

leisure opportunities. In ten years' time a joint concession <Road Pricing - Selected Projects> Program, undertaken under a project finance scheme, will leverage investments for the implementation of:

- the remaining 120 km of the Metropolitan External Beltway;
- 100 km of new subway lines (underground);
- 100 km LVT lines (Light Vehicles on Tires);
- 350 km of pavement upgrading of dual carriage ways;
- leisure areas and public parks worth US\$ 1.5 billion;
- an urban rehabilitation program US\$ 1 billion;
- an environmental education, transit and use of the public transportation system program worth US\$ 500 million.

These investments will allow the recovery of the mobility that the Sao Paulo population had in 1977, that is, 1.53 trips/inhabitant/day in five years. Massive investment in public transport will benefit the low-income groups, which suffered the most from the loss of mobility.

Notes

- i Public transit is performed basically by buses, as demonstrated in the previous papers on Sao Paulo.
- ii By definition, slow traffic occurs when the green light time at intersections is not able to absorb the queue of vehicles.
- iii *Relatório de Avaliação do Rodizio*, April de 1998
- iv Scaringella, Roberto - *Sistema de Trânsito Tarifado, uma solução abrangente Revista Perspectiva - Fundação SEADE - June 1995*
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Socioeconomic Characteristics, Land Use and Travel Patterns in Seoul

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I. Introduction

Seoul is notorious for its severe traffic congestion. To address the problem, the policy focus of Seoul Metropolitan Government (SMG) had been placed on the supply side (new highway and subway construction) until the early 1990's. The road construction, TSM (transportation system management), and subway line expansion were key words of transportation policy. However, after 1993, the city started a different approach to the traffic problems in Seoul. The approach was transportation demand management (TDM) in association with the improvement of service quality of public transit system operated in Seoul. The policy concern shifted from concern about transportation system supply to its users. Beginning in 1995, another important policy item was implanted in the policy list, the green transportation which placed emphasis on encouraging walking and biking.

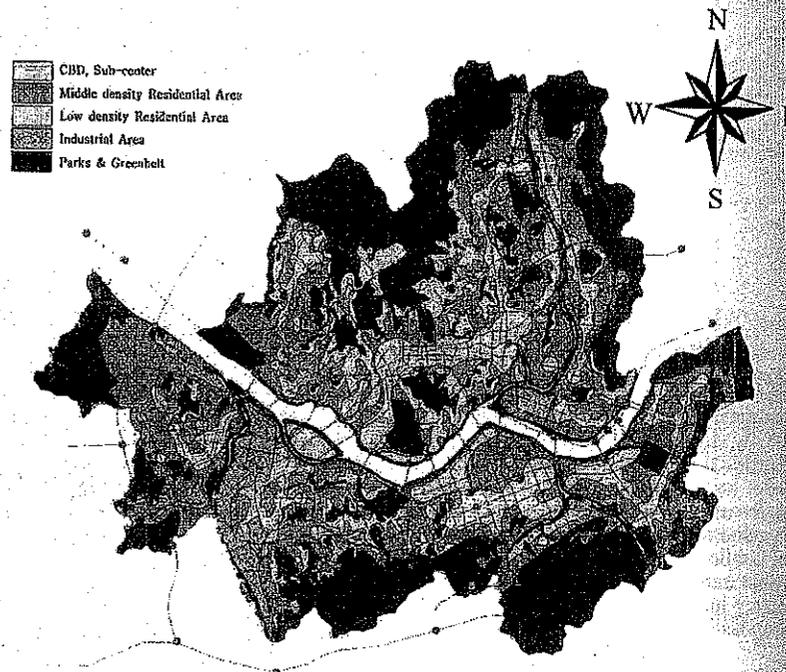
The purpose of this paper is to understand the nature of the city in terms of the need for public transportation. The public transportation modes to be dealt with are subway, bus, and taxi. This paper consists of three parts. At first, it will discuss the socioeconomic and land use elements, which affect the transportation environment in Seoul. In the second part, historic reviews on the travel patterns will be presented. Finally, it will discuss specific policy alternatives applied for solving the problems in Seoul.

II. Land Use & Socioeconomic Characteristics

The very densely populated city of Seoul is over 600 years old. In 1997, a population of 10.6 million resided within an area of 605 km², only 374.5 km² was used for human activities. The Han River flows in the middle of the Seoul Metropolitan Area, which is surrounded by mountains. Only a small area, the southwestern part of the Han River, is zoned for industries. Numerous shopping centers and about 30 colleges and universities are spread all over Seoul. The roadway system of Seoul is a radial structure, and therefore there is heavy traffic congestion in the central area of Seoul. Over 25 percent of total trips commute toward the CBD. Around 6 percent of total trips is through-traffic just passing through the central area (see Picture 1).

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Picture 1: Land Use Map of Seoul

The population of Seoul has increased continuously over the last 25 years until it peaked in 1995 (See table 1). The number has risen from 5.433 million in 1970 to 10.595 million in 1995. As the residential movement to newly built satellite cities began in 1990, the residential population was down to 10.418 million in 1996. Seoul Development Institute (SDI) forecasts the population will be diminishing to 9.839 million in 2006 (SDI, 1998).

On the other hand, the employment has been increasing continuously, which implies the movers to satellite cities still commute to Seoul for work. SDI forecasts the employment number in Seoul will grow up to 6.295 million in 2006 in spite of the declines of residential population. This trend implies that Seoul would have more long-distance commuters in the future.

