A MEASURE TO IMPROVE

PUBLIC TRANSIT IN SHANGHAI

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1. INTRODUCTION

The Shanghai Metropolis is one of the largest cities in the world with a population of 12 million and a mobile population of 1.34 million in 1986. Serious transportation problems are faced in the city proper, which includes, a)heavy traffic congestion present in both inner city and many arterial roads, b) inconvenience imposed on riders and users of transportation modes, specially in terms of crowded buses and trolley buses and drastically lowered traffic speeds, c) inordinately high traffic accidents, and d) environmental damage arising in the form of traffic noise, exhaust fume. Growth of both motor vehicles and bicycles are most frequently cited as responsible for creating the basis of these problems without adequate provision of roads and parking lots.

2.PRESENT TRAFFIC SITUATION

2.1. Road infrastructure

The road infrastructure of the city proper is due to historical reasons, it is characterized by an east-west orientation of the road network, while thoroughfares in north-south direction are missing. This is especially valid for the area encircled by the loop road on the west side of the city core and the Huang Pu River on the east side.

Table 2-1: Characteristics of the Road Network in 1986 (1)

	City Proper(*)	Inner City	Former City Proper
Total Road Length (km)	1259	1140	900
Road Density (km/km^2)	3.56	4.36	6.43
Average Width (m)	15.0	14.6	14.4
Road Area (million m^2)	18.9	16.7	13.0
Road area per person (m^2)	2.6	2.4	2.1

* city proper: the Shanghai Metropolis divided into 12 administrative districts and 10 counties, the former is city proper, the latter is suburb; inner city: 10 continuous developed administrative districts in 1986; former city proper: 10 continuous developed administrative districts in 1984.

In the inner city of Shanghai, the road area ratio is 6.4%, the density of the road network is 4.36 km per square km, the road area per person is 2.4 square meters (comparing of Beijing 6.0 km^2; Moscow 7.2 km^2; New York 11.2 km^2). Due to the narrow road which normally have a width of 15 to 20 m (9 to

16 m of them being vehicle lanes), a clear separation of the various types of traffic (motorized vehicle, bicycles, pedestrians) is practically impossible, thus causing severe frictions and mixed flow between traffic participants.

2.2. Traffic Situation

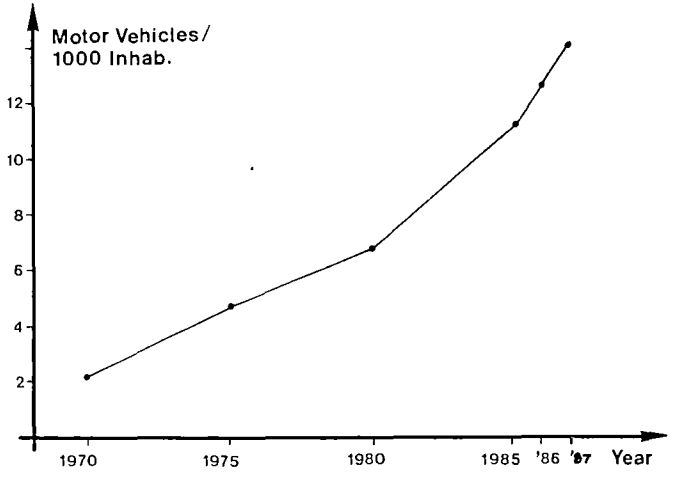
In the meantime, the number of vehicles has increased from 22,500 to 176,000 between 1970 to 1987, which is an average annual growth rate of 12.9%, which the number of bicycles also increased from 885,000 to 4,764,000, giving an average increase of 10.7% per annum during the same period (see table 2-2 and figure 2-1(a),(b)).

