vending machine availability (%)	—	99.1	99.7	99.7
Peak-hour factor (%)	13.6	10.8	11.9	12.1
Single-ride ticket passengers as percentage of total LRV passengers	66	71	64	57
Average fare per boarding (\$)	1.43	1.43	1.83	2.00
Detectable fare evasion rate (%)	—	0.32	0.33	0.20
Passenger complaints per million passengers (no.)	44.0	14.5	8.8	6.6
Fatal accidents (no.)	1	4	2	2
Total no. of passengers and public injured per million km-run	28.2	16.7	10.8	15.0
Incidents causing delay to service of over 20 min	6	13	7	7
System revenue (HK\$ millions)	30	111	161	195
Direct operating costs (excluding corporate overhead) (HK\$ millions)	64	129	166	193
Deficit after depreciation (HK\$ millions)	82	111	104	104

<sup>a</sup>1988 statistics are from 18 September.

The KCRC adopts a risk-free approach in its property business, entering into joint ventures with reputable property development companies that provide the cash required for the government land premium as well as construction cost for the development in return for a share of the profits.

## THE FUTURE

As described earlier, the extensions in Tuen Mun totaling 5 km and 10 stops and costing more than HK\$300 million were completed in February 1992 (hence the operating system now totals 28 route km with 51 stops).

A HK\$150 million 2-km extension with four stops is being built to serve another new town called Tin Shui Wai, which will house 135,000 people by 1996, to be commissioned by early 1993. To cope with patronage growth and to serve the Tin Shui Wai extension, 30 new LRVs costing almost HK\$400 million are on order and they will be delivered between October 1992 and early 1993.

With continued population growth in the TSA and system expansion, it is projected that the LRT daily patronage will reach 420,000 by 1996.

Other potential extensions to the regional LRT system are on the drawing board, including a 2.1-km line in north Yuen Long—which will provide relief to the section running through Yuen Long town—further extensions in Tin Shui Wai, and a line in southeast Tuen Mun.

The government is now studying a rail link between the LRT and the urban rail system(s). The LRT could also possibly be extended northwards to the Chinese border at Lok Ma Chau to link with a proposed LRT system in the Shenzhen special economic zone that will connect to its Huang Tien Airport.

LRT systems have also been proposed for other areas in Hong Kong and these are being examined in detail by a rail development study commissioned by the Hong Kong government to be completed in early 1993. There is little doubt that the LRT has established its place in Hong Kong's public transport scene and will further grow and develop in the coming decade.