Table 1: The trends of residents and employment

	1970	1980	1985	1990	1995	1996	1997
City residents (in thousands)	5,433	8,366	9,626	10,726	10,596	10,464	10,389
Employment (in thousand)	-	-	2,926	4,505	5,014	5,073	-

Source: Seoul Metropolitan Government, 1998

The number of daily trips increased over four times from 1970 to 1995 (See

table 2). It jumped from 5.750 million in 1970 to 27.099 million in 1995. The number has been increasing steadily due to continuing growth of vehicle ownership in the region and long-distance commuters from satellite cities. While the average daily person trips were 2.29 in 1990, it jumped to 2.62 in 1997. This increase is related with both car-ownership increase and tripled household income during the period between 1985 and 1995.

Table 2: The Trends of Daily Trips

	1970	1980	1990	1995	1996	1997
Daily trips (in thousands)	5,750	12,600	24,638	27,099	27,762	27,203

Source: Seoul Metropolitan Government, 1998

III. Travel Patterns

1. Roadways

The total length of roadways in Seoul was 7,689 km in 1996 (See table 3). The length of two-way streets whose width is wider than 12m is only 1,590km. It is only 20.5 percent of the total length. The size of the street over 12m width is 42.7 km², 57% of the total, and the road rate is about 20.42% in 1997 (picture 2).

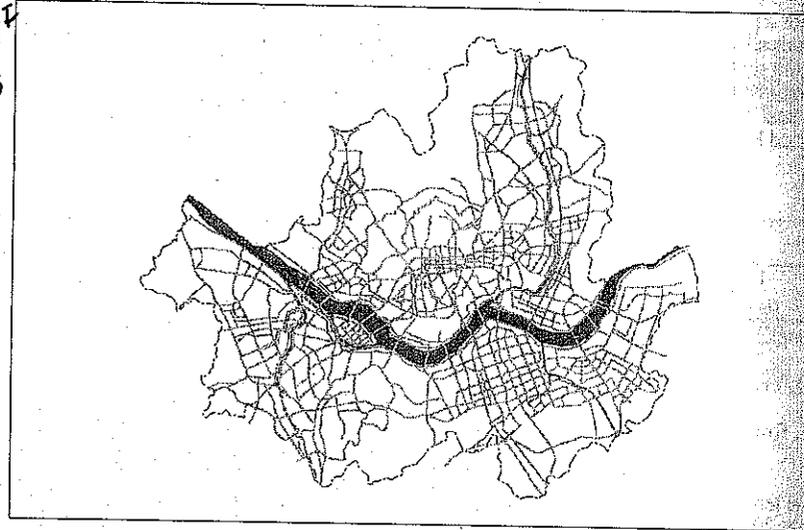
Table 3: Roadways

Year	Length(km)	Area(km ²)	Paved road ratio(%)
90	7,427	69.3	18.5
95	7,675	74.4	19.85
96	7,689	75.6	20.19
97	-	-	20.42

Source: Seoul Metropolitan Government, 1998

The Olympic Freeway, the Riverside Freeway and the Dongbu Freeway are the backbone of the Seoul Freeway and roadway system. The total length of these three freeways is only 135km. Thus, they are heavily congested in all sections throughout a day. A signal operation system is essential to road efficiency. However, Seoul's signal operation system does not respond automatically to changes in traffic volumes. Instead, it is fixed or actuated to predetermined cycles.

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Picture 2: Arterial Roadways

2. Main Travel Modes

The trend of vehicle ownership has been in line with the rapidly increasing trends of daily trips in Seoul. The number of vehicles increased from 60,000 vehicles in 1970 to 207,000 in 1980 (see table 4). There was a 3.5% increase in vehicle ownership during the period. The number increased more rapidly beginning the late 1980s. They reached one million in January 1990. There was a 5.7% increase in vehicle ownership for the last ten years. The yearly growth rate has been decreasing since 1990, however, the total number still keeps rising. In 1997, over 2.2 million vehicles were registered in Seoul. They are quickly turning the city into auto oriented society.

Table 4: The Trend of Vehicle Ownership

	1970	1980	1990	1995	1996	1997
Total number of vehicles (in thousands)	60	207	1,193	2,043	2,168	2,249
Passenger cars (in thousands)	18	99	883	1,595	1,704	1,698
Vehicles per 1000 Population	10.9	24.7	109.4	192.8	-	216.5
Vehicles per 1000 house holds	54.7	112.4	358.4	592.5	-	642.7

Source: Seoul Metropolitan Government, 1998

Note: In 1998, the number has been decreasing by 50 per day due to the IMF economic crisis.

The city of Seoul has two subway systems; Seoul-subways and Metro-rails. The Seoul Metropolitan Government is fully in charge of the system construction. In 1997, the Seoul subways consisted of 4 routes with 132 km in length, while the Metro-rails were comprised of 3 routes with 83.5 km in length. In addition to the subways, 57.3 km of Korea-Rails are served within the city boundary. They are constructed and operated by the Korea National Rail Company.

Seoul's bus system consists of company buses and community buses (see table 6). The total 89 private bus companies operated 398 routes with 8,655 vehicles in 1997. In 1997, the company buses consist of 4 different types; 6,399 regular buses, 1,960 deluxe buses, 296 circular buses. While the number of company buses decreased, the number of community buses is increasing. In 1997, the total 232 routes were operating with 1,260 vehicles and average route length was 7 km.

There were 69,635 taxis in 1997, which consisted of 23,187 company taxis and 46,448 private taxis. The private taxis included 4,652 deluxe taxis. The supply of taxi was restricted to 70,000 vehicles. Currently, the customer-in-taxi running ratio is 70% out of total running km. Therefore, it is still not easy to catch a taxi in Seoul. The fare of regular taxi is 1,300 won (\$1.09) up to 2 km, and increases 100 won (\$0.08) by 210m and increases 100 won (\$0.08) per 51 second when running under 15km/h. On average, customers pay 3,500 won (\$2.94) for a 6km ride. The fare of deluxe taxi is 3,000 won (\$2.52) up to 3km, and increases 200 won (\$0.17) by 250m and 60 second.