Table 2-2: Growth Trends of Motorization and Bicyclization (3)

Year	Inhabitants (1000)	Vehicles (1000)	Vehi./ 1000 inha.	Bicycles (1000)	Bicy./ 1000 inha.	Annual bicycle growth/1000 inha.
1970	10720	22.5	2.10	885	82.5	—
1975	10760	51.3	4.77	1288	119.7	7.7
1980	11460	79.0	6.90	1769	154.4	5.2
1985	12160	138.2	11.37	3688	303.2	14.6
1986	12320	157.7	12.80	4237	343.9	13.4
1987	12500	176.2	14.09	4764	381.1	10.8

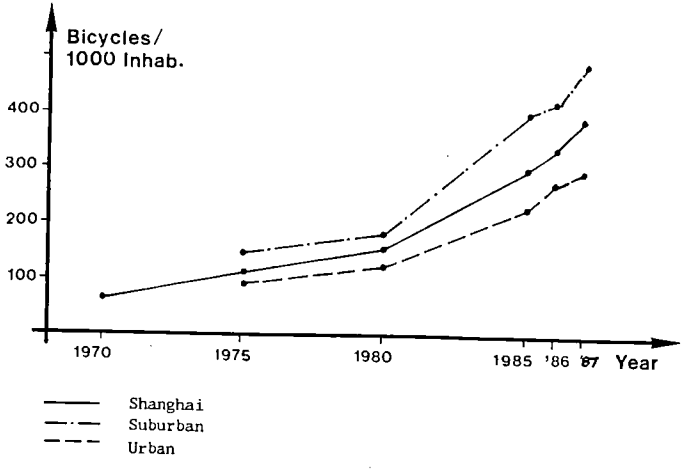
* inhabitants (not included mobile population coming from other cities)

Figure 2-1 (a): Growth Trends of Motorvehicles



This results in great problems, in general, which exerts an influence on decrease of public transit speed.

Figure 2-1 (b): Growth Trends of Bicycles



3.RESIDENT TRIP CHARACTERISTICS

In the Shanghai Metropolis, 21,000,000 daily trips to work, shopping and for other purposes are presently made by bicycle 33%, walking 38%, other vehicular modes 3%, and public transit using buses and trolley buses 26%. To supply the transit services, about 5500 buses and trolley buses carry 14,000,000 average daily passengers in 1986 (included mobile population and number of transfers). The following table 3-1 shows public transit network.

Table 3-1 Public Transit Network (2)

	City	Suburb	Intercity	Total
No. of Bus Lines	146	142	60	348
Total Length of Bus Network(km)	1547	3959	11176	15779
No. of Buses	n.a(*)	n.a.	n.a.	4579
No. of Trolleybuses	926	—	—	—

* n.a.: not available

The average Transit network is now more than 2.1 km per square km in the city proper area, which is up to 4 km per square km in CBD.

3.1. Increment of Transit Daily Ridership

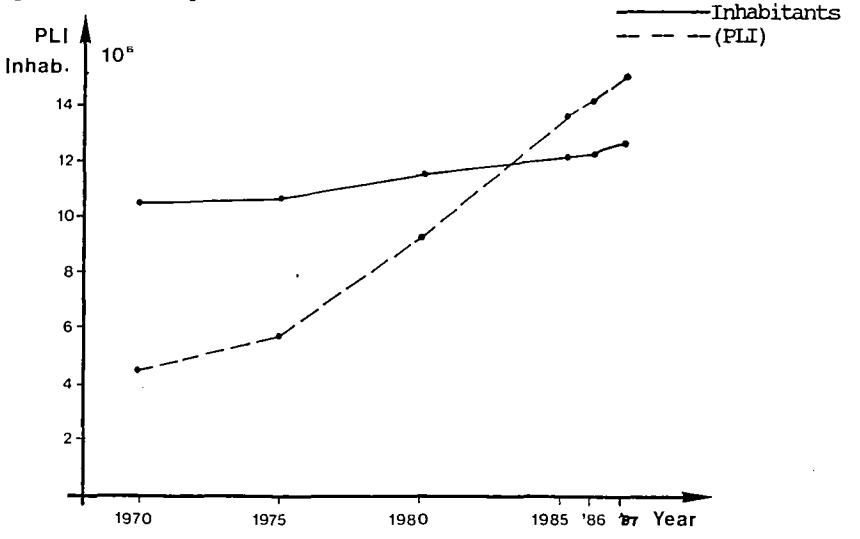
The results of the survey are summarized in table 3-2 and figure 3-1.

