Paper to be delivered to the 5'th World Transp. Research Conf.
in Hamburg 1983
by Tom Rallis, Dr. techn., the Technical University of Denmark.

Summary

Public transport in major cities in developing countries.

The growth in population and private vehicles have given serious capacity problems in the street networks, because of lack of traffic engineering, enforcement and education. The public transport system is often privately owned without subsidy from the government, therefore subways are too costly to build and instead paratransit systems develop, which decreases the economic result for buses. The lack of economic ressources also means serious environmental conditions: accidents, noise and airpollution stressed by the poor housing conditions and climate.

The theories of simple capacity and forecasting procedures by Leibbrand are connected with the effect of city form on public transport given by Rice and the low cost strategy given by Thomson together with the balanceprinciple between environment and accessibility given by Buchanan.

Practical examples from cities such as Calcutta, Bangkok, Hongkong, Singapore and Cairo are presented using the abovementioned theories to provide better conditions for public transport.

The route spacings, the service intervals and the number of buses are compared by use of Holroyds formulas. The fares are discussed as well as the travel times. Further camparisons to developed cities such as London, Paris, Copenhagen and Los Angeles are given. Especially the administrative comparison. The accessibility of public transport, the road area pC and road lengths/km^2 (20, 10 ,5) are compared to the number of vehic km/km^2/hour (6000, 3000, 1500) and number of bus km/km^2/hour (100, 30, 10). The connectivity and circuit indices are given, as well as detour factors. Also taxi and paratransit transport are discussed.

Further the traffic limitation strategy is dealt with.

PUBLIC TRANSPORT IN MAJOR CITIES IN DEVELOPING COUNTRIES
(Operations and service changes - planning approaches)

by
Dr. Tom Rallis
The TECHNICAL UNIVERSITY OF DENMARK, Build. 115
Copenhagen, 2800 Lyngby
Denmark

A. INTRODUCTION

1. The appropriate operation and planning methodology depends on the stage of economic development and the political situation.

Rostow (1) distinguished between five stages: traditional, transition, take-off, mature and consume stage. There is a link between the stages, the net national income, the capital formation, the ability to invest, especially in infrastructure i.e. technical development and political influence.

Cities like Calcutta and Dar es Salaam have inhabitants with an aver. yearly GNP of 200$, Cairo, Bangkok and Manila inhabitants have 400-600$, Rio, Mexico City and Kuala Lumpur inhabitants have 1000-1600$ and Hongkong and Singapore inhabitants 3000$, compared to London and Copenhagen inhabitants 5000-10.000$. The number of private vehicles corresponding to the first mentioned incomes is 30-100 per 1000 inhabitants against 250-300 for developed cities like London and Copenhagen.

2. Further the methodology depends on the city size, the form, the land use and the planning level.

Cities like Calcutta, Cairo, Mexico City, Rio and London are in the 10-15 Mio inhabitant class, with all their problems. Bangkok, Manila and Hongkong are in the 4 Mio class, while Singapore, Kuala Lumpur, Dar es Salaam and Copenhagen are in the 1-2 Mio inhabitant class. The number of trips per day vary for the greatest cities from 8-16 Mio trips down to 1-2 Mio trips for the 1 Mio class.

Further the urban form is of interest as well as the land use and geographical situation. The homogeneous city occupies almost twice as much land as a centralised city or a multicenter city, while the mean trip length in minutes in a satellite or linear city is almost 3 times that of a multicenter city. Very high population densities are found in the central city from 10.000 persons/km^2 in London to 400.000 in Calcutta. This often gives small road area percentages from 7 in Calcutta to 14 in London. Rivers can divide cities in separate parts connected only by bridges or tunnels. This gives irregularities in the road network, just as parks, palaces and class segregation do.

The earlier generation of land use/transport studies unsuccessfully attempted to apply sophisticated traffic modelling technique to cities in developing countries. These studies required large and accurate data-bases, depended on mathematical models for which assumptions often went unstated, considered limited policy options with a bias towards capital-intensive solutions, based their justification on cost-benefit analysis, built into which were extremely doubtful values of time and capital costs.

They generally failed to leave local planners with a tool they understood sufficiently to help them in the continuing task of transport planning. (2)

3. Finally optimisation methodology for public transport can be divided into improvements outside and inside the control of the operator.

