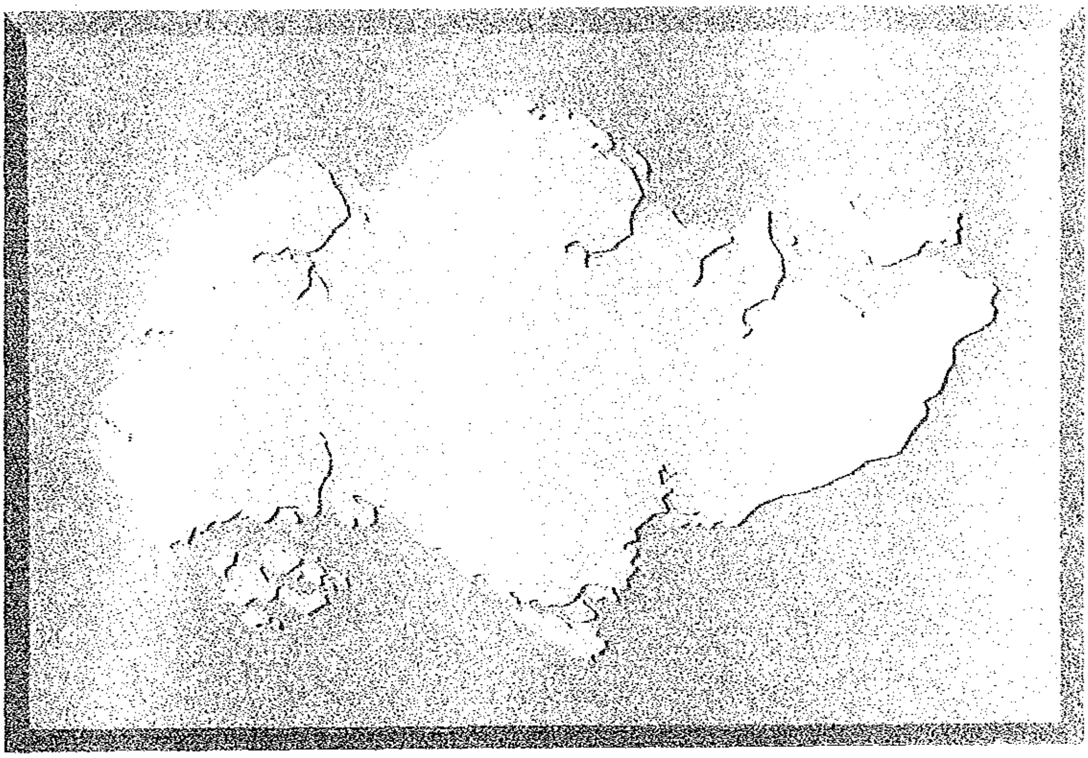
REPUBLIC OF SINGAPORE

SINGAPORE URBAN TRANSPORT IMPROVEMENT STUDY (SUTIS)

EXECUTIVE SUMMARY



NOVEMBER 1988

Japan International Cooperation Agency

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PREFACE

In response to a request from the Government of the Republic of Singapore, the Government of Japan decided to conduct a study of the Urban Transport Improvement Project in Singapore and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Singapore a study team, led by Mr. Shizuo IWATA, comprising experts from ALMEC Co., Ltd. and the Pacific Consultants International Co., Ltd. three times; firstly from September 1987 to January 1988, secondly from March 1988 to July 1988, and lastly in August 1988.

The team had discussions with the officials concerned of the Government of the Republic of Singapore and conducted field surveys.

After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the development of the Project and to the promotion of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Singapore for their close cooperation extended to the team.

November 1988

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

November 1988

His Excellency Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Sir:

We are pleased to formally submit herewith the final report on "Singapore Urban Transport Improvement Study (SUTIS)". This study report comprising an Executive Summary, a Main Text and five (5) Technical Reports, embodies the results of the study undertaken by ALMEC Corporation in a joint-venture with Pacific Consultants International from August 1987 to November 1988.

The main objective of the study for the first phase was to study, on a schematic basis, the introduction of new transit systems in large-scale new towns and other potential areas. For the second phase, to examine in detail, the feasibility of a case study for the selected areas. We hope that this study would be of valuable assistance to the Government of the Republic of Singapore for the future development of its transportation schemes.

We wish to express our appreciation and sincere gratitutde to the officials of your Agency, Advisory Committee, the Embassy of Japan in Singapore as well as to the officials of the agencies concerned in the Government of Singapore, particularly the Public Works Department, for the assistance and cooperation extended to the Study Team.

Very truly yours,

SHIZUO IWATA
Team Leader
The Singapore Urban
Transport Improvement
Study (SUTIS)

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1. INTRODUCTION

- The two-phase Singapore Urban Transport Improvement Study (SUTIS) commissioned in September 1987 to the JICA Study Team, has the following objectives:

  - Under the first phase, to study on a schematic basis, the introduction of new urban transit systems in large-scale new towns already developed and/or are in the process of development now or in the future. This phase of the study shall also take into account the existing and planned construction of the expressway system and the Mass Rapid Transit (MRT) system to improve the towns' public transport system and environment. Potential areas other than new towns are also to be considered; and

  - Under the second phase, to examine in detail the feasibility of introducing new urban transit systems as a case study in selected area(s) identified in the first phase.

- During the first phase, the study consisted of the following activities:

  - Submission/Discussion of Inception Report.

  - Conduct of supplemental transport surveys, including a limited home interview survey (HIS) for Ang Mo Kio new town residents, interviews with Public Works Department (PWD) officials, and passenger and bus survey at the Ang Mo Kio bus interchange.

  - Analysis of feeder transport demand.

  - Study of the Housing Development Board (HDB) New Towns.

  - Comparison of existing new transit systems.

  - Preliminary planning on the improvement of feeder transport system for the identified areas.

  - Environmental study for new towns.

  - Selection and identification of study areas and possible public transit systems, for further study in the second phase.

- The results of the first phase study were included in the Interim Report discussed in March 1988. Several areas were identified for case studies under the second phase. The extent of work for each case was also defined, as follows:

  1) Ang Mo Kio New Town: This area represents a typical, developed new town. A detailed study was undertaken.

2) Simpang New Town: This area is being planned and is, therefore considered suitable for a case study on the feasibility of integrating new town development that includes planning for a new transit system. Conceptual plans were subsequently prepared and their feasiblity examined.

3) Other Areas: For purposes of a preliminary study and conceptual planning activities, the following areas were also considered:

   a) Ang Mo Kio/Hougang/Marine Parade Route
   b) Orchard Road/Marina Centre Corridor
   c) Orchard/Sentosa Route

A group of new transit systems with intermediate passenger capacity were selected for further study in each of the above study areas.

- Under the second phase, the following activities were undertaken:

  - Conduct of supplemental transport surveys, including a limited HIS for Ang Mo Kio new town residents, interviews with PWD officials, and passenger survey at the Ang Mo Kio bus interchange to determine "after situation" of the commencement of operation of the MRT system; and, a pedestrian survey along Orchard Road.

  - Conduct of more detailed case study for Ang Mo Kio new town to include transport demand analysis, route planning, systems and operations planning, facility planning and construction cost estimation, project evaluation, etc.

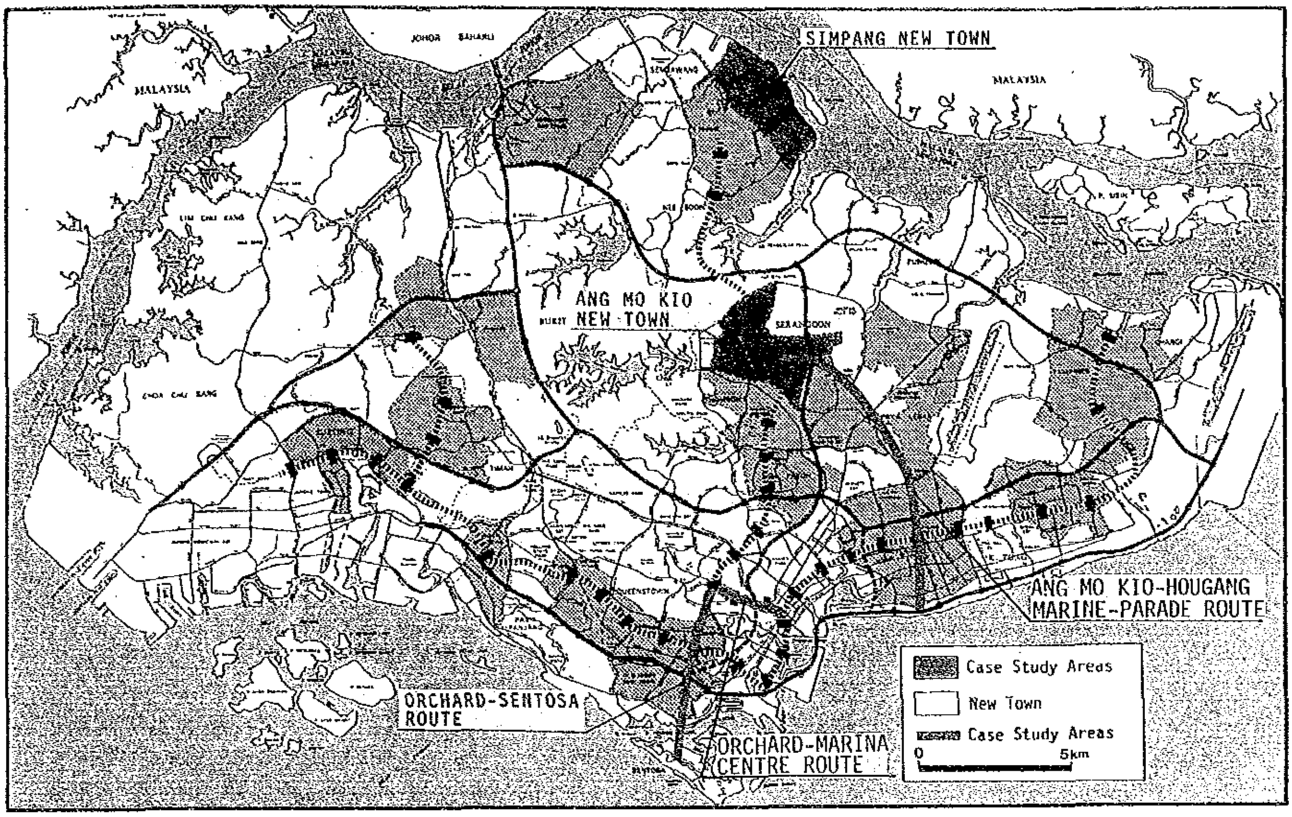
  - Conduct of case studies on preliminary basis for Simpang new town, Ang Mo Kio/Hougang/Marine Parade Route, Orchard/Sentosa Route, and Orchard/Marina Centre Route.

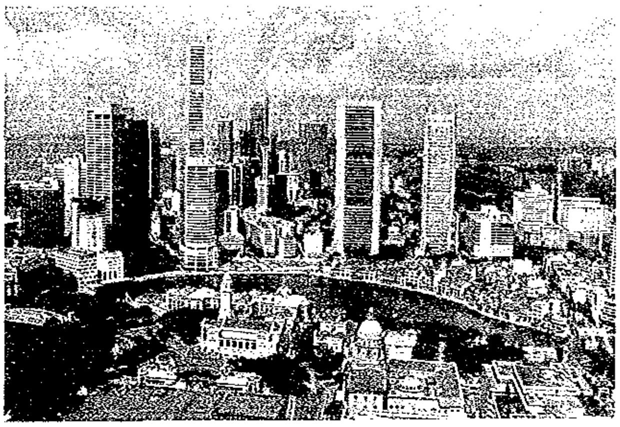
This Report summarizes all the results, conclusions and recommendations of the first and second phases of the Study undertaken between September 1987 and July 1988, as well as, incorporate pertinent comments and reviews submitted during discussions with relevant government agencies.

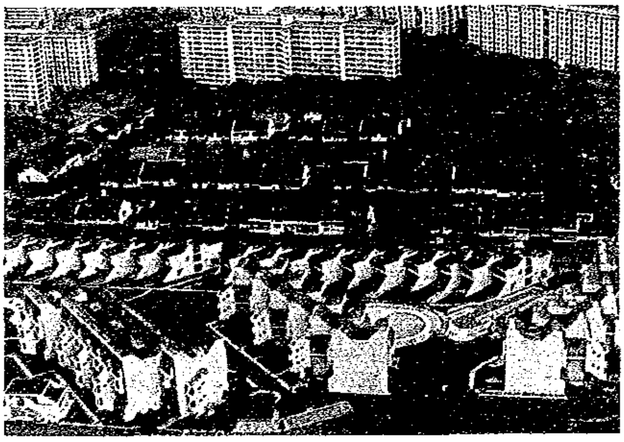
In addition, five technical reports were prepared to provide more detailed information on major aspects of the study. These technical reports are, as follows:

1) Supplemental Transport Surveys
2) Existing Feeder Transport System and Demand
3) Study on HDB New Towns
4) Environmental Surveys
5) Comparison of Available New Transit Systems

Figure 1 The Location of Study Areas







2. URBAN DEVELOPMENT PROFILE

- Singapore is one of the few countries in the world where urban planning initiatives have been successfully implemented. The Concept Plan lays out the overall directions on a long term basis, while the Master Plan sets out the regulations for land use through zoning, density, and plot ratio control and land reservation for various public uses, i.e., for implementation within the short-term period. The Concept Plan, otherwise called the Ring Plan, envisages the development of a ring of new satellite towns around the Central Water Catchment Area.