Table 3-2 Increment Transit Daily Ridership In Shanghai (million) (3)

Year	Daily Riderships (PLI)	Annual Growth Rate(%)	Year	Daily Riderships (PLI)	Rate (%)
1975	5.78	--	1982	10.52	4.2
1976	6.06	4.8	1983	11.25	6.9
1977	6.18	1.9	1984	12.44	10.5
1978	6.86	11.0	1985	13.72	10.2
1979	8.22	19.8	1986	14.20	3.5
1980	9.31	13.2	1987	15.18	6.9
1981	10.09	8.3			

The aggregate number of transit daily riderships in 1987 was 1.35 times larger than that of 1978 during last decade. This indicates that the Shanghai Metropolis travel demand grew at an extremely rapid rate due to both mobile population growth and rising living standard of the people (Economic reform has made a great success). On the other hand, the bus and trolley bus has an extensive coverage, a frequent service and a reasonable fare (current fare is very low), however, it is in operation, suffering from over capacity and over crowded, the average daily passenger per bus is as large as 2500. In addition, many lines are passing through the inner city, compounding the CBD congestion.

Figure 3-1 Development of Inhabititants and Transit Ridership (PLI)



3.2. Modal Split

The modal split shows significant difference between 1981 and 1986 in the city proper areas as following in table 3-3.

Table 3-3: Modal Split (%) (1)

Mode	Metropolis (1986)	City Proper (1986)	City Proper (1981)
Walking	37.92	36.63	58.44
Bicycle	33.17	25.62	12.49
Transit	26.01	35.21	27.72
Others	2.90	2.54	1.34

Due to drop service level of transit in the city proper, the share of buses and trolleys to bicycles are decreased from 69:31 in 1981 to 58:42 in 1986. It is faced aggravate trend and more traffic congestion to be shift from public transport sector to private transport sector.

3.3 Trip Purpose

The distribution of trip purposes is shown in table 3-4.

Table 3-4 Distribution of Trip Purposes in 1986 (%) (1)

Trip Mode	Hom_based Work	Hom_based Shopping	Hom_based University	Hom_based Pri.&Mid. School	Hom_based Other	NonHom _based
100.0	48.23	11.91	0.99	11.21	19.32	8.34
Walk	28.2	74.6	14.9	77.7	40.5	28.3
Bicycle	41.4	14.8	22.6	14.8	26.2	31.5
Transit	27.6	9.7	61.5	6.8	30.2	27.7
Other	2.8	0.9	1.0	0.7	3.1	12.5
Total	100.0	100.0	100.0	100.0	100.0	100.0

These figures show that 1,746,000 and 2098,254000 daily trips are respectively made by "Nonhome_based" purpose 8.34% and "Homebased" purpose 91.66%. Furthermore, they reveal that most of the trips are home based ones as the purpose "Hom_based work " accounts for approximately 48.23% of the trips, so that trip chains only exist to a small extent.

