Table 3.10

Assessment of Feeder Bus Operating Conditions by PWD Officials

Item		% 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 Attitude	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

Source: PWD Officials Survey, 1987

3.2.2 Kiss and Ride

This is a practice wherein a person is brought by car to a bus stop/interchange or MRT station and transfers onto a public transport to continue the journey.

According to the PWD survey, 20% of PWD officials practice kiss and ride; out of these, daily or regular usage (daily plus 3-4 days/week) account for only 8.4% (refer to Table 3.11).

The same table shows that their purpose is mainly to/from work (59%) and more than 60% are brought by family members.

Table 3.11

Practice of Kiss and Ride

Item		No. of Persons	%	%
Usage	Practice Do not Practice	75 295		20.3 79.7
	Total	370		100.0
Frequency per week	5 - 7 days 3 - 4 days 1 - 2 days Seldom No Answer	26 5 6 36 2	34.7 6.7 8.0 48.0 2.7	7.0 1.4 1.6 9.7 0.5
	Total	75	100.0	20.3
Purpose	To/From Work Others No Answer	44 26 5	58.7 34.7 6.7	
	Total	75	100.0	
Driver	Family member Friend Neighbours Others No Answer	46 12 2 10 5	61.3 16.0 2.7 13.3 6.7	
	Total	75	100.0	

Source: PWD Officials Survey in 1988.

3.2.3 Park and Ride

Park and ride means that a person drives himself to the bus stop/interchange, parks his car and then transfer to a public transport mode to continue the journey. This is not a very popular practice in Singapore. According to the PWD officials survey in 1987, only 4.4% of officials or 10.8% of those who belong to car-owning households practice park and ride. Those who practice it daily or regularly constitute only 2.1% of total PWD officials, as shown in Table 3.12.

Table 3.12

Park and Ride Practice of PWD Officials

Particular		Percentage		
Frequency	Daily 3-4 days/week 1-2 days/week Seldome	7.4 1.5 3.6 22.5	18.0 3.6 8.8 54.8	21.2 4.2 10.3 64.3
	Sub Total	35.0	85.2	100.0
Main Purpose	to/from Work Others	- -	- -	80.7 19.3
	Sub Total	-	-	100.0
Who Drive	Family Members Others	- -	- -	65.4 34.6
	Sub Total	-	-	100.0
Total Carowning Household		41.0	100.0	-
Total Who Replied		100.0	-	-

Source: PWD Officials Survey 1987

Their purpose is usually to/from work and cars are mostly parked either at fringe car parks of the CBD or somewhere outside the CBD.

The park and ride practice is therefore not foreseen to increase significantly under the present situation.

3.2.4 Walk

Walk is the largest and unavoidable feeder mode. However, there are not many studies nor information to determine the characteristics of walking in Singapore. Therefore, the study team obtained information on the characteristics of walking in various surveys. The results are summarized, as follows:

a) Walking Distance to Transport Facilities: Table 3.13 shows the average walking distance between the nearest MRT station or bus stop and home. It shows that MRT users walk for long distances of 700-800 meters, while bus users walk for less than 500 meters.

Table 3.13

Average Walking Distance/Time to Transport Facilities

To/From Home	Distance Meters	Time Minute	Data Source
MRT Station	705	(10.8)1/	PWD Official Survey, 1988
MRT Station	(810)1/	12.4	Ang Mo Kio HIS 1988
Bus Stop (Feeder Bus)	(320)1/	4.9	Ang Mo Kio HIS 1988
Bus Stop (Trunk & Feeder)	(410-450)1/	6.3-3.9	PWD Officials 1988

1/ Estimated based on walk speed of 65 meters per minute.

b) Walking Distance/Time for Walking Only Trips: According to the HIS survey in Ang Mo Kio New Town, the average walking time or distance for walk only trips within the new town is 16.5 minutes or 1,100 meters, as shown in Table 3.14. Within the new town, they walk for long distances, even if feeder bus services exist.

Table 3.14

Average Walking Time by Trip Purpose in AMK New Town (Walk only trips)

Trip Purpose	Average Walking Time (minutes)	Estimated Walking Distance (meters)1/
To Work	35.5	2,310
To School	16.9	1,100
To Home	16.3	1,060
Part of Business	16.1	1,050
Private	12.5	810
All Purpose	16.5	1,070

Source: Ang Mo Kio HIS, 1988.

1/ Estimated based on 65 meters per minute.

The other walking distance survey conducted in Orchard Road area shows that the average walking distance of pedestrians is about 600 meters. However, 50% of pedestrians walk for less than 400 meters, as shown in Table 3.15. The table, also, indicates that walking distance varies by purpose. "At work/business" and "to work/home" trips walk less than those with other purposes. Males walk farther than females.

Table 3.15

Distribution of Walking Distance of Pedestrians Along Orchard and Scotts Road

Items	Less than 100m	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1,000-1,499	1,500-1,999	2,000 and over	Total	Average Distance (Meters)
Trip Purpose:															
Shopping	4.2	14.9	13.6	12.8	10.6	5.1	4.4	8.1	4.7	2.5	12.2	3.6	3.2	100	636
Eating/Social	4.2	13.8	15.9	18.6	7.5	4.8	6.6	4.4	2.2	1.8	7.4	4.5	8.4	100	678
At Work/Business	9.0	14.7	17.7	13.7	9.0	6.2	7.0	3.9	3.0	5.4	8.0	0.5	1.9	100	503
To Work/Home	5.6	23.8	12.1	17.2	13.8	5.5	7.5	2.5	2.2	1.4	4.5	1.2	2.7	100	477
Others	6.6	13.7	14.6	14.4	7.4	9.4	8.5	1.0	5.4	3.4	5.7	1.5	8.4	100	693
Sex:															
Male	4.1	13.7	16.2	14.6	9.2	4.5	5.9	6.5	5.3	2.4	8.4	3.4	5.8	100	670
Female	6.3	18.7	12.4	16.2	11.2	6.6	6.5	3.5	2.1	2.5	8.4	2.2	3.4	100	537
Hand Luggage:															
With Heavy Load	8.2	17.1	14.5	12.6	10.2	6.9	2.2	6.2	4.7	1.4	6.7	7.2	2.1	100	576
Without Heavy Load	5.1	16.4	14.2	15.5	10.1	5.5	6.3	5.0	3.6	2.5	8.5	2.6	4.7	100	603
Total	5.2	16.5	14.3	15.3	10.1	5.6	6.2	5.0	3.7	2.4	8.4	2.8	4.6	100	602
Total Accumulated	5.2	21.7	36.0	51.3	61.4	67.0	73.2	78.2	81.9	84.3	92.7	95.5	100.0	-	-

Source: Orchard Area Pedestrian Survey, 1988.

c) Perception of Walking Distance

According to PWD officials survey in 1988, respondent officials do not mind walking 800 meters between SIA and MND building. Moreover, 76% of the total can tolerate long walking distances between CK Tang and Center point (1,700), as shown in Table 3.16. It seems that fairly long walks are acceptable. The other questions in the same survey presented in Table 3.17 shows how walking time is perceived. Normally, people do not mind walking about 5 to 10 minutes. However, if walking time increase more than 6 minutes those who dislike it increase gradually. There are no significant differences in the perception between car-owning and non-car-owning household members. The same question was posed on the walking distance. It is interesting to note that the answers on the perceived distance do not correspond to the perceived time at all, nor express any statistically meaningful results.

Table 3.16

Perception of Walking Distance for Selected Sections

Section	No Problem	Tolerable	Too Long	Total
SIA - Tanjong Pagar (400m) (6 mins)1/	300 (81.7)	62 (16.9)	5 (1.4)	367 (100)
MND - Tanjong Pagar (600m) (9 mins)	303 (82.6)	62 (16.9)	2 (0.5)	367 (100)
SIA - MND (800m) 12 mins)	270 (73.8)	86 (23.5)	10 (2.7)	366 (100)
CK Tang - Centerpoint (1,700m) (26 mins)	131 (35.8)	148 (40.4)	87 (23.8)	366 (100)

Source: PWD Officials Survey, 1988.

1/ Walking Time is estimated based on 4,000/hr.

Table 3.17

Perception of Walking Distance/Time for To/From Work Trips

Case \ Distance	Less than 100m	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1,000 and over	Total	Average Distance (Meters)
Distance do not mind at all	38.4	19.2	11.1	6.1	10.1	-	1.0	1.0	-	7.0	6.1	100	418
Distance willing to walk	26.3	24.2	9.5	7.4	15.8	1.1	1.1	2.1	-	4.2	8.4	100	439
Distance not want to consider	2.2	10.9	6.5	9.8	13.0	5.4	1.1	-	4.3	28.3	18.5	100	1,022

Case \ Time	1-3	4-5	6-10	11-15	16-20	21-30	31 and over	Total	Average Time (Minutes)
Distance do not mind at all	7.3	41.5	34.8	9.4	3.5	2.0	1.5	100	9.3
Distance willing to walk	4.7	26.5	33.1	17.7	10.2	6.7	1.2	100	11.8
Distance not want to consider	0.6	2.1	15.9	18.9	19.8	29.5	13.3	100	24.4

Source: PWD Officials Survey, 1988.

d) Factors which Affect Walking Distance

Table 3.18 shows what factors affect walking distance. It shows that weather has a strong influence on walking distance.

Table 3.18

Factors which Affect Walking Distance

Factors	% of Answers
Weather	30.4
Trip Purpose	7.0
Physical Condition	5.7
Environmental Condition	12.7
Shade	13.8
With or Without Companion	3.6
Street Lighting	3.5
Climbing Up and Down the Stairs	14.5
Adequacy of Pedestrian Road	6.0
Street Scape	2.8
Total	100.0

Source: PWD Officials Survey, 1988.

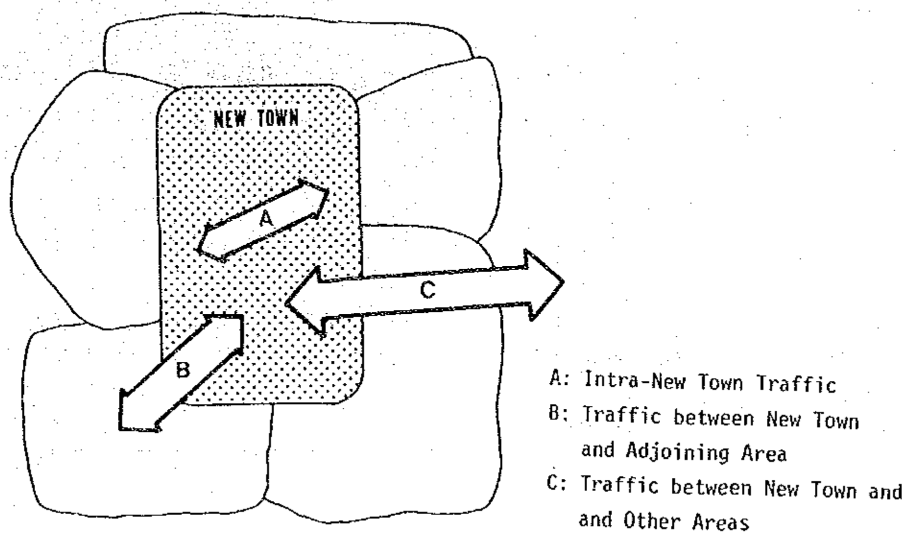
3.3 Feeder Transport Demand

3.3.1 Feeder Transport Demand in New Towns

Traffic demands of new towns can be broadly classified into three types, as shown in Figure 3.3, while the levels of those traffic are summarized in Table 3.19. Traffic movements within new towns and to/from adjoining areas relatively have short trip lengths, while traffic to/from other areas beyond adjoining areas have longer trip lengths. With the different natures of traffic, all types are for potential feeder traffic, either wholly or partly.

Figure 3.1

Types of New Town Traffic Demands



Although the figures shown in Table 3.19 vary depending upon the size of zones or areas defined as adjoining areas, it is observed that the traffic in new towns is not really directed towards the CBD or certain areas alone, but is fairly widely distributed and relates with various areas. The traffic distribution pattern is presented in Figure 3.4. It can be generally stated that the distribution of the demand would require a fairly comprehensive network with various capacities, if the demand is to be met more directly.

Table 3.19

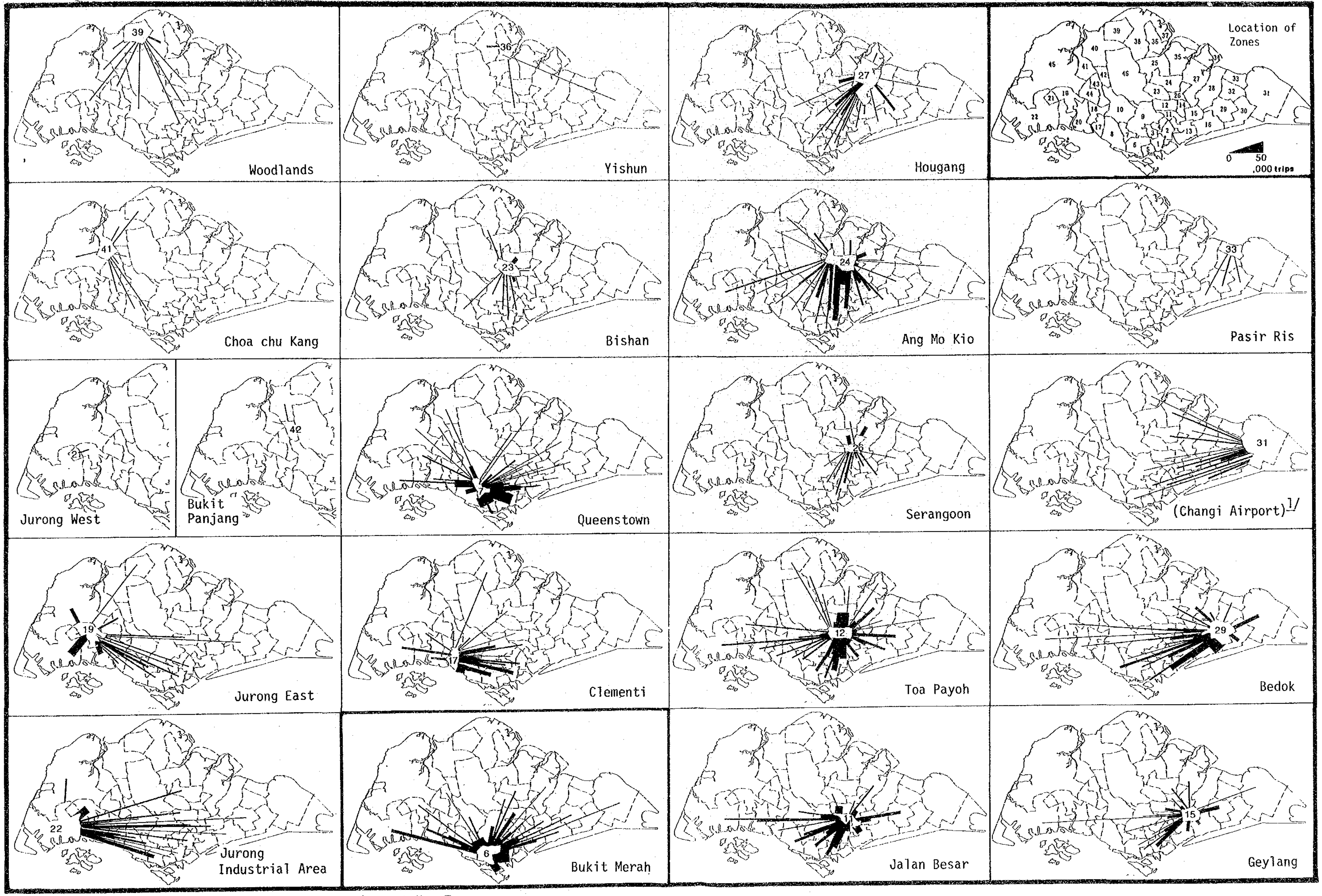
Summary of Traffic Demand (Public Mode Only) of HDB New Town, 1980

CORRIDOR/ NEW TOWN		Intra-zonal		to/from Adjoining Area		to/from CBD		to/from Other Areas		Total		% of Public Mode to Total Traffic
		000	(%)	000	(%)	000	(%)	000	(%)	000	(%)	
EAST	1. Geyland	2.0	(1.7)	40.7	(35.2)	23.6	(20.4)	49.5	(42.7)	115.7	(100)	63.7
	2. Bedok	41.4	(16.7)	74.9	(30.1)	27.7	(11.2)	104.3	(42.0)	248.3	(100)	57.5
	3. Tampines	-	(-)	0.5	(30.0)	0.2	(12.7)	1.0	(57.3)	1.8	(100)	35.3
	4. Pasir Ris	-	(-)	1.3	(9.1)	0.9	(6.3)	12.1	(84.6)	14.3	(100)	61.8
NORTH EAST	5. Serangoon	2.3	(4.0)	29.1	(50.9)	7.0	(12.3)	18.8	(32.9)	57.2	(100)	48.3
	6. Hougang	12.6	(15.1)	28.6	(34.2)	6.0	(7.2)	36.4	(43.5)	83.6	(100)	54.0
NORTH	7. Jalan Besar	6.2	(3.5)	61.8	(35.1)	37.8	(21.4)	70.6	(40.0)	176.4	(100)	59.4
	8. Toa Payoh	21.0	(8.6)	57.0	(23.2)	34.1	(13.9)	133.2	(54.3)	245.3	(100)	56.1
	9. Bishan	0.3	(1.0)	13.5	(40.7)	3.0	(9.1)	16.4	(49.1)	33.2	(100)	41.1
	10. Ang Mo Kio	41.4	(17.4)	36.4	(15.2)	25.5	(10.7)	135.8	(56.8)	239.1	(100)	60.4
	11. Yishun	0.2	(1.5)	5.8	(43.2)	1.1	(8.5)	6.3	(46.8)	13.4	(100)	57.1
NORTH WEST	12. Bukit Panjang	-	(-)	5.9	(55.6)	0.2	(2.4)	4.4	(42.0)	10.5	(100)	52.0
	13. Choa Chu Kang	0.6	(1.8)	15.3	(44.2)	0.2	(0.7)	18.5	(53.3)	34.7	(100)	73.6
	14. Woodlands	2.9	(7.3)	11.0	(27.5)	0.7	(1.7)	25.4	(63.5)	40.0	(100)	70.9
WEST	15. Bukit Merah	50.0	(15.1)	111.7	(33.7)	84.9	(25.6)	85.1	(25.7)	331.7	(100)	61.6
	16. Queenstown	27.8	(11.6)	82.0	(34.2)	39.8	(16.6)	89.8	(37.5)	239.4	(100)	60.2
	17. Clementi	5.0	(4.1)	29.4	(23.8)	14.3	(11.6)	74.5	(60.5)	123.2	(100)	57.1
	18. Jurong East	18.6	(16.2)	48.1	(41.8)	4.5	(3.9)	44.0	(38.2)	115.2	(100)	61.8
	19. Bukit Batok	-	(-)	0.9	(60.0)	-	(-)	0.6	(40.0)	1.5	(100)	37.0
	20. Jurong West	0.4	(4.3)	5.9	(70.1)	-	(-)	2.1	(25.6)	8.4	(100)	70.1

Source: 1980/81 HIS Analysis

Regarding the traffic moving within new towns by feeder bus, the results of a survey conducted by SBS in 1985 indicated that the number of daily feeder bus passengers is approximately 70,000 to 100,000 for selected new towns, as shown in Table 3.20. The traffic is composed of that completed only within new town and that moving to/from outside areas using trunk buses.

