

SOME MEASURES OF INCREASING RAIL TRANSIT RIDERSHIPS: CASE STUDIES

ZHANG Yunqian¹, YAN Xiaopei¹, CLAUDE Comtois²

(1. Centre for Urban & Regional Studies, Zhongshan University, Guangzhou 510275, P. R. China; 2. Centre for Research on Transportation, University of Montreal, Montreal H3C3J7, Canada)

ABSTRACT: This paper is mainly concerned with how to increase rail transit ridership and how to coordinate with multimodality to optimize the entire public transportation systems. Three case cities, Montreal, Toronto and San Francisco, with metro systems are reviewed in different aspects, including urban planning, transport policy, flexible fare system, safety and security measure, special service, new technical application to improve the quality and value of its service for increasing revenues and profit, contributing to the long term development of public transit. Some conclusions can be drawn: 1) urban planning should be closely connected with urban transport planning; 2) the role of government is predominant to implement rail transit; 3) the facilities of rail transit should be advanced, reliable and safe; 4) quality service should be match with rail facilities; 5) special service for the disabled, young and senior should be advocated.

KEY WORDS: rail transit; ridership; transport policy; integrated fare system

CLC number: F911.99 Document code: A Article ID: 1002-0063(2000)01-0080-09

1 INTRODUCTION

It is well known that rapid rail transit, as one of the modern public transport modes with greater capacity, speed, safety and reliability, is playing more and more important role in most of metropolitan regions. However, the system's nonflexibility, longer construction period and vast capital and operating costs usually aggravate pressure and burdens for most metropolises, even though rapid rail systems have completely operated for years. Rarely can you find that no subsidies are supplied by municipalities except for Hong Kong (ALLPORT, 1997). Obviously, transit riderships are closely related to revenues or profit of operators. Currently in China, there are increasing trends of diversified investors, public and private sectors, and confronting with a dilemma both

to increase passenger volume and to reduce traffic congestion under insufficient resources. Montreal, Toronto and San Francisco have established complete and distinct rail transit systems after World War II. A lot of experiences and lessons from North America are worth being referred and absorbed by many Chinese cities, whose subway systems are under construction or in planning and design stages, despite different social systems and lifestyles.

2 MONTREAL

Montreal is one of the oldest cities in North America, whose name has a undisguisedly French meaning — Mount Royal. Montreal Metropolitan region had a population of 3.327 million in 1996, 60 percent of whom lived on the main Montreal island,

Received date: 1999-04-26

Foundation item: Under the auspices of the Provincial Natural Science Foundation of Guangdong and the Canadian international Development Agency.

Biography: ZHANG Yunqian (1963-), male, a native of Hangzhou City, Ph. D., candidate in Center for Urban and Regional Studies, Zhongshan University, associate professor. His research interests in urban planning and urban rail transport.

© 1994-2010 China Academic Journal Electronic Publishing House. All rights reserved. <http://www.cnki.net>

the largest one on the St. Lawrence River. The urban population was 1 016 376 and urban area of 177.10 km². The city is one of 29 communities and more than 70 townships making up the Montreal Urban Community (CUM), which covers an area of 490 km². About three quarters of the area has been developed. Over past two decades, a shift of population outwards from the city center to suburbs could be identified, particularly at the eastern and western ends of the main island (WALMSLEY *et al.*, 1992).

Montreal completed the 1st section of its metro on Oct. 14, 1966 and nowadays the total systems comprises 65 stations on 3 main lines (line 1, 2, 4) and 1 branch line (line 5 passing through the river). The commuter or suburban rail network in Montreal extends toward west and northwest along 2 main lines, Montreal–Deux–Montagnes (CN–Canada National Railway) and Montreal–Rigaud (CP–Canada Pacific Railway), with a total of 28 stations. The system has been shifted under the management of the Metropolitan Transportation Agency from Soci   de Transport de la Communaut   Urbaine de Montreal (STCUM) since Jan. 1, 1997, and the metro and bus systems are authorized by STCUM. The entire transit network consists of 4 metro lines (almost underground), total rail length of 61 km, 140 daytime bus routes and 20 night service bus routes. The fleet has 1657 buses and 79 minibuses for the disable. In 1995, STCUMS' buses travelled 77.3 million km, and maximal capacity of bus with 95 passengers including 43 seats.