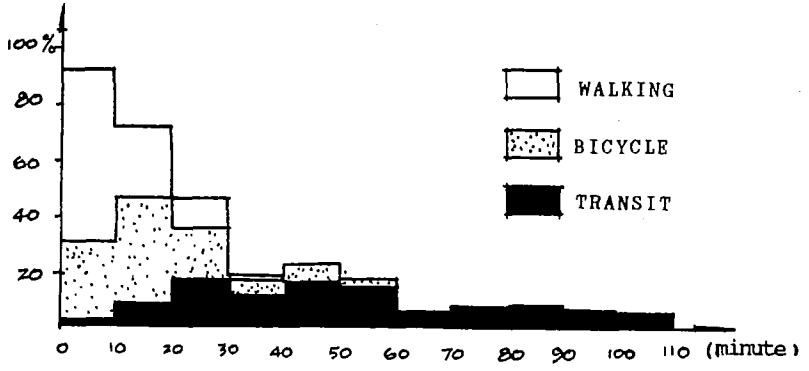
3.4 Travel Time

Information on travel time based on home interview survey is shown in table 3-5 and figure 3-2. The average travel time of work trip by various modes calculated from the frequency distribution. An estimate of the average trip length for public transit is roughly 6.9 km in accordance with 47 minutes average trip time of work trip purpose, assuming an average operation speed of 13 km/hr during the peak hour, average walking time of 6.2 minutes from/to home(work place) to/from bus stop, and average wait and transfer time of 3 minutes.

Table 3-5: Work Trip Time Distribution by Various Modes in City Proper(1)

Time-consuming (minute)	Transit	Bicycle	Walking	Others	Total
0-10	1.07	31.42	60.94	7.45	27.73
11-20	8.21	36.07	27.28	8.73	21.33
21-30	18.67	17.86	8.97	10.33	15.33
31-40	12.25	6.25	1.58	6.41	7.23
41-50	17.14	4.84	0.76	10.04	8.68
51-60	16.14	2.27	0.25	17.29	7.64
61-70	3.58	0.33	0.02	4.03	1.64
71-80	5.09	0.35	0.04	6.72	2.34
81-90	6.89	0.35	0.02	13.18	3.22
over 90	10.96	0.27	0.14	15.82	4.96
Total	100.00	100.00	100.00	100.00	100.00
Average trip time	47.02	20.84	12.62	55.42	31.28

Figure 3-2: Work Trip Time Distribution by Various Modes



3.5. Conclusions

a) There exists a large gap travel demand and the transit supply (facilities).

b) Under these circumstances, it is urgent to specifically focus on public transport. How is the development of public transport prioritized?

c) How to solve the problems for long time (or long distance) passengers of home-based work-purpose during the peak hour.

4. STUDY OF THE "RAPID AND DIRECT COMMUTES SYSTEM" (RDCS)

As a long term policy measure, a comprehensive public transport system should be developed for the Shanghai Metropolis. This would define as: the role various component modes including subway, rail transport (LRT), new

transit systems, stage buses, skip-buses, minibuses and taxis. In particular a readjustment policy is in place calling for significant shifts in emphasis on the mass rail transport system. The planned subway network and the optimum passenger transport structure is shown in figure 4-1 and figure 4-2.

At present there are plan for 8 metro lines with 176km, metro line 1 of Shanghai is under construction. Due to difference in socio-economic conditions between developed countries and developing countries, mass rail transport system is so expensive that few developing countries can afford such a large system. However, the systems will have a long life once constructed.