Figure 3.2 Distribution of Demand to/from New town, 1980
(Public and Private Modes)



Source : Prelinary Analisis of 1980 HIS 1/ : not New Town

3.3.2 Feeder Bus Traffic Demand in New Town

1) Feeder Bus Passenger Traffic

It is estimated that SBS and TIBS feeder bus services carry a total of about 740,000 passenger trips per day, which account for 30% of the total daily passenger trips of SBS and TIBS bus services of 2.31 million passenger trips in 1986). The number of passengers, passengers per bus-km and per trip by new town are shown in Table 3.20. It shows that feeder bus services in Ang Mo Kio, Bedok, Bukit Merah, Clementi and Toa Payoh New Town have a large number of passengers per bus-km, because these new towns are already developed and there is a large demand of feeder buses compared with their route distance.

Table 3.20

Feeder Bus Passengers in HDB New Town

New Town	No. of Services	No. of Scheduled Trips/day	No. of Passenger/day 1/	No. of Passengers/Service	No. of Passenger/Bus km	No. of Passenger/trip
1. Ang Mo Kio	7	1,417	128,339	18,334	12.43	90.5
2. Bedok	10	1,487	146,890	14,689	14.19	98.7
3. Bukit BAtok	4	661	28,716	7,179	8.47	43.4
4. Bukit Merah	5	929	48,634	9,727	12.85	52.4
5. Clementi	4	406	21,119	5,280	13.13	52.0
6. Hougang	5	699	54,164	10,833	11.03	77.5
7. Jurong East	4	721	55,901	13,975	8.69	77.5
8. Jurong West	6	804	88,506	14,751	10.10	110.1
9. Queenstown	2	157	3,281	1,640	3.18	20.9
10. Serangoon	2	187	5,023	2,511	5.83	26.9
11. Tampines	5	1,011	50,168	10,033	10.28	49.6
12. Toa Payoh	5	885	67,887	13,577	15.04	76.7
13. Woodlands	2	305	14,300	7,150	8.64	46.9
14. Yishun	5	656	26,800	5,360	5.91	40.9
Total	66	10,325	739,728	-	-	-
Average	-	-	-	11,208	11.03	71.6

Source : SBS, TIBS 1987
1/ No. of Passengers/day is estimated as : No. of Cash Rides/0.7

2) Traffic by Time Period

According to the bus survey conducted at a bus interchange in Ang Mo Kio New Town, feeder bus passenger traffic during morning and evening peak periods (2 hours) both recorded a 20% share, as shown in Table 3.21. The hourly passenger traffic for feeder buses is shown in Figure 3.5.

Table 3.21

Share of Feeder Bus Passenger Traffic During Peak and Off-Peak Periods (Ang Mo Kio Bus Interchange)

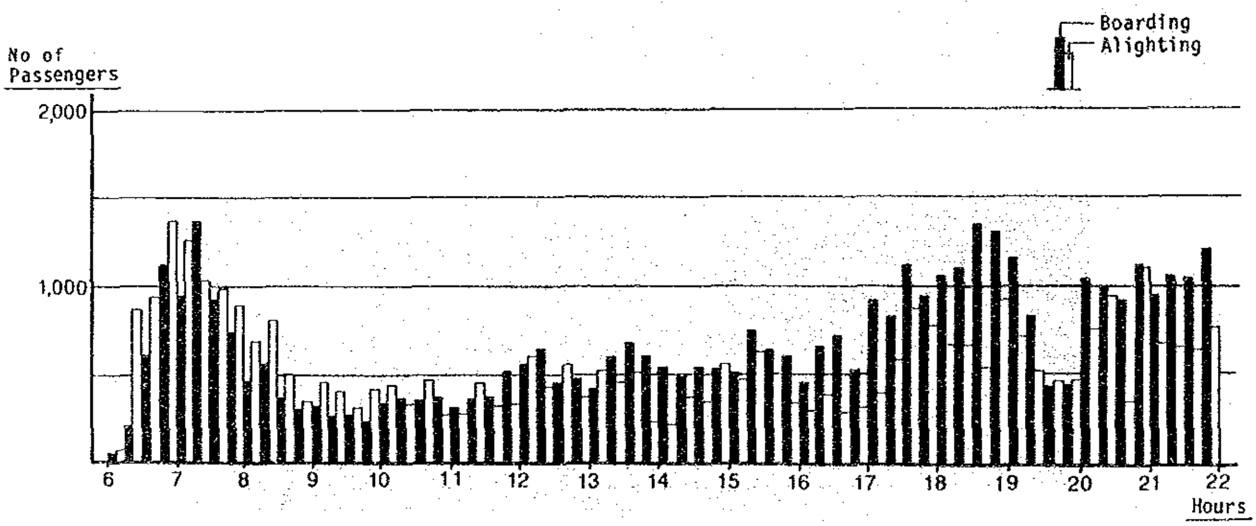
	Boarding Passengers	Alighting Passengers	Total
Morning Peak	17.2	24.2	20.4
Evening Peak	22.5	17.1	20.0
Afternoon Off-Peak	12.0	10.6	11.4
Others	48.3	48.1	48.2
Total	100.0	100.0	100.0

Source: Ang Mo Kio Bus Survey, 1988.

Note: Morning Peak : 0630 - 0830 Hours
Evening Peak : 1730 - 1930 Hours
Afternoon Off-peak: 1430 - 1630 Hours

Figure 3.3

Hourly Passenger Traffic for Feeder Bus at Ang Mo Kio Bus Interchange



3) Transfer Passengers at Bus Interchange

Tables 3.22 and 3.23 show the transfer passengers to feeder and trunk bus at Ang Mo Kio bus interchange, respectively. Forty-two percent of feeder bus boarding passengers transfer from trunk bus, while 35% of trunk bus boarding passengers transfer from feeder bus. Approximately 32,000 persons transfer between feeder and trunk bus services at bus interchange.

Table 3.22

Transfer Passengers to Feeder Bus at Ang Mo Kio Bus Interchange

Previous Mode of Travel	Morning Peak Hours		Evening Peak Hours		Afternoon Off-Peak Hours		Total	
	No. of Persons	(%)	No. of Persons	(%)	No. of Persons	(%)	No. of Persons	(%)
Walk	1,118	(16.3)	993	(11.1)	571	(7.6)	5,541	(13.9)
Bicycle	–	(–)	–	(–)	–	(–)	–	(–)
Motorcycle	–	(–)		(–)	34	(0.5)	62	(0.2)
Car	21	(0.3)	–	(–)	105	(1.4)	208	(0.5)
Car-pool	–	(–)	–	(–)	–	(–)	–	(–)
Taxi	–		46	(0.5)	28	(0.4)	144	(0.4)
Van/Pick-up/Others	–	(–)	–	(–)	17	(0.2)	17	(0.0)
MRT	449	(6.6)	3,310	(36.9)	2,249	(30.0)	8,213	(20.6)
Feeder Bus	1,867	(27.2)	1,655	(18.5)	912	(12.2)	8,103	(20.3)
Trunk Bus	2,873	(41.9)	2,956	(33.0)	3,508	(46.8)	16,564	(41.5)
Scheme B/CSS	96	(1.1)	–	(–)	–	(–)	96	(0.2)
School/Co. Bus	–	(–)	–	(–)	–	(–)	65	(0.2)
Others	–	(–)	–	(–)	–	(–)	–	(–)
Unknown	430	(6.3)	–	(–)	70	(0.9)	862	(2.2)
Total	6,854	(100.0)	8,960	(100.0)	7,494	(100.0)	39,875	(100.0)

Source: Ang Mo Kio Bus Survey, 1988.

Table 3.23

Transfer Passengers to Trunk Bus at Ang Mo Kio Bus Interchange

Previous Mode of Travel	Morning Peak Hours		Evening Peak Hours		Afternoon Off-Peak Hours		Total	
	No. of Persons	(%)	No. of Persons	(%)	No. of Persons	(%)	No. of Persons	(%)
Walk	2,592	(24.9)	964	(14.2)	1,308	(17.2)	8,467	(19.4)
Bicycle	11	(0.1)	32	(0.5)	–	(–)	70	(0.2)
Motorcycle	–	(–)	–	(–)	9	(0.1)	9	(0.0)
Car	94	(0.9)	92	(1.4)	283	(3.7)	657	(1.5)
Car-pool	–	(–)	–	(–)	–	(–)	–	(–)
Taxi	32	(0.3)	76	(1.1)	59	(0.8)	234	(0.5)
Van/Pick-up/Others	–	(–)	21	(0.3)	75	(1.0)	129	(0.3)
MRT	169	(1.6)	1,135	(16.7)	1,468	(19.3)	4,339	(9.9)
Feeder Bus	3,994	(38.3)	1,812	(26.7)	2,079	(27.3)	15,409	(35.3)
Trunk Bus	3,217	(30.8)	2,428	(35.7)	2,110	(27.7)	12,862	(29.5)
Scheme B/CSS	–	(–)	–	(–)	27	(0.4)	66	(0.2)
School/Co. Bus	53	(0.5)	45	(0.7)	33	(0.4)	138	(0.3)
Others	–	(–)	10	(0.1)	13	(0.2)	23	(0.1)
Unknown	268	(2.6)	180	(2.6)	152	(2.0)	1,249	(2.9)
Total	10,430	(100.0)	6,795	(100.0)	7,616	(100.0)	43,652	(100.0)

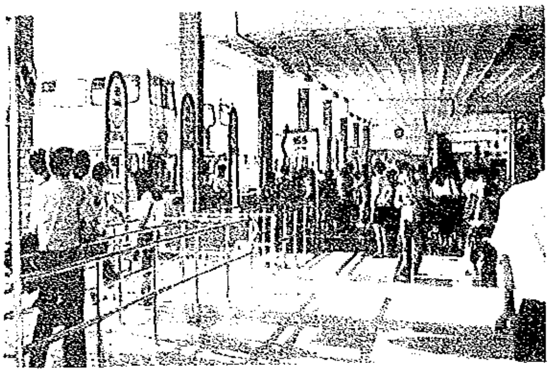
Source: Ang Mo Kio Bus Survey, 1988.

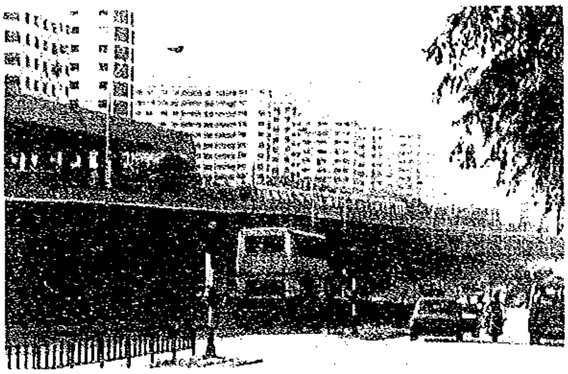
Table 3.24

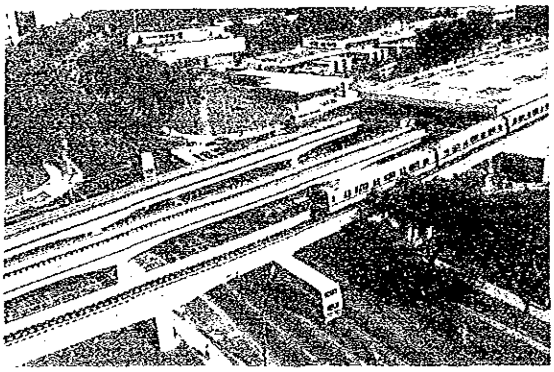
Influence of MRT on Residence

Location of Residence	Average Decrease in Travel Time (Minutes)	Average Increase in Fare (Cents)	Average Increase in Walking Time (Minutes)	No. of Samples
HDB New Town	14.5	8.1	2.4	52
Other Area	8.6	38.8	0.9	18
Total	13.0	15.6	2.0	70

Source: PWD Officials Survey, 1988.







4. FEEDER TRANSPORT IMPROVEMENT PLANNING DIRECTION

4. FEEDER TRANSPORT IMPROVEMENT PLANNING DIRECTION

4.1 Planning Opportunities and Directions

As discussed earlier, the issue here is how urban planning and transport planning would contribute to realizing the ideal or desired society in the future in Singapore. This would include a more convenient and comfortable travel, better environment and diversified services and activities. This section intends to define more specifically the planning areas and directions for the case studies. The areas concerned include:

- o Transportation
- o Environment
- o Urban development

1) <u>Formulation of Integrated Feeder Transport Network with MRT</u>

As cities grow and the transport system becomes congested, provision for door-to-door services is getting more and more difficult and uneconomical both for private and public transport. Efficiency and economy of the transport system becomes a predominant factor in transport planning. This usually leads to the hierarchical configuration of transport activities, particularly, the segregation of trunk transport and feeder transport with provision for purpose-built interchanges. Singapore's public transport system is also configured in such a way that trunk transport provides line-haul services, while feeder bus provides access/egress services via bus interchanges, particularly, in most new towns.

It is clearly proven that the increase in transport service level has to be discussed from the viewpoint of improving door-to-door transport services. This is the case in Singapore where the existing system is clearly distinguished between trunk and feeder transport. Taking into account the time distribution between trunk and feeder services, the improvement of feeder transport becomes a critical factor for the improvement of door-to-door transport. The recent opening of MRT, for example, has reduced the travel time of trunk transport between Ang Mo Kio new town and CBD from 40 minutes to 20 minutes, while considerable time is still required to reach the MRT. Accordingly, there are two basic viewpoints for feeder transport improvement, as follows:

a) Short-term viewpoint: How to organize and structure feeder transport system in compliance with the MRT within the existing transport system.

b) Medium to long-term viewpoint: How to develop/create a more competitive new public transport system by integrating the MRT with the new transit mode and other effective means and measures.

2) Contribution to Improving Local Environmental Conditions:

The environmental concerns of the people will become increasingly higher as their living standards increase. This is true in the case of the residential areas. Although the overall environmental improvement must be considered from a more comprehensive viewpoint, the transportation sector is also a major factor of concern in view of traffic noise, air pollution and traffic safety.

3) Factors in Accelerating the Desired Urban Development:

One of the possibilities which could be achieved in Singapore, but where most of the other cities have failed, is to obtain an efficient public transport system that can be competitive against private cars. The favourable factors to accomplish this are: 1) a strategically located MRT with high quality service linking all major new towns and CBD and other major traffic generating sources, 2) relative ease of reaching consensus in Government, and 3) effective means and capabilities of controlling urban development. Critical to the achievement of the above goals is the application of a comprehensive strategy to total urban development. Investments, for instance, into quality transport development will always require such sizeable resources that they can hardly be justified by mere replacement of the existing system with a new system, but would become feasible only when the new system becomes an integral and strategic part of the total envisioned urban/community development. The following are the possible areas to be examined from the above viewpoints:

a) Development of "new" new towns to meet the future high living demand of people. This means the new transit system is fully an integral part of the development process to provide the required services.

b) Development of new sub-centres with diversified functions as conceptually defined in the 1971 Concept Plan. For example, expansion and strengthening of Ang Mo Kio town centre as a regional sub-centre would be possible and realistic. The strengthening and diversification of functions of town centres would not only serve the residents but also attract outsiders.

c) Renovation/redevelopment of existing urban centres including sub-areas of CBD and other activity centres, (i.e., major tourist destinations) is another important aspect of urban development. Accessibilities and amenities are the factors to continuously attract the changing demand and activities in these areas. It is unlikely that a conventional road-based transport system alone would support these develop-ments. Furthermore, the impact of rail/guideway-based system on land use/urban development is usually more significant, as is typically experienced in Japan.

The overall objectives of introducing a new transit system as a means of realizing a desired community are summarized, as follows:

a) Improve the living environment by way of

- reducing noise, air pollution and other nuisances caused by motor vehicles

- increasing overall amenities

b) Improve transport capabilities and efficiencies by way of

- improving the present situation within the public transport sector

- competing with the private car

c) Encourage better urban development by way of

- providing transport services to various land uses where demand exists/expected

- realizing the envisioned community/urban develop-ment

4.2 Selection of the Study Areas

Based on the discussions extensively held, the review of available data, and the conduct of field observations and surveys, 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 at 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. Several possible areas were initially identified and discussed in the Interim Report. The selected areas for further case studies are shown in Table 4.1 and listed, as follows:

A. New Town:

a) Ang Mo Kio New Town
b) Simpang New town

B. Other Areas:

a) Ang Mo Kio-Hougang-Marine Parade Route
b) Orchard-Sentosa Route
c) Orchard-Marina Centre Route

Coverage of the work, however, differs in each case study area. A detailed study is undertaken for Ang Mo Kio new town to assess the feasibility of introducing a new transport system from the technical, traffic, economic, financial and environmental view-points. On the other hand, for the remaining areas, studies are limited to their preliminary stage only.

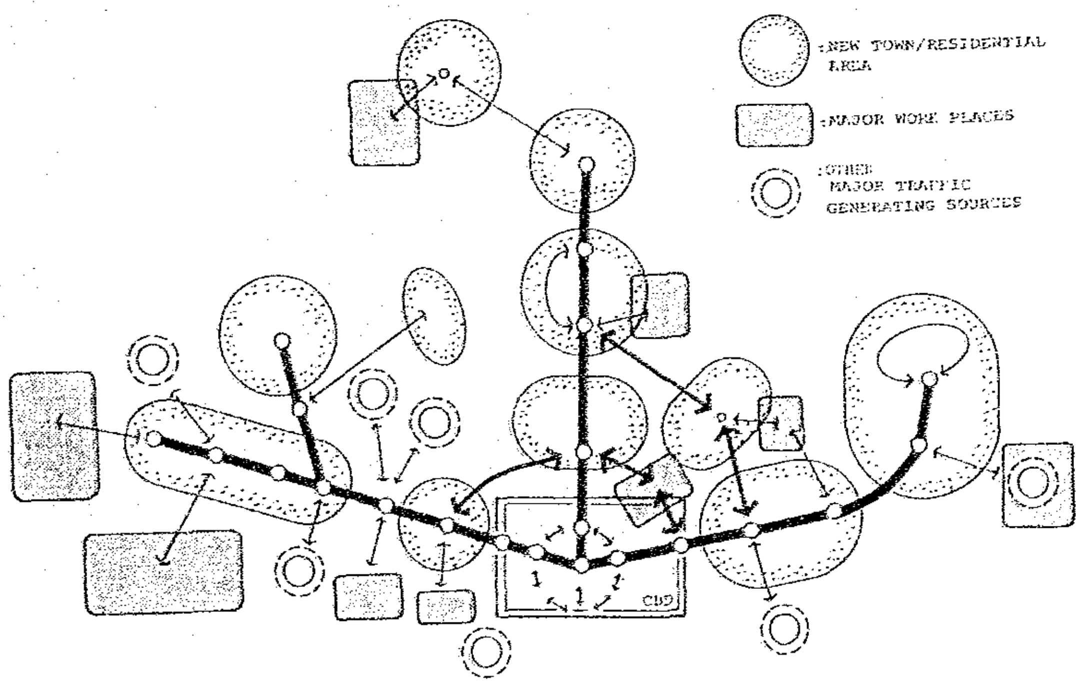
Table 4.1

Areas Selected for Case Studies

		Reason for Selection and Planning Objectives
New Town	Ang Mo Kio	Selected as a typical completed new town Feeder service improvement with integration of MRT Improvement of intra-town movement
	Simpang	Selected as a future possible new town with built-in new transport system
Other Areas	Ang Mo Kio-Hougnag-Marine Parade Route	To develop circumferential secondary transport route to relieve load of trunk system To improve feeder sevices to the area along the route including new towns (Serangoon, Hougang) To develop a secondary transit route to encourage development of subcentres.
	Orchard-Sentosa Route	Encourage development of new urban axis for tourism and socio-economic activities by providing a direct link between Orchard and Sentosa Feeder service improvement in the areas along the route and new town
	Orchard-Marina Centre Route	Further strengthening and vitalization of international activity corridor by improving internal accessibility

Figure 4.1

Conceptual Understanding of Possible Areas Regarding the Introduction of New Transit Systems



4.3 Assessment of Available New Transit Systems

At present, the term "new transit system" has not been clearly and specifically defined. It is usually called the "automated people mover" or "automated guideway transit". The system introduces a transit mode in which automated cars operate without drivers on a separate guideway, therefore, completely independent of automobile traffic. The technology available for variations on the system are at different stages of development. Although a considerable number of countries have developed or have been developing various systems, wide spread application of such system has yet to be seen.