In 1969, Montreal paid \$ 213 million for its 16 mile subway or \$ 13.2 million per mile, including its cars and attractive stations. The cars cost \$ 45.5 million and station ranged from \$ 10 million for Berri–De Montigny at the intersection of 3 lines to \$ 315,000 for Jarry (PARKINSON, 1970). Network Plan of metro lines in Montreal is shown in Fig. 1.

Due to rapid urban sprawl, the aging of population and the flight of young families to the suburbs, a sharp rise in the rate of car ownership appears. All these elements are changing commuting needs and expectation of the population towards the public transit.

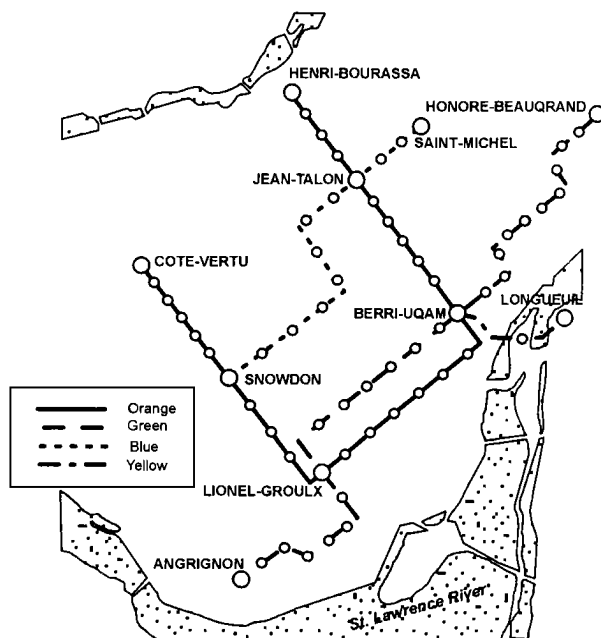


Fig. 1 Montreal metro network plan

Loss of ridership and successive reductions in its public financing have combined and speeded up the decline of public transit in relation to the automobile. At the same time, the STCUM found itself with major budgetary restrictions. Confronting the serious challenges, STCUM, depending their skills, knowledge and confidences, considered that they could attract and increase riderships by means of adoption of effective measures through survey for commuters.

Through field surveys and research, STCUM came to recognize that the riders concerned such transit demands as the punctuality of buses, the reduction and the management of service interruptions in the metro lines, the feeling of safety within transport facilities and the courtesy of personnel. They quickly responded and focused on both transit facilities ("Hardware") and personnel quality ("Software") to accommodate the diversified demands.

The punctuality is closely related to efficiency, while high operating efficiency is dependent to a large degree on advanced technology and coordination between personnel and transit facilities. First, the planners of municipality scientifically planned the metro lines, passing through density downtown areas, and forming a fabric network accessible for most resi-

dents. The station's design and construction fully considered amenity environment in with European artistic fashion and different architectural styles under the prerequisite of guaranteeing transport function. It is no doubt regarded as the models of integrating architects with artists. From wall, floor, ceiling, materials, colour and lighting to music echo in Metro stations, you would be strongly impressed by the distinguished artistic circumstance and atmosphere. The environment is greatly attractive to the residents. Not only can it satisfy the trip needs, but the systems can provide the enjoyment and appreciation with architectural masterworks.

Secondly, STCUM introduced advanced rapidrail facilities including metro train cars, communication equipment, electronic control and automation as well as fare collection system etc. Considering with the landscape and morphology of Montreal, adoption and innovation of Paris-alike subway systems had been made, using rubbertires with nitrogen instead of air, the results led to the more reduction of noise and better adhesion than steel wheel on steel rails, facilitating the acceleration and deceleration while the train is pulling out and in the station. The ramp away near the station is usually steep, and the slope's inclination exceeding 6 degree in most situations. Advanced electronic signalling control and automation technology make the train safe and high efficient in operation. The headways are only several minutes, maximal speed between stops can be up to 82 km/h, so the capacity can reach 50 000– 70 000 passengers per hour per direction. Especially, Montreal's metro systems mostly operate underground and exclusively rights of way, no traffic congestion may occur. The punctuality of commuters can be effectively assured. Using higher voltage of 750V in the 3rd rail, the consumption of electric energy is relatively lower than lower voltage of 600V in most cities. Because power losses in an electric system vary inversely as the square of the voltages for a given power requirement (LANG *et al.*, 1964). Only one train operator is needed, and headways can be adjusted on the passenger flow basis in weekdays and holiday so that the

higher labour productivity may be achieved.