  These planned urban developments including the medium to high density new towns, CBD and industrial areas are designed to be linked and integrated with strategically developed island-wide expressways and MRT systems. The basic urban infrastructure in Singapore is approaching completion.

- The socio-economic features of the Singapore society has changed rapidly over the years. Population growth rate decreased from a high of 2.8% per year in 1970 to 1.3% in 1980 and further to 1.1% in 1986. Reduction in the average household size or family nuclearization has also been taking place. As of 1986, 85% of the total population reside in HDB new towns. Per capita GDP grew from S$10,149 in 1978 to S$16,494 in 1987. Alongside with the increase in household income, household ownership of durable assets also increased, except cars, which is relatively low compared to the income level of Singaporeans. It is foreseen that with the further growth of Singapore's economy and improvement in the standard of living there will be a stronger demand and better prospect for more diversified urban services/activities and higher quality/level of transport services, as well as the desire for car ownership.

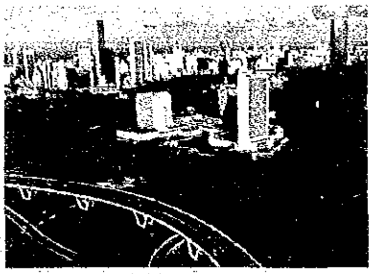
- There are, at present, twenty HDB new towns with an average overall completion rate of about 68%. Approximately, half of these have been completed, while the other half are in various stages of development. These new towns are expected to form the central activity centers of the Ring Plan.

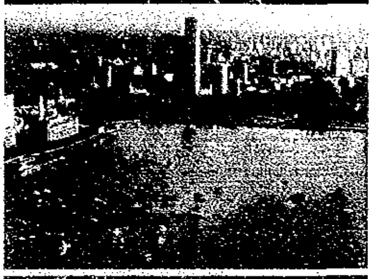
Table 1

Changes in Land Use Between 1967 and 1982

Land Use	1967		1982		Increase/Decrease	
	Area in ha.	(%)	Area in ha.	(%)	Area in ha.	(%)
Residential	7,484	(13.8)	8,716	(15.3)	1,232	(16.5)
Commercial	710	(1.3)	803	(1.4)	92	(13.1)
Industrial & Warehouse	728	(1.3)	3,345	(5.9)	2,620	(360.0)
Educational/Institution	1,471	(2.7)	2,506	(4.4)	1,035	(70.4)
Transportation	2,656	(4.9)	7,457	(13.1)	4,801	(180.8)
Utilities	438	(0.8)	1,002	(1.8)	564	(128.8)
Sub-Total (Urban Use)	13,859	(25.5)	24,351	(42.7)	10,492	(75.7)
Agricultural	14,282	(26.3)	8,101	(14.2)	-6,181	(-43.3)
Reserved and Others	26,162	(48.2)	24,588	(43.1)	-1,574	(-6.0)
Total	54,303	(100.0)	57,040	(100.0)	2,737	(5.0)

Source: 1982 Land/Building Use: Report of Survey Planning Department, Ministry of National Development





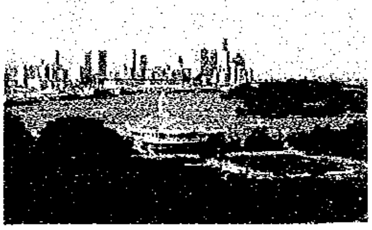


Figure 2 Urban Growth Pattern

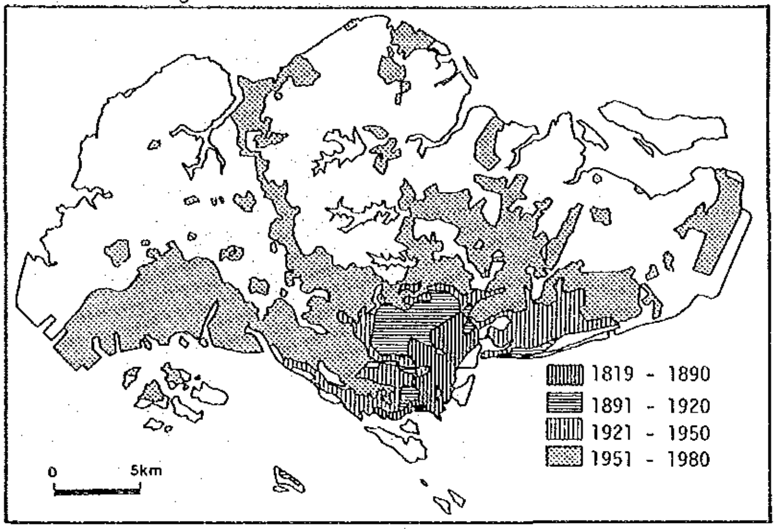
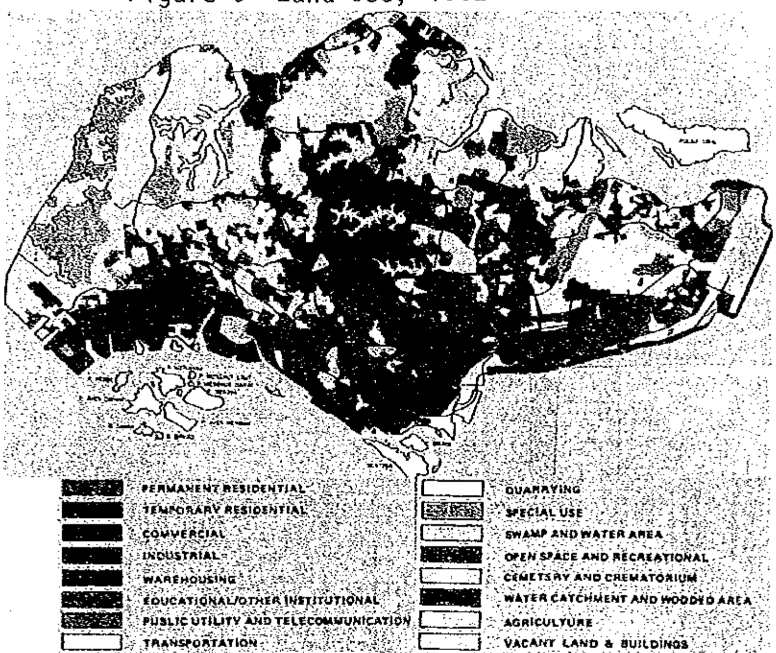
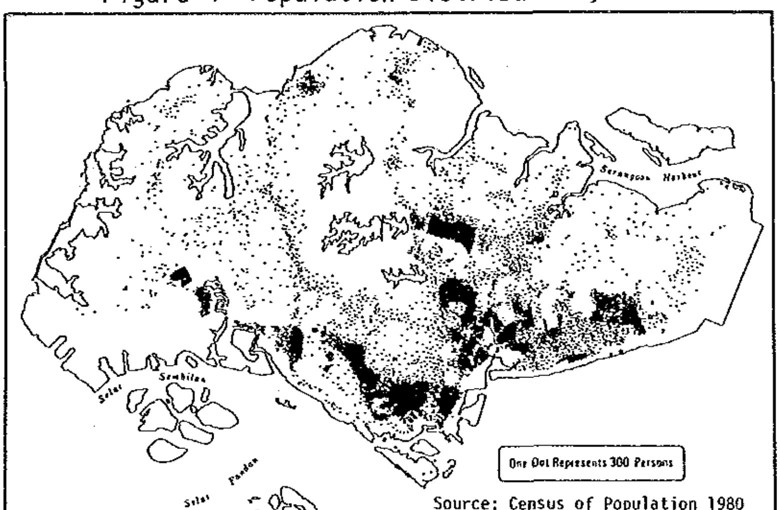


Figure 3 Land Use, 1982



Source: Report of Survey Planning Department on the 1982 Land & Building Use

Figure 4 Population Distribution, 1980



Source: Census of Population 1980

3. URBAN TRANSPORT SYSTEM

- Singapore's urban transport system consists primarily of well-developed road networks, coupled with a densely configured bus transport system. Public roads in 1986 had a total length of 2,690 kms, including 77 km of expressways and 460 km of major arterial roads. The 67-km long MRT system, comprising of a 22-km long North-South line and a 39-km long East-West line with a 6-km long branch line, started partial operations in November 1987 and is expected to be in full operation by 1990. The MRT system of 42 stations (15 underground and 27 above ground) connects major new towns and the Orchard Road Corridor and the CBD. It, thus, offers a very attractive transport mode with a high level of services.

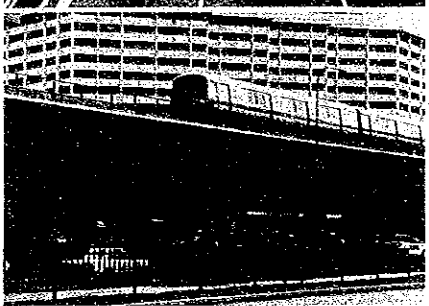
- In 1980, urban transport demand totalled some 3.7 million trips/day and is estimated to reach 4.2 million by 1990. The modal split between public and private (53% and 47% in 1980) is expected to remain the same due mainly to the current policy of restricting ownership and usage of cars. The traffic demand distribution pattern is not so CBD-oriented, inasmuch as of the total traffic demand, trips to/from the CBD accounts for only about 25%.

- Singapore is one of the world's few metropolises that is relatively free from urban transport problems such as traffic congestion, excessive environmental pollution, and high accident rates. This is largely due to the successful simultaneous implementation of several transport system management measures and policies, such as: (a) extensive road network development, (b) well-controlled land use and urban development, (c) restriction in ownership of private vehicles, (d) extensive implementation of traffic control and management, including Area Licensing Scheme for CBD, (e) well-developed bus transport system, and (f) strong/effective enforcement capabilities. The development of the MRT system and the expansion of planned expressways will further contribute to the improvement of the existing traffic situation.

- While much has been done on the supply side, demand for mobility and transport services has been changing rapidly at the same time. The economy has grown tremendously and is expected to grow further. With increased household income, the expenditure pattern of the people has accordingly changed that will result to increasing demands for improved levels of services and various activities. The major areas of concern in the future society of Singapore would be, as follows:

  - increased demand for diversified services and activities;
  - increased demand for car-ownership; and,
  - increased demand for a better living environment.

  In addition to the above internal requirements, Singapore would also have to meet the increasing demand from the international community, either in terms of tourism or other business endeavors. An efficient and quality urban system in Singapore will, therefore, continue to be an important infrastructure to maintain its principal advantage of attracting increasing demands of the international community.