3. Mode Share

Overall, the ridership of buses and taxis is declining, while subway and auto vehicles have been increasing (see table 5). In 1997, the subway has become, for the first time, the most predominant travel mode in Seoul, accounting for 30.8 percent of daily trips. Until 1996, buses were the most heavily used travel mode in Seoul. The bus patronage has kept declining both because of worsening road traffic congestion and widening subway services. Taxis served 10.1 percent of person trips in 1997, but the share has been decreasing continuously. Other vehicles include two-wheeled vehicles, rental vehicles, and passenger cars. A sharp increase of passenger car share between 1995 and 1996 is partially attributed to a disclosure of new O-D survey results conducted by Seoul Development Institute in 1996. It is noteworthy that in spite of heavy investment on subway construction, it contributed more to the reduction of bus ridership rather than reducing auto vehicle use.

Table 5: Percent of Daily Trips by Travel Modes

	1980	1985	1990	1995	1996	1997
Buses	66.0	58.0	43.3	36.7	30.1	29.5
Subways	7.0	14.0	18.8	29.8	29.4	30.8
Taxis	19.0	16.5	12.8	10.7	10.4	10.1
Others (Pass. Veh)	8.0 (NA)	12.5 (NA)	25.1 (14.0)	22.8 (14.5)	30.1 (21.1)	29.7 (20.6)

Source: Seoul Metropolitan Government, 1998

Note: For the subway case, transfers between different lines were counted as another independent travel.

4. Road Traffic Conditions

Seoul's traffic conditions were normal, without a serious congestion problem

up to the early 1980s, except during the period of rush hours. However, traffic patterns changed from rush-hour peaks to all-day peaks by the end of 1980s. The overall traffic speed on major arterials in Seoul kept declining until 1996 and bounced back in 1997 (see table 6). This trend resulted from significant changes of the traffic environment in Seoul. The economy started sliding down in 1997 and passenger vehicle drivers using Namsan 1&3 Tunnels linked to the CBD were charged 2,000 won (\$1.68) congestion fee beginning in the late 1996. Furthermore, the most recent speed survey shows a drastic improvement of road speed. The sudden change is associated with the sharp increase in both the unemployment rate caused by IMF economic crisis and an increase of oil price by about 30% increase of oil price as of December 1997 (SMG 1998b).

Table 6: The Trend of Travel Speed Changes
(unit : km/hr)

		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
auto	All	32.60	24.22	24.57	22.62	23.53	23.18	21.69	20.09	21.06	25.41
	CBD	18.70	16.40	17.66	19.28	19.97	20.04	18.25	16.44	16.85	17.72
	other	37.17	25.78	21.89	22.87	23.79	23.40	21.93	21.23	21.33	25.90
bus		18.60	18.80	18.15	16.88	17.02	18.42	18.79	18.35	18.69	20.07

Source: Seoul Metropolitan Government, 1997b, 1998b, 1998c

The trend of road traffic speed changes is closely associated with the rapid increase of vehicle ownership and uses. The traffic volumes on major arterials have increased continuously over the last ten years (see table 7). Traffic crossing the boundary of Seoul has almost tripled during this period. The majority of them are long-distance trips, and therefore must have had a sizable negative impact on the traffic speed. Considering this tendency, the future transportation policy of Seoul Metropolitan Government should be focused on dealing effectively with these long-distant auto trips.

Table 7: The Trend of Traffic Volume on Cordon Lines
(unit : 1,000 trips)

	1989	1990	1991	1992	1993	1994	1995	1996	1997
Total	3,792	4,257	4,516	4,578	5,402	5,894	5,601	6,069	6,345
CBD	1,288	1,270	1,286	1,277	1,706	1,819	1,709	1,730	1,657
Han river bridges	1,394	1,562	1,541	1,611	1,721	1,763	1,804	1,906	1,927
Border lines of Seoul	1,170	1,425	1,689	1,740	1,975	2,433	2,088	2,433	2,761

Source: Seoul Metropolitan Government, 1997a

Note: There is a slight difference in the amount of CBD trips in 1993 because trips were

surveyed from 06:00 hours to 22:00 hours until 1992 and from 1993, surveys were conducted for 24-hour periods.

5. Prospects for the Future

Traffic conditions in Seoul are projected to worsen. The travel demand is expected to increase continuously until the beginning of the year 2000 if the city successfully overcomes the IMF economic crisis in a near future. The number of vehicles is expected to increase to 3 million by 2001. The number of vehicles per one thousand households is expected to increase from 593 in 1995 to 810 by 2001.

The rates of trip generation and trip population will keep growing because economic, social, and leisure activities are expected to increase in the region. People will be more attracted to private transportation modes because they prefer more convenient and comfortable trips. Further, they will prefer faster public transportation modes because their value of personal time is increasing. The schedule of the second-phase subway construction is delayed until 1999 (planned in 1996). The plan for the third-phase subway construction is still in progress. Thus, the passenger transport capability will be insufficient in the near future.

IV. Conclusions

The ancient city of Seoul is not a planned, but a naturally formed city centering around the downtown. Seoul's radiated structure makes the traffic problems difficult to deal with. Since 1988 when the Seoul Olympics were held, the number of vehicles has been increasing steadily. The new satellite cities generated a large number of long-distance auto drivers. The land price is high and land supply is limited for road expansion. To make it worse, the nationwide economic crisis is restraining the government financing for subway building. In every respect, fighting traffic in Seoul will be a difficult task in a near future.