Thirdly, adoption of integrated tickets and flexible ratings should be highly appreciated. The integrated ticket, such as monthly pass, weekly pass, various tickets are valid whatever modes you ride within STCUM. All the stations are now installed with slide-through card readers that, by decoding the magnetic strip on the pass, unlock the turnstiles. You are permitted to unlimitedly ride, but the ticket bought by cash can help you complete a entire trip within 90 mintues when you transfer bus or metro mode. Shopping or visiting someone in the mid way to workplace or home is not allowed if you want to use transfer ticket, which is available in bus or fare machine near metro ticket collection booth. According to occupation and identification of riders, discount or reduced ticket and pass can be available for seniors and students in many place, such as metro stations and grocery stores. The Table 1 lists ticket types and fare rates in Montreal.

Table 1 Fare scale and reduced rate valid
in bus and metro network

Local fare	Regular fare	Reduced fare
CAM Pass	\$ 45	\$ 19
Weekly CAM	\$ 12	
Tickets	6/ \$ 8	6/ \$ 4
Cash fare	\$ 1.85	\$ 1.0
Tourist Pass	\$ 5/ 1d	- -
	\$ 12/ 3d	- -
Regional fare	\$ 73	\$ 40

Fourthly, special sevices for disabilities are supplied. Caring and looking after the disabled is a kind of demonstration that civilized society should be involved. The STCUM's transportation service for the disabled is a door-to-door public transit service that operates on a reservation basis. To have access to the service, the disabled find eligible beforehand. The service was officially launched on April 1, 1980 and it is available to the residents of CUM territory who are disabled. It is a reservation-based minibus and taxi transportation service. In 1995, 1.1 million trips

were made, a 37.5% increase in three years. Other services, e.g. Telecité (a luminous panel mounted on bus or metro car, which makes riding the metro or bus easier for visually impaired or hard of hearing passengers), TELBUS (calling for reservation of bus) are also available. There are 3 types of rapid bus service: the EXPRESS, the METROBUS and the R-BUS (R, for "Reserved"). A-U-T-O-B-U-S provides the riders with inquiries for bus routes by telephones.

Fifthly, human safe measures are emphasized. Safety is the most fundamental needs for customers. Safe and reliable transit facilities and measures are main elements contributing to increase in riderships and revenues of transit carriers. STCUM has been employing the advanced equipment and facilities. The metro trains are interlocked, if the doors are not properly closed, the train will not operate. In the event of a blowout or loss of gas pressure, the ever present steel wheels will immediately and automatically take over on steel track; Clear and bright color lines, overhead strip lighting remind passengers of watching out to prevent them from falling into track trenches; Several public telephones and emergence calls are equipped in stations to protect riders, notably women from being attacked; The buses are painted blue and white, and yellow on the bus floor for sake of safety; In case of emergency, the red Intercom was installed in every metro car allows passengers to safely speak to the train operator. All these measures for passenger's safety lead to the increase of ridership.

3 TORONTO

Toronto is the center of economy, information and culture of Canada. It is located on the north shore of Lake Ontario, covering an area of 632 km², with a total population of 2.4 million. There are 7 satellite municipalities around Toronto, and about one third of Canadian population is located within 160 km radius of Toronto. It is now ranked the 1st in Canada, and the 5th in North America on a populous basis. In 1994, it was the 4th of the world cities for quality of

life by the Corporate Resources Group of Geneva, and in the top ten Fortune magazine's best cities in the world to do business. It is called "Silicon Valley North", with 7 of the top 10 information companies. The University of Toronto is one of the most famous in North America. Proximately 75 000 businesses employ more than 2.1 million people, and most of top 500 Canadian companies have established their headquarter or representative office in Toronto. The immigrants account for about 48%, forecasting 50% in 2001. Only in 1997, Toronto received 80 000 immigrants from 169 countries and regions.

Now entire subway systems consist of 2 main lines (yellow and green) and 1 extension of green line, blue line, with 66 stations total. It operates at most underground. The subway network plan is shown Fig. 2.