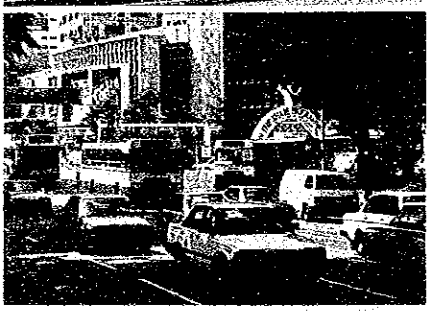


Figure 5 Major Transport System

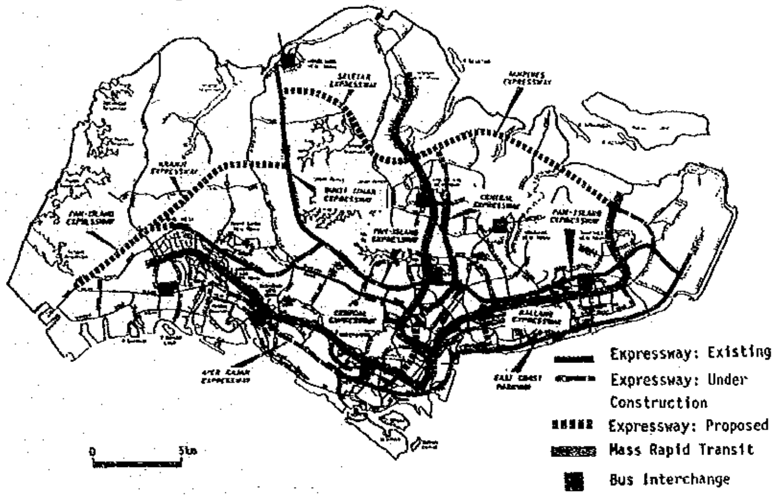


Figure 6 Bus Network

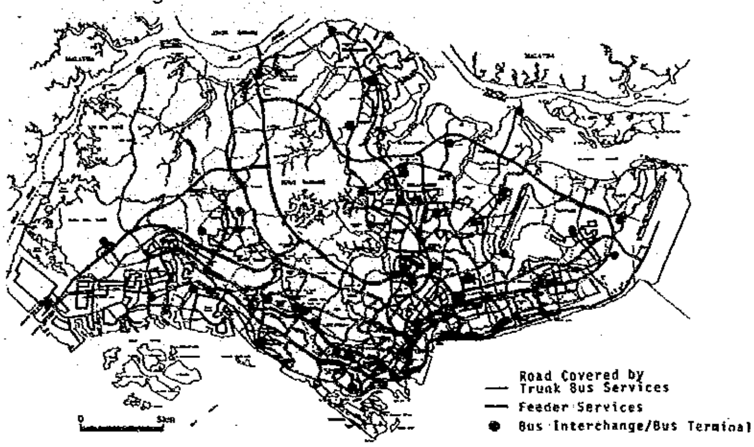
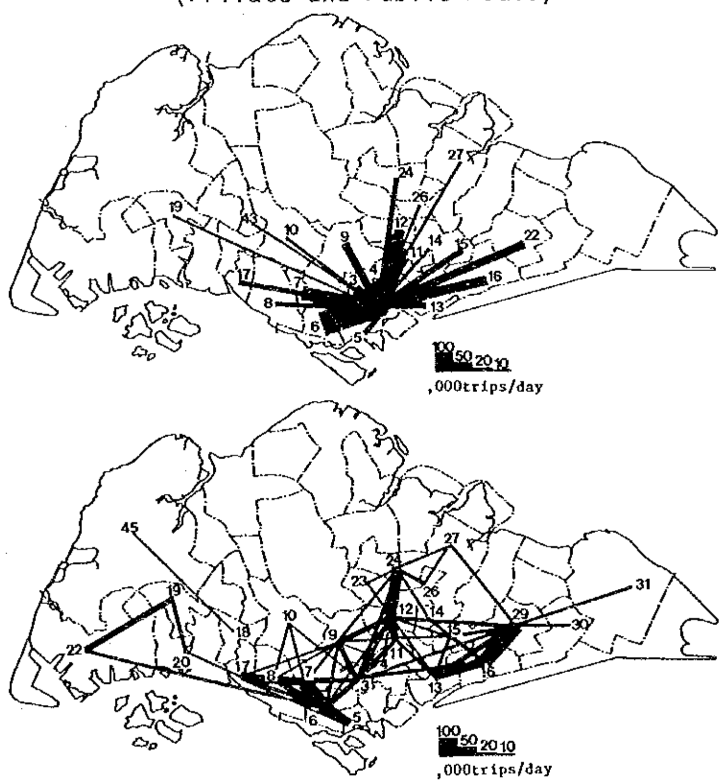


Figure 7 Distribution of Inter-Zonal Trips (Private and Public Modes) 1980



Zone No.	
6	BKT. Merah
7	Queenstown
11	Jalan Besar
12	Toa Payoh
15	Geylang
17	Clementi
19	Jurong East
21	Jurong West
22	Jurong Industr.
23	Bishan
24	Ang Mo Kio
26	Serangoon
27	Hougang
29	Bedok
31	Changi Airport
32	Tampines
33	Pasir Ris
36	Yishum
39	Woodlands
41	Choa Chukang
42	Bikit Panjang

4. FEEDER TRANSPORT SERVICES

- The existing feeder traffic is best described, in the Singaporean context, as that which includes: (a) portion of trips made by sub-modes other than the representative modes, (b) local trips, and (c) other types of trips distributed outside the trunk transport system. In order to examine the characteristics of feeder traffic demand, the following supplemental surveys were conducted:

  (a) Limited HIS for Ang Mo Kio residents, before and after the opening of the MRT system.

  (b) PWD officials survey, before and after the opening of the MRT.

  (c) Bus traffic survey at Ang Mo Kio bus interchange before and after the opening of the MRT.

  (d) Bus waiting time survey.

  (e) Orchard Road pedestrian survey.

- Among the feeder transport modes in Singapore, the more important ones are, as follows:

  Feeder Bus: This is the most widely practised feeder transport mode in Singapore. Among the PWD officials who stay in new towns, more than 40% use it one way or another.

  Walk: This is the largest and most unavoidable feeder mode. The few limited surveys conducted in SUTIS indicate that contrary to expectations, people do not mind walking. If the walking time is less than 5 minutes, very few mind; complaints become obvious only when it is more than 10 minutes walking. Average travel time of walk only trips of Ang Mo Kio residents is 16 minutes.

  Car (Kiss & Ride, Park & Ride): This is a practise wherein a person is driven by car to a bus stop/interchange and then transfers onto a public transport to continue the journey. "Kiss and ride" is more popularly practised rather than "park and ride." Among the PWD officials, 35% of the total or 85% of the car-owning households practise "kiss and ride." Of those who practice kiss and ride, 21% do it daily and mainly to/from work. On the other hand, only 4% of the total or 11% of the car-owning households practises "park and ride."

- Feeder bus services cover major HDB new towns, Jurong Industrial Area and other housing and industrial estates. They ply within the new towns or industrial areas for passenger collection and distribution to/from the bus interchange and also for local travel within the area. In 1987, there were 84 feeder bus services, out of which 65 services or 77% operate in HDB new tonws, while 19 operate in the other areas including Jurong Industrial Area and HDB housing estates. They are provided by Singapore Bus Service Ltd. (SBS) and Trans Island Bus Service Ltd. (TIBS). TIBS provides 7 services in Woodlands and Yishun new towns, while SBS provides 59 for the other new towns.

Feeder bus services mostly originate or terminate at a bus interchange to be connected with trunk bus services. They are characterized as follows:

- Short Route Distance: The average round trip distance is 6.9 km and 86% cover a route distance less than 10 kms.
- Wide Coverage of Service Areas: The average spacing between bus stops is 410 meters. The residential areas in new towns are generally well covered by feeder bus services mostly within 250 to 300 meters from bus stops.
- Frequent Service: An average bus service operates every 5.1 minutes. The most frequent service operates every 3 minutes for peak hours.
- Long Operating Hours: It usually operates from 0500 hours through 2400 hours, approximately thirty minutes earlier or later than trunk busoperation.
- Cheap Bus Fare: It has a flat fare system. Most feeder services in new towns charge only 15 cents.

The feeder bus services are assessed by PWD officials as shown in Table 3.

Table 2
Modal Interchange of Inter-Town Trip of Ang Mo Kio New Town (From Town to Outside Only)

Main Mode \ Access Mode	Walk (Direct)	Car	Traukn Bus	Feeder Bus	Total
Motorcycle	100	-	-	-	100
Car	99	-	-	1	100
Car-pool	87	-	-	13	100
Taxi	100	-	-	-	100
MRT	54	2	3	41	100
Trunk Bus	51	-	7	42	100
Feeder Bus	83	-	-	17	100
Scheme B	100	-	-	-	100
School/Company Bus	93	-	-	2	100
Othres	100	-	-	-	100

Source: SUTIS 1988 HIS

Table 3
Assessment of Feeder Bus Operating Conditions by PWD Officials

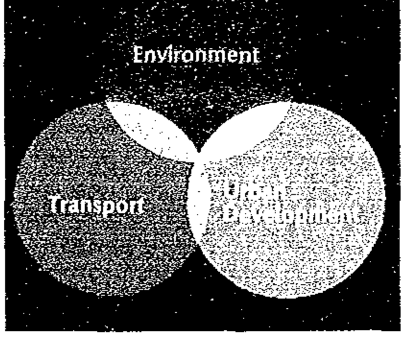
Items		% of those who consider: bad or very bad	acceptable	good
Service Frequency	Peak Hrs	28.9	53.8	17.3
	Off - peak	40.5	55.7	3.8
Operating Hours	Peak Hrs	26.5	58.3	15.2
	Off - peak	35.9	55.8	8.3
Riding Condition of Bus	Drivers Attidude	13.3	74.1	12.6
	Seat Availability	21.9	64.4	13.7
	Riding Comfort	16.3	73.6	10.1
	Cleanliness	22.0	71.7	6.3
Discomfort in Bus	Air Pollution	31.6	65.8	2.6
	Noise	43.1	60.0	1.9
	Heat / Temperature	54.8	42.7	2.5
Physical Condition of Bus	Steps	17.8	77.1	5.1
	Door Width	16.5	76.6	7.0
	Safety at Steps/ Door	13.2	80.5	6.3

5. FEEDER TRANSPORT INPROVEMENT PLANNING DIRECTION AND OPPORTUNITIES

- The recently opened MRT provides high quality tranport services and the competitive opportunity for the public transport system vis-a-vis private cars along the MRT routes. However, it is also clear that an overall improvement of transport services has to be addressed from the viewpoint of door-to-door transport service. This is particularly the case in Singapore where the existing public transport system is normally distinguished between trunk and feeder transport. While the MRT reduces the present travel time along trunk routes nearly to half, people have to spend relatively much more time, under less comfortable situation, for feeder transport. In this context, the improvement of feeder services is likely to become a critical issue.

- It would be ideal to obtain an efficient public transport system that can be competitive, or serve as an alternative for private cars. Singapore is one of the countries which can best achieve this goal due to the following inherent factors : (a) a strategically located MRT providing high quality service linking all major new towns, the CBD and other major traffic generating sources, (b) administrative ease of planning and decision making in a city state with one level of government, and (c) the presence of an instiutionally effective means and capabilities of controlling urban development.

  In order, however, to achieve the above goal effectively, it is essential to look into the issue not only from its transportation aspect but also from the total urban development aspect. Investments into quality transport development always require such sizeable resources that it would be difficult to be justified by mere replacement of the existing system with a new system; it would only become feasible when the new system is developed as an integral and strategic part of the envisioned total urban/community development scenario. The overall planning goals of feeder transport improvement can, therefore, be set as follows:



Improve the living environment
- Short-term: reduce noise, air pollution and other nuisances caused by motor vehicles
- Long-term: increase overall amenities

Improve transport efficiency and capabilities
- Short-term: restructure existing feeder transport system in compliance with the MRT within the existing transport system.
- Long-term: develop/create a more competitive new public transport system by integrating the MRT with the new transit mode. To substitute or compete with *the private car usage.*

Encourage better urban development
- Short-term: provide transport services to various land uses where demand exists/is expected
- Long-term: realize the envisioned community/urban development.

- Various areas where feeder transport improvements are required in different manners were identified. They are categorized, as follows:

  Area I: where better feeder transport system for new town residents and activities can be provided. The major function is to link MRT station(s) with the residences to make new town movement efficient and to preserve better living environmental conditions. Most of the new towns are included in this category (not only those which are served by MRT directly but also those which are isolated from MRT)

  Area II: where better transport links and services between MRT stations and major traffic generating sources, such as industrial area, educational facilities, port and airport, recreational facilities, and others can be provided. For example, one end of a trip is a new town or residence area, while on the other end, various activity areas are distributed. For the improvement of door-to-door services, Area II must be considered simultaneously with Area I.

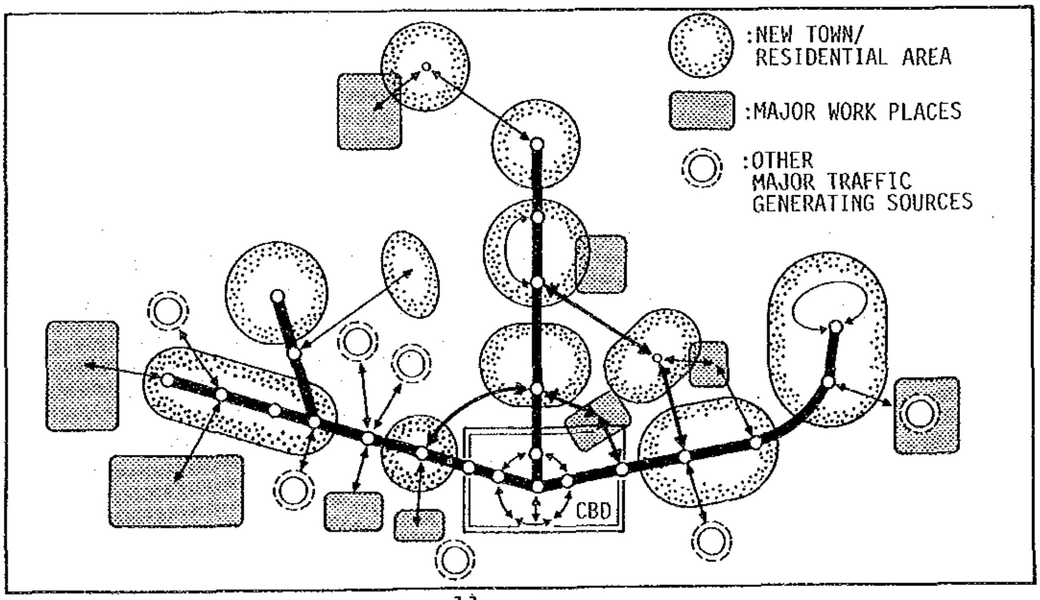
  Area III: where a better internal feeder transport network can be provided. There are a number of locations where demand is high within a relatively small area; hence, it would require quality service. They include various parts of CBD, university campus or science park, airport complex, etc.

  Area IV: where the existing/planned trunk transport system can be more effectively configured or supplemented by an intermediate capacity transit system rather than by an expanding trunk system. Development of secondary transport route along circumferential direction has a great possibility.

  The possible planning areas are conceptually identified, as shown in Figure 8.

Figure 8

Conceptual Understanding of Potential Areas of Feeder Service Improvement



6. AVAILABLE NEW TRANSIT SYSTEMS

- Three groups of existing systems have been carefully studied for possible introduction to each of the case studies as to: (a) transport capabilities; transport capacity and flexibility in operation, (b) impact on the environment; noise and aesthetic factor, (c) technological maturity, (d) construction cost, and (e) operation and maintenance costs. The selected groups of transport systems are, as follows:

<u>Group I</u>: The systems of this group are supported with relatively matured technologies and most widely applied, particularly in Japan and USA. An average car has approximately 75 to 100 passenger capacity, supported by rubber tyre. The systems are fully automated and meet passenger demand of 5,000 to 10,000/hour/direction. Considering the transport capabilities and technological maturity and experiences, they are considered the most realistic ones to be applied in most of the new towns in Singapore.