There has been described five strategies of city transport (3): Full motorisation of an urban area as Los Angeles, a weak-centre strategy for an urban area as Copenhagen and a strong-centre strategy for an urban area as Paris are expensive solutions, writes Thomson. Low cost strategy and traffic limitation strategy are better solutions according to Thomson. He mentions Calcutta and Singapore as examples. A low cost solution must require little new infrastructure. The city consists of a high density central area with a major centre served by bus and tram corridors. Further subcentres exist. A traffic limitation strategy for an urban area means that it owns a strong city center well served by public transport. Main radial roads are reduced in capacity as they approach the city center, to keep through traffic away from the centre. The limitation includes parking charges, restrain of private vehicles from certain areas and priority for buses. This of course is of hindrance to private vehicles, but it lowers the environmental and congestion inconveniences. Of special hindrance to traffic in developing cities such as Calcutta is the great number of people living and shopping on the road area, further the cows, the rickshaws, the derespect for traffic laws and shortcoming of traffic enforcement.

Within the control of the operator and without hindrance to others are the public network form and route spacing as well as scheduling and futher the organisation and integration of public transport companies. It is also possible to improve only a part of a bus system or develop a new system f.inst. an urban railway. The network connectivity is often poor, the number of buses few, only 0.15 buses per 1000 inh.in Calcutta, compared to 1 bus per 1000 inh. in London, often however only 50% of the buses are in operation in Calcutta or Dar es Salaam, the rest is under repair. There is competition between several bus companies and all the paratransit operators: minibuses, jeepneys, special taxies etc.. These operators are not subsidised by the government as is the case in developed cities.

B. METHODS

1. Comparisons, history, modes and demand.

Although many developing cities have other problems now than the developed cities in Europe, many of the problems are wellknown to the developed cities during the last hundred years. It is interesting to note that the main omnibus routes often follow waterways, bridges and main streets, in either radial or rectangular network, that the first urban railways (subway or elevated) were used to serve the railway terminals, which often had a peak hour commuter traffic so high, that the passengers could not be brought or taken away by bus or tram, therefore in London the urban railway was constructed, however in Paris for a long time passengers access and egress were by foot, and still are, because the walking distances are shorter in a strong center. In developing cities a short cut in transport mode evolution often is a handicap.

As London grew from 1 Mio inhabitants in 1850 to 8 Mio today the number of passengers entering London city per 3 hours increased from 0.25 Mio to 1.25 Mio and the mode distribution changed from 80% pedestrians and 10% by bus to 70% by rail and 10% by private vehicles.

2. Demand

The transport demand model that can be used is that given by Rice (4) for a developed city, and that given by Cowiconsult (5) for Dar es Salaam.

Rice used parameters such as urban form, area, population, employment, pC of population and employment in the city centre, trip lengths and road lengths and from this he found trips per day, trip kms and trip hours, further mode distribution, by minimizing the impedance per unit volume and the space. He also used the ratio of the change in travel time to the change in space as an index.

Cowi used as parameters population, distance from city and bus service.

Both got 1-2 trips/pers/day, a simple model.

3. Service levels, capacity and mode distribution.

A theoretical model of commuter traffic in the central areas of towns has been developed by Smeed (6), and the max number of people, who can travel to a given area by private vehicle and public transport, can be calculated depending on among others the size of the area, the road area percent and the travel speed.

Even if Smeed worked out his model for access to the city center, it is possible to use his model also for second class centers in great cities, e.g. railway terminals, shopping centres. This is a simple method to distribute traffic to modes. However it is necessary to make sensitivity analysis to alter his assumptions about road area pC, the number of peak hours, the utilization of vehicles and buses etc.. Further it is necessary to include railway traffic in own tracé, and pedestrians and bicyclists.

For London city 30 km^2 with road area 14% (f) and speed 14 km/h he found that all commuters N can enter by car, if $N<441\ f^2c^2T^2G$, by bus if $N<20\ f^2c^2T^2G$.

However commercial vehicles was set to 30%, G = 333 ft^2

T peak period to 2 hours

c utilization of vehicles 1,5 pers. buses 42,5

If a percentage is more than 100, it means that the peakperiod is less than 2 hours or the speed greater than 14 km/h.

<u>Table 1:</u>

With	30.000	pass.	90%	can go by private vehic.	or	560%	by bus
	100.000	-	49%	- - - -	- -	310%	- -
	300.000	-	28%	- - - -	- -	180%	- -
	1.000.000	-	16%	- - - -	- -	97%	- -
	3.000.000	-	9%	- - - -	- -	56%	- -
						(35% by rail)	

To compare these capacity results with subways and light traffic one has:

Table 2:

The capacity per 4 m carriage way width is

by footway	32.000	pass/h
bicycle	12.000	-
expressway	1.600	-
street	1.200	-
street, buses	8.000	-
- , trams	16.000	-
subway	40.000	-