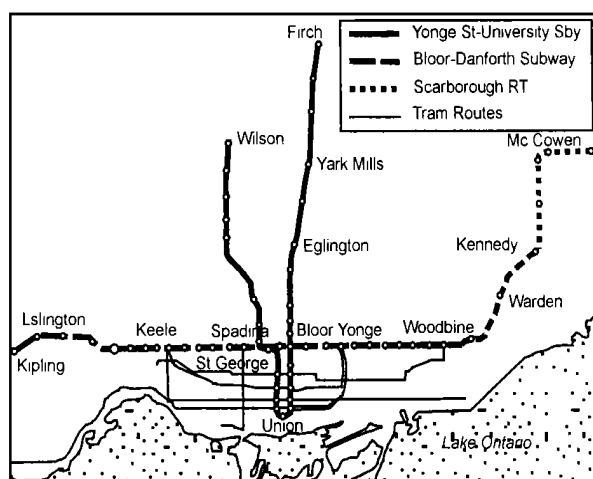


Fig. 2 Toronto metro network

In 1988, the subway carried 994 000 revenue and transfer passengers per average weekday, which is 38% of total public transport trips. Overall, there were 463.5 million riderships in the entire system the same year and this had been increasing steadily since 1978 (WALMSLEY *et al.*, 1992). According to Statistics Canada (1994), per capita rates of public transit use (linked trips per year) were 186, the index is the highest per capita ridership in North America. The operating revenue / cost ratio is about 70%, compared with 46.5% in Montreal. The employee's turnover is about 3%, half the industry average in

Ontario. Toronto Transportation Commission (TTC) has won the top American Public transit Association traffic safety awards 15 times in last 18 years as the top transit system in metropolitan cities.

It has been claimed that Toronto public transit system is the best in the world. Let us explore several secret myths on how to draw and increase the patronage.

3.1 Complete and Distinct Public Transit Network

Toronto substantially is a migrant-based city. During earlier period, most of residents centered on Yonge street. Public transport arrived in the shape of horse-drawn carriage along Yonge street, the North/South street in 1849. With a rapid increase of population, surface traffic congestion happened. It is reported that there was 219 000 people in 1901, 368 500 in 1910, while 818 000 in 1931. By the end of World War II, the data reached 950 000 (WALMSLEY, 1992; HARRIS, 1998). Due to predominant proportion in workers from abroad, the foundation of public transit priority had been laid to deal with traffic problems. TTC insisted on the policy. Surprisingly, the investment of constructing subway was almost recovered by operating transit revenues during 1950s – 1960s. TTC has been planning and constructing the network of public transport network. In addition to subway systems, there are light rail transit, bus, trolleybus, historic streetcar, taxi, trans-wheels for the disabled, forming a relatively complete transit network to accommodate the diversified demands in narrower urban street fabric systems. The municipality designed and built numerous residential and recreational spaces near transit station or around terminus to draw the flow. The subway corridor had promoted land development, having great effects on urban expansion within a rational limit. The joint development of rail transit and land use, between the public and private sectors, set up the models of how to raise vast funding. They remain the streetcar systems in operation, which was early removed in most American cities in 1930s – 1940s. The old systems are

found useful and appealing to the public.

3.2 Providing Quality Service for Passengers

The TTC is one of the safest transit systems in the world. The TTC contain 640 modern subway cars, 1701 buses, 248 streetcars, 28 Scarborough LRT (light rail transit) cars, 148 wheeltrans/community buses, 7 bus garage, 3 subway carhouses, 278 escalators and 13 elevators, including total staff of 9491. These safety measures including 1) Transit Community Watchers. All TTC employees including station collectors, are transit community watchers. They contribute to safety and security on the transit system and in the community by reporting such things as personal safety incidents, accidents or fires; 2) Public Telephones. In case of emergency, the riders can dial 911 free of charge from public telephone. They are located on all subway and Scarborough Rapid transit station platforms, at station entrances, and in many bus and streetcar transfer areas; 3) Security Mirrors. Mirrors are located at many points in the transit system to help the riders to see around corners or into other passageways; 4). Designated Waiting Areas (DWAs). DWAs are located on all subway and rapid transit platforms, with brighter lighter, Intercom, a closed-circuit television camera, a public telephone and a bench to sit, for commuters' safety and convenience while waiting for the train; 5) Passenger Assistance Alarms (PAAs). PAAs are the black and yellow strips located above the windows and at the ends of subways or LRT cars. It is convenient to use.