Table 4

Outline of New Transit Systems Selected for Case Studies

ITEM		GROUP I		GROUP II		GROUP III	
Definition		· Intermediate transit capacity · Technologically matured · Relatively extensive applications		· Smaller transit capacity · Limited application		· Highly expected systems in the near future	
						Magnetic Leviated	Personal Rapid Transit
Representative System		Kobe Portliner	Miami Metromover	Dortmund H-Bahn	Sydney Mini-monorail	M-Bahn	Morgan Town PRT
System Outline	Purpose	feeder to MRT intra-island loop	feeder to MRT CBD loop	feeder to S-Bahn shuttle in campus	feeder to MRT CBD loop	feeder to S-Bahn experimental line	feeder to MRT intra-area service
	Route length (km) Station Spacing (m)	6.4 943	3.0 375	1.05 1050	3.6 450	1.6 800	6.5 300
	Route Configuration	double track loop/shuttle	double track loop	single track shuttle	single track loop	double track shuttle	double track shuttle
	Guidance	lateral guidance	central guidance	running beam	running beam	lateral guidence	central guidance
	Car Support	rubber tyre (stuffed)	rubber tyre (air)	rubber tyre (solid)	rubber tyre	Magnetic leviated	rubber tyre
	Power	3 ph. alt. 600V	3 ph. alt. 380V	3 ph. alt. 500V	3 ph. alt 500V	DC360V	3 ph. alt. 575V
	Automation	full	full	full	full	full	full
Vehicle	Size: L x W x H (m)	8.4 x 2.4 x 3.2	11.9 x 2.9 x 3.6	8.2 x 2.1 x 2.4	32 x 2.1 x 2.3 (7 units/train)	11.8 x 2.3 x 2.3	4.7 x 2.0 x 2.7
	Weight (tons)	10.5	14.5	7.3	22/train	7.5	3.9
	Capacity/car	75	100	42	170/train	71	21
	Max speed (kph)	60	36	50	33		48
	Acc. (km/h/sec) Dec. (km/h/sec)	3.5 3.5	3.2 2.4	3.6 7.2	2.5 2.5	4.7 - 10.8 3.6	2.2 4.4
	Propulsion	90 kw x 8/train	75 kw x 2/car	23 kw x 4/car	37 kw x 6/train	Linear motor	45kw/car
Structure	Guideway	concrete partially steel	PC concrete and steel box	steel	steel	steel	PC concrete
	Max Gradient (%) Min Curvature (m)	50 30	100 24	45 30	up 44, down 60 20	120 30	100 9.1
Current Status		In operation since 1985	In operation since 1986	Operated only within University. Extension planned	Commercial Operation has started 1 Jul.1988	Commercial Operation has started 1 Jul 1988	In operation since 1974
Similar Systems		Osaka New Town Yukarigaoka YOMA Saitama Ina Line Others	Altanta A.P Tampa A.P Seatle A.P Changi A.P		Sentosa Monorail	HSST	CVS

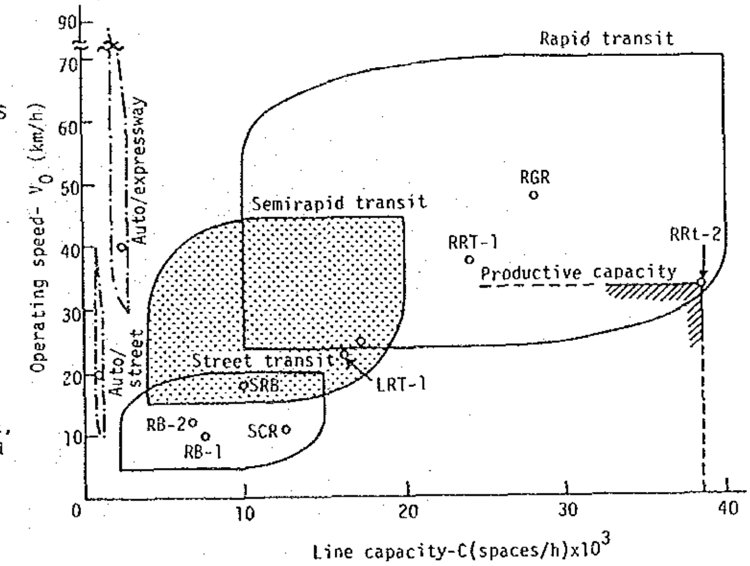
Source: Worked out by Study Team based on available information

Group II: This group specifically represents minimonorails which have smaller capacity than Group I systems. Lighter vehicle and monorail structure provide better aesthetic features. Although the application cases are yet limited, they are suited in CBD, recreational places, other activity centres.

Group III: The systems of this group are expected to be more highlighted in the near future. The one is the magnetic levitated systems and the other more personal type systems. The former with less noise and better riding comfort is an alternative to Group I systems. The latter system intends to provide more personal and flexible transport services.

Figure 9

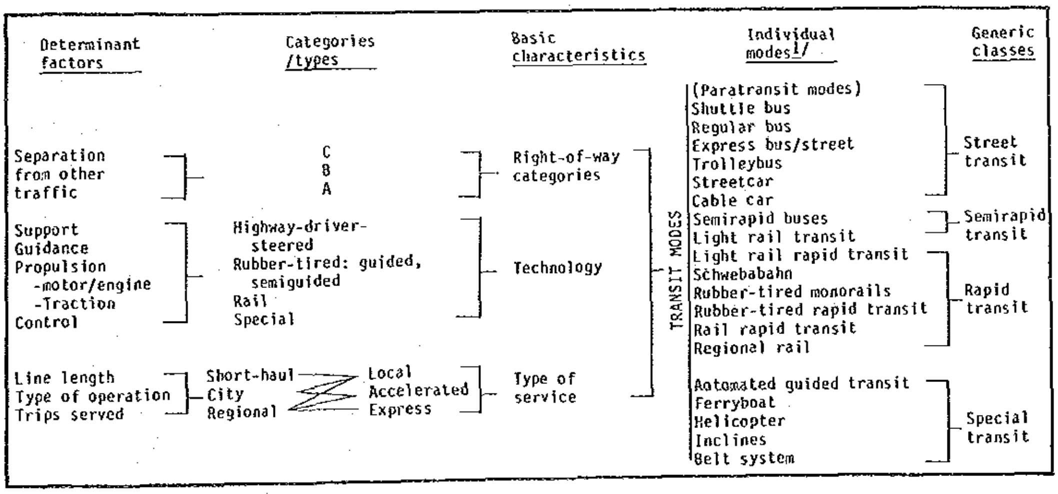
Transport Capabilities of Various Transit Modes



Note: RB: Regular bus,
SCR: Street car,
SRB: Semirapid bus
LRT: Light rail transit,
RRT: Rubber fired rapid transit
RGR: Regional rail

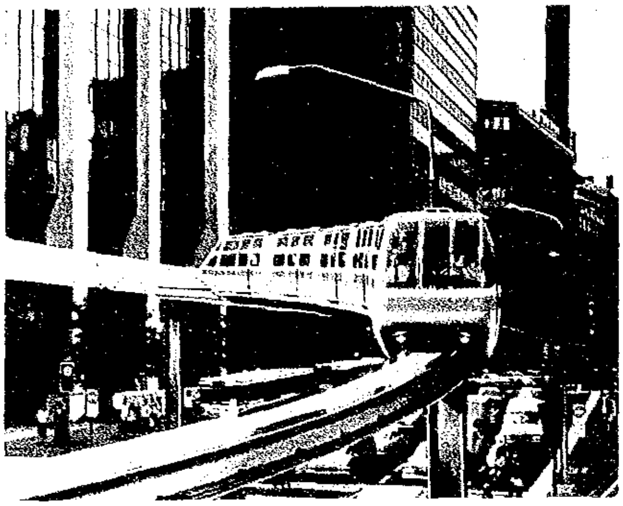
Figure 10

An Overview of Transit Mode Definition Classification, and Caracteristics

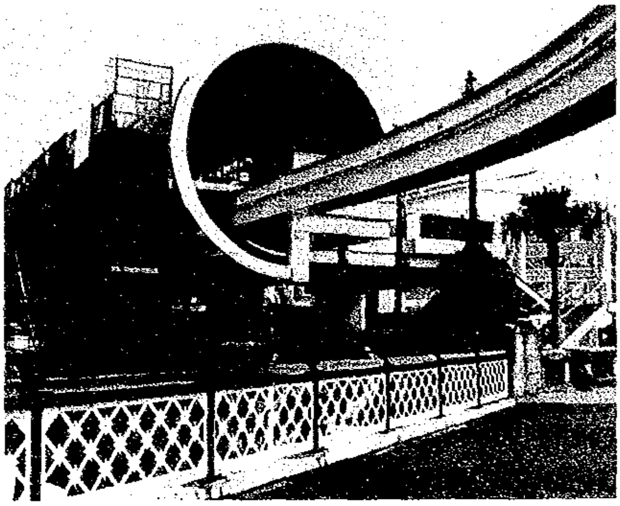


Source: Urban Public Transportation Systems and Technology Vukan, R. Vuehic, 1981

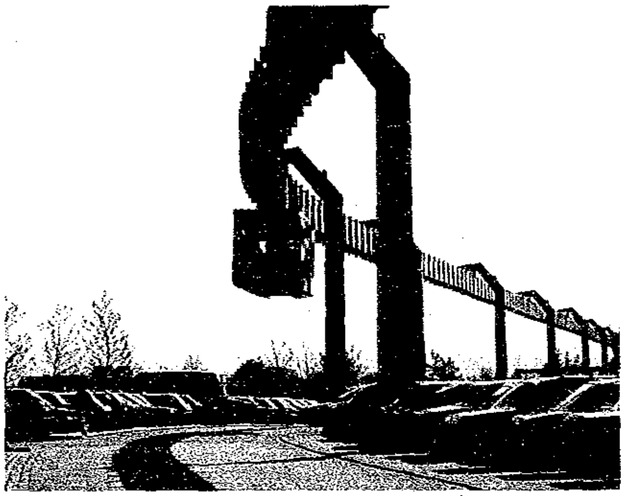
1/ A; fully controlled without grade crosing, B; longitudinally physically separated but with grade crosing, C; surface