Traffic Load A in Terminals
By the traffic load A is meant the average number of traffic arrivals per unit of time, N, multiplied by the average time, b, required for running over, or staying in, the service section; b being expressed in the same unit of time as N.

$$A = N\,b$$

Consider a terminal layout with n stands, all of which are freely accessible, i.e. each arriving traffic unit is able to use any of the un-occupied stands. The traffic load is assumed to be A. If there are so many stands that each traffic unit can immediately find an unoccupied stand or berth (corresponding to a service section), the average number of simultaneously occupied stands is equal to A, since A is the average number of traffic arrivals during the average time required for running over, or remaining in, the service section. With the terminal layouts normally encountered in practice, however, some of the traffic units will arrive at times when all the stands are already occupied, so that the traffic units are "rejected" or delayed. One has

$$n = A + k\sqrt{A},$$

where k is a constant. $K \sim 2$

4. Network characteristics (7)
The elements called vertices v are nodes, where links e are connected, so that a link is a connection between two nodes. A network is disconnected if it contains p isolated subgraphs. A route is a finite set of links e. A ring is a finite route in which the initial node coincides with the terminal node of the route. A tree is a connected network of at least two nodes such that the network does not contain any ring (circuit).

The number of rings is $m = e-v+p$.
The max number of links in a completely connected network is $e_{max} = \frac{1}{2}v(v-1)$.
The min number of links (in a tree) is $e_{min} = v-1$.
The max number of rings (circuits) is $e_{max}-e_{min}$.
The ring index a is the ratio between the observed number of rings to the maximum number of rings.
$a = \frac{e-v+p}{2v-5}$ for planar graphs.

The ratio index b is the ratio between e and v, $b = \frac{e}{v}$.
The connectivity index c is the ratio between e and the max number of links $c = \frac{e}{3(v-2)}$.
The greater the connectivity (near one) the more direct travel, more places to which one can travel non stop.

The detour factor is route length divided by air distances i.e. 1,27 for square network. The accessibility is the number of stops divided by the area. The approx. route spacing is twice the area divided by route length.

5. Bus service levels
Holroyd (8) considered the problem of finding the optimum position of busroutes and the optimum frequency of buses on each route in an urban area.

The criterion of optimality was that the sum of the time costs of the journeys and the cost of providing the bus service should be a minimum.

The model was a bussystem operating in a large uniform area with routes forming a square grid or other patterns, buses running right across the area and the same frequency of buses in each route. Assuming that passengers choose the quickest routes, and making certain other assumptions, formulae are derived in terms of parameters such as:

the value of time (unit h)	k (waiting, walking, travel)
the cost of operating a bus	b per hour
the density of journeys	j journeys originating per km^2/h
the walking speed	u
the bus speed (travel speed)	v>>u (including stops)
the regularity of buses	h (waiting time/bus interval) 0,5 konstant

He found

Route spacing (km), $s^3 = \frac{b\ h\ u^2}{jkv}$

Bus service interval (min), $i^3 = \frac{b}{j\ k\ h^2\ u\ v}$

Number buses/area unit km^2, $m^3 = \frac{j^2 k^2 h}{b^2 uv}$

Newell and Potts have worked with pairing(bunching)of buses (Adelaide). (9)
Vuchic has used this theory for subways. (10)
Brouwer has used the indices Regularity and Punctuality h factor for buses in Bruxelles. (10)

The quality index of regularity is equal to the sum of the squares of the standard intervals over the period of observation, divided by the sum of the squares of the observed intervals.

In an ideal situation Q_r equals 1,00. To the extent that the service is irregular one finds correspondingly lower values.

The quality index of punctuality is equal to the sum of the waiting times when timetable is adhered to, divided by the sum of the same number plus increases due to late running.

In an ideal situation Q_p is equals 1,00.

For bus 14 in Copenhagen the sum of the squares of the standard interval 6 min. was 25·36 = 864, whereas the observed interval sum was 880, i.e. $Q_r = \frac{864}{880} = 0,98$. The increase in waiting time due to late running was an extra 200, i.e. $Q_p = \frac{864}{1064} = 0,80$.

These approximate results are based on rather rough-and-ready arguments. Nevertheless, they are useful.

C. EXAMPLES

1. Calcutta is a linear city parallel to Hooghly River (Ganges), from the center 40 km to the north and 15 km to the south. (11) A single main road runs up each side of the river, with four main-roads feeding in from each side. The two sides are linked with only one bridge Howrah bridge (1940). Railways follow a similar pattern to that of the main roads except that the Bally railway bridge over the river is located 10 km north of Howrah bridge (which only takes road traffic). A new bridge is being constructed. There are a railway station on each side of the city center near Howrah bridge, i.e. Howrah on the west and Sealdah on the main side (east). There are 12 suburban railway lines with 80 stations and 660 wagons.