To respond to transportation problems under the circumstances, SMG sets its first priority of transportation policy as promoting public transit (for instance, bus, subway, and taxi) by improving their service quality. To encourage public transit uses, however, SMG thinks that TDM should be combined with transit improvement simultaneously. In Seoul, the share of private autos accounts for 60 percent of the total volumes on the streets, but they carry only 20 percent of the total daily trips. Because of excessive private vehicle uses, the total amount of social costs is estimated to be 2,400 billion won (\$2 billion) per year, consuming 2.9 billion liters of gasoline per year. Auto use is held responsible for 72 percent of the air pollution in Seoul.

In order to increase the subway ridership, the SMG will provide more Park & Ride facilities from the current 21 lots with 4700 spaces to 61 lots with 28,700 spaces, and ten multi-mode transfer centers.

To improve the carrying capacity and convenience of buses, SMG will expand exclusive bus lanes from 37 routes of 154km in length to 64 routes of 270km by 1998, and expand the central exclusive bus lanes. For securing consistent high quality service, the city has under consideration the evaluation of the service level of each bus company based on the results of customer interviews and service monitoring. According to the evaluation results, it plans to differentiate the financial supports among bus companies. To make transfers more convenient among buses and subways, the SMG plans to integrate different fare collection systems into.

To have a more convenient and comfortable taxi service (easy to catch), the city plans to provide more deluxe taxis, increasing from now 4,652 vehicles to 20,000 vehicles, and permit increasing fares of regular taxis. It plans to expand the Call-Service system to the entire taxi fleet. As a result, the share of passenger mileage is expected to drop from 70% in 1997 to 60% in a near future. In addition, to prevent illegal taxi business near subway stations and remote areas, and to strengthen subway station accessibility, the modified taxi systems are under consideration, for instance, route taxi, van taxi, and so on. For securing qualified drivers, SMG will invest fare amount funds to build a welfare center for taxi drivers.

To cut excessive auto use, SMG started charging, starting from November 1996, 2,000 won (\$1.68) congestion pricing for 1-2 occupant vehicles in Namsan 1.3 tunnels, and on major arterials linking the southern part of Han River with the CBD. The results of year-long implementation show traffic volumes reduced 13.6%, and that the average vehicle speed improved 38% from 21.6km/h to 29.8km/h. Therefore, the city plans to expand it in other major congested arterials in the near future.

The employer-base trip reduction program has been implemented since 1995, and intends to reduce the Traffic Impact Fee (compulsory tax burdened on large size building owners) over 20% if employers (or building owners) implement trip reduction programs, and reduce travel demand over 20%. It is similar to the Regulation XV program applied in Southern California, USA.

Also, the SMG plans to levy a local gasoline tax on the use of gasoline to control the excessive use (22 thousand km per car per year) of private autos. It is estimated that a 30% gasoline price increase lead to 7% reduction in auto traffic volumes (SDI, 1998). To prevent the opposition of city residents, the city is considering reducing the burden of the Automobile tax.

SMG introduced a Parking Ceiling system in 1997. It will increase the existing parking lot requirement for buildings from 20 percent to 40 percent in heavily congested areas and overpopulated areas, including the downtown.

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Urban Public Transportation in Seoul: System, Operation, Use by People

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I. Introduction

Subways and buses are two of the most important public transit systems served in Seoul. Bus service for Seoul started over 50 years ago. There are two different types of bus services in Seoul, which are 8,700 company buses and 1,300 community buses. Subway service in Seoul started in 1974. In 1997, subways and buses together accounted for over 60% of the mode share. Ultimately, the Seoul Metropolitan Government (SMG) hopes to increase this to 75 percent of total trips by 2001.

This paper describes details of these subway and bus systems. In this paper, however, community buses are not dealt with in detail because the firms operating them do not produce statistical data on their operations. Also, since company buses are owned by private firms, it is difficult to get the information requested. The data used is from 1996 and 1997. The paper consists of three parts: system characteristics, operations, and usage. The system part discusses system and route information. The operations part discusses organization, operation characteristics, and facilities. Finally, the part on usage includes mode shares, ridership trends, and user characteristics.

II. System & Facility Characteristics

Subway System

The Seoul Metropolitan Government is fully in charge of the subway system construction. The city of Seoul has two subway systems: Seoul-subways (line 1-line 4) and Metro-rails (line 5 - line 8). These systems are very similar in vehicles and power systems besides the dates of operations started. Seoul Metropolitan Subway Company (SMSC) is in charge of Seoul-Subway operations and Seoul Metropolitan Rapid Transit Company (SMRTC) is in charge of Metro-Rail operations. In 1997, the Seoul subways consisted of 4 routes with 133km in length, while the Metro-rails were comprised of 3 routes with 83.5km in length (see table 1). In addition to the subways, 57.3 km of Korea-Rails operates within the boundary of Seoul. The Korea-Rails were constructed and operated by the Korea National Rail Company, mainly providing intercity rail travel in the nation.

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Table 1: Subways and Urban Rails within Seoul (in 1997)

	Seoul Subway		Korea-Rails
	Seoul-Subways	Metro-Rails	
Length(km)	133	83.5	57.3
Construction Period	1971-96	1990-96	Korea-Rails were constructed by Korea National Rail Company.
No. of Stations	114	83	
No. of Trains	1,944	83	