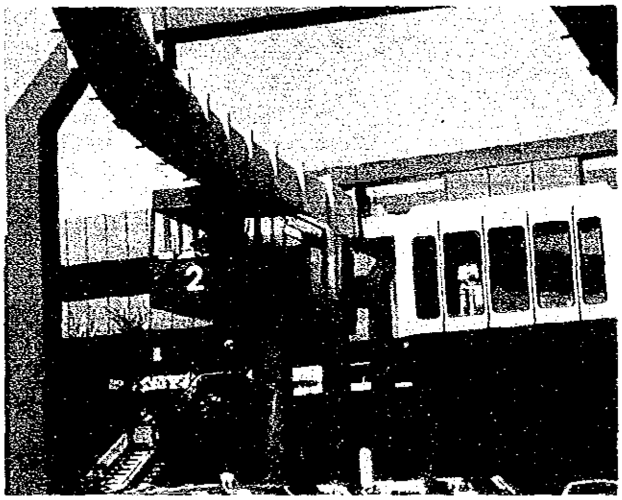
Sydney Mini-monorail



Sydney Mini-monorail Station

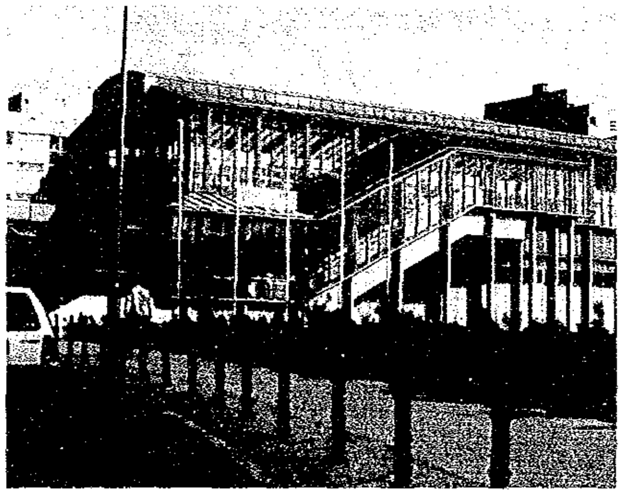


H-Bahn

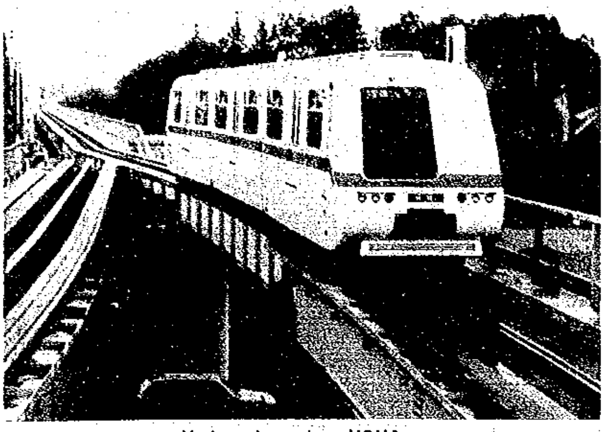


H-Bahn Station

M-Bahn



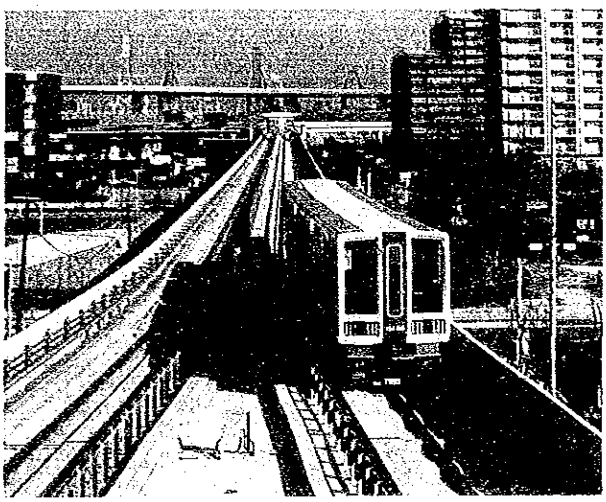
M-Bahn Station



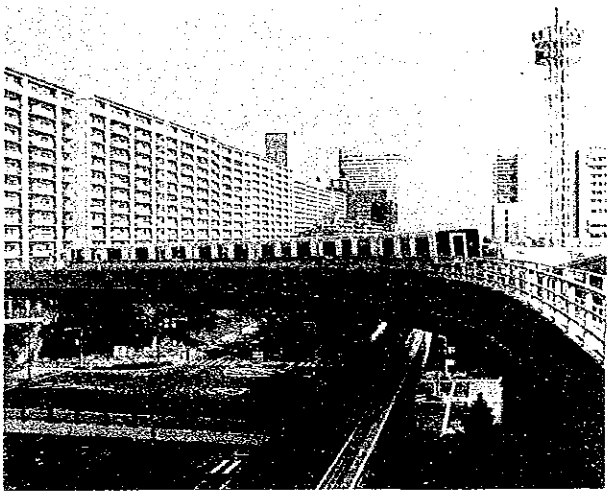
Yukarigaoka VONA

Figure 11

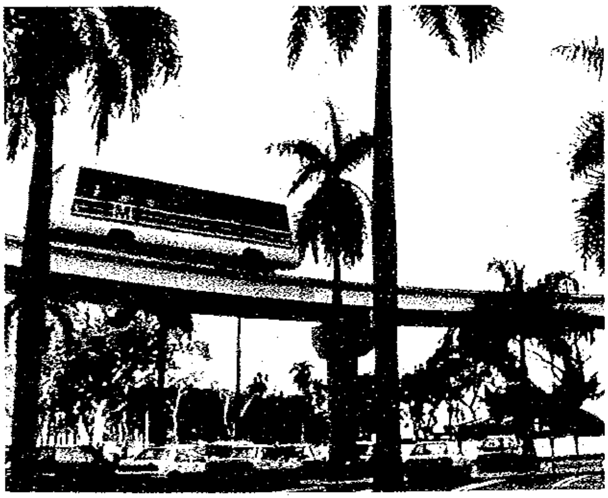
New Transit Systems Selected for Case Studies



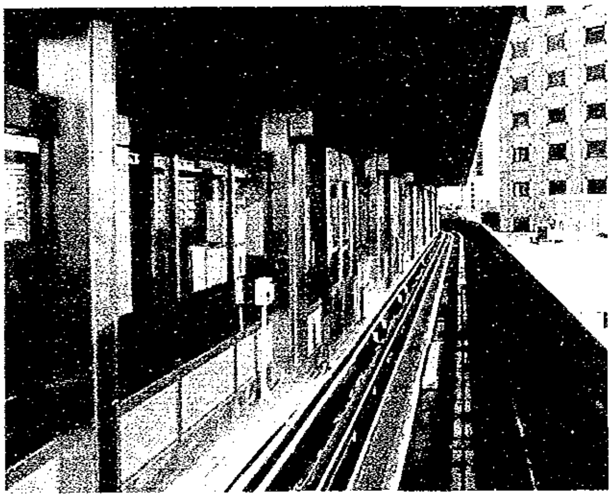
Osaka Nanko New Tram



KOBE Port Liner



Miami Metro Mover



Platform Door (Kobe Port Liner)

7. CASE STUDY ON ANG MO KIO NEW TOWN

New Town Profile

- Ang Mo Kio new town has some 200,000 residents occupying 740 ha of land and is located in the north, about 12 to 15 km from the CBD. The area extends over 4 km in the east-west and 3 km in the north-south directions. Of the total land, 37% is allocated for residential use, while 17% and 16% are for industrial use and major road space, respectively. It provides 33,000 employment opportunities.

- Ang Mo Kio is served by both road transport and the MRT. With the commencement of the MRT operation, travel time along the trunk transport route has been reduced considerably: for example 55 to 65 minutes of bus travel time compared to MRT's 19 minutes between CBD (City Hall). bus travel time compared to MRT's 19 minutes. However, However, the bus remains the major transport mode for trunk system. Feeder services are dominated by the feeder bus system. The feeder bus system is operated with 55 buses at 3 to 8-minute headway, between 5:30 a.m. and 1:00 a.m. It serves 90,000 cash rides or a total of 128,000 passengers a day. The new town areas are densely covered by this bus network.

Traffic Demand

- The total traffic demand for Ang Mo Kio new town was estimated to be 405,500 motorized trips which comprised of 272,300 trips or 67% of the total by residents and 133,200 trips or 33% by non-residents. Of the total, public mode shares 319,600 trips or 79%, while private mode involves 85,900 trips or 21%. Walk trips dominate intra-new town movements. Feeder bus, school/company bus and car are the major transport modes for intra-town movements and share 44.3% 23.5%, and 13.6% of the total intra-new town traffic demand, respectively. On the other hand, trunk bus, MRT, and private car are the major modes for inter-town movements, which account for 43.5%, 19.7%, and 14.0% of the total inter-town traffic demand, respectively.

  Feeder traffic characteristics were examined by analyzing the sub-modal choice of trips based on the HIS results . In the case of inter-town trips, 54.1% of MRT users walk to/from stations, while 41.1% use feeder bus, 2.6% use trunk bus, and 1.8% use a car. On the average, the percentage of those who rely on feeder modes and use the MRT and trunk bus registered 45.9% and 49.1%, respectively. While 43.9% of public mode passengers use feeder modes, only 0.9% of private mode users rely on feeder modes. Intra-town trips, on the other hand, rely less on additional feeder modes.

- The average travel time for trunk bus users with and without feeder transport is 56.4 and 43.3 minutes, respectively. This implies that, on the average, a trunk bus user spends 13.2 minutes for a feeder transport. Considering that trunk bus passengers are likely to spend some time walking, the actual time required for feeder transport is estimated to be roughly 16 to 17 minutes. On the other hand, the average door-to-door travel time for intra-town movements is 20.5 minutes for the average of all modes. Those who walk all the way spend 16.5 minutes, while those using motorized modes spend 20 to 30 minutes.

Figure 12 Existing Land Use of Ang Mo Kio New Town

Table 5 Modal Share of Motorized Trips for Ang Mo Kio New Town

Representative Mode		Intra-Town		Inter-Town		Total	
		No.of Trips	%	No.of Trips	%	No.of Trips	%
Public Mode	MRT	1,400	1.6	62,500	19.7	63,900	15.8
	Trunk Bus	9,500	10.8	138,300	43.5	147,800	36.4
	Feeder Bus	38,900	44.3	9,200	2.9	48,100	11.9
	Scheme B	–	–	200	0.1	200	0.0
	School/Company Bus	20,700	23.5	28,500	8.9	49,200	12.1
	Others	1,200	1.4	9,200	2.9	10,400	2.6
	Sub-Total	71,700	81.6	247,900	78.0	319,600	78.8
Private Mode	Car	12,000	13.6	44,500	14.0	56,500	13.9
	Car-pool	–	–	1,700	0.5	1,700	0.4
	Taxi	1,200	1.4	4,000	1.3	5,200	1.3
	Motorcycle	3,000	3.4	19,500	6.2	22,500	5.6
	Sub-Total	16,200	18.4	69,700	22.0	85,900	21.2
TOTAL		87,900	100.0	317,600	100.0	405,500	100.0
Walk only		110,100	–	6,200	–	116,300	–

Source: 1988 SUTIS HIS
1/ Including trips by non-residents

Table 6 Sub-Modal Choice in Inter-Town Trips of Ang Mo Kio New Town

Trunk Mode	Feeder Mode (To/From)	No.of trips/Day				% of Trips Using Feeder
		Residents	Non-Residents	Total	%	
MRT	Walk	21,600	12,200	33,800	54.1	45.9
	Trunk Bus	1,000	600	1,600	2.6	
	Feeder Bus	16,400	9,300	25,700	41.1	
	Car	700	400	1,100	1.8	
	Car-pool	200	100	300	0.5	
	Sub-Total	39,900	22,600	62,500	100.0	
Trunk Bus	walk	45,100	25,300	60,400	50.9	49.1
	Trunk Bus	5,800	3,200	9,000	6.5	
	feeder Bus	37,600	21,000	58,600	42.2	
	Car-pool	200	100	300	0.2	
	Sub-Total	88,700	49,600	138,300	100.0	

Source: 1988 SUTIS HIS

- The impact of MRT on travel pattern is significant according to 1988 HIS conducted for Ang Mo Kio residents:

  - Travel Time: 94.2% of the residents say travel time has been reduced; the reduction in average travel time is 17 minutes. Considering that 5.8% say their travel time reduction increased by 13 minutes, the weighted average of travel time reduction is 15.3 minutes.

  - Fare: On the contrary, 91.4% of the residents say fare has been increased by 27 cents on the average, while 8.6% say fare has decreased by 91 cents. The weighted average of travel fare increase is 17 cents.

  - Walking Distance: 63.5% of the residents say walking distance has increased by 11 minutes, while 36.5% say it decreased by 8 minutes. The weighted average of increase in walking distance is therefore 4 minutes.

  - Punctuality and Reliability: 95% of the residents feel punctuality and reliability of travel have been increased. Half of them agreed the increase is considerable.

- The potential feeder traffic demand for the proposed new transport system is composed of the following traffic for both residents and non-residents:

  (a) Feeder portion of the existing inter-town traffic of public transport mode.

  (b) Existing intra-town traffic of public transport mode.

  (c) Diverted traffic from existing private car trips.

  (d) Diverted traffic from existing walk trips.

  (e) Induced traffic due to the decrease in generalized transport cost (sum of time cost, distance cost, and comfort).

  (f) Generated traffic as a result of urban development which is made possible due to the construction of the proposed system.

  The potential feeder traffic demand was estimated based on the existing modal share of the feeder traffic, and more particularly, with the following considerations:

  - The overall service level of the proposed new transit system will be higher than the existing feeder bus, although its coverage and application will be slightly less.

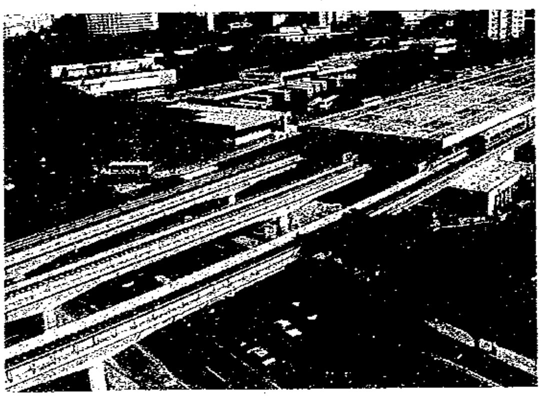
  - Diversion from private mode and walk trips can be expected.

  - Induced traffic and traffic due to urban development are not considered at this stage.

- The low side of the estimate is 122,700 passengers/day which is slightly lower than the present feeder bus passenger traffic of 138,350. The high side of the estimate is as many as 224,200 passengers/day. The percentage of inter-town traffic against total feeder traffic demand is 65% and 71% for low-side and high-side estimates, respectively.

Table 7
Estimated Potential Feeder Traffic Demand for the Proposed New Transit System

Mode		Intra-Town Trips Residents	Intra-Town Trips Non Residents	Intra-Town Trips Total	Inter-Town Traffic Residents	Inter-Town Traffic Non Residents	Inter-Town Traffic Total
Total Actual Demand	Public Private	56,200 10,300	15,500 5,900	71,700 16,200	158,600 47,200	89,300 22,500	247,900 69,700
	Total Motorized	66,500	21,400	87,900	205,800	111,800	317,600
	Walk	110,100	-	110,100	6,200	-	6,200
Actual % of Feeder Bus User	Public Private Walk	60.1 0 0	62.3 0 0	60.6 0 0	37.9 0.8 0	38.1 0.9 0	38.0 0.9 0
Estimated Share of NTS (%)	Public: High/Low Private: High/Low Walk: High/Low	70/50 20/0 20/0	70/50 10/0 20/0	- - -	50/35 30/0 0	50/35 30/0 -	- - -
Estimated Demand for NTS	Public: High Low	39,300 28,100	10,900 7,800	50,200 35,900	79,300 55,500	44,700 31,300	124,000 86,800
	Private: High Low	2,100 0	600 0	2,700 0	14,200 0	6,800 0	21,000 0
	Walk: High Low	22,000 0	4,300 0	26,300 0	0 0	0 0	0 0
	Total: High Low	63,400 28,100	15,800 7,800	79,200 35,900	93,500 55,500	51,500 31,300	145,000 86,800
	TOTAL:	HIGH: 224,200 LOW: 122,700 (Existing Feeder Bus Traffic: 138,350)					



System Plan

- There are a few types of systems which can be introduced in Ang Mo Kio new Town. However, the choice is practically for the systems between Group I and Group II. The major differences between the two groups pertain to transport capacity, structure type and operational experiences. For Ang Mo Kio, it is considered that Group I will meet the reqirements better because of the following reasons:

  (a) Group I system can handle more economically Ang Mo Kio new town's expected transport demand which is considerably large.