Figure 4-1 Metro Network, Present Proposal

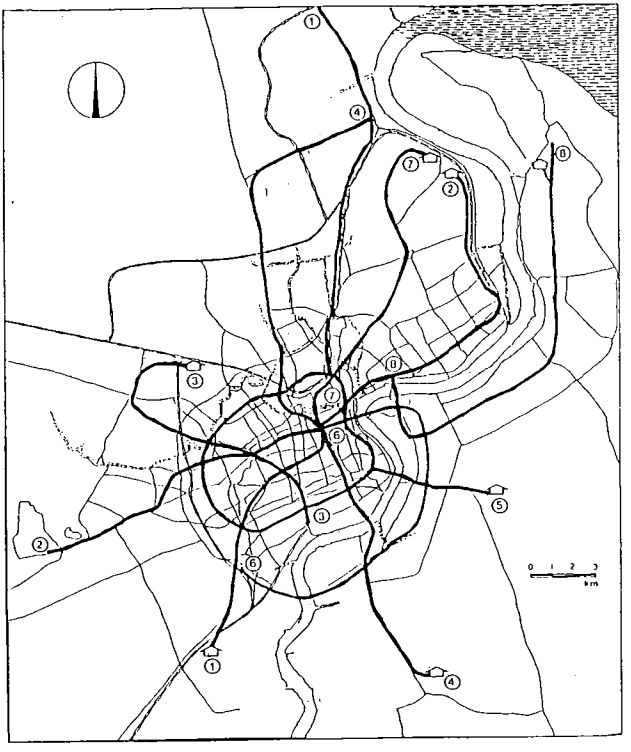
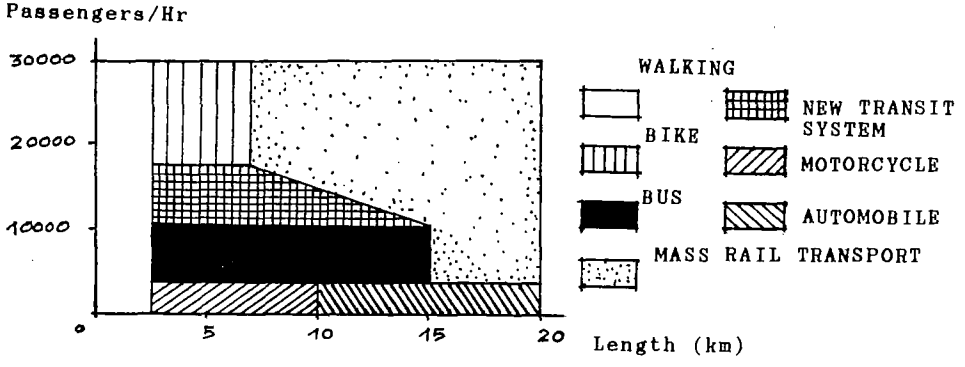


Figure 4-2: Public Transport Structure (4)



4.1. Definition of the RDCS

The "rapid and direct commutes system" (RDCS) is a short term measure to improve present public transit in Shanghai. The RDCS adopts a fixed departure, fixed place, fixed person (implies that trip time to and from work is more than two hours), and a special monthly ticket method to send the passengers to their destinations rapidly and directly during the peak hour. This process decreases the number of transfer, reduces trip time and increases the passenger comfort and accessibility.

According to the survey and mentioned earlier, the traffic data showed that total passenger flow ratio of on-work and off-work rush hours is between 20% and 25%. The passengers during the peak hour which have a trip time to and from work is more than two hours and trip length over 12 km account for approximately 400,000 per day. If these passengers difficulty in trip-making can be eased, the public transit in Shanghai will be improved.

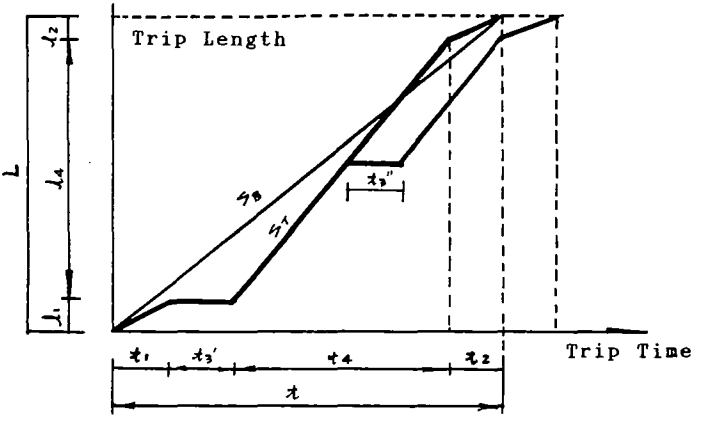
4.2. Elements of the time saving

During the process of passenger trip activity in public transit, it is known that the time-consuming consists of four parts: a) t1 (walk time from home to boarding bus stop), b) t2 (walk time from alighting bus stop to destination (work place)), c) t3 (transfer time including waiting time), and d) t4 (operating time on bus) (can see figure 4-3). The longer the trip length it is, the more transfers and the more trip time.