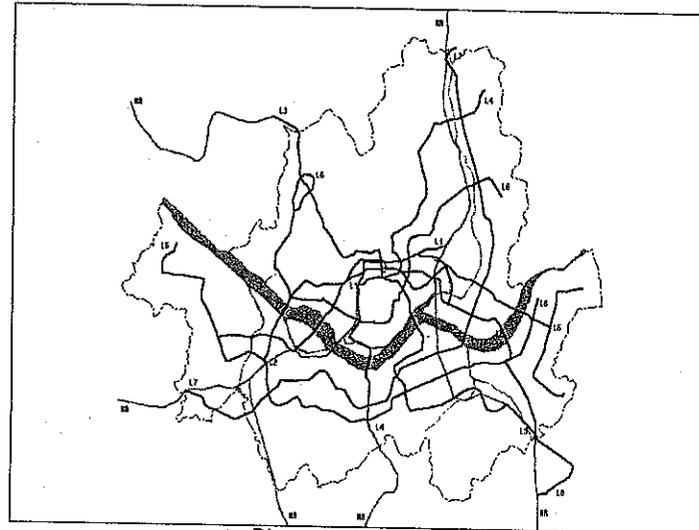
Source: Seoul Metropolitan Government, 1998

Reviewing system characteristics by line, line 2 is the longest (see table 2 & picture 1). The construction of line 1 started in 1997, and line 2 took the longest time to build. There are 197 stations in total, and line 5 includes the highest number of stations (51). There are 2,778 subway cars amounting to an average of 13 cars/km.

Table 2: System Characteristics of Subway System by Line

	#1 line	#2 line	#3 line	#4 line	#5 line	#7 line	#8 line	total
Length (km)	7.8	54.5	35.7	32.3	52	16	15.5	216.5
Construction Period	71-74	78-96	80-93	80-94	90-96	90-96	90-96	-
No. of Stations	9	49	31	25	51	19	13	197
No. of Cars	160	834	480	470	608	136	90	2,778

Source: Seoul Metropolitan Subway Co., 1997



Picture 1: Subway Routes

Bus System

Seoul's bus system consists of company buses and community buses (see table 3). The 87 total private bus companies operated company buses with 398 routes and 8,655 vehicles in 1997 (see picture 2). The bus industry has declined in size from 1996 to 1997 by 70 buses, reversing previous growth rate from 1990.

In 1997, the company buses consisted of 3 different types: 6,695 regular buses and 1,960 deluxe buses. The regular buses (length: 9m, seats: 20) run an average of 7.3 times a day on 317 routes. The route length is 31.4km and average round trip time takes 102.7 minutes. There are 3,878 stops for regular buses.

On the other hand, the deluxe buses (length: 9m, seats: 45) run on average only 6.4 times per day on 131 routes. Since the route length is 48.8km on average and 17km longer than the regular buses, they are mainly in charge of serving long-distance users. Also, since running longer distance, the average running time per round trip takes 22 minutes more than the regular buses. There are a total of 892 stops for deluxe buses.

Table 3: Private Bus Operation System

		1985	1990	1995	1996	1997
Company Bus	No. of Routes	348	379	460	448	398
	No. of Buses	8,301	8,283	8,725	8,725	8,655
	No. of Companies	90	90	89	89	87
Community Bus	No. of Routes	-	112	Na	na	232
	No. of Buses	-	446	Na	na	1,260
	Bus-only lane (km)	-	-	161.4	228.5	242.8

Source: Seoul Metropolitan Government, 1997, 1998



Picture 2: Bus Routes

While the number of company buses is remaining steady, that of community buses is increasing (see table 3) rapidly. In 1997, a total of 232 routes were operating with 1,260 buses and an average route length of 7 km.

Subway Facilities

As the number of passengers using the subway increases and some facilities become old, the subway companies (SMSC, SMRTC, and KORAIL) constantly promote the improvement of services and facilities for more comfortable, efficient and safe operations.

First, for improving system safety on the platform, the SMSC has installed color TV monitor and automatic alarm systems on every platform. The system rings an alarm, lights information signs, and plays information broadcast automatically in sequence whenever trains arrive.

Second, unlike the recently opened 2nd phase subways, the 1st phase subways did not have enough air-conditioning equipment for peak cooling needs in the summer. The SMSC has been moving forward with air-conditioning work since 1985 in stations that were not air-conditioned because they were built in the early stage. Currently, 17 stations are air-conditioned.

Third, the subway company is improving system accessibility and convenience by installing facilities for bike users and for persons with disabilities. Fixed and mobile wheelchair lifts were set up in every station. Also, toilet facilities in twenty stations have been equipped for the handicapped. Floor bumps and dot blocks for blind people were installed in every station. Bike racks were provided in 24 subway stations, and 3,340 bikes can be stored.

Fourth, to promote usage and park and ride service, Seoul operates twenty-three parking lots, with a capacity for 6,044 cars. Besides these, 24 new parking lots with 11,800 spaces were built in 1998.

Bus Facilities

A representative roadway facility for bus is the exclusive bus lane (EBL). To enhance bus operations, improve travel times and service, 218.5km bus-only lanes on 59 road sections were implemented. This accounted for 25.4% of the total length of major arterials in Seoul. The majority of EBLs are designated on the outside lane except one 4.5km EBL designated on the center lane. The 56 sections with 209.6km operate from 06:00 to 21:00, and 3 sections with 8.9km operate during two time periods of the day, 07:00 to 10:00, 17:00 to 21:00 during the peak hours. The monitoring results show that EBLs helped in improving bus speeds by 10%.

Almost all the buses are equipped with air-conditioning and heating systems. However, there are no buses equipped with lifts for the handicapped, and no CNG buses have been introduced.

III. Operational & Managerial Characteristics

Subway Operating Characteristics

The average speed of the subway is 35km/h. The headways are different among subway lines. The subway congestion during rush-hours is 207% of its capacity and the peak hour headway is 3 to 5 minutes and non-peak headway 4 to 6

minutes (see table 4). The service frequency (number of trains per day) ranges from 1,009 trains on line 2 to 350 trains on line 7. The subway service starts at 05:30 and operates until 01:00, for 19.5 hours every day.