  (b) There are more cases of applications for Group I system, with proven technologies and operational experiences.

  Although a system has been selected, its specification on size, dimension, design and performance of cars and other sub-systems can be changed or modified within a certain range to best meet local requirements.

  Based on the various current state-of-the-art information, car cost was analyzed for different specifications. In general, the smaller the size, the higher the cost. Considering also the impact on structure cost, a decision was made to introduce a 75-passenger capacity car, with full automation and air conditioning.

- Alternative plans were prepared for routes of the proposed transport system with due consideration given to network configuration, alignments and location of stations. More specifically, the following factors were considered:

  - Traffic demand, in terms of quantity and quality
  - Required transport service level (scheduled speed, riding comfort, accessibility)
  - Land use
  - Availability of construction space
  - Environment
  - Geographical conditions
  - Minimum interference to existing structures/facilities as a restrictive factor

  The selected plan is composed of 21.6 kms of a single track loop route with 29 stations and 420-meter station spacing. This plan can cover most of the new town areas except the industrial area near Yio Chu Kang Station. It is also planned that the system can be extended towards the east eventually to form a regional secondary transit route.

- In order to confirm the proposed route more specifically, an alignment study was undertaken in detail, including a limited topographic survey along the possible routes/roads with frequent field reconnaissance surveys. The structures are planned, as much as possible on available public spaces. They are not placed in the middle of the roads but along the sidewalks for passenger convenience and for aesthetic appeal. Moreover,it would occupy less visual space and have more chances of being hidden by roadside trees.

Figure 13

An Image of the Proposed Car for Ang Mo Kio System

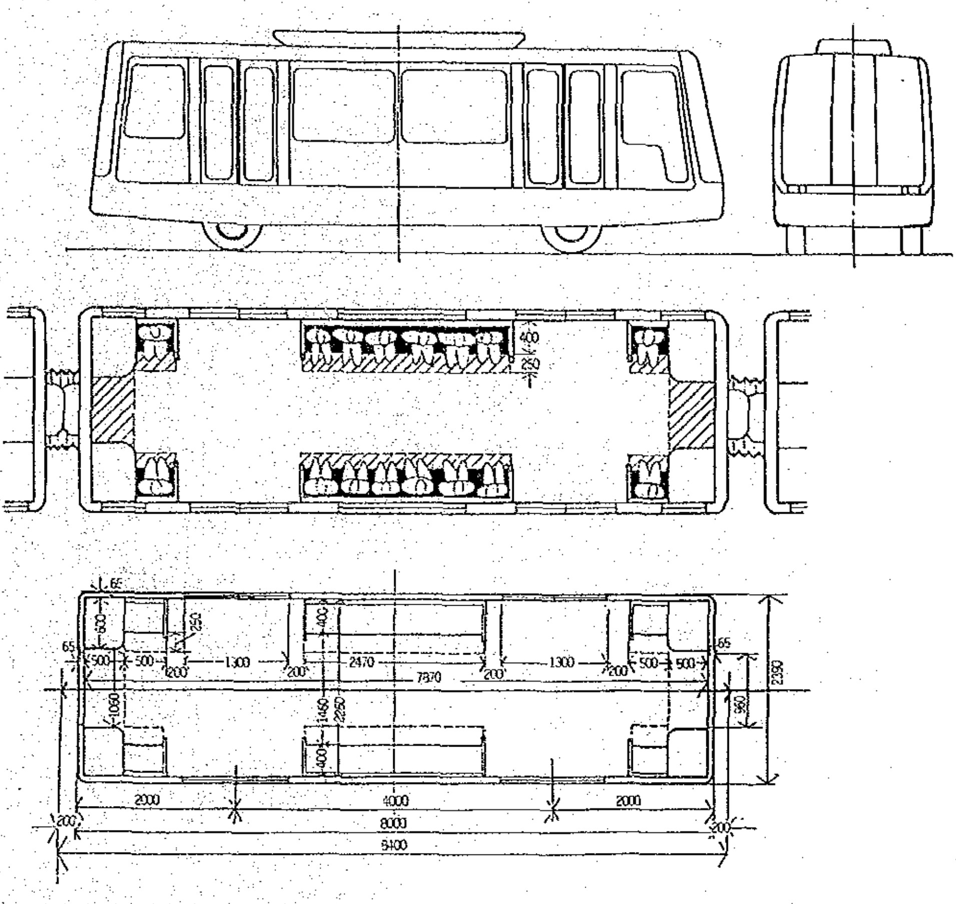


Table 8

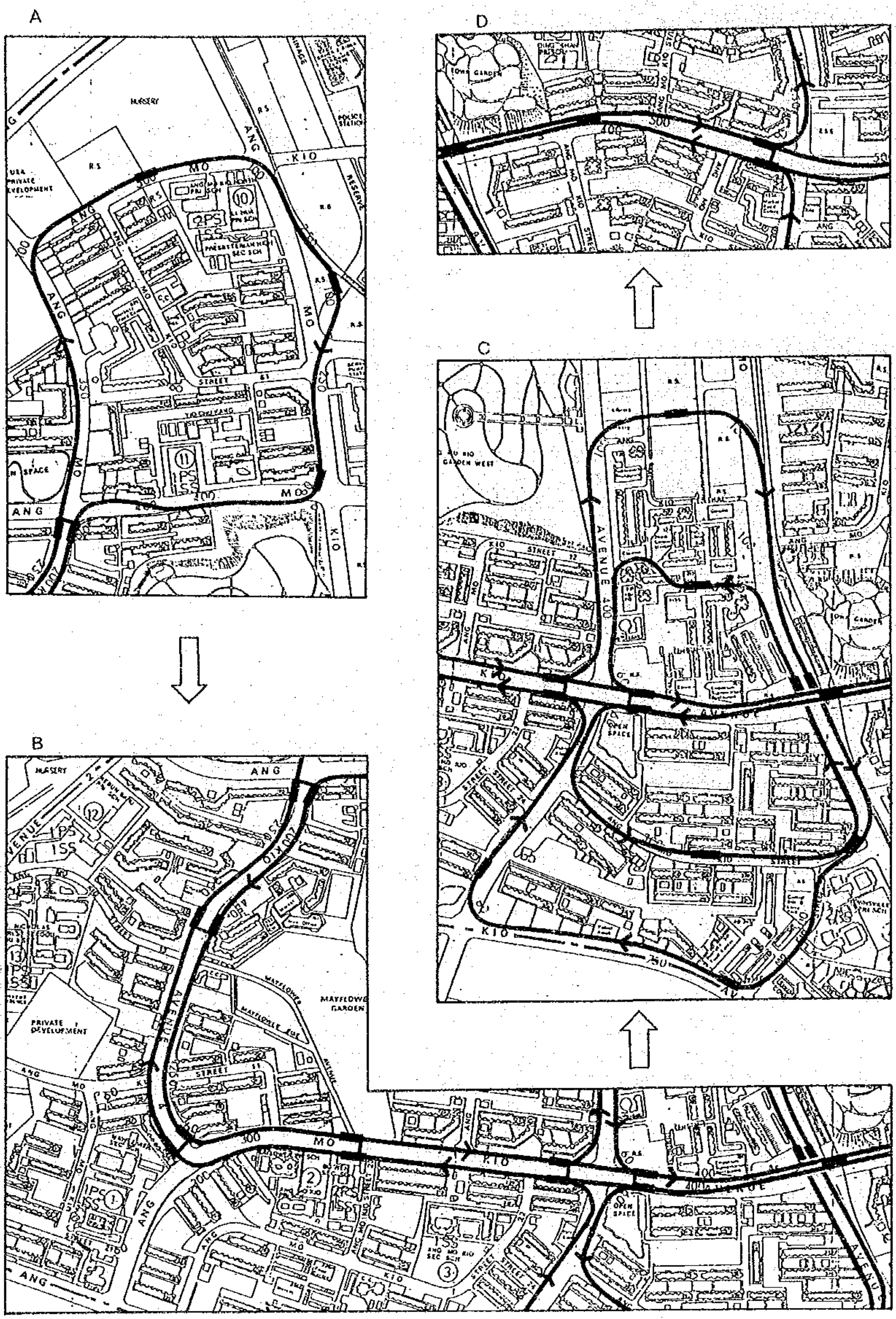
Summary of Operational Characteristics of the Proposed Ang Mo Kio System

Paticular			Desciption
A. System Performance (2 to 4-car train)			
	1. Transport Capacity (4-car-train	1) Max. Theoretical Sgl. Direction Cap.	18,000
		2) Max. Practical Sgl. Direction Cap.	12,000
	2. Headway	3) Min.Theoretical Headway	60 sec.
		4) Min. Practical Headway	90 sec.
	3. Speed	5) Max. System Civil Speed	65 Kph
		6) Average System Speed	Approx. 20kph
	4. Operation	7) Operating Modes	Scheduled
		8) Hours of Scheduled Operation per Day	18 - 20 hours
		9) Travelling Unit	up to 4-car trains
B. Vehicle Performance (guideway assumed clean and dry)		1) Max. Speed	65 kph
		2) Max. Gradeability	6 ‰
		3) Service Acceleration	1.0 m/s2
		4) Service Deceleration	1.0 m/s2
		5) Max. Jerk	1.0 m/s3
		6) Emergency Deceleration	1.25 m/s2
		7) Stopping Precision in Station	500mm
		8) One or Bi-directional	One directional
C. Stations		1) Type	On-line
		2) Type of Boarding	Level
		3) Minimum Vehicle Station Dwell Time	20 sec.

Table 9

Summary of Physical Description of Vehicle

Particular			Description
A. Vehicle			
	1. Suspension Type		Air tire (safety wheel) 4-wheel independent suspension; air bags as secondary suspension.
	2. Lateral Guidance		Solid rubber tired guide wheels, two per steering beam, two independent steering beams per car.
	3. Comfort		Enclosed vehicle, ventilated cooled
	4. Security		Two-way communication to central control
	5. Car Dimension	1) Overall Length	8,400 mm
		2) Overall Width	2,400 mm
		3) Overall Height	3,200 mm
	6. Weight	1) Empty Weight	10,000 kg.
		2) Gross Weight	18,000 kg.(fully loaded)
	7. Passenger Area	1) Total Pax Area	17.8 sq.m
		2) Floor Area for Seated Pax	5.3 sq.m
		3) Floor Area for Standing Pax	12.5 sq.m
		4) Vehicle Design Capacity	16 seated; 50 standing at 4/sq.m
		5) Vehicle Crash Capacity	16 seated; 100 standing at 8/sq.m
	8. Doors	1) Doorway Width	1,300mm
		2) Doorway Height	1,850mm
		3) No. of Doors per Vehicle	2 left side; 2 right side
B. Propulsion			
	1. Two compound-wound dc motors, chassis mounted		
	2. Motor Rating		100 kW at 1,100 rpm (1 h)
	3. Type Power		300 Vdc at 330 A
	4. Power Collection		440 (600)* VAC, 3-phase through steering beam-mounted collector shoes *When traffic demand is heavy