The need for a "new transit system" was discussed seriously in the 1960s by the U.S.A. Rapid urbanization which took place from 1940 through 1960 had resulted in the sprawl of urban areas and deterioration in the CBD area. The U.S. Department of Housing and Urban Development issued "Tomorrow's Transportation - New systems for the Urban Future, 1968" wherein the foreword of the President stated that cities must be renewed to increase employment opportunities, to promote health and to provide better education. These objectives will only be realized by rehabilitating the transit systems. The following goals were set for the development of new transit systems:

a) To ensure a non-biased mobility within urban areas: The disabled, non-car-owners, children, and the aged should be provided with proper transportation services;

b) To improve the quality of transport services: Quality public transport services which can compete with private car transport is a need to be realized;

c) To relieve traffic congestion;

d) To achieve maximum/effective use of available transport facilities;

e) To encourage efficient use of land;

f) To minimize adverse environmental impact;

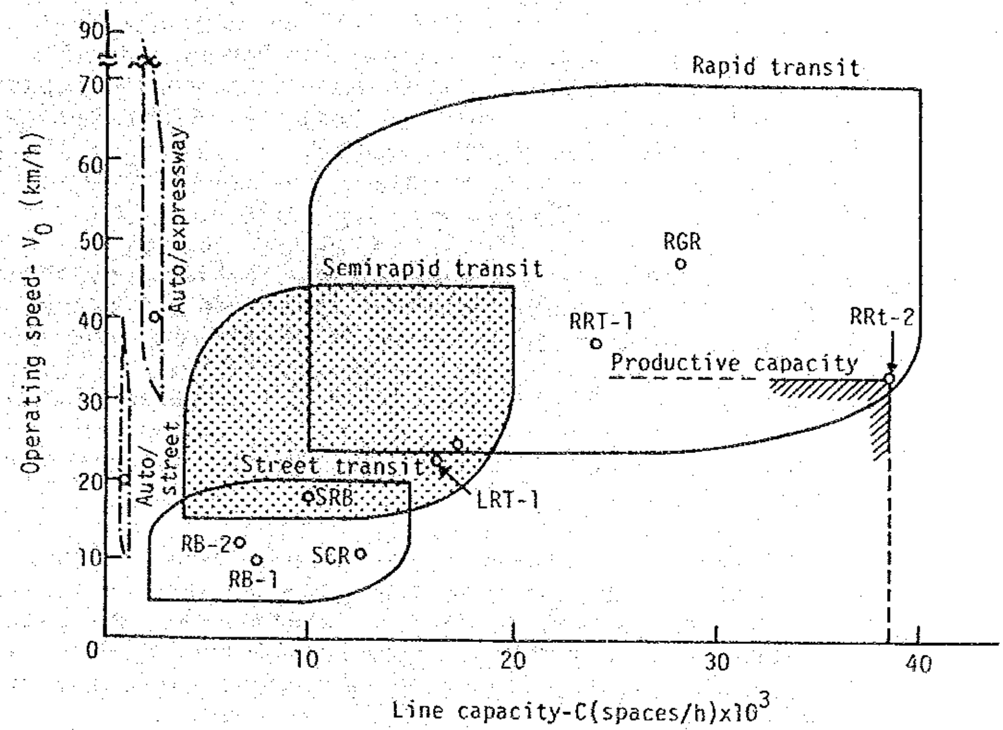
g) To meet various transport demands due to varied urban development patterns in a flexible manner; and

h) To improve institutional aspects which become obstacles to the extension of new systems or technologies.

In general, it has been realized that conventional transit modes represented by subway/heavy railway and bus could not necessarily cover the varied transport demands sufficiently,

Figure 4.2

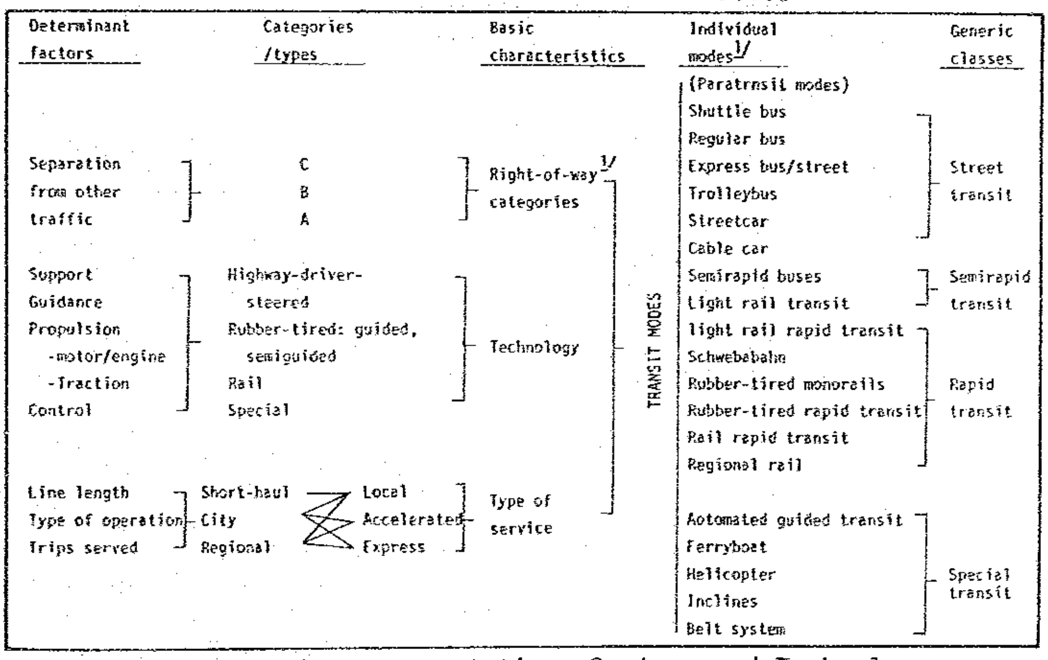
Transport Capabilities of Various Transit Modes



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

Figure 4.3

An Overview of Transit Mode Definition, Classification, and Characteristics



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

1/ A: fully controlled without grade crossing, B: longitudinally physically separated but with grade crossing, C: surface either due to their rigid hardware, inflexible operation system or due to financial constraints. It seems that there are three areas where conventional systems can hardly meet the demand. They are: 1) a transit system with intermediate capacity, in between bus and heavy rail system; 2) a personal transit system with flexible operation which can compete with private cars; 3) short-haul mass transport system to cover a distance of around 500 to 1,000 meters.

Accelerated by the above movement and initiated by the U.S.A., a number of countries, including Japan, West Germany, France, U.K., and Canada. had started to experiment and construct various systems especially in the 1970s. Although the activities have slowed down or diverted from the original concepts, both government and private sectors in the above countries have been continuing development efforts in various places.

Figures 4.2 and 4.3 show where various modes of new transit systems fall under and how they can be classified within the total urban transit system. Existing major systems are explained in the Technical Report entitled "Study on Existing New Transit Systems". They are classified into the following groups:

A. Guideway Transit System

a) Intermediate capacity transit systems
b) Monorail
c) Mini-monorail
d) Personal Rapid transit

B. Continuous Transit System

a) Moving walk
b) Capsule

C. Dual Mode Transit System

a) Dual mode bus

D. Non-Guideway Transit System

a) LRT
b) Demand bus

Although the Systems for possible introduction to case studies are limited to those of Guideway Transit System, brief description is given to other systems as follows: 1) Continuous Transit System has relatively large carrying capacity but is also quite expensive. Therefore, the system is best suited for short distance (say up to 1,000 meters) with heavy traffic. Application cases are typically seen in the airports, terminals and commercial complexes; 2) Dual Mode Transit Systems serves for the route which comprises line-haul and feeder lines.

Application cases, therefore, are seen in the areas between CBD and sub-urban areas; 3) Of the non-guideway transit systems, demand bus can meet scattered demand but is not necessary to serve the areas with large demand. LRT is considered one of the most practical alternative solution in the areas where typical guideway transit systems with intermediate capacities are suited. The system has proven and improving technologies and, requires relatively low cost and affords efficient operation. Therefore, it would be quite attractive to consider the introduction of LRT into the areas where the system can be constructed at-grade without adversely affecting the road traffic situation. The systems which fall into c) above and studied and further grouped into three as summarised in Table 4.2 and shown in Figure 4.4.

<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 type. The systems are fully automated and meet passenger demand of 5,000 to 10,000/hour/direction. Considering the transport capabilities and technologies maturity and experiences, they are considered the most realistic ones to be applied in most of the new towns in Singapore.

<u>Group II</u> : 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 and other activity centres.

<u>Group III</u> : The systems of this group are expected to be more highlighted in the near future. 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 anflexible transport

The Guideway Transit System can further be grouped into three, according to transport capacities:

a) Systems with relatively heavy capacity such as the monorail normally has the capacity of 10,000 to 40,000 passenger/hour/direction and is considered too large for feeder system.

b) Systems with smaller capacity such as personal rapid transit with normal transport capacity of less than 1,000 passengers/hour/direction is too small to serve the demand in new towns, and is also expensive and technologically immature yet.

c) Systems with intermediate capacity are of major concern in this study. There are quite a number of this systems being operated, tested and planned. Different types of intermediate capacity transit systems including mini monorails and magnetic levitated systems exist.

It is to be noted that their sub-systems are not necessarily fixed as specified in the table but can be modified within certain ranges to meet specific requirements, except fundamental structures such as guidance, car support, propulsion, etc. More detailed information regarding these selected systems are discussed in each case study.

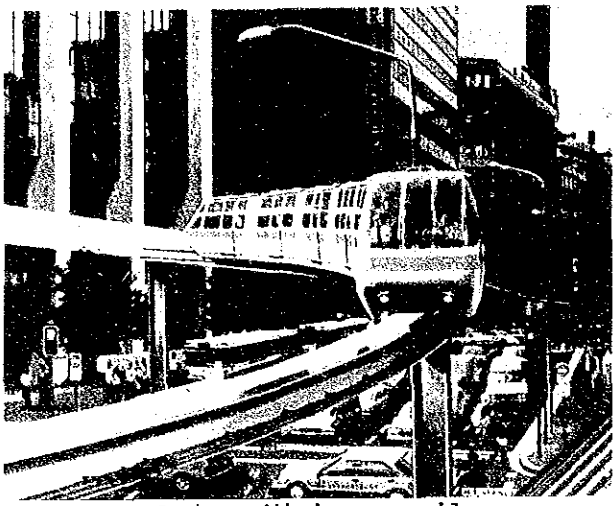
Table 4.2

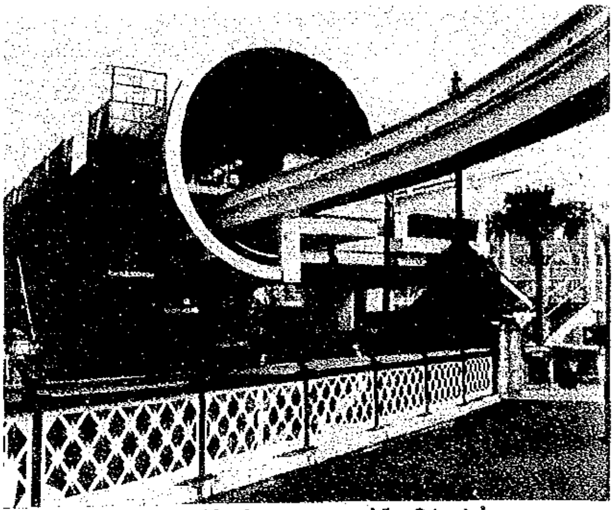
Outline of New Transit Systems Selected for Case Studies

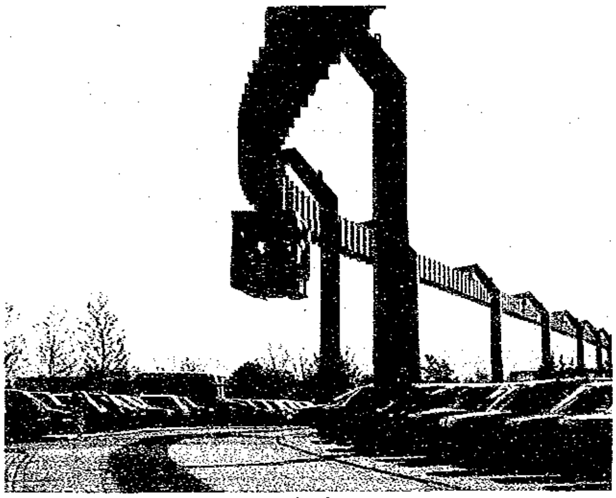
ITEM		GROUP I		GROUP II		GROUP III	
Definition		. Intermediate transit capacity . Technologically matured . Relatively extensive applications		. Smaller transit capacity . Limited application		. Highly expected systems in the near future	
						Magnetic Leviated	Personal Rapid Transit
Representative 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	side guide rail	central guide rail	guide wheel	guide wheel	Linear motor	Lateral guide wheel
	Car Support	rubber tyre (stuffed)	rubber tyre (air)	rubber tyre (solid)	rubber tyre	Magnetic levitated	rubber tyre
	Power	3 ph. alt. 600V	3 ph. alt. 380V	3 ph. alt. 500V	3 ph. alt V	Linear motor	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 1/	71	21
	Max speed (kph)	60	96	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 (4M 2T Cars)	75 kw x 2/car	23 kw x 4/car	37 kw x 6/train	Linear motor	45 kw DC
Structure	Guideway	concrete partially steel	PC concrete 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 VONA Saitama Ina Line Others	Atlanta 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

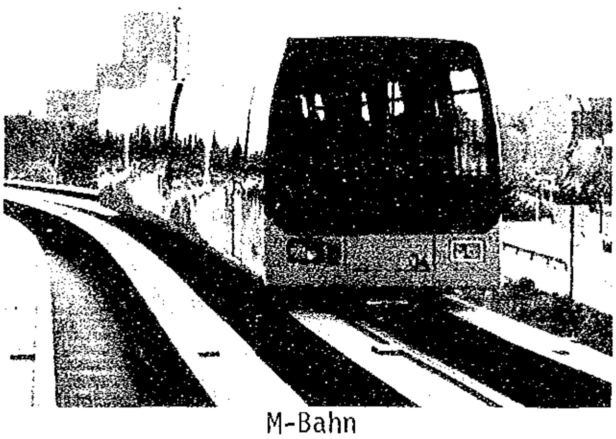
1/ Comprising seven cars

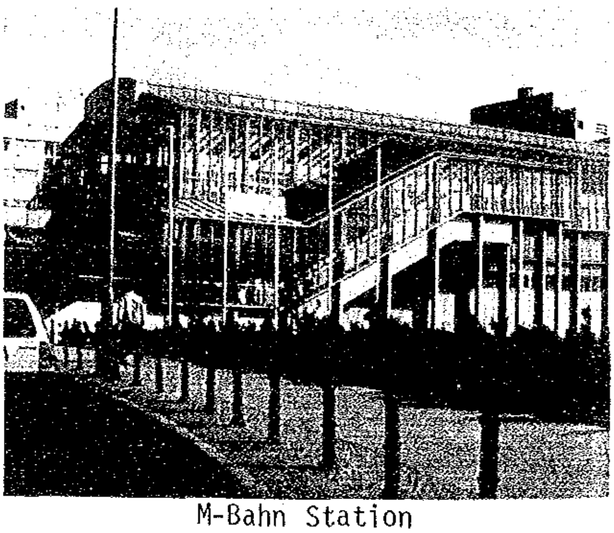

Sydney Mini-monorail

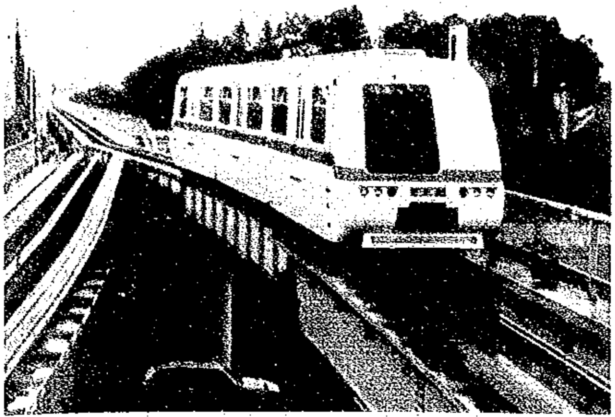

Sydney Mini-monorail Station


H-Bahn

H-Bahn Station

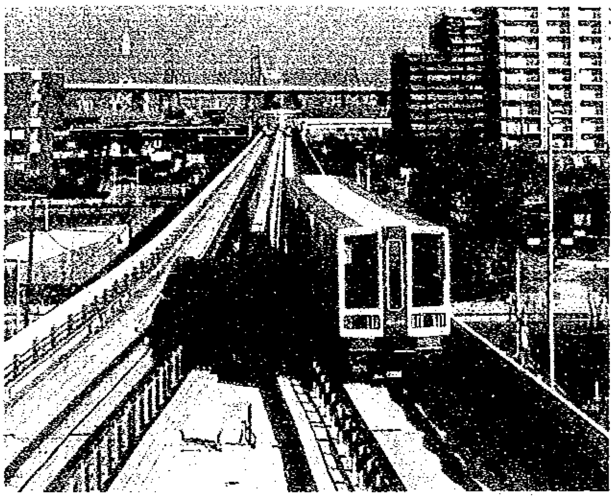

M-Bahn


M-Bahn Station

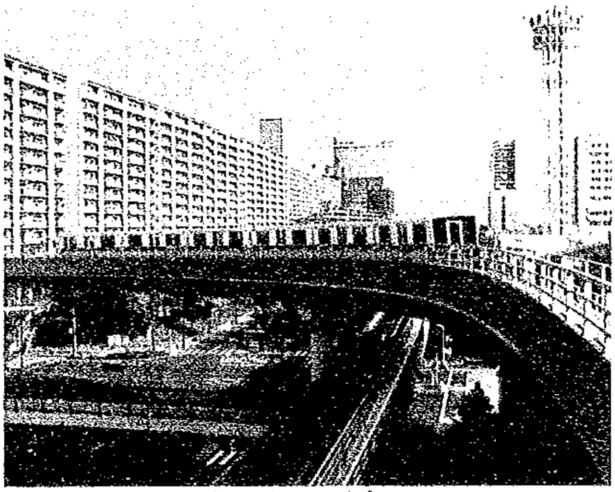


Yukarigaoka VONA

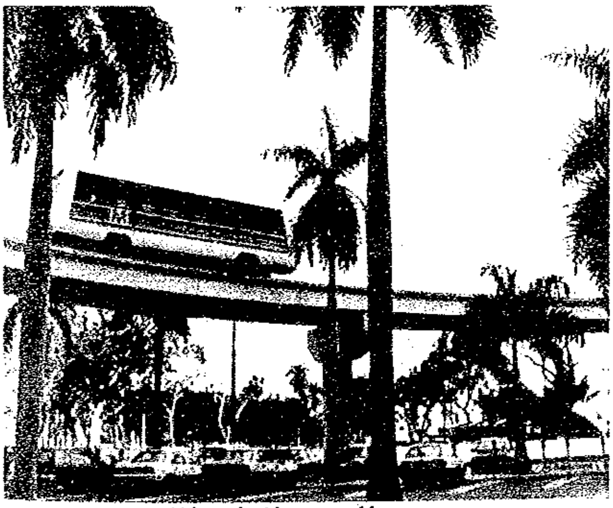
Figure 4.4
Transport Systems Selected
for Case Studies



Osaka Nanko New Tram



KOBE Port Liner



Miami Metro Mover

Platform Door

5. CASE STUDY FOR ANG MO KIO NEW TOWN

5. CASE STUDY FOR ANG MO KIO NEW TOWN

5.1 Profile of the Study Area

Ang Mo Kio new town is inhabited by approximately 180,000 residents, occupying an area of 740 ha. It is located in the north, approximately 12 to 15 kms from CBD. Ang Mo Kio was constructed between 1973 and 1982 while the first HDB flat was completed in 1975. The area extends over 4 kms east-west and 3 kms north-south . As shown in Figure 5.1, Ang Mo Kio new town adjoins other new towns such as Bishan, Serangoon and Hongang. The new town is ideally served by both the MRT expressway and major arterials.