Where: L.....Trip Length.
l1.....Length From Home to Bus Stop.
l2.....Length From Bus Stop to Destination (Work Place).
l4.....Operating Length.
t1.....Walk Time from Home to Boarding Bus Stop.

t2.....Walk Time from Alighting Bus Stop to Destination.
t3'.....Wait Time at the Bus Stop.
t3''.....Transfer Time.
t4.....Operating Time on Bus.
Sb.....Bicycle Speed.
St.....Bus Speed.

Figure 4-3: Components of Trip Time (5)



Because the average transit network density is high, so that walk length is short from/to home (destination) to/from bus stop. The following table 4-1 shows the transit network density.

Table 4-1 Transit Network Density (*) (km/km2)

Year	Sum	Bus	Trolleybus
1980	2.36	1.88	0.81
1981	2.41	1.93	0.83
1982	2.48	2.12	0.84
1983	2.66	2.21	0.94
1984(**)	1.88	1.72	0.55
1985	1.96	1.76	0.57
1986	1.96	1.81	0.57
1987	2.09	1.94	0.60

**: a) In July 1984, city proper extended area from 230 square km to 329 square km.

*: b) 10 continues developed administrative districts.

According the following formulation, it was calculated that average t1 of all day is 8.2 minutes and length from home to bus stop is about 617 meters in 1987.

$$T1=2(L0/4+1/3.5D)1/V$$

Where: T1/T2.....Walk Time from/to Home/Destination to/from Bus Stop.
L0.....Average Bus Stop Length, assuming L0 of 690 meters all day.
D.....Transit Network Density in 1987, assuming D of 2.1 km per square km.
V.....Walk Speed, assuming V of 4.5 km per hour.

Based on the Home Interview Survey, the average t1 and t2 are about 6.4 and 6.37 minutes of work-purpose during the peak hour, assuming an average walk speed of 4.5 km per hour, an estimate of the average length is only 490 meters. Obviously, it is impossible to reduce the sum of t1 and t2. In order to save t3 and t4, the RDCS concentrates on solving long distance commuters.

4.3. Selected the RDCS Line

The origin-destination matrix for public transit mode showed the detailed desire trip flow for each traffic zone. Figure 4-4 depicted the O-D desire line which the O-D travel times by transit mode for each pair of traffic zones is more than 90 minutes and number of transfers are between two and three. According to O-D passenger distribution ,selected a RDCS line should be considered several indicators as following:

a) A RDCS line should have sufficient passengers for supporting the request of 80% RDCS loading factor.

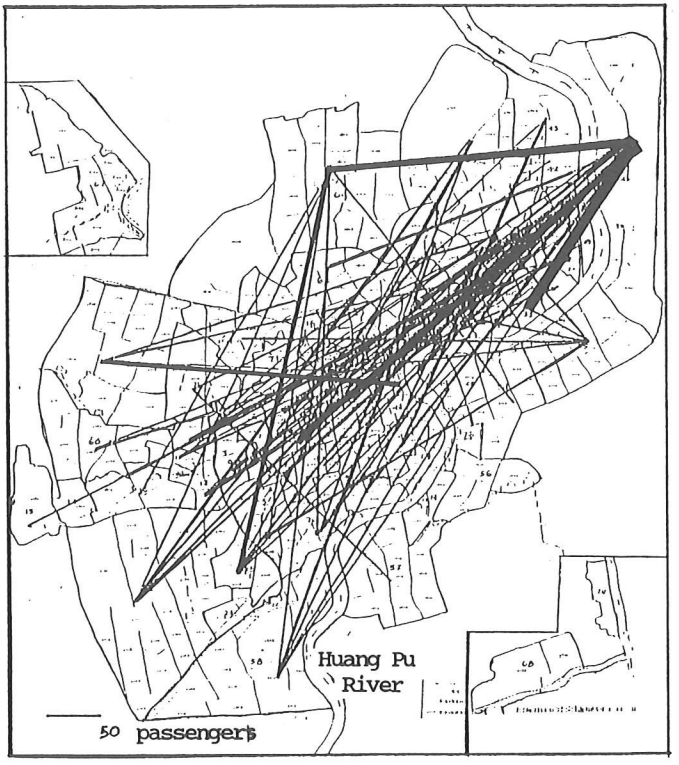
b) A RDCS line length had better 13-18 kilometers long.

c) In order to form RDCS bus network and operate at least two directions, terminals of RDCS line should locate within the residential areas.