Table 4: Subway Operating Characteristics

		#1 line	#2 line	#3 line	#4 line	#5 line	#7 line	#8 line	total
Headway (min)	Peak	3	2.5	3	2.5	2.5	5	4.5	-
	Non-peak	4	5.5	6	5	4	6	6	-
Service frequency		577	1009	423	530	596	350	359	3,844

Source: Seoul Metropolitan Subway Co., 1998

Tickets used in the subway are classified into regular tickets, fixed amount tickets, complimentary tickets, transfer tickets and group tickets. Regular tickets are good for one ride in a designated zone regardless of the purchase date and transfer (see table 5). Fixed-amount tickets are valid for any ride regardless of the purchase date, and they are available in 5,000 won (\$4.20), 10,000 won (\$8.40), and 20,000 won (\$16.80) tickets. There is 20% student discount and 10% general discount on 10,000 (\$8.40) and 20,000 won (\$16.80) tickets, and one can travel even the longest distance even if only 10 won (\$0.01) is left. There are complimentary tickets for people over 65 and people of national merit such as war heroes. Transfer tickets are used for linking subway and bus, and 10 won (\$0.01) is discounted from the fare. Group tickets are for groups of more than 20 people going together to the same destination. There is a 20% discount for general group and a 30% discount for student groups of middle school and over. The subway fares are bi-level by sections, 450 won (\$0.38) and 550 won (\$0.46) per ride. There are no weekly, monthly, or daily free-use tickets.

Table 5: 1st Section Fare Changes of Regular Ticket

Year	Fare level	Fare level reflecting consumer price index	Rate of increase
1981	100	100	-
'85	170	147	-
'87	200	163	17.6%
'90	250	132	25%
'93	300	163	20%
'94	350	179	16.7%
'95	400	196	14.3%
1997	450	na	12.5%

Source: Seoul Metropolitan Subway Co., 1997

Bus Operational Characteristics

The average bus operating speed was 20.07km/h in 1998, which is the fastest average speed for the last ten years (see table 6). This improvement is associated with a continuous extension of exclusive bus lanes and a sharp increase in the unemployment rate. Still, the current bus speed is much lower than the auto vehicle speed, 25.4km/h in 1998. The speed difference between autos and buses

had been 2.3 km/h, and therefore the widening difference is likely to shift bus passengers to autos.

Table 6: Trend of Bus Operating Speed Changes
(unit : km/hr)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Bus	18.60	18.80	18.15	16.88	17.02	18.42	18.79	18.35	18.69	20.07

Source: Seoul Metropolitan Government, 1997b, 1998b

The average bus headway is 7.9 minutes for regular bus (including circular bus), and 8.8 minutes for deluxe buses. There are 25 routes licensed with over 15-minute headways. The highest frequency (6 to 9 minutes) of operation is on 168 out of 448 routes. The bus operation starts at 4:00 in the morning, and ends at 2:00 in the morning, or 22 hours per day.

The fares per ride vary by type; 450 (\$0.38), 1,000 won (\$0.84) for regular bus and deluxe bus, respectively. There are no periodic tickets. When purchasing a pre-paid Bus Card (IC card), there is a discount of 5%.

Subway Organization

The Seoul Metropolitan Subway Corporation (SMSC) management structure was composed of a president, four directors, an auditor, 20 department, 50 sections, 29 field offices and 115 stations in 1996. There were 11,492 staff members in the SMSC. Six of them were officers, 11,275 were in regular government service and 211 were security police. Regular government staff was composed of 4,638 desk workers and 6,637 technicians. More than half of the staff has worked with the SMSC for over 10 years.

The Seoul Metropolitan Rapid Transit Corporation (SMRTC) is composed of one institute, 14 department, 43 divisions, and 13 site offices. As of December 1995, 2,795 staff members worked for SMRTC.

Bus Organization

There are 89 private bus companies operating 8,725 company buses in 1997. The biggest company operates 272 buses and the smallest does 22 buses. According to Korean Auto Transport Industry Law, a company should have 70 buses to be licensed, but the 21 companies have less than 70 buses. About 24 thousand employees work for the industry. Among them 83% are drivers and mechanics, and the rest of them are office workers and officers. On average, a company hires 268 employees in total, 197 drivers, and 24.6 repair workers. There are two drivers and 0.44 office workers per bus.

Subway Financing

The budget of SMSC in 1996 was 1.02 trillion won (\$857 million). The debt budget was 47.7 billion won (\$40 million). The revenue budget by item: 512.6 billion won (\$431 million) came from the fare revenue, 25.4 billion won (\$21 million) came from non-operating revenue, 1.3 billion won (\$1.09 million) came from disposal of fixed assets, and 41.3 billion won (\$34.7 million) was balance

brought forward. In the case of the auxiliary fundraising: 363.6 billion won (\$306 million) came from the bonds and 100 billion won (\$84 million) came from the investment by the Seoul Metropolitan Government. In the expenditure budget, 418.8 billion won (\$352 million) was spent on operating expenses, two billion won (\$1.68 million) on non-operating expenses, 483.3 billion won (\$406 million) on redemption of principal, 85.8 billion won (\$72 million) on investment and 54.3 billion won (\$46 million) as a balance to carry forward.

Bus Financing

The total asset of 89 bus companies is 354 billion won (\$297 million) and on average 4 billion won (\$3.36 million) per firm. The total debt is 400 billion won (\$336 million) and on average 4.6 billion won (\$3.86 million) per firm. The debts exceed the assets by 47 billion won (\$39.5 million) in aggregate. The average capital per firm is only 540 million won (\$0.45 million). These numbers imply how serious the financial situation of bus industry is. The 53% of firms recorded financial deficit in 1997, on average 760 million won (\$0.64 million) per firm. The deficit-ridden industry tends to be less attractive to reinvest resulting in continuous degradation of the services.