Special services involve WheelTrans for the disabled, such as special accessibility information, hearing impaired service (TTD). TTC also provide reservations, customized services, community bus and training programs for the disabled.

3.3 Flexible Fares and Rates

According to the riders' classification and duration to ride, various kinds of fares and rates are determined, seeing Table 2.

Table 2 Fares and rates for passengers in TTC

Item	Fares and rates	Memo
Adult:		
cash fare	\$ 2.00	
tickets/ tokens	10/ \$ 16.00	50/ \$ 80
metropass(monthly)	\$ 83.00	
metropass discount	\$ 76.00	
Students/ Senior Citizen:		
cash fare	\$ 1.35	
tickets	10/ \$ 10.70	
metropass(monthly)	\$ 73.00	
metropass discount	\$ 67.00	
Child:		
cash fare	\$ 0.50	less than 24 month: free
tickets	10/ \$ 4.00	2- 12 years
Day/ Family Pass	\$ 6.50(less than 6 persons, adult 2or less)	
GTA Weekly Pass	\$ 35.00	

3.4 Convenient Transfer and Good Tips for Passengers

Toronto had made up integrated ticket systems. The tickets or pass is valid within TTC public systems . if the commuters have to take more than one bus, streetcar, subway or LRT , they can get a free paper transfer where and when the commuters pay their fare. Keep this transfer if the commuters are changing from one vehicle to another. The way to get the transfer is by the operator or from the automatic transfer machine in the subway or LRT stationsstations. However, it is not permitted for commuters to get off TTC for doing some shopping and then using the transfer again.

Metropass Discount Plan is a bargain for passengers. The benefits include real saving of \$ 84 per year, convenient free parking for a year, convenient home delivery by mail, convenient per authorized payment and price guarantee for 12 months.

4 SAN FRANCISCO

The San Francisco area, located on west shore of the Pacific, was first settled at at least 15 000 years ago by the Ohlone Indians, who lived in the coastal area between San Francisco Bay and Point Sur. In

1579, Sir Francis Drake and his crew arrived on the Golden Hind. San Francisco was a tiny settlement before the Gold rush of 1849. The Gold Rush brought a wild , boisterous crowd. In 1869, the first west-bound train arrived in San Francisco, and in 1870, it had become the tenth largest city in the United States.

At present, San francisco is one of top 10 largest cities in the United States. The population is over 3 million (1997) in the metropolitan area . The urban area is 75 km². The population of the metropolitan area(18 000 km²) was 6 million in 1993. It is the center of culture and finance in Western America. The public transit systems consist of two main components — BART (Bay Area Rapid Transit) and Muni (the San Francisco Municipal Railway) . BART network plan is shown Fig. 3.

BART system was discussed in 1946, constructed in 1964 and opened in 1972. Now the automated rail transit system comprises 4 main lines , total length of 130 km and 37 stations (10 surface, 13 aerial and 14 subway) . In 1990, the track length was 115 km, of which 37.4 km was in tunnel, 37 km elevated and 40.6 km at grade(WALMSLEY, 1992) . The construction cost was \$ 1 629 million including basic system of \$ 1, 443 million and Transbay Tube Engineering of \$ 176 million. The Transbay Tube,

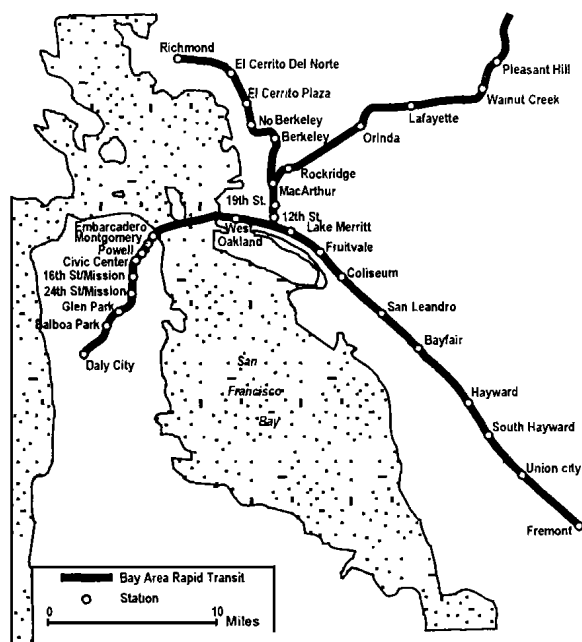


Fig.3 BART network plan in San Fransisco

36 miles long, twin- section , reinforced- concrete structure, was buried in a underwater trench ranging from 75- 185 feet deep. The advanced civil engineering techniques were applied.