Ang Mo Kio is designed to be a satellite new town rather than the so-called bed town. Although the functional independency is not in the original concept, it also provides sizeable employment opportunities to attract external traffic. Its land use is shown in Figure 5.2 and Table 5.1. Of the total land area of 742 ha, residential areas share 37%, followed by 17% of industrial area. Nearly 16% of the land is alloted for major roads which, however, is considered higher than that of normal HDB planning standards. Bus interchange occupies 1.6 ha in the town centre. The structure of the new town is shown in Figure 5.3. It comprises one town centre, six neighbourhood units and three industrial areas.

The blocks and dwelling units are distributed as shown in Table 5.2. There are a total of 359 blocks and 49,483 units with an average of 138 units per block. The height of blocks ranges from two to 25 storeys and the most prevailing ones are 12 storey blocks (see Table 5.3). The size of the dwelling units varies from one-room to five-room, the most popular ones are three-room or four-room. (See Table 5.4.)

The socio-economic features of Ang Mo Kio new town are summarized in Table 5.5. Population figures vary by information source.

5.2 Existing Transport System

Ang Mo Kio new town is served by both road transport and MRT. Road transport comprises mainly of buses and cars, while MRT has only been opened for traffic between Yio Chu Kan and Toa Payoh in November 1987, extended to Outram Park in December 1987 and to Clementi in March 1988. The impact of MRT along the trunk route is significant as shown in Table 5.6. Travel time using public transport along the trunk routes have been drastically reduced due to the opening of MRT and even less than that of cars between certain areas.

Figure 5.1 Location and Area Profile of Ang Mo Kio New Town

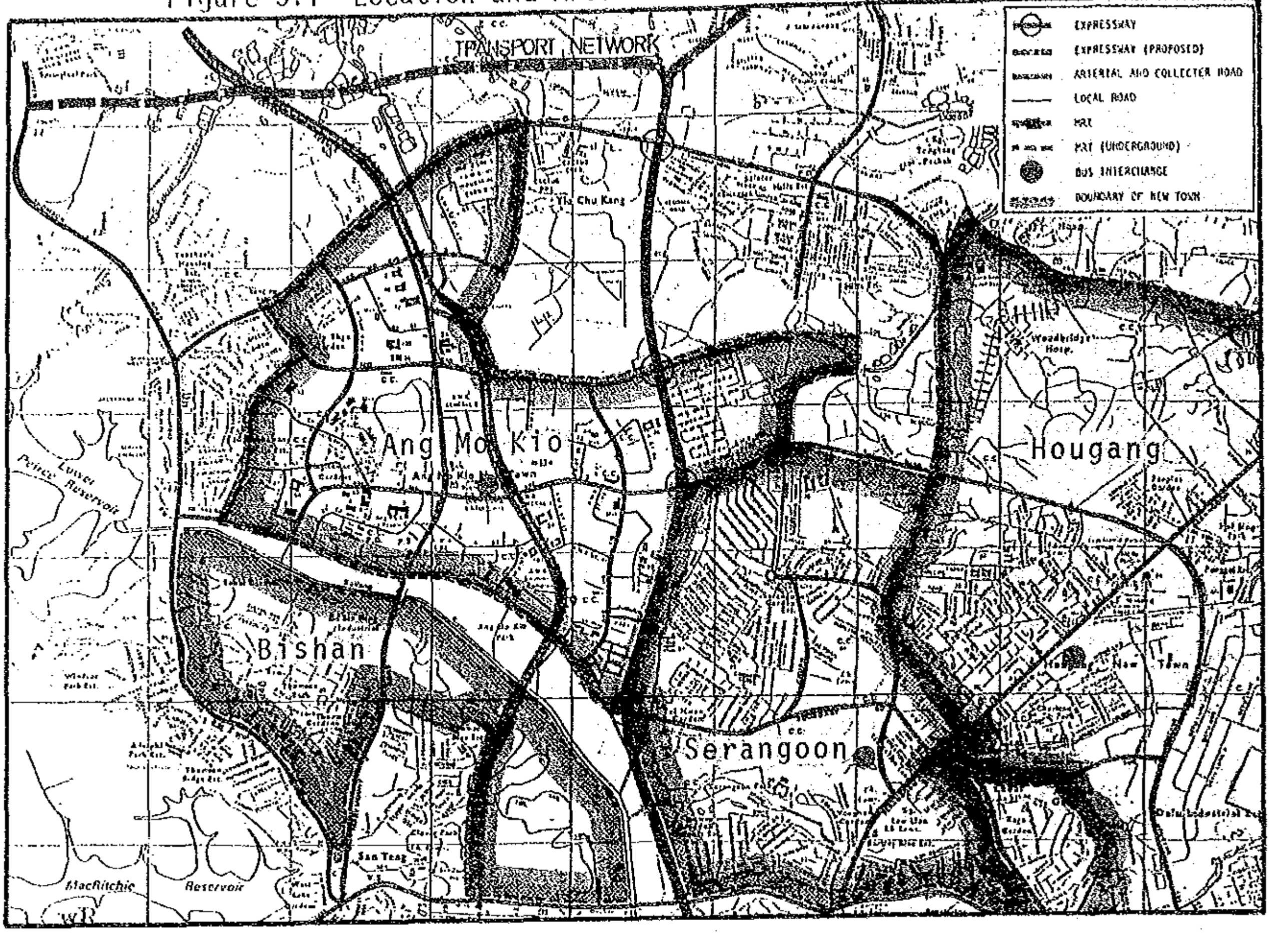


Figure 5.2 Existing Land Use of Ang Mo Kio New Town

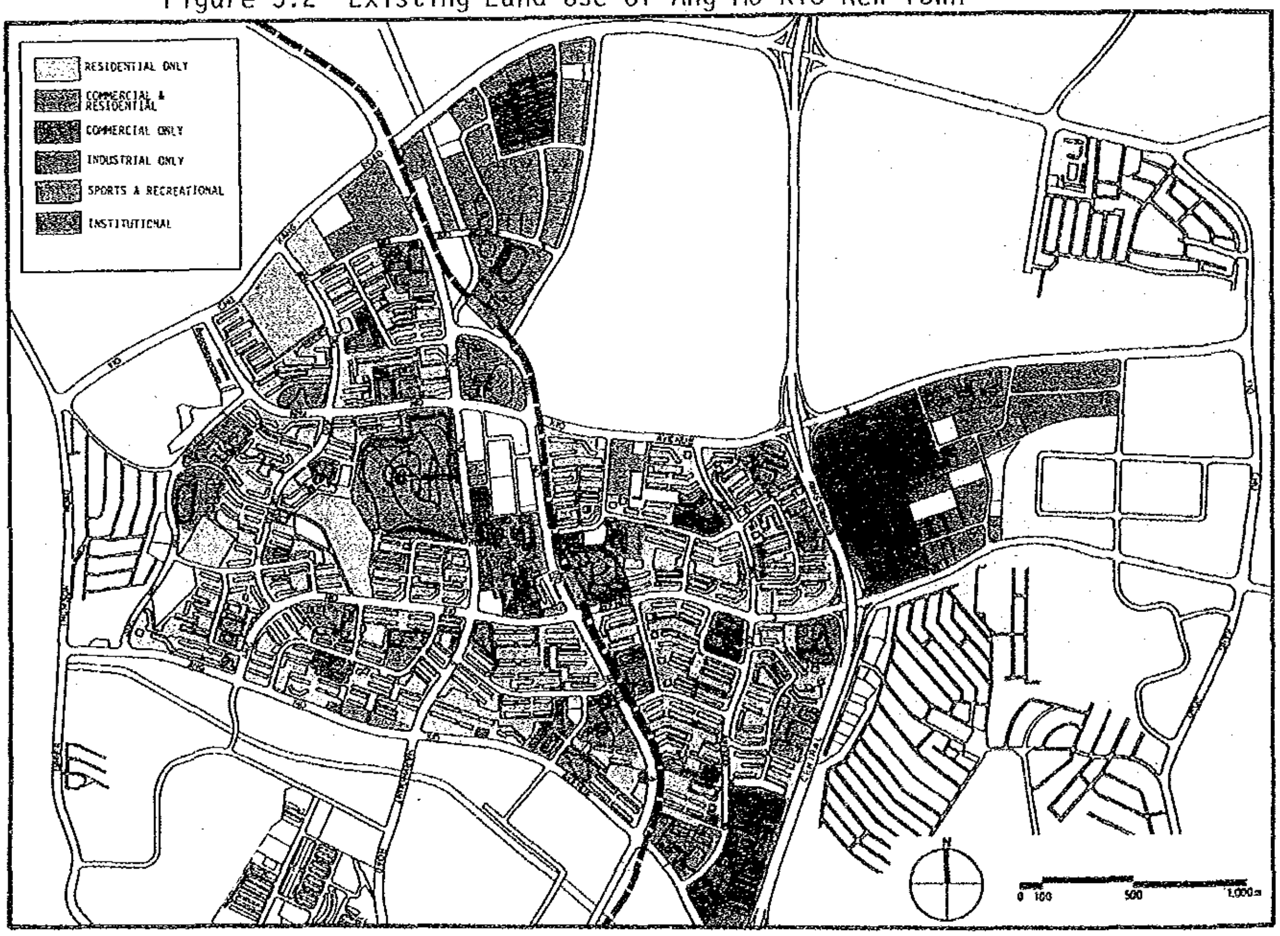


Table 5.1

Landuse of Ang Mo Kio New Town

Landuse	Area	
	ha	%
1. Residential	277.2	37.4
1) HDB area	248.2	
2) Private development	29.0	
2. Commercial	54.0	7.3
1) Commercial only	35.5	
2) Mixed commercial with residential	18.5	
3. School	58.6	7.9
4. Open Space	42.2	5.7
5. Sports Complex	11.7	1.6
6. Institutions	32.3	4.3
7. Industry	128.5	17.3
8. Utilities & Others	19.3	2.6
Sub Total	623.8	84.1
9. Roads	116.7	15.7
1) Avenues	91.7	
2) Streets	25.0	
10. Bus Interchange	1.6	0.2
Sub Total	118.3	15.9
Total	742.1	100.0

Source: Housing A Nation, 1985 HDB and HDB Ang Mo Kio new town map.

Figure 5.3

Structure of Ang Mo Kio New Town

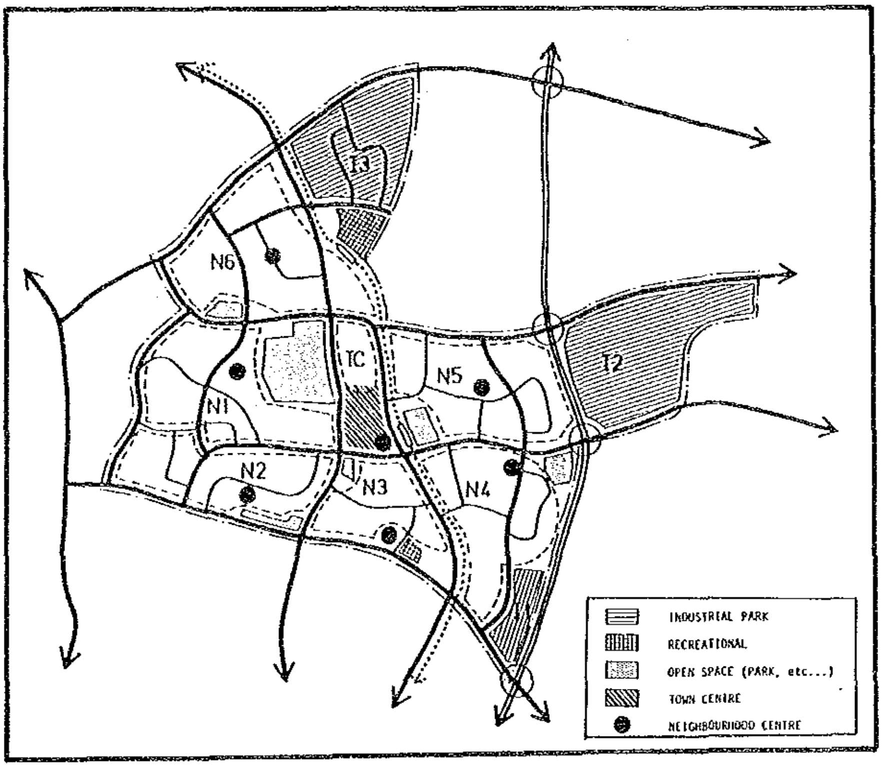


Table 5.2

No. of Blocks and Dwelling Units by Neighbourhood

Neighbourhood	No. of Blocks	No. of Units
1	58	8,274
2	54	7,798
3	46	6,690
4	74	9,878
5	71	9,693
6	41	6,586
Town Centre	15	564
Total	359	49,483

Source: HDB

Table 5.3

No. of Blocks by Storey

Storey of Building	No. of Blocks (%)	Storey of Building	No. of Blocks (%)
2	19 (5.3)	14	11 (3.1)
4	27 (7.5)	15	2 (0.6)
8	1 (0.3)	16	5 (1.4)
9	4 (1.1)	17	1 (0.3)
10	16 (4.5)	19	2 (0.6)
11	42 (11.7)	20	2 (0.6)
12	158 (44.0)	25	18 (5.0)
13	51 (14.2)	Total	359 (100)

Source: HDB

Table 5.4

No. of Dwelling Units by Size (Excluding Private Estate)

Size	No. of Dwelling Units (%)
1 Room	2,696 (5.4)
2	5,432 (11.0)
3	26,714 (54.0)
4	11,355 (23.0)
5	3,286 (6.6)
Total	49,483 (100)

Source: HDB

Table 5.5

Socio-economic Index for Ang Mo Kio New Town

	1980 Census	CTS		1988 HIS
		1981	1990	
1) Population	70,655	198,661	160,100	221,100
2) No of Households	15,139	43,627	41,600	49,483
3) Ave. Household Size	4.67	4.55	3.85	4.47
4) Employment				
a) Manufacturing	n.a.	11,490	15,450	n.a.
b) Retail	n.a.	4,097	3,600	n.a.
c) Others	n.a.	17,756	18,250	n.a.
Sub Total	n.a.	33,343	37,000	n.a.
5) School Enrollment				
a) Students	n.a.	17,864	29,100	n.a.
b) School Children	n.a.	41,324	31,354	n.a.
Sub Total	n.a.	59,188	60,454	n.a.

Source: CTS and SUTIS

Table 5.6

Travel Time to Selected Areas from Ang Mo Kio New Town

Destinations	Travel Time (minutes)		
	MRT 1/	Bus 2/	Car 3/
CBD: City Hall	19	55 - 65	25 (10 Kms)
Toa Payoh	7	32	15 (6 kms)
Bedok	(45)	55	35 (14kms)
Clementi	38	60	38 (15kms)
Jurong	(45)	74	50 (25kms)

Source: Worked out by the Study Team based on available information

1/ MRTC scheduled time from Ang Mo Kio Station. Destinations are assumed to be MRT stations. Figures in parenthesis are estimates only.
2/ Assumed that origin is Ang Mo Kio bus interchange and the time is based on SBS time table.
3/ Estimated based on the interviews.