The bridge has 0.5 Mio pass per day (0.3 Mio by tram/bus), 40.000 vehic/day. The stations have each 300.000 pass/day, 70 Mio pass/year (like Liverpool Str. St). The public bus and tram companies own 1100 buses of which 600 are operating on 11 routes and 470 trams,360 on 26 routes, they have 1000 Mio pass per year. The road network is highly defective.

Inbound daily traffic to central Calcutta is:

by public transport 1.2 Mio trips (0.5 Mio by rail, o.4 Mio by tram, 0.3 Mio by bus)
by individual transport 0.2 Mio trips (0.1 Mio by priv. vehic., 0.1 Mio by truck and taxis).

With about 8 Mio inh. one can expect about 8 Mio trips per day. 1967 the number of public transport trips was 4 Mio trips per day.

1976 the number of public transport trips was 6 Mio trips per day. To this comes priv. vehic., taxi and truck trips 1 Mio trips per day. With 1.5 Mio trips inbound to CBD, still only 10-15% can use priv. vehicles according to Smeed, the rest uses public transport, however this depends on the number of relevant peak hours, the road area pC and the utilization of vehicles, further the commercial vehic. pC.

The buses and trams cannot take 50.000 pass/peak hour at the rail terminals. Therefore a subway is going to be opened.

It will be 3.8 km E-W connecting the railway stations and 7.6 km N-S connecting the Airport (DumDum) with the Tollyganj.

There will be established 17 stations. The urban rail system must link with many other transport systems and be fed by them. The Metro will not be operational before 1986.

According to Smeed 24.000 commuters can enter the city center by car, if the road area percent is 14, the car occupancy 1.45 and the number of peak hours 2, further the commercial cars percent is 30. In Calcutta the road area percent is 7, so only 6.000 commuters can enter the city center by car, however if the car occupancy is 3, again 24.000 commuters can enter. It is not realistic to alter the commercial car percent. With 9 persons per car, it is a jeepney or minibus system, 96.000 commuters can enter. Another possibility to increase this figure is to allow 3 or 4 peak hours.

935.000 commuters can enter by bus, if the road area percent is 14, the bus occupancy 42, the number of peak hours 2 and the commercial percent still 30. With 7 pC road area, but 80 pass per bus, the figure is still 935.000. With higher occupancy or trams one could by 160 pass per unit take 3.600.000 commuters in 2 hours, if the public network was ideal in layout. With 20 nodes and 25 linkes in the tram network the ring index is 0.17, the ratio index 1.25 and the connectivity 0.50.

With 14 nodes and 14 linkes in the suburban rail network the ring index is 0.04, the ratio 1 and the connectivity 0.40, however a planned subway will bring 5 more nodes and 4 more links, it is a decrease in indices to 0.03, 0.95 and 0.3.

There are great detour factors for travel across the river. According to Holroyd the route spacing should be 400 m, h = 1 b = 140 Rp/h K = 1Rp/h j = 4.000 journ./km^2/h u = 5 km/h v = 15 km/h, the service interval in aver. 5 min and the number of public vehic. approx. 2000. If j = 40.000 journ/km^2/h the spacing should be 170 m, the service interval 2 min and the number of public vehic. approx. 4.000.

2. Bangkok (12) town area covers 300 km^2 with street area-% 8-10. In former days most of the transport took place on waterways (canals). Within the city center there is a grid network with streets going north-south and crossing east-west. The outer network is not simple and good connected. The river Chao Phraya divides Bangkok and Thonburi town and there are only four bridges to connect the city parts, distributed with 7 km distance. Therefore two new bridges are constructed. Bangkok is an important port in Thailand. Busservice is covering 620 km road and 39 companies with 4.000 buses (30 pC not operational). There are 45 radial lines and 6 ring lines plus 33 lines outside city area. Memorial bridge has 5.000 vehic/h of which 325 buses per direction (22.000 pass). There are 3 railway stations (Thonburi, Wonq both west and Bangkok east). 30% of passengers entering the city area use private vehicles, 60% buses and 10% paratransit.

47 km subway (3 lines) is now constructed. Buslanes have given less congestion.

Buslanes were introduced in 1980. Before and after studies showed that both bus and car mean travel times increased (up to 25-30%). Busflows were up to 250 conventional buses and 150 minibuses per single bus lane per peak hour. First regulations did not permit buses to leave the lane. This increased bus bunching. Later half the buses were running outside the bus lane. Then bus travel times were further reduced and car travel times increased, but remained less than before buslanes were introduced.