Since BART is safe, reliable, economical and energy-efficient, it has attracted thousands of commuters to ride the system. According to statistical reports, the riderships are rapidly increased from 32 million (1975) , 58.9 million (1986) to 250 000 per weekday in 1998(about 75 million per annum) . Since 1972, BART has carried 1 billion riders and 15 billion passenger-miles.

4.1 Long Service and Flexible Fares

BART's operating timetable is reasonable and perfect for passengers. On weekdays (from Monday to Friday), starting at 4:00 a.m. lasts midnight. On Saturdays, 6:00- 22:00 is served, and on Sunday business time is from 8:00 a.m. to midnight.

The fares vary from \$ 1.1 to \$ 4.7, depending on the trip taken. Other fare categories are flexible on the commuters. Tips of discount for tickets are common.

- * New High-value Ticket \$ 48 (\$ 3 discounted)
- * BART Blue Ticket (B) \$ 32 (\$ 2 discounted)
- * BART Red Ticket (R) \$ 4 (\$ 12 discounted for the disabled and 5- 12-year child)
- * BART Green Ticket (G) \$ 4 (\$ 12 discounted for the seniors more than 65 years)
- * BART Plus \$ 28- 61 (8 different values on zones, the tickets are integrated between BART and Muni. Expiry is 2 weeks from 1st- 15th, or 16th - the end day in the month)
- * BART Express Bus Ticket Book (EB) (It is good for 20 riders, \$ 19 for zone1 and \$ 30 for zone2)

BART tickets are available from a variety of Tickets-to-Go Vendors and the Lake Merritt, Montgomery Street and Embarcadero Stations or by mail.

4.2 Good Feeder Service for BART

The most of passengers to ride BART are fedded by Muni. In designing BART, there are 4 stations integrated with Muni system. BART and Muni have formed an interdependent and efficient transit network.

The Muni is the 7th largest public transit system in the United States, as measured by ridership. Muni has 700 000 boardings , compared with 250 000 in BART, on an average weekday. Annual boardings are 216 millions. Its fleet consists of 1000 vehicles, over half of which are electric, including subway-surface light-rail vehicles (metro streetcars), electric trolley buses, diesel buses, the world famous cable cars and an unique collection of historic streetcars. Like BART, it has flexible fare system, such as Monthly Pass (\$ 35, also valid on BART and Caltrain within San Francisco; \$ 8 for the senior, disabled and youth), Weekly Pass (\$ 9) , Muni Passports (1 day for \$ 6, 3 days \$ 10 and 7 days \$ 15), Transfer from BART (The passengers can save \$ 1, validity is 72 hours), Free transfer for bus and streetcar (two uses in any direction within 90 minute to 2 hours), Cash fare (\$ 1 for adult and \$ 0.35 except cable

car), Cash fare for cable car (\$ 2 for regular service and \$ 1 from 9:00 p. m. to 7:00 a. m.) and Tokens (cheaper than cash, usually 10 for \$ 8). Now Muni is improving their service with new Breda LRVs (light rail vehicles, imported from Italy), and is planning the 3rd street LRT project to perfect feeder system.

4.3 Special Service Measures

BART provides park-and-ride service for the commuters, free of charge for all stations except Lake Merritt station for only \$ 0.25. Parking space available is 33 708. With regard to Holidays, such as Columbus Day, Veteran's Day etc, operating schedules may be modified to accommodate customized demands. In order to the potential passengers riding bicycles and motorcycles, BART permits them into the stations, and supplies them with racks, plus special locks for extra security. BART has developed their home pages to ask comments from the public and riders for better service.

5 CONCLUSION

The issue of increasing rail transit ridership should be highlighted. In practice, it is usually ignored by the planners and decision-makers. Some conclusions can be preliminarily drawn from above 3 cases.

1) Urban master planning and zoning should be closely connected with urban / regional transport planning

During urban and regional planning, cautious, scientific and systematic approaches should be suggested. It is necessary to accurately forecast the size and intensity of economic activities in the future for a designated city. Sound urban transport policy originates from scientific computation and estimation. The transport planning is a main element of urban planning, moreover, the transportation is characterized in integration of social and economic functions.