At present, the bus is the major transport mode for Ang Mo Kio new town, both for trunk transport and feeder transport. Bus systems are well provided with extensive coverage, well configured routes, relatively high frequencies and reasonable level of fares. Bus routes are classified into the following three types:

a) Trunk bus which terminates at Ang Mo Kio bus interchange: 16 routes (See Appendix 5.A).

b) Trunk bus which passes through Ang Mo Kio new town: 15 routes (See Appendix 5.A).

c) Feeder bus which serves Ang Mo Kio new town and the

Figure 5.4 Feeder Bus Route for Ang Mo Kio New Town

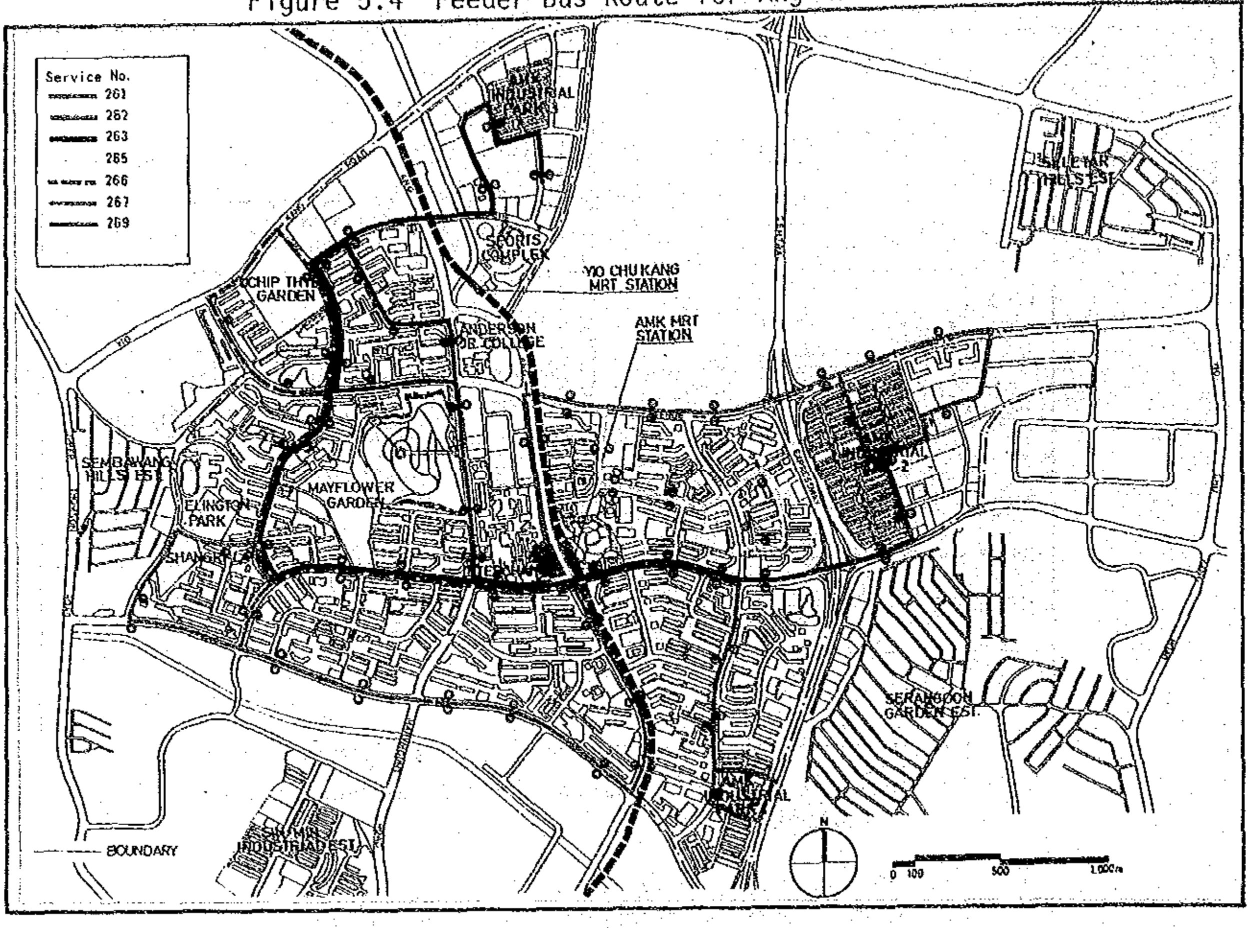
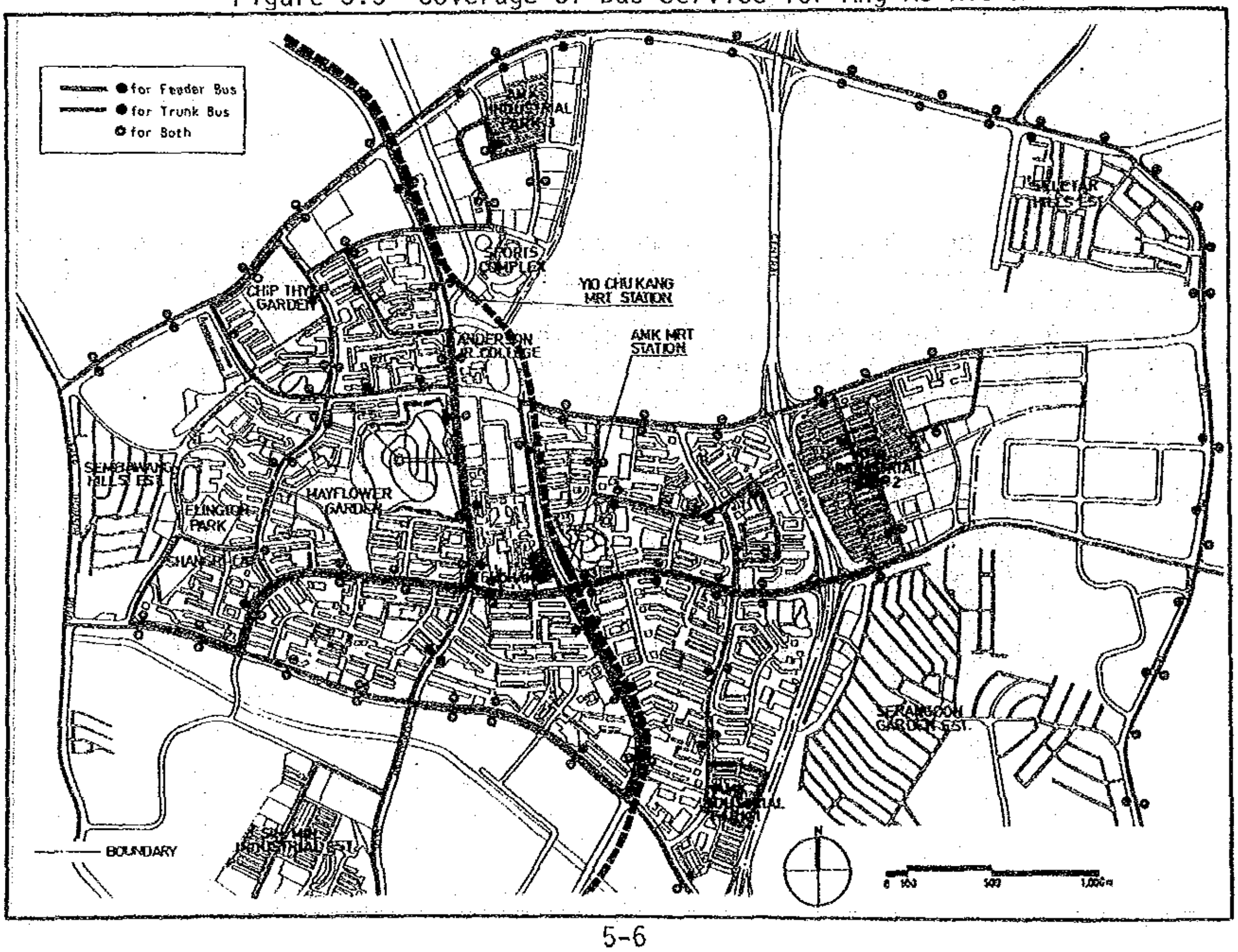


Figure 5.5 Coverage of Bus Service for Ang Mo Kio New Town



Among the three bus route types mentioned, the feeder bus plays a significant role for intra-town movement. As shown in Table 5.7 and Figure 5.4, 55 buses are being operated at 3 to 8-minute headways between 5:30 am through midnight to 1:00 in the morning. The current number of passengers is approximately 90,000 cash rides or 128,000 passengers, inclusive of non-cash rides.

With these bus services, the new town areas are covered densely by the bus network, as shown in Figure 5.5. However, it is to be noted that the dense coverage does not necessarily mean passengers can travel to any destination without transfers.

Table 5.7

Feeder Bus Services Characteristics

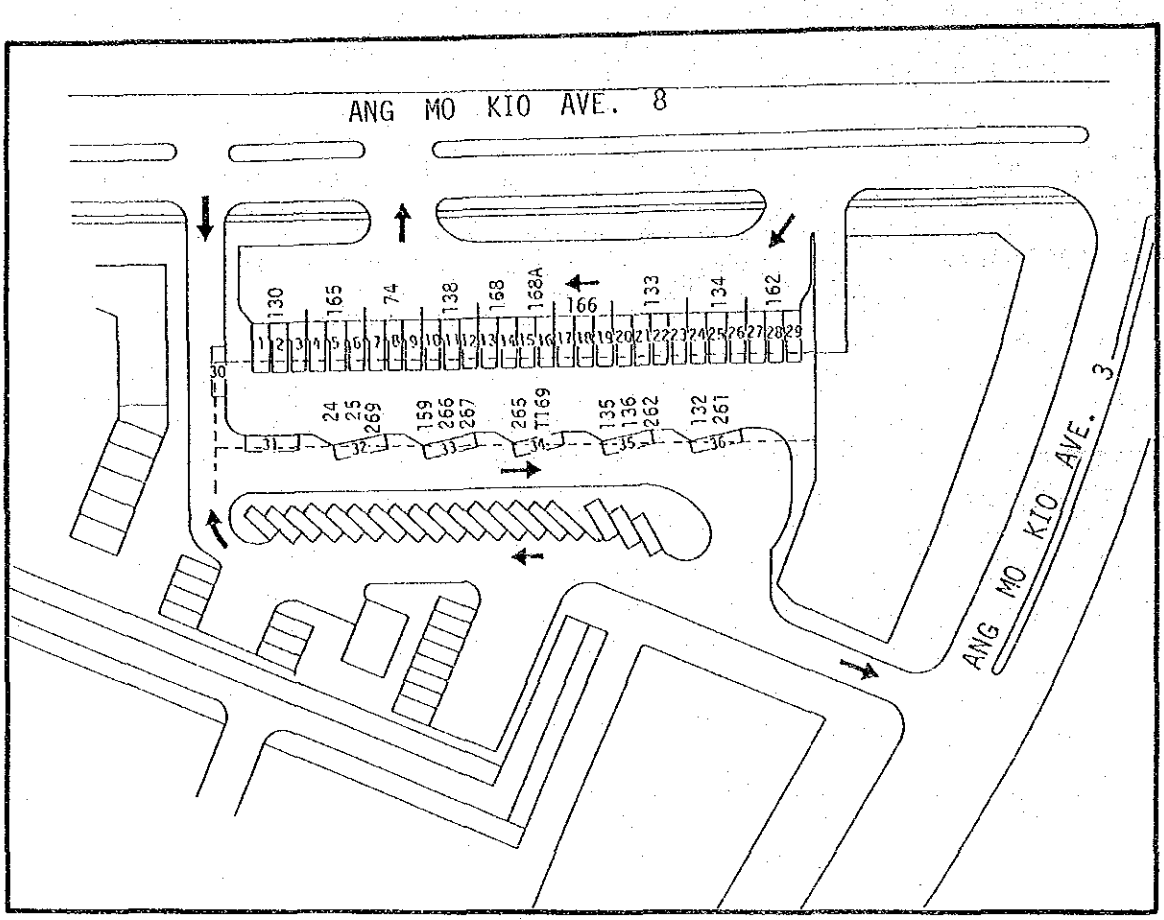
	Service No.	Service Name (Destination)	Roundtrip Distance (km)	No. of Bus Stops Served	Roundtrip Running Time(mins)	Average Speed (km/h)	Scheduled Trips/day	Frequency Peak/ Off Peak (hours)	No. of Buses Allocated	No. of Daily Cash Rides in 1987
1	261	AMK Interchange -I'dustrial Pk.1	5.13	14	28	11.0	332	2.5/4	10	19,210
2	262	AMK Interchange -AMK Ave.2	9.23	23	40	13.8	143	8/8.5	6	9,837
3	263	AMK Depot -I'dustrial Pk.2	14.95	42	59	15.2	143	5/8.5	10	10,648
4	265	AMK Interchange -AMK Ave.10	5.65	14	28	12.1	218	3/5.5	7	12,050
5	266	AMK Interchange -AMK Ave. 4/5	7.64	17	32	14.3	219	3/5	9	18,106
6	267	AMK Interchange -I'dustrial Pk.2	7.00	16	26	16.2	177	2.5/7	7	8,451
7	269	AMK Interchange -AMK St.61	5.60	15	24	14.0	228	3.5/6	8	11,535
	Total of 7 Services		55.20	141	-	-	1,460	-	57	89,837
	Average of 7 Services		(7.89)	20	33.9	14.0	209	3.7/6.0	8	12,834

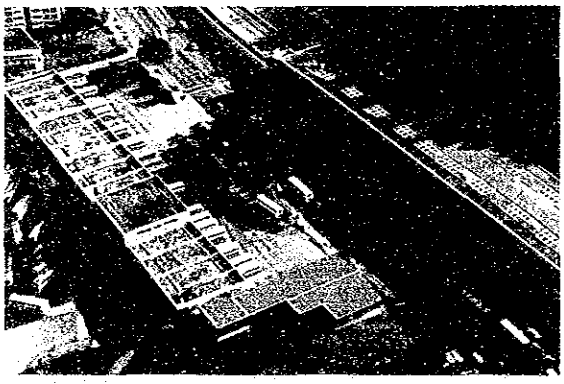
Source : SBS

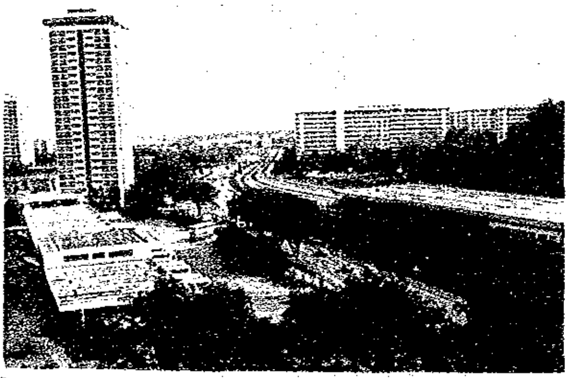
Ang Mo Kio bus interchange is the comprehensive interchange for Ang Mo Kio new town. Although Yio Chu Kan Station has become an additional transfer point after the opening of MRT, the existing bus interchange would continuously be a strategic point located in the town centre and in front of the MRT station. The current layout of the Ang Mo Kio bus interchange is shown in Figure 5.6. The berths of trunk bus and feeder bus are provided on the same platform which facilitate easy transfer for passengers at minimal walking distance.

Figure 5.6

Layout of Ang Mo Kio Bus Interchange







5.3 Transport Demand

5.3.1 Overall Demand Characteristics

As shown in Table 5.8, total traffic demand for Ang Mo Kio new town is estimated to be 405,500 motorized trips which comprises 272,300 trips or 67% of the total by residents and 133,200 trips or 33% by non-residents. Of the total, public mode

Table 5.8

Overall Traffic Demand of Ang Mo Kio New Town

	Mode	Intra-Town	Inter-Town 1/	Total
Residents Trip	Public Private	56,200 10,300	158,600 47,200	214,800 57,500
	Motorized Sub-Total	66,500	205,800	272,300
	Walk	110,100	6,200	116,300
	Total	176,600	212,000	388,600
Non-residents Trip	Public Private	15,500 5,900	89,300 22,500	104,800 28,400
	Motorized Sub-Total	21,400	111,800	133,200
	Walk	-	-	-
	Total	21,400	111,800	133,200
Total	Public Private	71,700 16,200	247,900 69,700	319,600 85,900
	Motorized Sub-Total	87,900	317,600	405,500
	Walk	110,100	6,200	116,300
	Total	198,000	323,800	521,800

Source: estimated by the Study Team based on the results of 1988 HIS for resident trips and other available information and the results of SUTIS bus survey for non-resident trips.

1/ including the trips to/from Ang Mo Kio new town only.

shares 319,600 trips (or 79%), while private mode shares 85,900 trips (or 21%). Walk trips dominate the intra-new town movements. The modal shares are further presented in Table 5.9. 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 car are the major modes for inter-town movements which share 43.5%, 19.7% and 14.0% of the total inter-town traffic demand, respectively.

Table 5.9

Modal Share of Motorized Trips for Ang Mo Kio New Town 1/

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

Source : 1988 SUTIS HIS.

1/ Including non-residents trips.

Table 5.10 showing the traffic demand by trip purpose indicates that "to work" trips share 30.7% of the total motorized trips and are considered to be the most important factor for planning. Walk trips, on the other hand, are dominant in "to School" and "private" trips. Table 5.11 shows the peak hour concentration of the traffic demand which is approximately 28% in the morning (0630-0830 hours) and 23% in the evening (1645-1845 hours).

Table 5.10

Traffic Demand, by Trip Purpose, of Ang Mo Kio New Town1/

Trip Purpose	Motorized Trips		Walk Only		Total	
	No. of Trips	(%)	No. of Trips	(%)	No. of Trips	(%)
To Work	124,600	(30.7)	7,400	(6.4)	132,000	(25.3)
To School	48,000	(11.8)	22,400	(19.3)	70,400	(13.5)
Part of Work	6,100	(1.5)	600	(0.5)	6,700	(1.3)
Personal Business	15,000	(3.7)	5,500	(4.7)	20,500	(3.9)
Shopping	9,900	(2.4)	19,300	(16.6)	29,200	(5.6)
Recreation	4,600	(1.1)	800	(0.7)	5,400	(1.0)
Eating/Social	7,900	(1.9)	5,200	(4.5)	13,100	(2.5)
To Home	189,400	(46.7)	55,100	(47.4)	244,500	(46.9)
Total	405,500	(100.0)	116,300	(100.0)	521,800	(100.0)

Source: 1988 SUTIS HIS

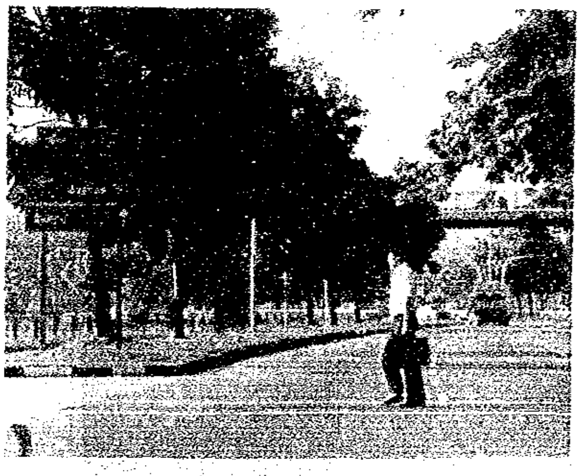
1/ Including non-resident trips

Table 5.11

Traffic Demand in Peak Periods by mode of Ang Mo Kio New Town

Mode	Morning Peak (0630-0830 hours)		Evening Peak (1645-1845 hours)	
	No. of Trips	% of Day	No. of Trips	% of Day
Public	87,800	27.5	73,800	23.1
Private	25,400	29.6	19,000	22.1
Motorized Sub-Total	113,200	27.9	92.800	22.9
Walk Only Trips	28,300	24.3	11,900	10.2
Total	141,500	27.1	104,700	20.1

Source: 1988 SUTIS HIS



5.3.2 Feeder Traffic Demand Characteristics

Feeder traffic characteristics are further examined by analyzing the sub-modal choice of the trips as shown in Tables 5.12 and 5.13 for inter-town trips and intra-town trips, respectively. The tables show how the trunk modes relate with other modes which are used as feeder modes. For example, in the case of inter-town trips 54.1% of the MRT users access/egress on foot, while 41.1% use feeder bus, 2.6% by trunk bus and 1.8% by car. The average percentage of those who rely on feeder modes to use MRT and Trunk Bus are 45.9% and 49.1%, respectively. While 43.9% of the public mode passengers use feeder mode, only 0.9% of the private mode users rely on feeder mode. Intra-town trips, on the other hand, rely less on additional feeder mode.

Table 5.14 presents the feeder bus traffic of Ang o Kio new town. Total number of trips is 138,350/day out of which 94,900 trips are those related to trunk modes (mostly trunk bus and MRT), while 43,450 trips are the movements within new town.

Average door-to-door travel time of intra-town trips and inter-town trips are shown in Tables 5.15 and 5.16, respectively. Table 5.16 shows only the travel time of trunk bus users to determine, at the same time, the approximate time passengers spend for feeder transport. Average travel time of trunk bus users, with and without feeder transport, is 56.4 and 43.2 minutes, respectively. This implies that the time an average trunk bus user spends for feeder transport is 13.2 minutes. Considerinthat trunk bus passengers who access directly would likely spend longer time for 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 al modes. Those who walk all the way spend 16.5 minutes, while those using motorized modes spend 20 to 30 minutes.