Movement of lorries is banned 4 hours per day for 6 wheel lorries, and 10 hours for 10 wheel lorries. The ban reduced travel costs to other road users by 1%.

15.000 lorries enter the city every day (66% 10-wheelers).

3. Cairo (13). The city is divided into two parts by the river Nile, so that the west Giza area with the Pyramids are connected to the city by bridges (4-5). There are 110 (government subsidised) buslines in the inner city, to this comes 60 regional lines with 2200 buses in total. One square (El Tahrir) is terminal for 55 lines. There are also 18 tramlines, 2 trolley lines and 4 ferry lines. There is about 5 Mio journeys by bus per day (60% of all trips), 20% is pedestrian journeys - and 20% priv. vehic. and taxi trips. Suburban railways in north and south are to be connected. There are 13 pass. per m^2. Two subway lines are planned, E-W and S-N. To this comes 60.000 taxies and 500 limousines.

4. Hongkong (14). The road network on the island is now connected to the main land (Kowloon) by a tunnel (800.000 trips per day). 75% of all trips are public transport. There are 2 Mio bus pass./day, 50% of trips (2800 buses), minibuses (4.000) (1 Mio pass/day) and subways (50 km 4 lines 50 stations), 26 km opened with bridge 1980 (forecast 1986: 0.6 Mio pass/day). A railway is linking Kowloon and Canton. Waterborne transport has 16 routes (0.6 Mio pass/day).

5. Singapore (15). The island is connected to the main land (Malaysia) by a tunnel and a railway. 11 bus companies were merged into 3 1972. 35% used priv. vehic. and taxi, 65% used buses and minibuses. There is built 80 km expressway and an urban railway is started, opening 1990. One expect 1 Mio pass/day by train. Two lines are built, E-W 32 km, N-S 14 km with 34 stations.

The traffic limiting strategy restricts car ownership and ridership. During the hours 7.30-10.15 a charge of S$ 5 is levied for entry by car or S $ 2 by taxi into the central business district (6 km^2) unless there are 3 passengers plus driver in the vehicle.

There is a parking charge for 20.000 parking spaces inside CBD and for 10.000 outside. A shuttle bus service from outside parking areas has been stopped.

The limitation means that almost all through traffic bypasses CBD and more than 50% of entering cars carry four or more passengers.

This means an increase in public transport from 40 to 65% (as mentioned) and a decrease in the number of cars from 56% to 46% entering CBD. Further the number of cars entering before 7.30 increased from 28% to 42%.

6. Kuala Lumpur (16). In 1976 the World Bank provided a loan to the Government of Malaysia for the implementation of a series of traffic engineering and management measures, the main objective of which was to increase the efficiency of the transport system of the capital city Kuala Lumpur. During 1978 traffic counts were carried out at a cordon around the central area, on a line close to the Inner Ring Road. Mode distribution to central areal, persons per peak hour:

private vehicles	23.000	37%
public transport x)	20.000	33%
motorcycle	8.000	13%
other	10.000	17%
	61.000	

In 1975 a system of minibuses was introduced in competition with the stage bus service. From 1975-78 the public ridership increased from 195 Mio pass. to 215 Mio pass., i.e. ridership per inh. has decreased from 180 trips per head per year in 1975 to a figure of 160 in 1978.

During peak hours: out of 20.000 persons going by public transp.:

	6.700 go by minibus,	11.800 go by stage bus
with load factor	18	39
utilization ratio	114%	65%
~number of buses	370	300
number of pass/day	120.000	220.000

The 500 buses in daily service are operated on 97 individual routes. 400 minibuses operate on 16 routes.

7. Dar es Salaam (5) in Tanzania. The city is situated on the Indian Ocean Cost, the harbour being the central part. There are 5 radial roads and 2 railwaylines.

The bussystem has 0.24 Mio pass/day, but expect 0.7 Mio 1985. There are 50 busroutes and 220 buses (of which 150 operational). There is also a regional bussystem with 50 buses. Some buses in regional traffic pick up local passengers illegally (this is called Dala-Dala).

The peak hour mode distribution of traffic into CBD is 25% by bus (including employer transit), 25% by priv. vehic. and motor cycles and 50% walking. The bus percentage is expected to increase to 40%. The busnetwork should be changed to some through radial routes and more ring routes.

The busfleet should be supplemented by at least 50 buses, especially workshops should be improved.

A new busterminal is to be constructed to relieve 2 existing.

x) including school buses and shared taxis.

(Area 1 ha).