IV. System Usage

Mode Share

Bus ridership has been declining, while subway ridership has been increasing. The 1997 bus patronage was half of 1985's level. The sharp decline is attributed to both worsening road traffic congestion and expanded subway system. On the other hand, in 1997 the subways were, for the first time, the most predominant travel mode in Seoul, accounting for 30.8 percent of daily trips in Seoul. It is noteworthy that in spite of heavy investment, the expanded system has only contributed to the reduction of bus ridership in Seoul. SMG expects and worries that the bus share may reduce to 20% in the early 2000's.

Table 7: The Trend of Mode Share Changes

	1980	1985	1990	1995	1996	1997
Buses	66.0	58.0	43.3	36.7	30.1	29.5
Subways	7.0	14.0	18.8	29.8	29.4	30.8
Taxis	19.0	16.5	12.8	10.7	10.4	10.1
Others	8.0	12.5	25.1	22.8	30.1	29.7
(Pass. Veh)	(NA)	(NA)	(14.0)	(14.5)	(21.1)	(20.6)

Source: Seoul Metropolitan Government, 1998c

Subway Ridership

The subway extensions and ridership have been improving over the last 7 years as the new subway lines keep opening (see table 8). The ridership of the 1 through 4 lines operated by SMSC peaked in 1995, but declined slightly in 1996 and again in 1997. The declines are caused by several factors. Most importantly, they are attributed to the opening of 2nd phase subway lines operated by SMRTC at the end of 1996. It is noteworthy from the effectiveness point of view that the opening of new subway lines does not have synergy impacts in terms of ridership among

existing services. This phenomenon implies that, from now on, subway policy in Seoul should place emphasis more on encouraging ridership of existing services rather than on building new lines. The most congested time period in a day is 08:00 to 09:00, which accounts for 14% of the daily ridership. Around 50% of the ridership is concentrated during the time periods of 07:00 to 10:00 and 17:00 to 20:00, and therefore ridership during non-peak hours needs to be increased.

A customer survey disclosed the following major complaints that tend to discourage subway usage. These are: inconvenient transfer facilities such as insufficient elevators and escalators, and poor access to subway stations.

Table 8: Subway Ridership by Year

		1991	92	93	94	95	96	1997
SMSC	Car km (1,000)	133,188	160,098	174,025	193,056	212,242	216,623	206,489
	Ridership (1,000)	1,241,157	1,354,150	1,388,037	1,404,233	1,476,788	1,422,570	1,354,818
	Person-km	9.23	8.46	7.98	7.27	6.96	6.57	6.56
SMRTC	Car km (1,000)	N/A	N/A	N/A	N/A	N/A	N/A	101,712
	Ridership (1,000)	N/A	N/A	N/A	N/A	N/A	N/A	282,041
	Person-km	N/A	N/A	N/A	N/A	N/A	N/A	2.77

Source: Seoul Metropolitan Subway Co. 1998

Note: SMRTC started revenue service in 1997

Bus Ridership

There is no detailed official bus ridership data, because the privately owned bus companies are not required to report this information and do not want to disclose the information. The only way to estimate bus ridership is through O-D survey conducted by SMG every 5 to 10 years. As shown in the above table 7, it is clear that the ridership is decreasing fast.

The decrease can only be explained indirectly by user surveys. According to a survey conducted by SMG in 1996, the most important reason not to ride the bus is the excessive waiting times. Wait times range from less than 5 minutes to over 40 minutes mainly because of road congestion. Over 51% of bus users experienced waiting times over 15 minutes. Reckless driving and rush hour in-vehicle crowds are second and third reasons for not using bus. About 60% of bus users responded during the survey stated that they are not satisfied with the current bus services.

V. Conclusions

This paper reviewed the two most predominant public transit modes in Seoul, the subway and bus systems. The contents include important characteristics of these modes in terms of system characteristics, operations, and usage.

The SMG plans the second-stage subways with the length of 145km to be completed by year 2,000. The third-stage subways with the length of 120km will

start construction in 1999. In total, the subways will include a total of 12 routes with a route length of 400km by the middle of year 2000. For service improvement, SMG plans to provide more accommodation facilities, user information program, and the elevator guide system for the disabled.

The SMG plans to keep the privately owned bus systems, but intends to reorganize bus route systems, and to support private bus companies for securing good quality public services. In addition, SMG plans to reduce long distance routes and winding lines, to increase the number of luxury-seat-buses and circular buses, and to replace old buses with air-conditioned buses. For securing consistent high quality services, the city has under consideration a plan to evaluate the service level of each bus company based on the results of customer interview and service monitoring. According to evaluation results, it plans to graduate the financial supports among bus companies. To make transfers between buses and subways more convenient, the SMG plans to integrate different fare collection systems into one by using the above mentioned Bus card system.

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Development of the New Transit System Concepts in Korea

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Abstract

New transit systems technologies including the Automated Guideway Transit (AGT), stand out in the world's major cities in respect to its promise of relatively lower construction costs compared to existing subway systems. In Korea, the development of new transit systems technologies has become necessary to cope with growing urban transportation problems. The Korea Transport Institute has completed a master plan for constructing the new transit system in the metropolitan areas of Seoul and Pusan. Currently, the basic design is on the board and the registration for RFP (request for proposal) has been made. In this paper, we will discuss the strategies for developing the new transit system technologies, especially automated guideway systems (AGT) in transportation planning, construction, operation, and financing aspects in Korea.

Introduction

In Korea, rapid economic growth and urbanization have been accompanied by over population and traffic congestion problems. Presently, transportation problems are the top issues to be solved at the government level. In order to solve the transportation problems, a balanced transportation plan, in demand and supply side, is required. To do so, comprehensive transportation plans are required to cope with

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various travel demand patterns.