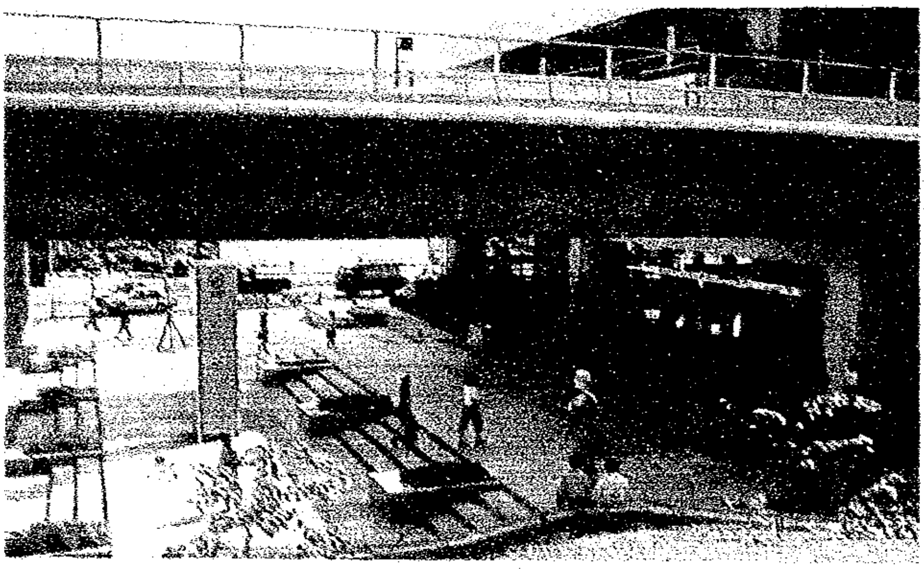


Table 5.12

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

	Trunk Mode	Feeder Mode (To/From)	No. of Trips/day Residents	Non-residents	Total	%	% of Trunk Mode	% of Trips using Feeder
Public Mode	MRT	Walk -	21,600	12,200	33,800	54.1	-	
		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	-	45.9
		Car-pool	200	100	300	0.5	-	
		Sub-Total	39,900	22,600	62,500	100.0	19.7	
	Trunk Bus	-	45,100	25,300	60,400	50.9	-	
		Trunk Bus	5,800	3,200	9,000	6.5	-	
		Feeder Bus	37,600	21,000	58,600	42.4	-	49.1
		Car-pool	200	100	300	0.2	-	
		Sub-Total	88,700	49,600	138,300	100.0	43.4	
	Scheme B	-	200	-	200	100.0	0.1	0
	School/ Company Bus	-	17,900	10,000	27,900	97.9	-	
		Feeder Bus	400	200	600	2.1	-	2.1
		Sub-Total	8,300	10,200	28,500	100.0	9.0	
	Feeder Bus	-	4,700	2,900	7,600	82.6	-	
		Feeder Bus	1,000	600	1,600	17.4	-	17.4
		Sub-Total	5,700	3,500	9,200	100.0	2.9	
	Others	-	5,800	3,400	9,200	100.0	2.9	0
	Total Public Mode		158,600	89,300	247,900	-	78.0	43.9
Private Mode	Car	-	30,200	14,000	44,200	99.3	-	
		Feeder Bus	200	100	300	0.7	-	0.7
		Sub-Total	30,400	14,100	44,500	100.0	14.0	
	Car-pool	-	1,000	400	1,400	82.4	-	
		Feeder Bus	200	100	300	17.6	-	17.6
		Sub-Total	1,200	500	1,700	100.0	0.5	
	Taxi		2,000	2,000	4,000	100.0	1.3	0
	Motor-cycle		13,600	5,900	19,500	100.0	6.2	0
	Total Private Mode		47,200	22,500	69,700	-	22.0	0.9
Motorized Trip Total			205,800	111,800	317,600	-	100.0	34.5
Walk and Bicycle			6,200	-	6,200	-	-	-
Grand Total			212,000	111,800	323,800	-	-	-

Source : 1988 SUTIS HIS

Table 5.13

Sub-Modal Choice in Intra-Town Trips of Ang Mo Kio New Town

	Trunk Mode	Feeder Mode (To/From)	No. of Trips/day: Residents	Non-residents	Total	%	% of Trunk Mode	% of Trips using Feeder
Public Mode	MRT	-	350	100	450	32.1	-	67.9
		Trunk Bus	150	50	200	14.3	-	
		Feeder Bus	600	150	750	53.6	-	
		Sub-Total	1,100	300	1,400	100.0	1.6	
	Trunk Bus	-	3,800	1,100	4,900	51.6	-	48.4
		Trunk Bus	650	200	850	8.9	-	
		School/ Company Bus	50	-	50	0.5	-	
		Feeder Bus	2,900	800	3,700	39.0	-	
		Sub-Total	7,400	2,100	9.500	100.0	10.8	
	School/ Company Bus	-	16,300	4,300	20,600	99.5	-	0.5
		Feeder Bus	100	-	100	0.5	-	
		Sub-Total	16,400	4,300	20.700	100.0	23.5	
	Feeder Bus	-	25,400	7,300	32,700	84.1	-	15.9
		Feeder Bus	4,800	1,400	6,200	15.9	-	
		Sub-Total	30,200	8,700	38,900	100.0	44.3	
	Others	-	1,100	100	1,200	100.0	1.4	0
	Total Public Mode		56,200	15,500	71,700	-	81.6	16.6
Private Mode	Car	-	7,600	4,400	12,000	74.1	13.6	0
	Taxi	-	800	400	1,200	7.4	7.4	0
	Motor-cycle	-	1,900	1,100	3,000	18.5	3.4	0
	Total Private Mode		10,300	5,900	16,200	(100.0)	18.4	0
Total Motorized Trip			66,500	21,400	87,900	-	100.0	13.5
Walk and Bicycle Trip			110,100	-	110,100	-	-	-
Grand Total			176,600	21,400	198,000	-	-	-

Source : 1988 SUTIS HIS

Table 5.14

Feeder Bus Traffic of Ang Mo Kio New Town

No. of Trips/day

Mode			Residents	Non-residents	Total
Inter-Town Trips	Between Feeder Bus and	MRT	16,400	9,300	25,700
		Trunk Bus	37,600	21,000	58,600
		School/ Company Bus	400	200	600
		Car	200	100	300
		Car-pool	200	300	500
		Sub-Total	54,800	30,900	85,700
	Feeder Bus Only	A Feeder Bus Only	4,700	2,900	7,600
		Transfer between Feeder Buses	1,000	600	1,600
		Sub-Total	5,700	3,500	9,200
	Total		60,500	34,400	94,900
Intra-Town Trips Total			33,800	9,650	43,450
TOTAL			94,300	44,050	138,350

Source ; estimated by the Study Team based on 1988 SUTIS HIS and other available information.

Table 5.15

Average Travel Time of Intra-Town Movements of Ang Mo Kio Residents

Door-to-Door Travel Time by mode (minutes)									Total Average
MRT	Trunk Bus	Feeder Bus	School Bus	Car	Taxi	Motor Cycle	Bicycle	Walk	
36.8	29.7	25.7	27.5	20.8	23.3	24.0	24.2	16.5	20.5

Source ; 1988 SUTIS HIS

Table 5.16

Estimated Travel Time of Inter-Town Trips of Ang Mo Kio New Residents

Zone	Average Travel Time of Trunk Bus Users (min)		
	With Feeder	Without Feeder	Difference in Feeder Time
AMK 1	57.2	42.9	14.3
AMK 2	56.6	42.1	14.5
AMK 3	54.8	41.1	13.7
AMK 4	54.4	44.2	10.2
AMK 5	-	-	-
AMK 6	59.5	51.3	8.2
AMK 7	-	-	-
TOTAL AMK	56.4	43.2	13.2

Source ; 1988 SUTIS HIS

5.3.3 Impact of MRT

Table 5.17 shows the modal split among the three major modes of travel between Ang Mo Kio and outside New Town. The characteristics are, as follows:

a) Reduction in average door-to-door travel time from New Town to the MRT served area is significant (39.5 minutes agains 52.0 minutes by trunk bus). This is the most important factor which explains diversion of traffic. However, a question can be raised, at the same time, why the diversion is not so significant compared to the reduction in travel time. This is probably due to the fact that trunk bus still has a much more extensive network to serve traffic demand directly; while MRT is a single line which therefore has to be associated with transfers. This implies that the fare system between feeder transport and MRT, such as through-ticketing and convenience at transfer points, will further affect the shift significantly.

b) As shown in Figure 5.7, the average travel time using MRT has been reduced to as low or to as fairly close to the level of the car. This implies that additional efforts for further reduction by particularly improving feeder services would give a fairly realistic opportunity to compete with car transport.

Table 5.18 shows how the activities and perception on travel of Ang Mo Kio residents have changed due to MRT. The characteristics are, as follows:

a) 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 increased by 13 minutes, the weighted average of travel time reduction is 15.3 minutes.

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

c) 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.

d) 95% of the residents feel punctuality and reliability of travel have been increased. Half of them agreed the increase is considerable.

Table 5.17

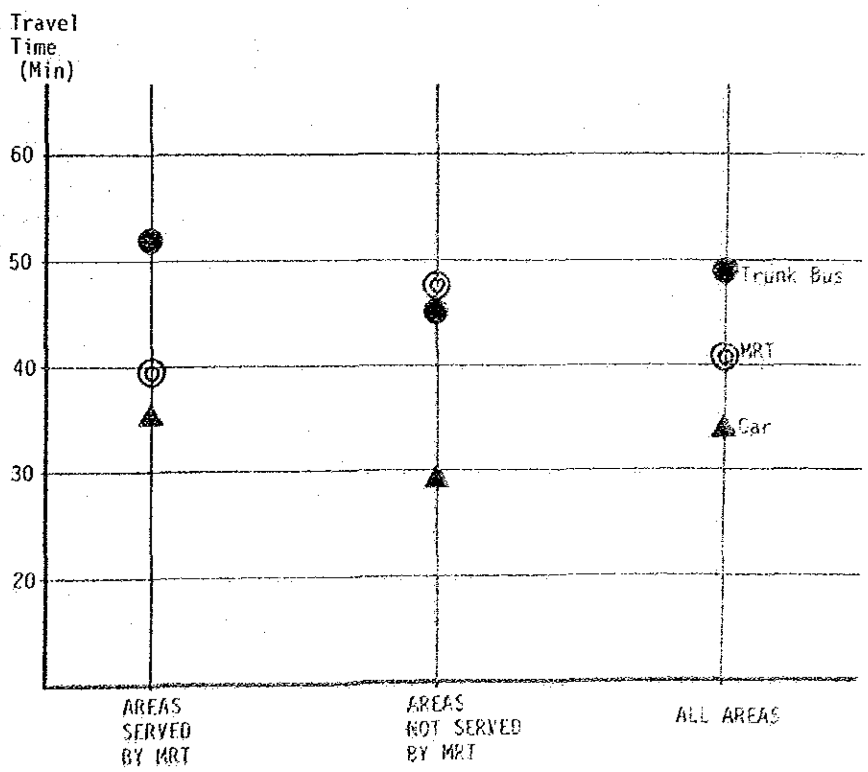
Modal Choice and Travel Time of Ang Mo Kio Residents
(From Town to Outside Only)

From AMK To	Major Representative Mode	All Purpose		To Work	
		Modal Split (%)	Ave Travel Time (Min)	Modal Split (%)	Ave Travel Time (Min)
The Areas Served by MRT	Trunk Bus	47.8	52.0	49.7	54.4
	MRT	34.8	39.5	29.9	44.0
	Car	17.4	35.2	20.4	34.7
	Sub Total	100.0	44.7	100.0	47.3
The Areas Not Served by MRT	Trunk Bus	68.3	46.4	63.0	48.1
	MRT	9.9	48.5	11.1	48.0
	Car	21.8	29.6	25.9	31.5
	Sub Total	100.0	42.9	100.0	43.8
All Areas	Trunk Bus	55.3	49.4	54.9	51.5
	MRT	25.7	40.8	22.5	44.8
	Car	19.0	32.8	22.5	33.3
	Sub Total	100.0	44.9	100.0	45.9

Source : 1988 AMK HIS

Figure 5.7

Average Travel Time of Ang Mo Kio Residents
(From Town to Outside Only)



Source : 1988 AMK HIS

Table 5.18

Changes in Transport Features Due to the Opening of MRT

	% of Answers		Amount		
	Decreased	Increased	Decreased	Increased	Weighted Average
1) Travel Time	94.2	5.8	17 min.	13 min.	15.3
2) Fare	8.6	91.4	9 cents	27 cents	16.9
3) Walking Distance	36.5	63.5	8 min.	11 min.	4.1
4) Punctuality:					
Slightly	3.4	51.2	-	-	-
Considerably	1.5	43.9	-	-	-
5) Reliability					
Slightly	4.5	42.3	-	-	-
Considerably	0.9	52.3	-	-	-

Source: 1988 SUTIS HIS

5.3.4 Estimate of Potential Feeder Traffic Demand for the Proposed New Transit System

Potential feeder traffic demand for the proposed new transit system would comprise the following traffic of both residents and non-residents:

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

b) Existing intra-town traffic of public mode.

c) Diverted traffic from existing private mode 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) Development traffic generating from the urban development which was made possible due to the construction of the proposed system.

However, as there are a number of uncertain factors, the estimate was made based on the existing modal share of the feeder bus traffic, as shown in Table 5.19. Considerations given in the estimate were, as follows:

a) Although the overall service level of the proposed system will be higher than the existing feeder bus, the coverage of the former will be less.

b) Diversion from private mode and walk trips can be expected.

c) Induced traffic and development traffic were not considered.

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 5.19

Estimated Potential Feeder Traffic Demand for the Proposed New Transport System

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

5.4 Planning Direction

5.4.1 Selection of the System

As explained in section 4.3, 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 requirements better because of the following reasons:

a) Group I system can handle more economically Ang Mo Kio new towns'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.

Further details of the systems are summarized in Tables 5.20 and 5.21.

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. It is not necessary to adopt the existing specifications as they are. For example, even within the same system, different sizes of cars are available. Other specifications such as location, number, and size of doors, layout of seats, airconditions colour etc. are also flexible. Therefore, it is to be noted that design of cars can be and should be examined to best meet local requirements.

Car size affects the transport unit and at the same time the size of structure. Smaller vehicles with flexible frequencies are advantageous both for demand and structure design, but would require more number of units. A smaller size car is relatively expensive. This is mainly because the sub-systems to be equipped with car require certain spaces and function regardless of car size. An exercise was made on the preliminary assessment of various function, as shown in Figure 5.9. The findings are summarized, as follows:

i) The most significant difference in car cost is the degree of automation. The figure indicates that if the other specifications are the same, a fully automated car costs more than 40 to 60 percent compared to a one-man operated car.

ii) Cost difference in car size is less significant. A 75-

passenger capacity car is more expensive than 35-passenger capacity car by approximately 15 to 25 percent, while a 100-passenger capacity car is more expensive than a 75-passenger capacity car by about 11%.

iii) Another significant factor is that a car can be operated individually or in an articulated way. The former case is more expensive than the latter, particularly when the unit car size is small. This is largely due to the fact that the economical size of space to accomodate the necessary equipment is larger than the existing car size.

iv) Although it is not shown in the figure, the availability of air condition, number of doors and driver's seats will affect car price. The difference is not so significant as indicated in the figure.

For Ang Mo Kio system, considering the level of demand, a relatively larger car size will be required. It is therefore planned that the type of car to be introduced is that specified in Figure 5.8.

Table 5.20

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

Table 5.21

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

Figure 5.8

An Image of the Proposed Car for Ang Mo Kio System

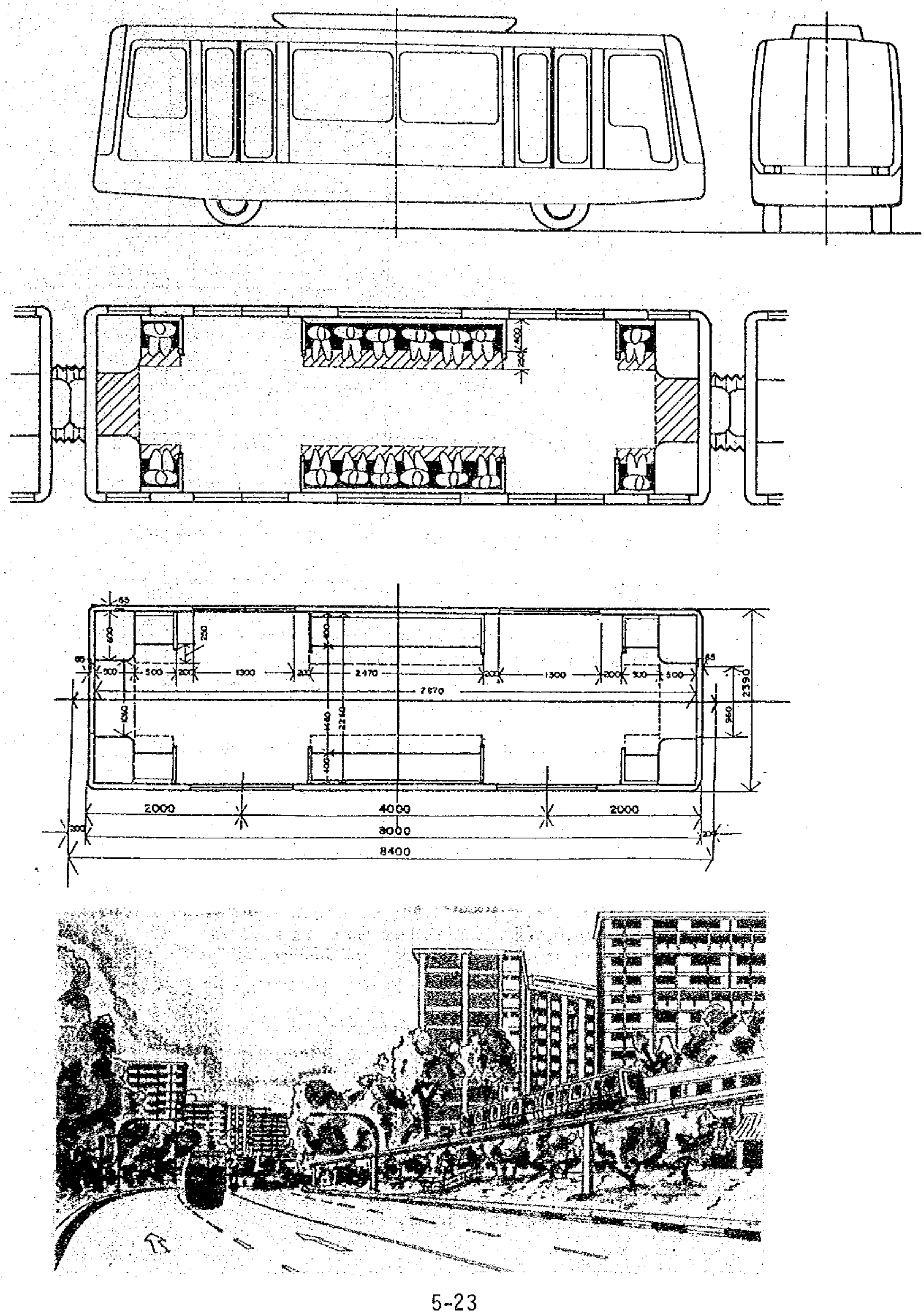
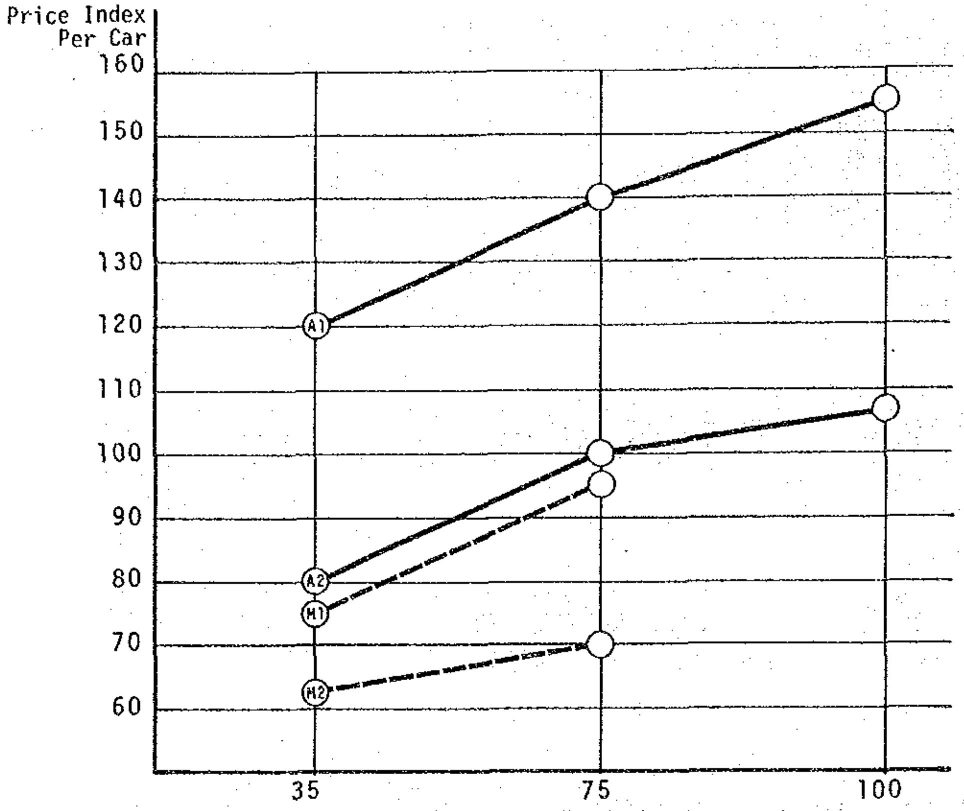