With N = 300 buses/h at the new terminal and an unloading/boarding time of 6 minutes, one should arrange for:

$$n = 300\,\frac{6}{60} + 2\sqrt{30} \sim 42$$ stands or berths, when buses arrive at random.

8. Mexico City (19) is situated to the west of Lake Texcoco in the valley of Mexico on the great central Plateau.

1980 the metro carried 2.5 Mio pass/day.

1967-72 3 metrolines (38 km) were built. Further 47 km and 3 new lines were started 1977. Sofretu has designed the metro with rubber-tyred trains like the ones in Paris and Montreal. Now 75 km suburban railway is constructed. 5 lines, of which 4 are radial and 1 ringline along the Periferico, will be constructed either along National Railways, or alongside or in the centre of major roads. 37 new stations above ground are provided for. 600-1000 cars will be used in 12 car trains (with 4000 pass. each).

9. Rio (20) in Brazil lies strung out for some 10 km along the western shores of Guanabare Bay, bridged by a road to the suburb of Niteroi, and backed by mountains.

Suburban lines from north and west bring commuters into the terminal Don Pedro II. First metroline 1 goes from Botafogo at the coast in a u-shape through the city center to Saens Pena. 1979. This line distributes rail commuters from the terminal.

Line 2 goes from Niteroi to Maria Gracia (total line 1 and 2, 36 km). However the outer part of line 2, 16 km to Pavuna, will be light railway (like Manila's metro). Line 3 will also be light railway, a ring line (N-W).

10. Manila (17) lies around Manila Bay on Luzon, main island of the Philippines.

In peak hours 75% of the trips use public transport, of which 50% is paratransit. However capacity and speed are low. An elevated light railway (tram) is going to be built above major roads without connection with the national railway. 15 km long from the airport in south via Central Terminal crossing Pasig River to the north. The line will open 1984 with Belgian articulated trams which can carry 375 persons. 3 cars of 30 m will use station platforms of 100 m length. Distance between stations is less than 900 m. With axleloads less than 10 t this construction will give lower civil engineering costs than a normal urban railway. Further earthquake must be taken into consideration.

CONCLUSIONS

1. Try to give public transport routes reserved lanes e.g. rails.
2. Try to connect buslines, light railway lines, urban railways, suburban railways and long distance railways.
3. Try to avoid busterminals in the city center, using double radial lines.
4. Try to avoid minibus service.

References

(1) Rostow, W.W.: "The Stages of Economic Growth", 1960

(2) Traffic Eng. & Control 1980, Nov.: Calcutta, 1981, May: Bangkok, Oct.: Cairo

(2) Railway Gaz. Int. 1982, May: Hongkong, July: Manila, Bangkok, Singapore

(3) Rallis, Tom: "The City and the Intercity Transport Centres", World Conf. Transp. Res., 1980

(3) Thomson, J.M.: "Great Cities and their Traffic", London, 1977

(4) Rice, R.G.: "The Effect of Alt. Urban Forms on two Mode Transp.", World Conf. Transp. Res., 1977

(5) Cowiconsult: "Dar es Salaam, Urban Pass. Transp. Study", 1982

(5) Hoff & Overgaard: "Maputo and Beira, Urban Transp. Study" 1982

(6) Smeed, R.: "The Traffic Problem in Towns", J. Transp. Econ. & Pol., 1968

(7) Kansky, K.J. "Structure of Transp. Network", Chicago Univ. paper 84, 1963

(8) Holroyd, E.M.: "The Optimum Bus Service", RRL, 1965

(8) OECD Road Res.: "Optimization of Bus Operation in Urban Areas", 1972

(8) ECMT: "Promotion of Urban Publ. Transp.", 1973

(8) ECMT, Round Table 40: "Paratransit" 1978

(8) Holland, E.P., Watson, P.L.: "Traffic Restraint in Singapore", Traf. Eng. and Contr. 1978

(9) Potts, R.B., Tamlin, E.A.: "Pairing of Buses". Austr. R.R.B. Vol. II, 2, 1964

(9) Newell, G.F., Potts, R.B.: "Maintaining a Bus Sched.", Austr. RRB, Vol II, 1, 1964

(10) UITP, 37th Int. Conf. Barcelona, 1967

(10) Vuchic, R. Vukan 38th Int. Conf. London 1969

(11) Wilbur Smith: "Calcutta Metropolitan Plan, Transp.", 1967

(12) Kocks, F.H.: "Bangkok Transp. Study", 1975

(13) Mathbout, M.M.: "Lebensweise < Verkehrsbedarf der Einw. Kairos", Aachen, 1980