A
B
C
D
NURSERY
POLICE STATION
PRIVATE DEVELOPMENT
MAYFLOWER GARDEN
OPEN SPACE
ANG MO KIO
STREET
AVENUE

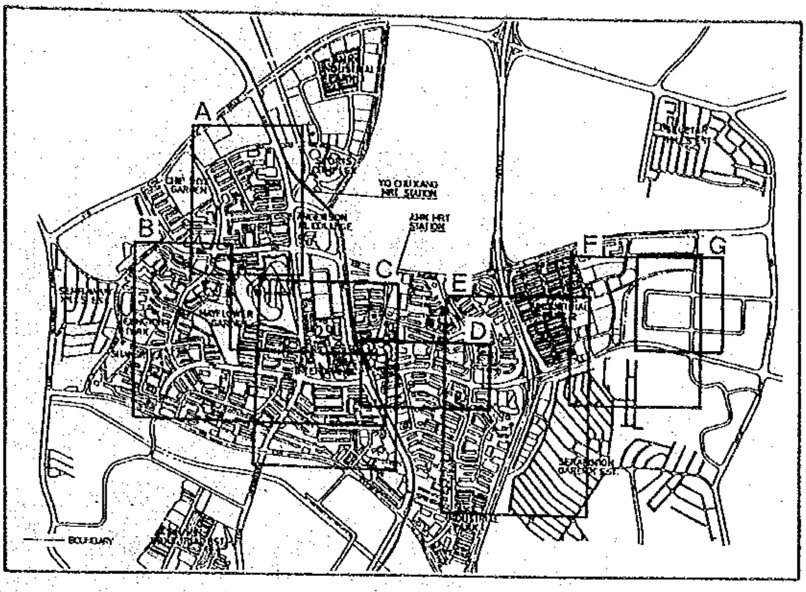
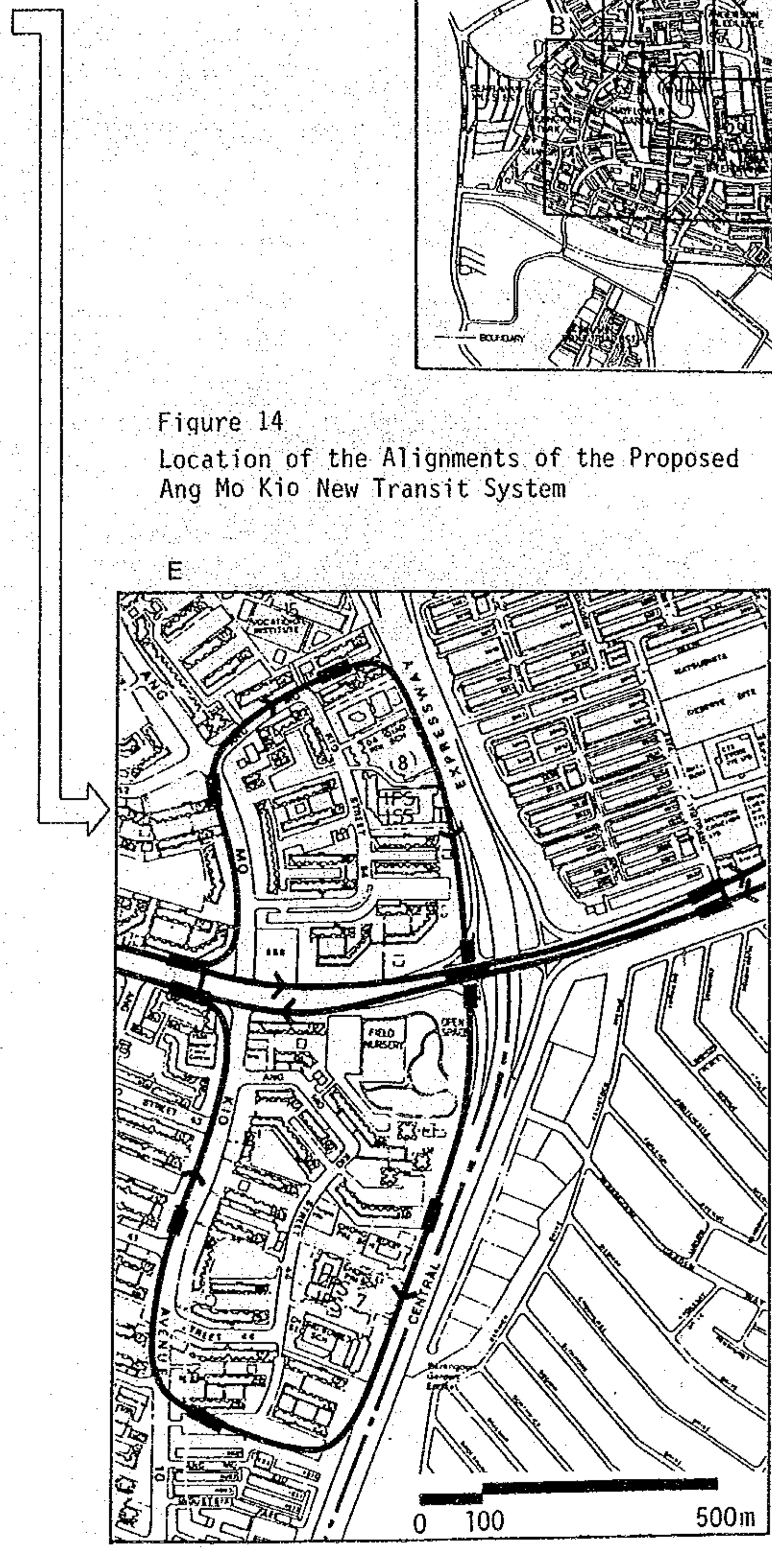


Figure 14
Location of the Alignments of the Proposed Ang Mo Kio New Transit System

E



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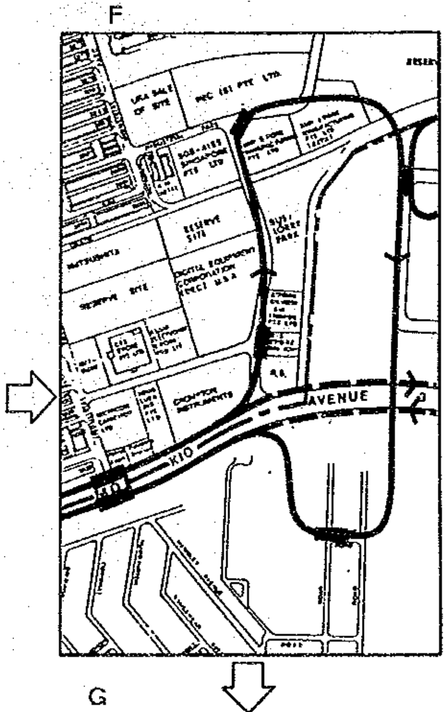

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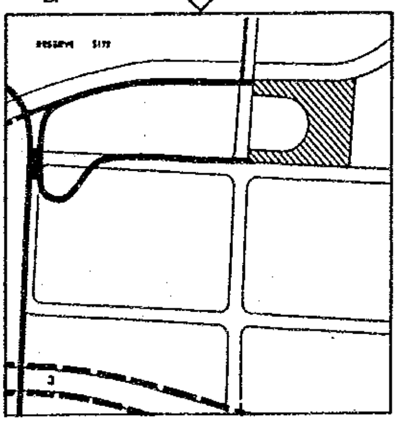


- Related facilities, i.e., carriageway structure, stations and terminals, depot/workshop, were studied in detail with due consideration of the following factors:

  (a) Assessment of the impact of car load on the structure to determine an optimal combination of car size and structure size.

  (b) Preparation of a set of temporary design standards to be applied for the proposed system. This includes loading condition, geometric standards for alignment, especially minimum curvature and maximum gradient.

  (c) Comparison of concrete structure and steel structure.

  (d) Aesthetic aspect of structures.

  (e) Environmental consideration.

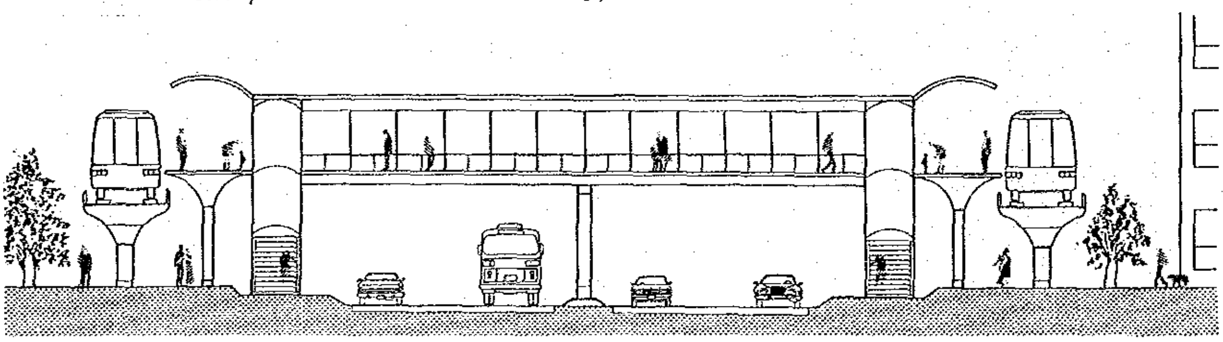
  (f) Users requirement and convenience with particular regard to the stations.

- Stations were designed to optimize convenience for the passengers/users. The basic design policy is to simplify station facilities as much as possible in order to lower costs, but at the same time, to allocate budget for the construction/provision of access facilities for the handicapped, such as lift and slope. Alternative plans were prepared for Ang Mo Kio central station, one underground and the other above ground. Although, at present, transfer to/from trunk bus is larger than that of to/from the MRT, it is likely that the MRT will increase its share as the system is extended and feeder services generally improve. Considering the above and cost implications, it is planned that the station be constructed right above the MRT so that passengers can transfer directly from one platform to the other.

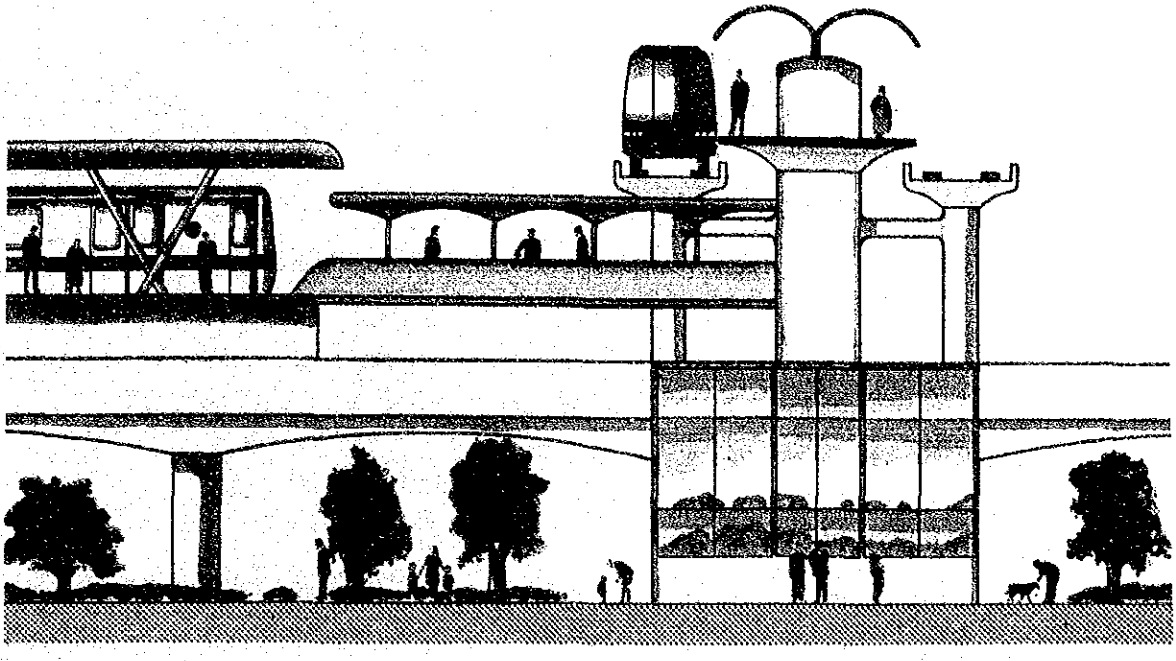
- Both depot and workshop are also required. It is more economical to put both in the same location due to size rather than provide them separately. Space requirement is approximately 1.4 ha for two storied type or 2.7 ha for at grade type, location of which will be in the industrial area, east of New Town.

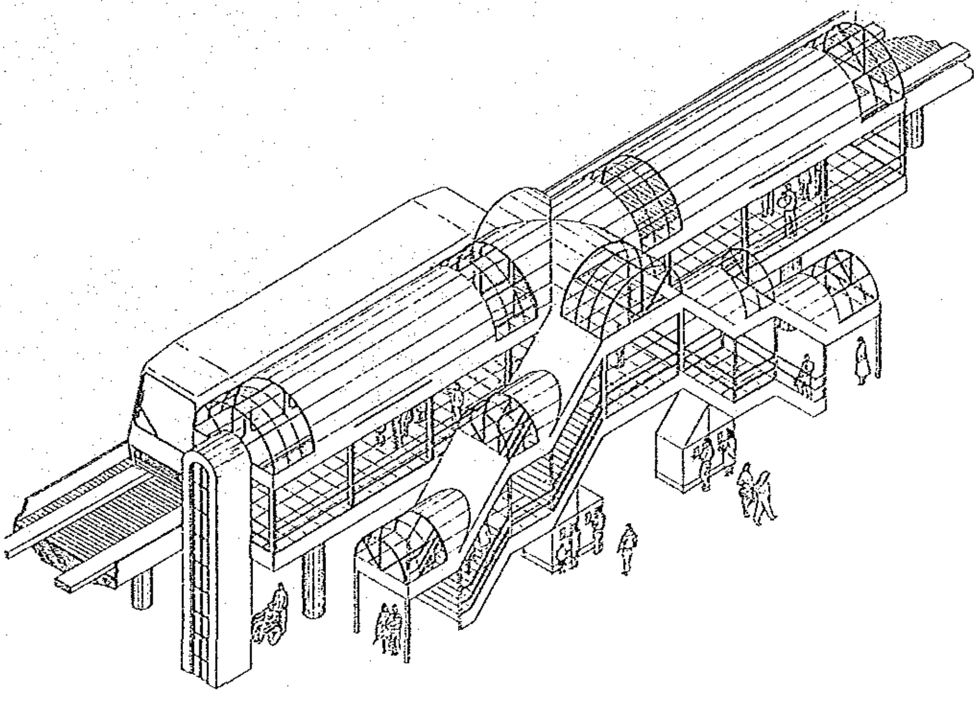
Figure 15

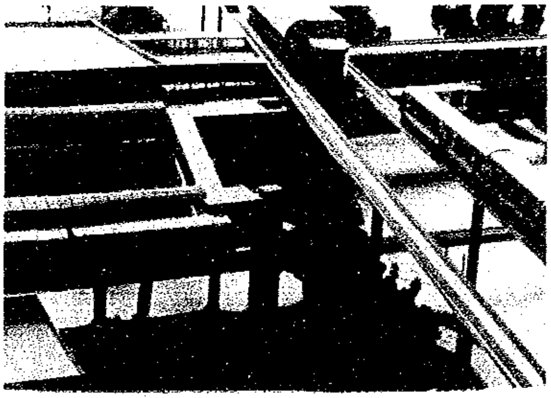
Conceptual Cross Section of Typical Intermediate Station

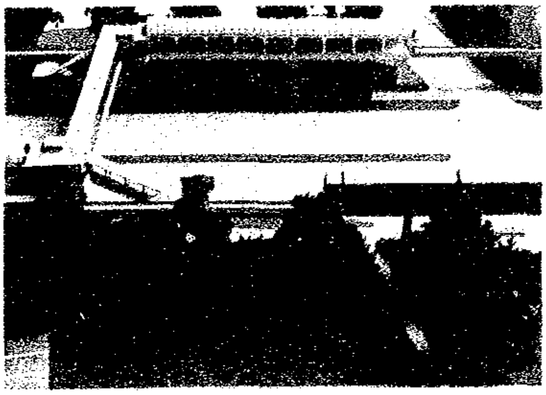


Conceptual Illustration for Ang Mo Kio Central Station









- In order to best meet the demand, the operational plan was set up with the following criteria:

  1) To meet the maximum passenger volume of 150,000 to 200,000 per day.