Figure 5.9

Differences in Cost of New Transit System



Source: Worked out by the Study Team based on available information with selected manufactures.

Note: 1) Symbols means as follows:

A1: fully automated, operational with single unit

A2: fully automated, operational with two articulated units

M1: one manned, operational with single unit

M2: one manned, operational with two articulated units

2) All types of vehicles are equipped with air conditioning, one side door and one end driver's seat.

Layout of the seats affect determining the passenger capacity of a car. Assumed capacity, of 75 passengers as determined on an average space requirement of a passenger of 0.23 sq.m (17.25 sq.m x 1/0.23 sq.m = 75 passengers) which is in between design capacity and crash capacity shown in Table 5.21. For Ang Mo Kio system, it is proposed to spare more space for standee because of the relatively short travel distance on the feeder system. As shown in Figure 5.8, either 12 seat plan or 16 seat plan would give better overall riding comfort.

5.4.2 Planning Approach

The overall planning objective of introducing a new transit system is to meet a higher level of demand/needs in transportation, environment and urban development as previously explained.

The route planning, facility planning and system planning (selection and operation of the system) are interactive. For example, route configuration affects train scheduling; alignment designs are affected by vehicle performance; vehicle dimensions affect structure/facility design and so on. As shown in Figure 5.15, a balanced solution for route planning, system planning and facility planning to achieve the targetted service level in the most effective manner must be found.

The targetted development objectives and service levels of the proposed system are set, as follows:

a) The system can take over the existing feeder bus services with better transport services, especially in terms of travel speed, waiting time, riding comfort and smooth transfer with MRT.

b) The system will contribute to the improvement of living environment, especially in regard to noise and air pollution.

c) The system will encourage urban development, especially the development of the existing town centre as a regional sub-centre. Therefore, the system can be extended towards the adjoining areas where demand exists.

d) The system will encourage intra-town movements among different land use and neighbourhoods.

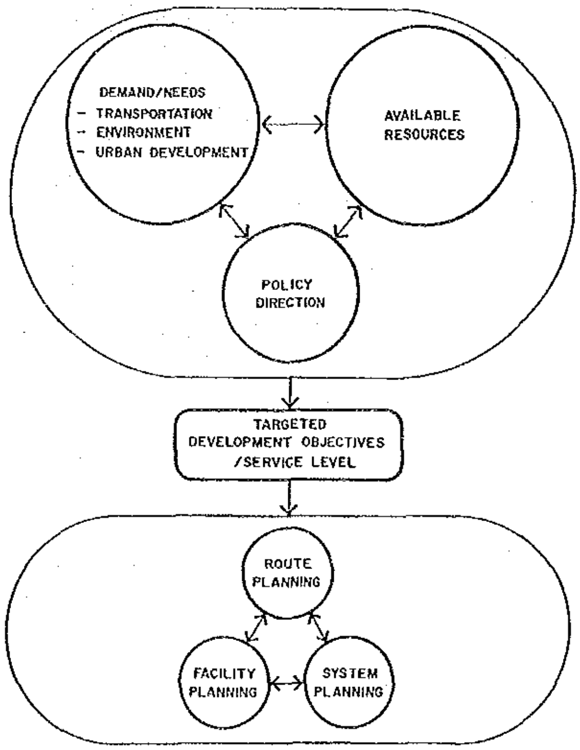


Figure 5.10

Route Planning in Total Planning Framework

5.5 Route Plans

5.5.1 Planning Considerations

Route planning will determine the following:

a) Network configuration: How to configure the route/network of the system will affect and will be affected by the land use/urban development in a broad sense, and directly determine the coverage of services in the project area. Whether the system would only serve a particular area or objectives are to be specified.

b) Alignments: A new transit system can be constructed in a much more flexible manner than other conventional rail-based transit systems due to its less adverse impact on the environment, and smaller vehicle dimensions. Specification of the horizontal and vertical alignments interrelates with environment, transport service level (scheduled speed, riding comfort and accessibility) and construction cost.

c) Location of the stations: Where stations are to be located is critical to have an effective catchment area or maximize the access to the system. Station spacing is a controversial factor. As the distance between stations become shorter, improvement in accessibility follows, but this will result in a decrease in vehicle speed.

Route planning was undertaken by taking into account the following factors:

a) Traffic demand in terms of quantity and quality

b) Required transport service level (scheduled speed, riding comfort, accessibility)

c) Land use

d) Availability of construction space

e) Environment

f) Geographical conditions

h) Minimum interference to existing structures/facilities as a restrictive factor.

5.5.2 Alternative Plans

Various alternative plans were prepared and studied based mainly on the following factors:

a) Route characteristics:

   i) The system serves Ang Mo Kio residents/visitors mainly as feeder to the MRT.

   ii) The system serves not only as feeder to the MRT but also as intra-new town transport system among various traffic generation sources within new town.

b) Coverage:

   i) Extensive coverage similar to existing feeder bus system.

   ii) Less extensive coverage with longer access than those of existing feeder bus system.

Figure 5.11 shows the alternative network plans when the system functions purely as a feeder system in the new town; while Figure 5.12 shows those wherein the system can be extended to the outside of new towns, in addition to the feeder service function. As an exercise, the services of the alternative plans indicate that the route of the new transit system could be configured as flexible as bus routes and cover fairly extensive areas with good accessibility. Since there will be no reason to duplicate the feeder services with the bus system, the alternative plan with dense coverage (Plan A of Figure 5.12) was selected for further study. The route plan is shown more clearly in Figure 5.13. This route will cover all the new town areas with the exception of the industrial area behind the Yio Chu Kan station. Those areas could be served either by shuttle type of a smaller system or more likely covered by trunk buses through minor rerouting.

Stations were allocated at the place where access of users is convenient but scheduled speed will not be lowered excessively. Accordingly, a total of 30 stations were allocated along 21.6 km route (single track length) with an average station spacing of about 400 meters. This will still enable a train to run at the scheduled speed of 20 to 22 Kph.

This system is designed such that it can be extended toward east and integrated with the proposed Ang Mo Kio-Hongang-Marine Parade route. Extension toward west is also possible but not very attractive.

Figure 5.11

Alternative Route Plans for Ang Mo Kio System (Mainly Serving as Intra-Town System)

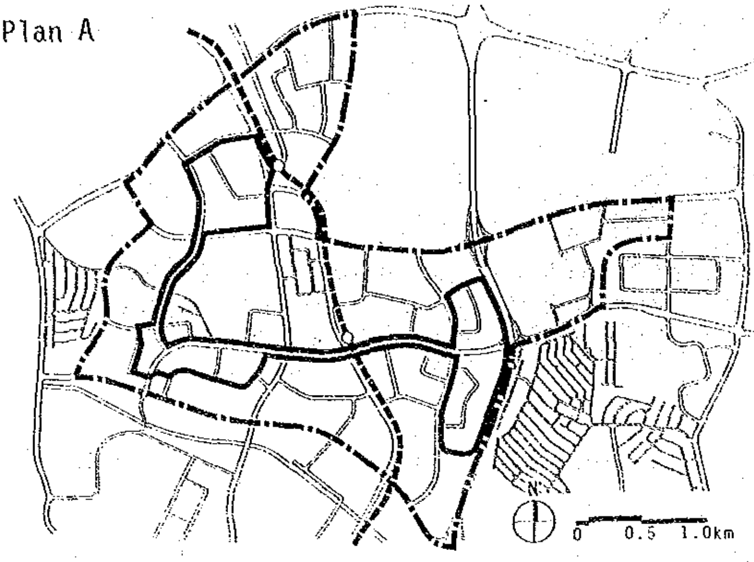
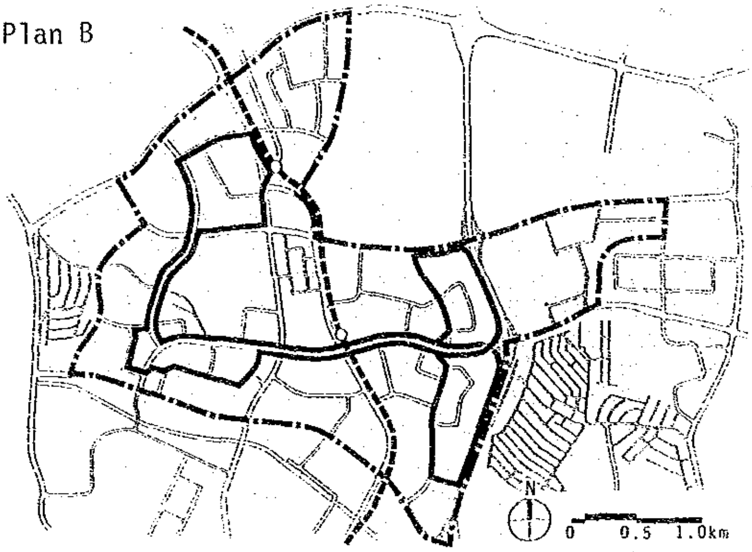
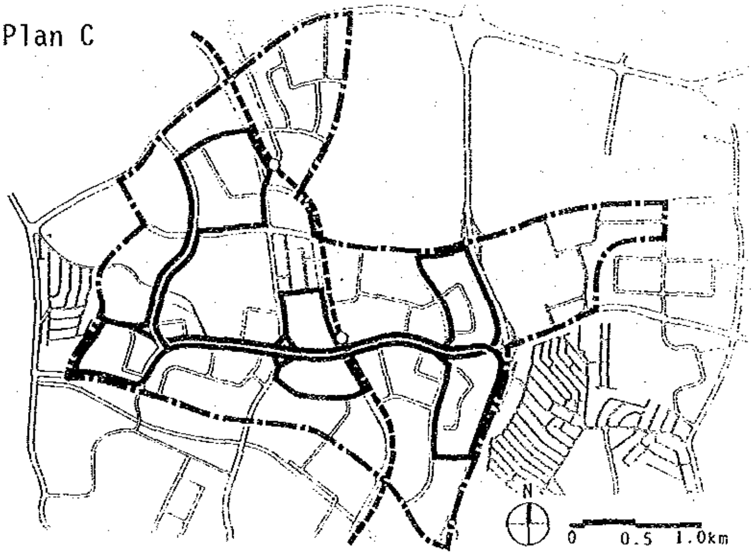
Layout	Description
Plan A 	o Simple loop route.
Plan B 	o Simple loop route with expanded coverage in the areas along the eastern loop.
Plan C 	o Expanded coverage with complex route configuration o A combination of different services is possible.

Figure 5.12
Alternative Route Plans for Ang Mo Kio System
(Serving both as Intra-Town and Regional Secondary Systems)

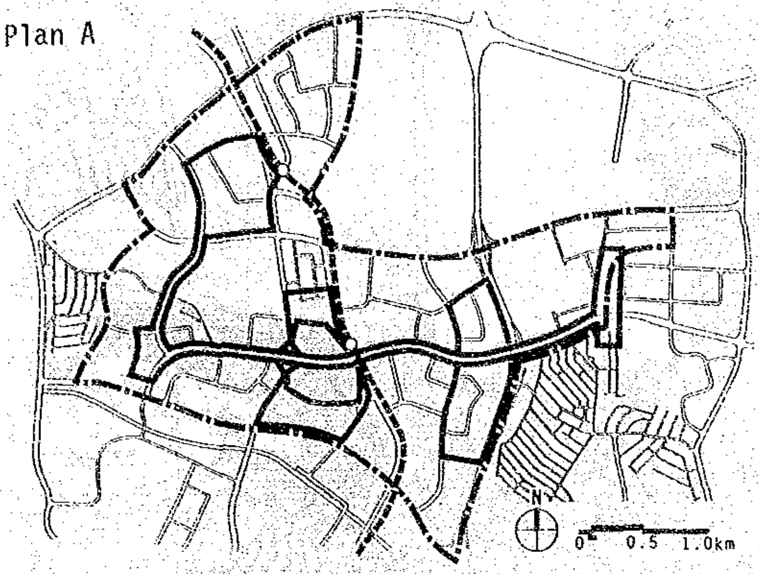
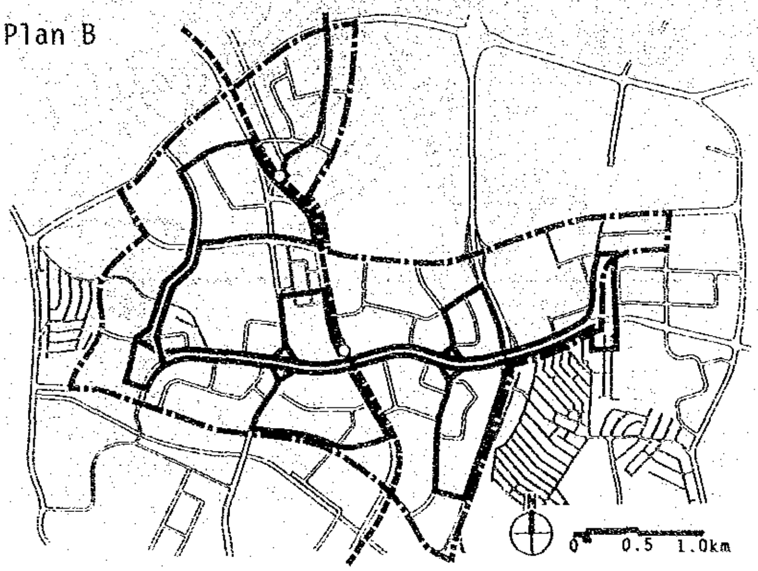
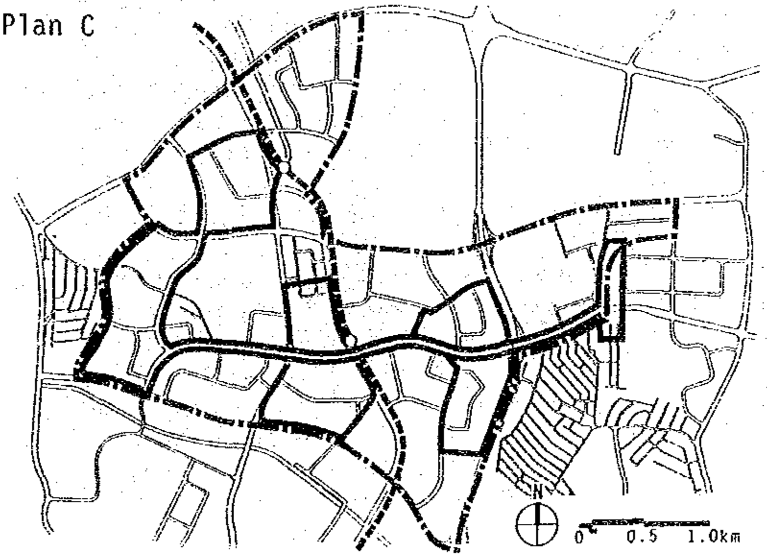
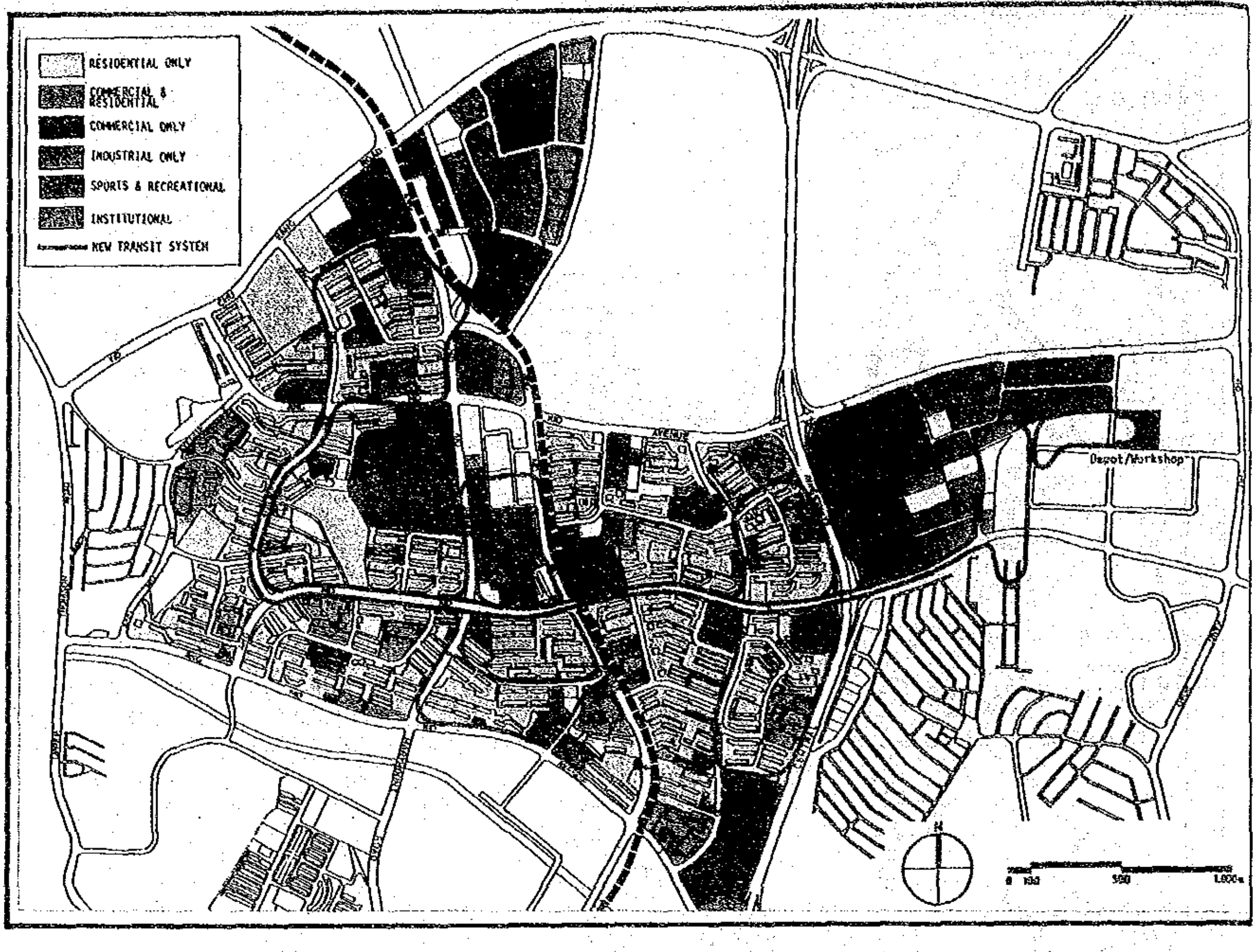
Layout	Description
Plan A 	o Extensive coverage with possible combination of different services. o Expandable to east. o Increased coverage and access to/from town centre.
Plan B 	o Extensive coverage with modified loop structure and addition of a shuttle route. o Expandable to east.
Plan C 	o Extensive coverage with modified loop structure. o Expandable to east.