(13) Abu-Lughod, Janet L.: "Cairo 1000 Years of the City Victorious", 1971

(13) SOFRETU: "Greater Cairo Study", 1970

(14) RRL "Hong Kong Pass. Transp. Survey", 1967

(15) Peat, Marwick & Mitchell: "Singapore Concept Plan", 1971

(15) TRRL Rep. 1018, Fouracre, P.R. & Maunder, D.A.C., Pathak, M.G., Rao, C.H.: "Publ. Transp. Supply in Indian Cities" 1981, Rep. Suppl. 709, 1981

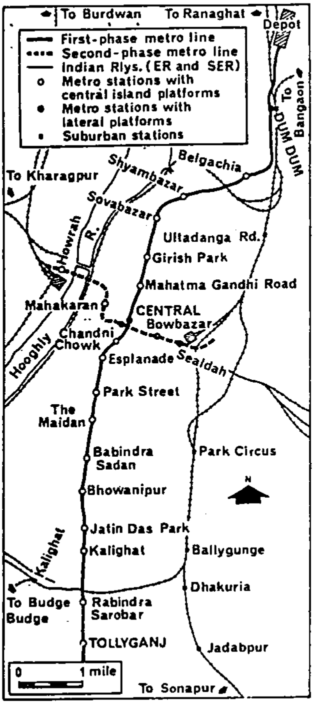
(16) TRRL Rep. Suppl. 678 and 683: "Kuala Lumpur", 1981

(17) Report: "Improvement of Mass Transp. in the Greater Manila Area", 1970

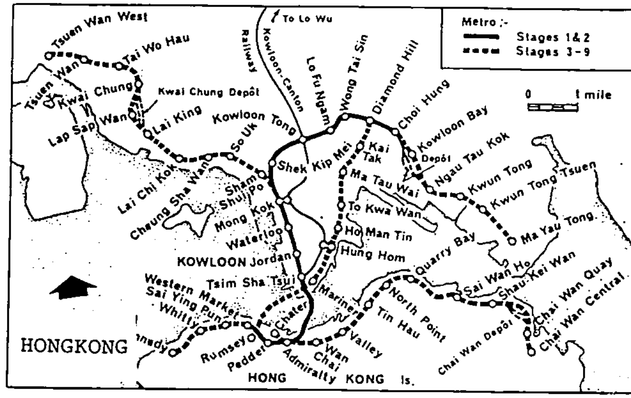
(19) Railway Gaz. Int.: "Mexico City, Aug. 1980

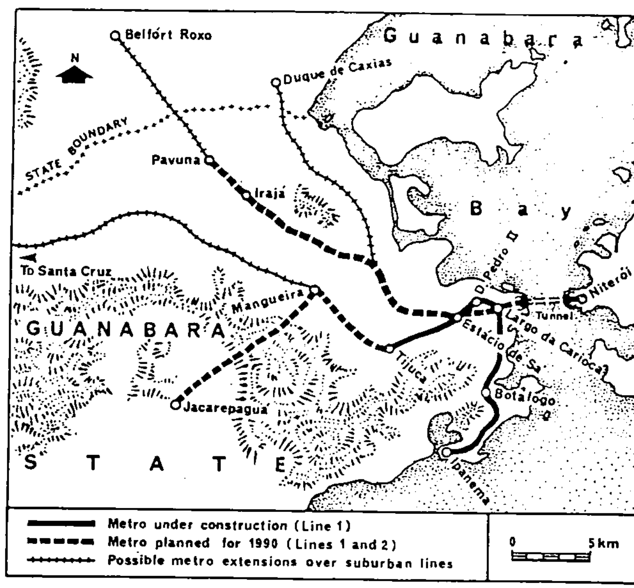
(20) Railway Gaz. Int.: "Rio", March. 1976, "Cairo", Aug. 1980

(20) UITP Rev. 1980, 2: "Hong Kong"