Using the transportation planning model and creating road base network and transit network at the commuter, It was set the Qu-yang and Xu-jiawei terminals, the RDCS 200 bus line was selected by the requests mentioned above based on shortest paths on base network. The RDCS 200 bus line length is about 16 km from the Qu-yang housing (north of the city) to the Xu-jiawei large scale terminal (south west of the city) (see figure 4-5).

Depending on the original RDCS bus line shortest path of the commuter modeling, after operation, the RDCS bus line path was modified and changed somewhere which maybe should demolish some buildings due to narrow roads. Actually , the RDCS bus line easily changed to suit new conditions of daily road network during the peak hour, avoiding the heavy traffic and bottleneck areas and optimizing road network.

Figure 4-4 O-D Desire Line of over 90 minutes of travel time and 2-3 Transfers by Transit Mode

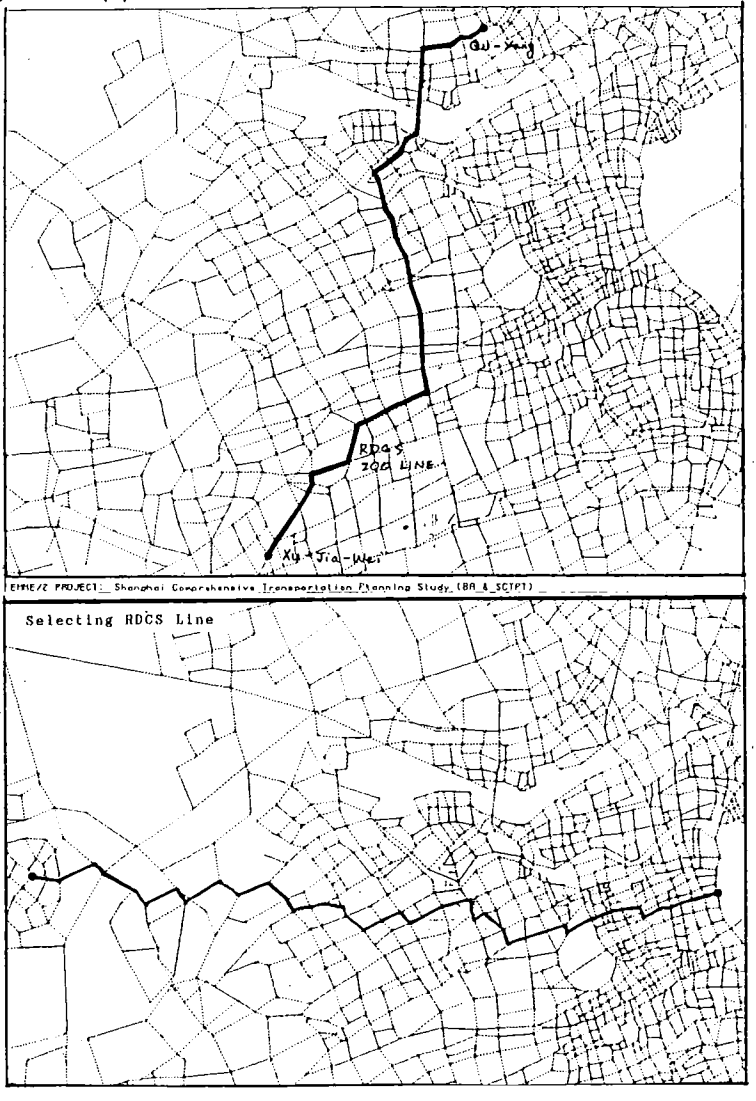


4.5. Evaluation of the RDCS 200 Bus Line

The RDCS is a good interim measure to improve the rider's trip time and comfort during the peak hour. A series of objectives could be obtained from the city of the RDCS 200 buses. It can carry 120 average passengers per bus per one direction. The load factor is about 0.82, the operating speed could reach to 20 km per hour, increased 18 % comparing the normal Shanghai transit buses. Every special passenger can save travel time of 30-35 minutes and go to work on time every day