Figure 5.13
Location of Proposed Route



5.5.3 Alignment Study

In order to confirm the route more specifically, the alignment study was undertaken in detail, including a limited topographic survey along the possible routes/roads and frequent field reconnaisance surveys.

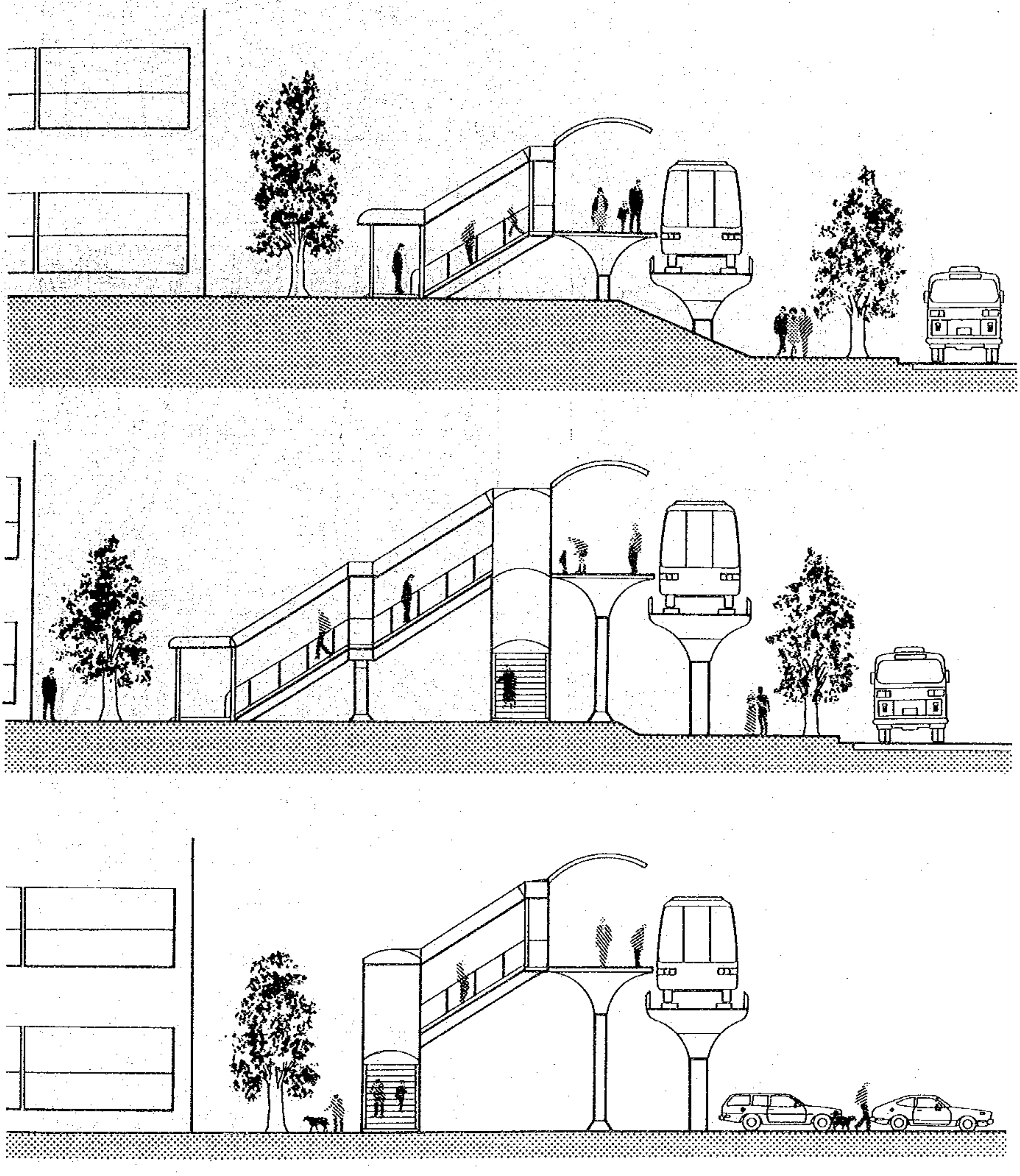
Figure 5.14 shows a typical cross section of the routes along the roads. The structures a r e not placed in the middle of the roads but along the sidewalks, considering the convenience of passengers and the aesthetic aspect. When the structures are constructed along the sidewalk, they would occupy less visual space and have more chances to be hidden by street trees.

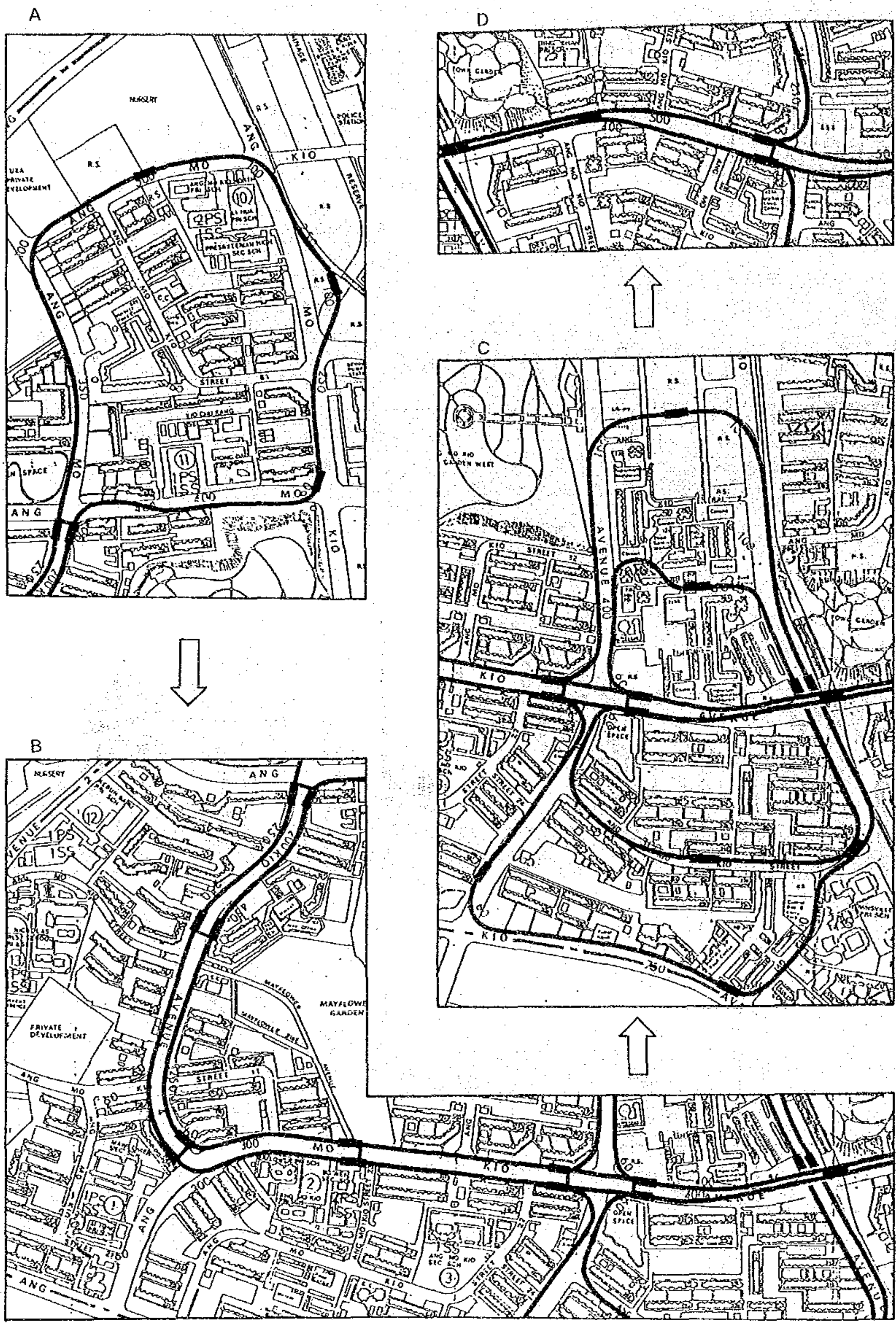
The detailed alignments of the route are shown in Figure 5.15.

Vertical alignments of the routes are moderate except the sections where the system has to cross MRT, expressway and future extension toward east. Gradient along these sections is 6%. On the other hand, horizontal alignments involve a lot of curvature with small radius due to densely configurated network. In order, however, to minimize the slowing down of train, the minimum curvature was limited to 60 meters radius and stations were placed near the curvature. The detailed alignments of the routes are shown in Figure 5.15.

Figure 5.14

Typical Cross Section of the Routes




A
B
C
D

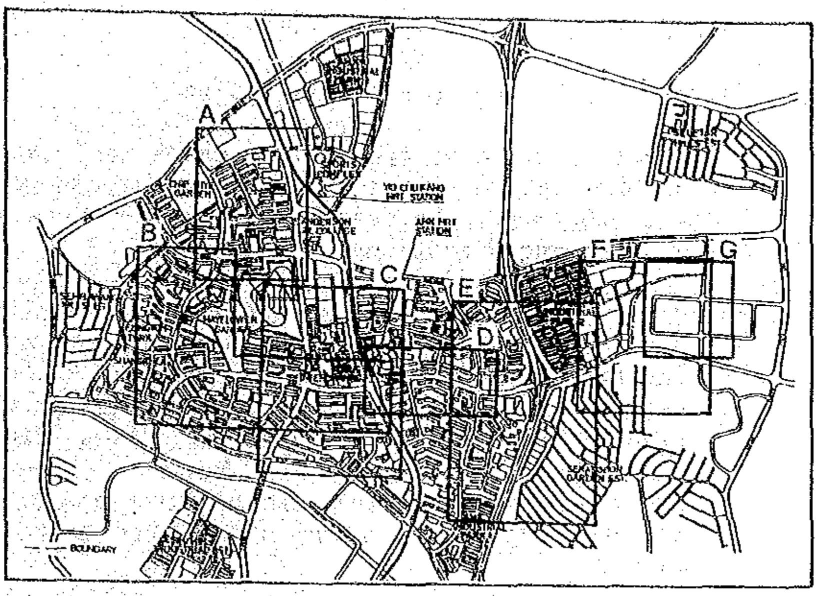
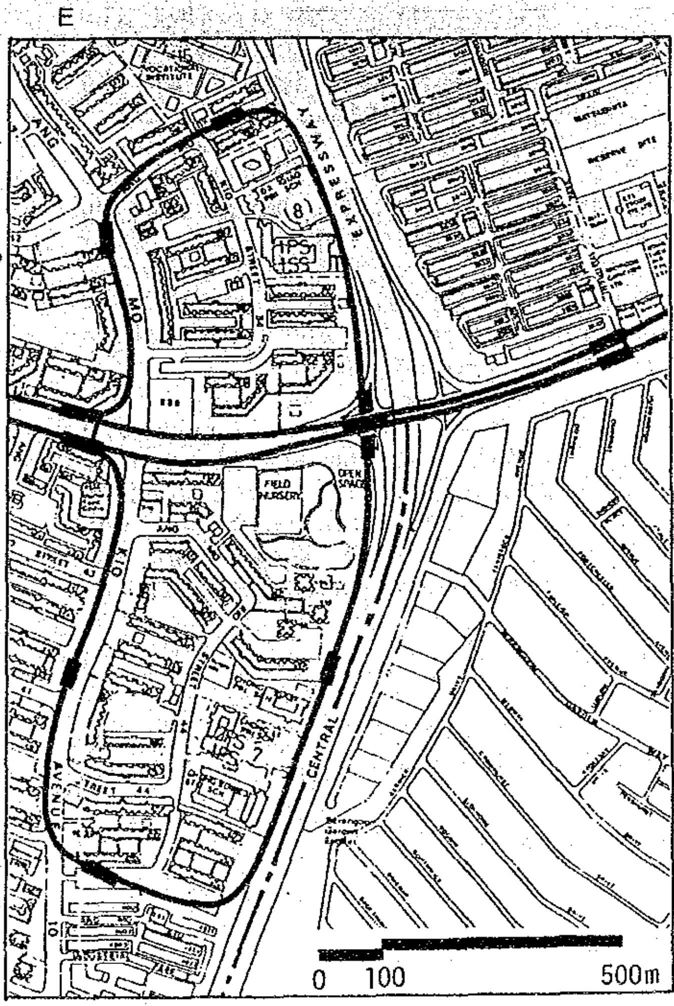
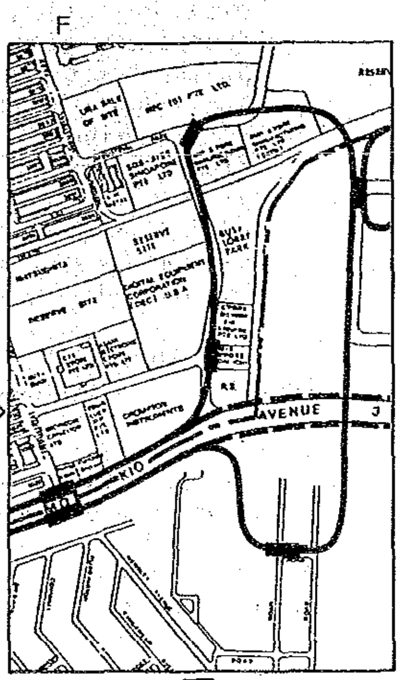
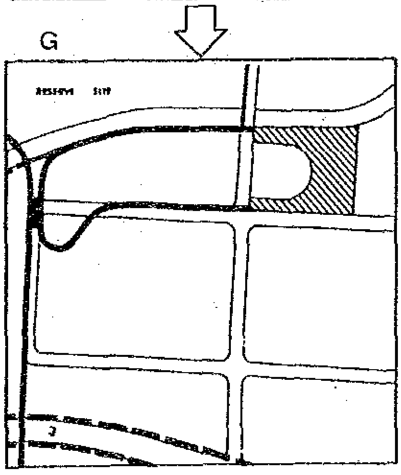


Figure 15

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







5.6 Transport Facilities

5.6.1 Factors Considered in Facility Design

This section explains the factors which were taken into account in the preliminary design of the carriageway and stations. Prior to the work, the following exercises were made to obtain better planning directions:

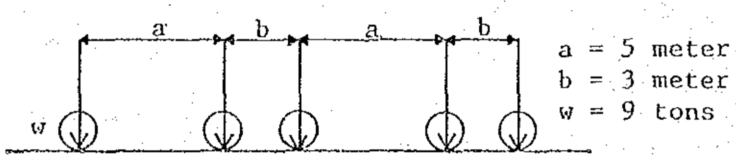
a) Preliminary assessment of the impact of vehicle size on the dimension and cost of the structure (See Appendix 5.B): The result indicates that the advantage of a train composed of smaller capacity vehicles (say 35 passengers) is not significant compared to that of larger capacity vehicles (say 75 to 100 passengers). Since a 35-passenger capacity car does not cost less in proportion to the car size, larger vehicles are advantageous when there are demands to match.

b) Comparison of structures between those of Japan and Singapore: Since there are no design standards available for the AGT systems, an exercise was made on how structure size under the same loading condition will be different between Singapore and Japan and what are the factors affecting the differences. The results indicate that the main contributory factors to the differences are earthquake and typhoon, with which alone approximately 40% of the area can be reduced for column, while minimal for girder. (See Appendix c)

In order to design the facilities in this case study, design standards were temporarily set for the following:

a) Vehicle size: A 75-passenger capacity car will be used for the case study. Accordingly, vehicle size and construction gauge were determined as shown in Figure 5.16.

b) Loading condition: Vehicle size and wheel axle are determined in section 5.5.1. Although the actual vehicle size is assumed to be 8.5 meters, the following loading condition is applied in this study, according to the "Standard Specification" of Japan. It is known that the closer the load axles, the larger the moment generated.



c) Geometric Standards for Alignment:

Standards of alignments greatly affect the performance of train operation. As typically experienced in this case when the system is introduced to an already developed area, construction space is limited and restricted by various physical and non-physical factors at various locations in the new town. A certain design criteria must be at least set for minimum curvature (both horizontal and vertical) and maximum gradient.

<u>Minimum Curvature</u>: Most of the existing new transport systems are designed to allow relatively small curvature of 25 to 30 meters. Although it is technically possible, trains are of course forced to slow down along these sections. In this case study, minimum curvature was set for 60 meters on commercial lines and 30 meters in depot. Lateral curvature which is considered to affect the riding comfort was set for 100 meters based on the experiences in the existing IMCT systems in Japan.

<u>Maximum Gradient</u>: This will affect accessibility and construction cost. If steeper gradient is possible, height of the stations and structures can be lowered which will enable users to go up and down the stairs easily. However, on the other hand, the steeper gradient requires higher vehicle performance and leads to faster tyre wear. Local conditions, especially in the event of a squall requires serious attention to slip of tyre. Although the vehicle performance and technical measures will allow 10%, it is determined in this case study to apply 6%, unless special consideration has to be given.

Figure 5.16

Kinematic Envelope and Structure Gauge