2) The role of government is predominant to implement rail transit

Due to the characteristics of urban rail transit, the central and local government should play a positive role in planning, organization and coordination. From the evolution of Western urbanization and the situation of developing countries in transportation, as well as the perspective of sustainable development, greatly developing public transit will become an overwhelming trend around the world. Not only is the government a manager, but it is a developer, guiding the orientation toward public transit.

3) The facilities of rail transit should be advanced, reliable and safe

Only by high performance, reliable trains, stations and control systems can the operators draw the riders to ride to meet the increasingly efficient demands. The introduction of high tech and modern information technology is urgent and necessary.

4) Quality service as software should be matched with "hardware".

Effective buses feeder system, integrated and flexible ticket system, fare collections as well as strong support from the community can guarantee the revenue operation, in return, the lower cost and higher revenues can better serve for the public, attracting more riders and leading to upward spiral circulations. The communication and exchange between the operators and commuters should be emphasized. Human resource is an important factor of contributors to transit advance, except for capital and equipment.

5) Special service should be advocated

The goal of rail transit can be divided into twofold: social and economic. As a transit enterprise, whatever the public or private owned, the operators should provide special service for the disabled, young and senior. Public transit is regarded as an equity trip mode, so it is no reason to not consider the proportion of riders. This is representation of human civilization and progress in contemporary society.

REFERENCES

ALLPORT R., 1997. Investment in mass rapid transit. In: STARES and LIU Zhi (ed). *China Urban transport Development Strategy*.

Washington: The Word Bank.

- BHATTACHARJEE D. *et al.*, 1998. Commuters' attitudes toward travel demand management in Bangkok [J]. *Transportation Research*, 5(3).
- CERVERO R. 1996. Mixed land use and commuting: evidence from the American housing survey[J]. *Transportation Research*. 30(5): 361– 177.
- CERVERO R. *et al.*, 1997. Twenty years of the bay area rapid transit system: land use and development[J]. *Transportation Research*. A 31(4): 309– 333.
- CURTIS C. *et al.*, 1997. Targeting travel awareness campaigns[J]. *Transport Policy*, 4(1): 57– 65.
- EDWARDS, M. *et al.*, 1996. Developing new urban public transit systems[J]. *Transport Policy*, 3(4): 225– 239.
- ELSE P., 1996. Subsidy requirements in a restructured rail network [J]. *Transport Policy*, 3(12): 13– 15.
- HARRIS N. G. *et al.*, 1997. Railway profitability and station closures [J]. *Transport Policy*, 4(1): 41– 47.
- HARRIS R., Lewis R., 1998. How the past matters: North American cities in the twentieth century[J]. *J. Urban Affairs*, 20(2): 159– 174.
- KANNINEN B. J. *et al.*, 1996. Intelligent transportation systems: an economic and environmental policy assessment[J]. *Transportation Research*, 30(1): 1– 10.

- KHATTAK A. J. *et al.*, 1997. The impact of adverse weather conditions on the propensity to change travel decisions: a survey of Brussels commuters[J]. *Transportation Research*. A 31(3): 181– 203.
- KRAFT G. *et al.*, 1971. *The role of transportation in regional economic development* [M]. Lexington.: D. C. Heath and Company Press.
- LANG A. S. *et al.*, 1964. *Urban rail transit: its economics and technology* [M]. Cambridge: The MIT Press.
- MILAN J., 1996. The trans European railway network: three levels of service for the passengers[J]. *Transport Policy*, 3(3): 99– 104.
- PARKINSON T. E., 1970. Passenger transport in Canadian urban areas[J]. *Canadian Transport Commission*, 4(3). 11– 20.
- PENDYALA R. M. *et al.*, 1997. An activity-based microsimulation analysis of transportation control measures[J]. *Transport Policy*. 4(3): 183– 192.
- SAVAGE I., 1997. Scale economies in the United States rail transit system[J]. *Transportation Research*. A 31(6): 459– 473.
- SMITH P. N. *et al.*, 1994. A method for the rationalization of a suburban railway network[J]. *Transportation Research*. A. 28(2): 93 – 107.
- WALMSLEY D. A. *et al.*, 1992. *The Effects of Rapid Transit on Public Transport and Urban Development* [M]. London: HMSO Press, 73– 105.