Figure 4-5 (a) The RDCS 200 Bus Line from Qu-yang Housing Terminal to Xu-jiawei Terminal
-Shortest Paths on Base Network

Figure 4-5 (b) Another RDCS Bus Line from East to West Direction



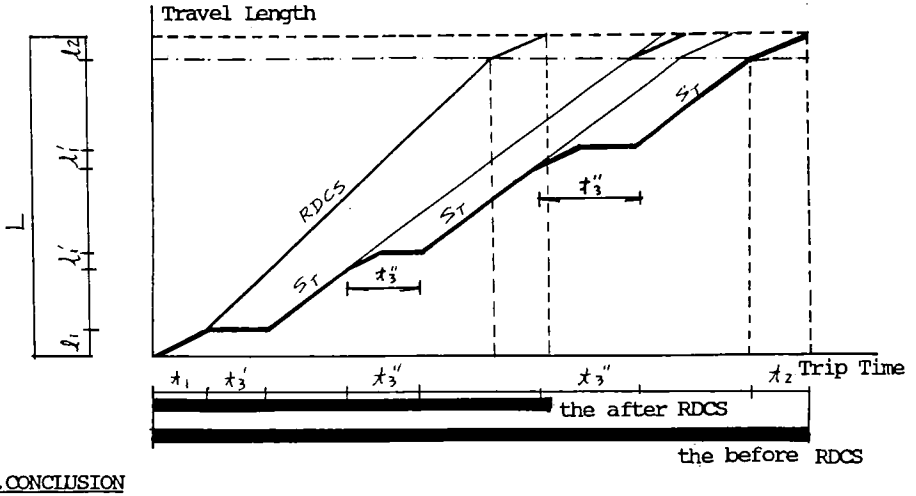
The evaluation findings are shown on table 4-2 (6)

Table 4-2 Evaluation Results on the before and the after RDCS

Objectives	Same Riders Present	Before	Ratio(%)
Average Transfer Number	0	2-3	—
Average Trip Time (minute)	45	78	57.7
Average Operating Speed (km/hr)	20	16	123.5
Average Travel Length (km)	12	4	300.0
Loading Factor (all day)	0.82	0.7	117.1
Comfort-Riders per m2 on Bus	6-9	12-13	66.6-69.2
Fare—Monthly Ticket	2.5 U.S.$	1.5 U.S.$	166.7
Safe	Excellent	Good	—

The following figure 4-6 provides relation between various of travel times and travel lengths based on practical results on the before and the after RDCS.

Figure 4-6 Relation of Trip Time and Trip Length



5.CONCLUSION

The RDCS is providing fast, safe, and cost efficient transport services for long distance passengers. According to planning, if the RDCS buses of Shanghai will have grown to 300 in the short-term, the long travel time passengers of home-based work-purpose during the peak hour can be solved, the public transit in city proper will be improved. On the other hand, the RDCS of Shanghai will obtain greatly social-economic benefits. The following table

5-1 depicts passengers vehicle trips

Table 5-1 Passenger Vehicle Trip

	Transit Bus	Unit Bus	Taxi	Total
No. of passenger vehicles	5487	21809	6708	34004
Daily passenger vehicle trips	17.40	2.706	4.457	5.243

* Interview these passenger vehicles

In Shanghai, a few large scale enterprises have a lot of unit buses which also carry long-distance employees, but daily unit bus trips are only 2.706. Transit bus trips are 17.4, so the RDCS is not only good measure to improve public transit in Shanghai, but also develops other cities and other countries.

In parallel, short term actions also includes improvements of bus terminals and on-street bus stop passenger waiting areas as well as services.

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