  2) To provide shorter headway services for passenger convenience.

  3) To allow for flexibility in operation and service pattern as demand changes.

  It will take 68 cars to be able to provide services at 3-minute headways during peak hours and 5-6 minutes during off-peak hours with a four-car train. An alternative is to operate at 2-minute headway with a three-car train.

- Subsystems are outlined, as follows:

  Control System: The proposed system is based on full automation. The advantages of full automation at present are not definitely justified, when compared with its relatively high cost, both for the control system and vehicles. However, at the same time, technological developments will work to push down the cost of automation. For such a system like Ang Mo Kio, which has a relatively complex route configuration compared with other existing new transit systems and intends to operate at short headways, an automatic control would be most ideal.

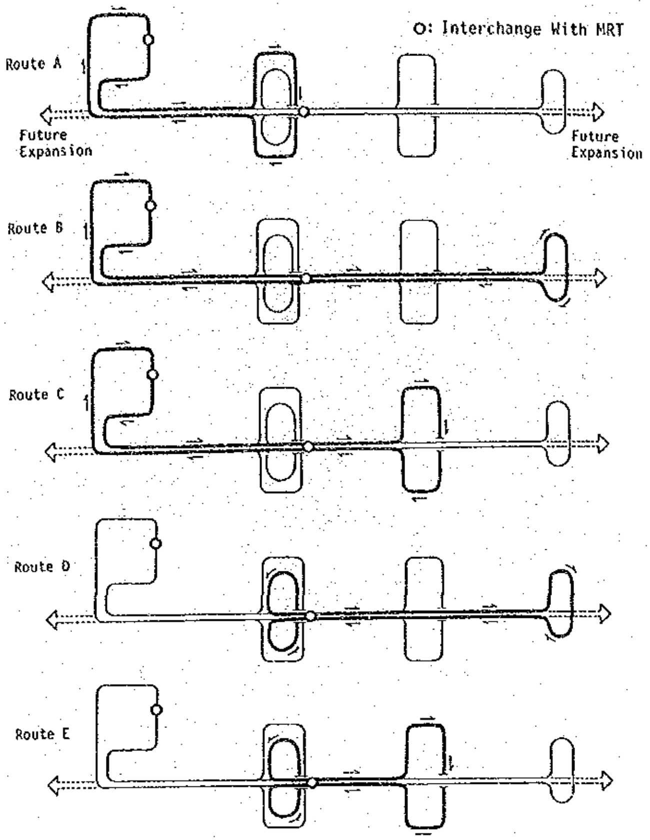
  Electric Power Supply: Electricity will feed the power. An industrial standard power voltage of 440v, 3-phase, 50HZ will be used. It is advantageous to apply said power due to its availability (the same is used for air conditions and the lighting system). In addition, it is possible to minimize cost using the system prevailing in the market.

  Fare Collection System: Since train operation is fully automated, fare collection might as well be fully automated, too. Through-ticketing with MRT is ideal for users. Flat fare will make it possible to simplify the facilities.

  Emergency and Safety Measures: Assurance in safety is one of the major concerns of the operator and society. This is particularly true to the various systems. During the early new transit system operation in Japan, an attendant was assigned on-board the fully automated train, mainly to relieve the anxiety of passengers and, partly, to monitor the automatic operation. After a few years of operation, this psychological aspect is no longer an issue and unmanned operation became the practice.

  Organization and Personnel: In order to operate and manage the proposed system, a separate organization with proper staffing is required. About eighty staff members and some contract workers will be needed.

Figure 16
Layout of Routes and Operation Indices

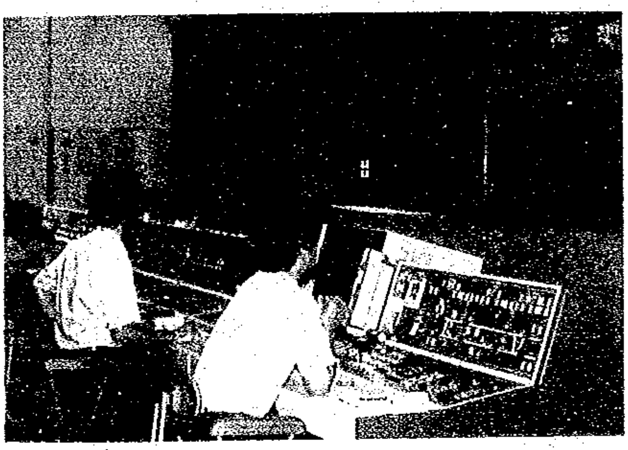


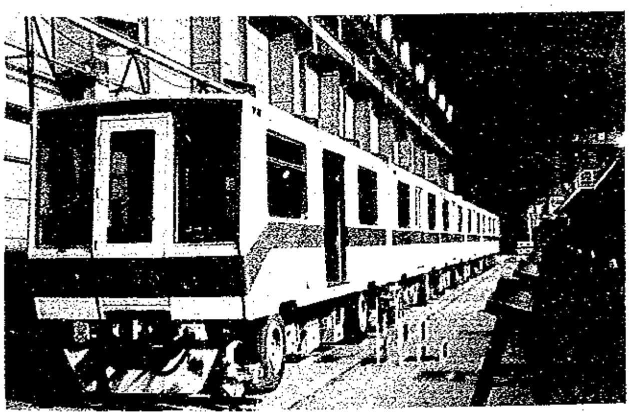
Operation Index by Route

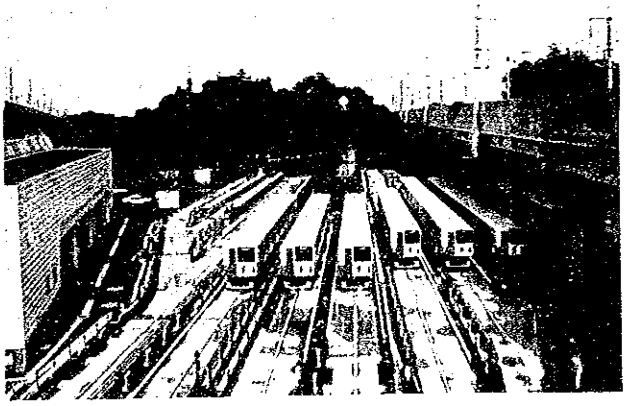
Route	Length (Km)	No. of Stops	Turn Around Time (min)	Scheduled Speed (Kph)
A	9.5	21	27	21.1
B	12.8	28	36	21.5
C	11.7	27	33	21.3
D	8.7	20	26	20.0
E	7.6	18	25	19.1

Table 10
Operational Characteristics of Selected Services

Item	Service Type			Total Operation
	A	B	E	
Service Kms	9.5 km	12.8 km	7.6 km	21.6 km of single track
No. of Sta.	20	28	18	29
Ave. Station Spacing (m)	475	456	422	420
Max. Speed (kph)	60	65	60	60 - 65
Scheduled Speed (kph)	21.1	21.5	19.1	19 - 22
Turn-around Time (min)	27	36	24	-
Headway (min)	6	6	6	3
No. of Train	4	7	4	A total of 15 trains
No. of Cars/ Train	4	4	4	4
No. of Cars Required	16	28	16	A total of 68 including 8 spare cars or 4 trains
Frequencies/day	121	122	121	A total of 243 at the most crowded section
Train kms/day	1,149.5	1,556.7	923.2	A total of 3,629.5
Car kms/day	4,598.0	6,226.9	3,692.9	A total of 14,517.8







- The total investment cost is estimated to be S$354 million or S$16.4 million/km (single-track length). Of the total investment costs, infrastructure costs, including civil works and station/building, share 44% while vehicle cost is 20% of the total.

  Accordingly, the operating cost is estimated to be S$7.6 million/year or S$20,720/day.

Table 11
Summary of Investment Costs for Proposed Ang Mo Kio System

Item	Amount: S$ 000	%
1. Civil Work	131,310	37.0
2. Station/Building	23,210	6.6
3. Depot	26,800	7.6
4. Vehicles	70,720	20.0
5. Power Supply	48,490	13.7
6. Control/Signalling /Telecommunications	53,610	15.1
Total	354,140	100.0
Cost/km (Single track length) : 16,400		

Table 12
Estimated Operating Cost for Proposed Ang Mo Kio System

Item	Amount: S$ 000	%
1) Vehicle Maintenance	1,523	20.1
2) Maintenance of Equipment and Facilities	2,592	34.3
3) Electric Consumption	1,431	18.9
4) Manpower	1,330	17.6
5) Overhead	688	9.1
Total: per year	7,564	100.0
per day ($)	20,723	-

An exercise was made to compare the construction costs of two single-track guideways and one double-track guideway for the carriageway. As the difference is only about 8%, it is recommend to use single track guideway mainly for aesthetic reasons and convenience in access to the stations.

Table 13
Comparison of Estimated Cost for Single-Track and Double-Track Guideways (Civil Works Only)

Guideway	Estimated (S$000/km)
Double-Track (A)	12,957
A Single-Track	6,977
Two Single-Tracks (B)	13,954
Ratio: (A)/(B)	1.08

Project Evaluation

o The project was evaluated from the economic, financial and environmental standpoints, the most critical of whch is its financial viability. The economic impact due to the completion of the project is extensive on transportation, environment, and urban development aspects. However, the tangible benefits are limited. Reduction in travel time has been the most significant factor. Assuming that each passenger will save 5 minutes, the project would generate an EIRR of 8.5% at an estimated average time value of S$3.1 for year 1988 and S$6.6 for year 2000, or Benefit Cost Ratio of 2.5 at 2% discount rate.

o The results of the financial analysis are summarized, as follows:

  (a) Without government subsidy, the project will not be financially viable.

  (b) If the government provides the cost of civil works and stations, the project will produce a positive internal rate of return of 2.7% at S¢30 fare level and 7.0% at S¢40.

(c) If the government provides for all investment costs, with the exception of vehicles, the project will give an attractive financial return of 14.5% at Sc30 fare.

- Positive environmental impact is expected in terms of noise and air pollution. Although the present environmental conditions in the new town are well within standard norms, the proposed transport system would further improve the situation. Impact on landscaping is subject to the design of structures and facilities. Light and single track guideway could add positive aesthetic value to the new town landscaping. Overall amenity in new town environment is expected to be significantly improved. Reduction in road traffic will not only increase road safety but will also increase road space, which can be of more and better use to pedestrians and other non-transport activities in the new town.

Table 14

Environmental Consequences due to New Transit System

Impact and Possible Consequences			NTS User	Road User	Community
Impact on Traffic	Reduction in Bus Traffic	Reduction in Noise and Air Pollution	○	○	○
Impact on Traffic	Reduction in Bus Traffic	Removal/Re-placement of Bus Facility	—	△ Saved space can be used for other purposes	
Impact on Traffic	Reduction in Bus Traffic	Improvement of Road Traffic Safety	△	○	○
Impact on Traffic	Generation of NTS Traffic	Improvement of Transport Amenity	○	—	—
Impact on Traffic	Changes in Pedestrian Traffic flow	Modification to Pedestrian Facilities	*	*	*
Impact on Traffic / Construction on NTS Facilities	Changes in Pedestrian Traffic flow / Station	Impact on Landuse	○	—	○
Construction on NTS Facilities	Station / Structures	Visual Effects	*	*	*
Construction on NTS Facilities	Structures	Blocking of Sunlight and Foliage	—	—	—

○ : Positive impact
△ : Positive limited impact
— : Insignificant impact
* : Impact could be positive or negative