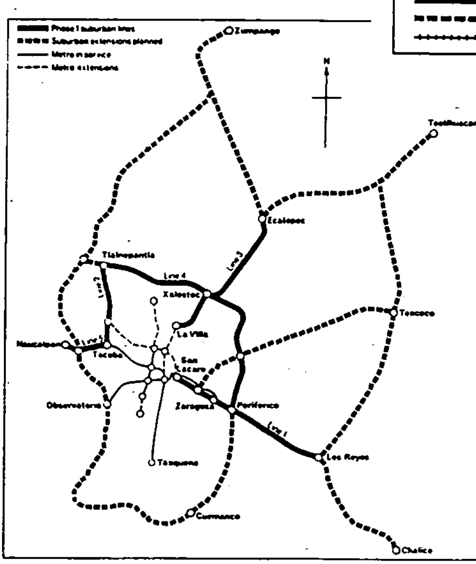


CALCUTTA

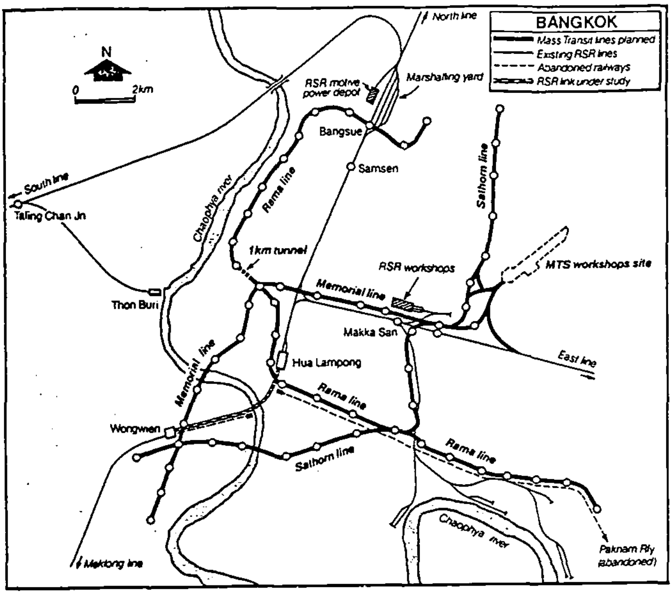


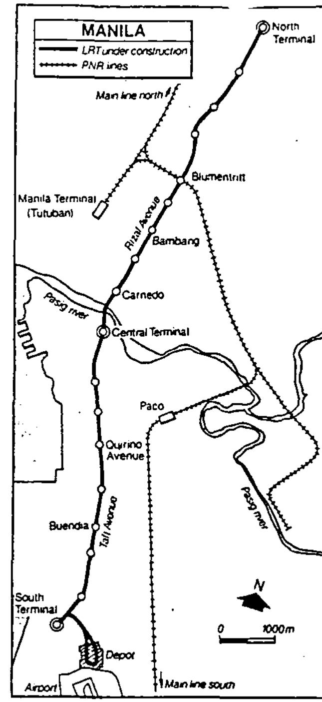


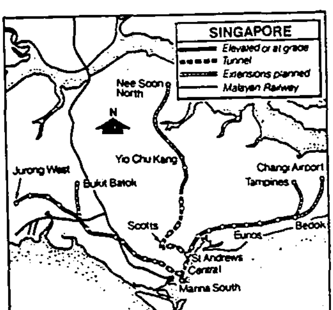
RIO

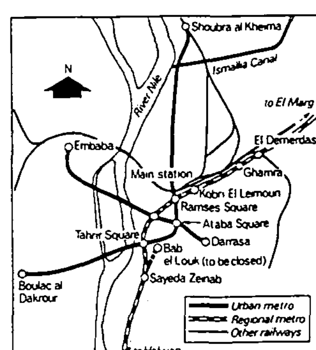


MEXICO CITY


BANGKOK
Mass Transit lines planned
Existing RSR lines
Abandoned railways
RSR link under study
N
0
2km
North line
RSR motive power depot
Marshalling yard
Bangsue
Samsen
South line
Taling Chan Jn
Chaophya river
Rama line
Sathorn line
1km tunnel
RSR workshops
MTS workshops site
Memorial line
Thon Buri
Makka San
Hua Lampong
East line
Memorial line
Rama line
Wongwien
Sathorn line
Rama line
Chaophya river
Maklong line
Paknam Rly (abandoned)


MANILA
LRT under construction
PNR lines
North Terminal
Main line north
Blumentritt
Manila Terminal (Tutuban)
Rizal Avenue
Bambang
Carnedo
Pasig river
Central Terminal
Paco
Quirino Avenue
Buendia
Taft Avenue
Pasig river
South Terminal
N
0
1000m
Depot
Airport
Main line south


SINGAPORE
Elevated or at grade
Tunnel
Extensions planned
Malayan Railway
Nee Soon North
N
Yio Chu Kang
Changi Airport
Jurong West
Bukit Batok
Tampines
Scotts
Bedok
Eunos
St Andrews
Central
Marina South


Shoubra al Khema
N
Ismailia Canal
River Nile
to El Marg
El Demerdash
Embaba
Main station
Ghamra
Kobri El Lemoun
Ramses Square
Ataba Square
Tahrir Square
Darrasa
Bab el Louk (to be closed)
Sayeda Zeinab
Boulac al Dakrour
Urban metro
Regional metro
Other railways
to Helwan

CAIRO