The necessity of shifting urban transportation systems from automobile to urban rail transit has been recognized and addressed by constructing subways, in large metropolitan areas such as Seoul and Pusan. However, in the long-term view, it is questionable whether the transit policy of single mindedly constructing subway systems is the best alternative due to its high construction costs. Presently, the development of the new transit systems in many countries around the world offer a better alternative in its lower construction costs and effective investment than the current subway.

The purpose of this paper is to derive a policy for developing the new transit system technologies in Korea through the review of construction and operation examples of the new transit systems technologies in other countries. In section two, we will review the characteristics of the new transit system. In section three, the construction examples of new transit systems in other countries along with Korea are evaluated. In section four, the background for introducing the new transit system and progress of development in Korea are presented. The provisions of future prospects for the new transit system in Korea are also discussed. In section five, a brief introduction of background and construction plan of the Kimhae corridor in Pusan metropolitan area and expected difficulties of the construction project will be discussed.

Definition of New Transit System

Urban rail transits can be classified into three types, based on their capacity: Heavy Rail Transit (HRT), Light Rail Transit (LRT), and Personal Rail Transit (PRT). Among these rail systems, the new transit system is defined as an advanced technology which has adopted the modern transit system on existing rail transit systems, using smaller vehicles than heavy rail transit systems and is run by the automated guideway system. This study has focused on the capacity and operation type of transit systems rather than vehicle type or physical appearance. The focus of the study is on the fully automated guideway transit (AGT) system.

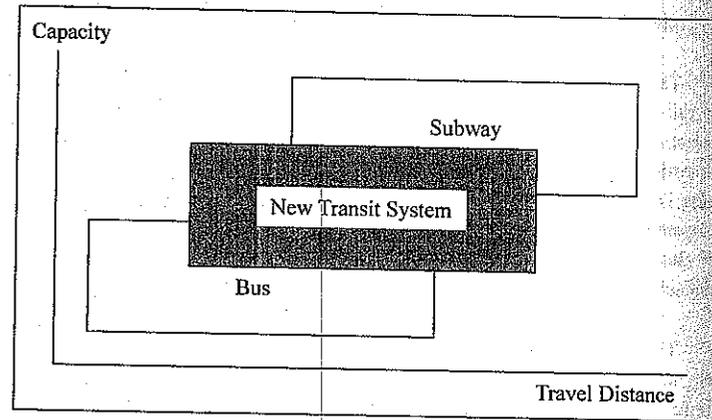


Figure 1: Application Range of New Transit System

Characteristics of New Transit System

Constructing and operating the new transit systems (AGT) in terms of transportation planning, construction costs, and operation aspects are evaluated as follows:

Transportation Planning Aspects

The major characteristic of the new transit system is its "medium" passenger capacity, moving 5,000-40,000 passengers per hour per direction (pphd) compared to bus capacity (1,000-5,000 pphpd) and heavy rail capacity (40,000-70,000 pphpd). Also, this system appears to be more cost-effective due to its lower construction costs and operational costs as discussed below. Due to the flexible running conditions of the vehicle such as handling tight turns and a steeper gradient, planning alignments and constructing feeder systems with other modes are easier. It can provide a better level of service for passengers in overall impacts of increasing transit riderships. However, its limited capacity makes it difficult to replace the function of trunk line railroads in the large cities.

Construction Cost Aspects

The components of construction costs of the new transit system are rails, guideways, stations, train depots, station facilities, rolling stocks and various system facilities for civil works. Due to the smaller size of its vehicle, civil construction costs are significantly less for infrastructures such as tunnels, elevated guideways, and track. Civil construction cost saving could vary such as saving of 40% for tunnel cross section of excavation and of 45% for elevated structure. Lightweight of vehicle can contribute to construction cost savings. Significant reasons are that it saves land compensation costs and civil construction costs through constructing elevated structures over existing roads.

Since Korea has no prior construction experience with the new transport system, there may be an increase in construction costs. Most new transit systems are patented technology, so vehicle and system technology costs are relatively high and the transfer and localization of the new technology take time. Table 1 shows the cost experience in Japan.

Table 1: Construction Cost (in Japan)
(in Millions of US\$)

Travel Mode	Subway	New transit system	Guideway Bus
Cost per Km	200-300	60-100	30

Source: New Transport System of Japan, 3rd International Conference on APM, 1991.

Operational Aspects

The new transit system is fully automated with ATO (Automatic Train Operation), ATC (Automatic Train Control), and ATP (Automatic Train Protection) systems. During peak hours or other situations, adding vehicles is relatively simple and compared to existing subway systems, the number of workers can be reduced to over 50%.

Labor costs of the Seoul subway systems take up 66% of total operation costs but the new transit system is expected to take up only 40%. The new transit

system has a significant advantage in operational cost saving. The percentage distribution of operating costs among various operating areas is shown in Table 2.

Table 2: Percentage Distribution of Operational Costs by Area

Items	Personnel Cost	Power Cost	Maintenance Cost	Management Cost
New Transit system 1	39	14	39	8
New Transit system 2	42	17	31	10
Existing subways (Seoul)	66	8	22	4

Note: New Transit 1, France, Lille city's VAL
New Transit 2, Japan, Osaka City's New Tram

A comparison of annual transit passengers per worker of existing subways and new transit systems shows that new transit systems have a higher operational efficiency. Figure 2 shows the comparison of number of annual passengers served per worker. In Lille, France, 260 workers served 44.2 million passengers in 1990. This shows that 170,000 passengers per worker were carried, which is almost twice the operational efficiency of the existing subways.

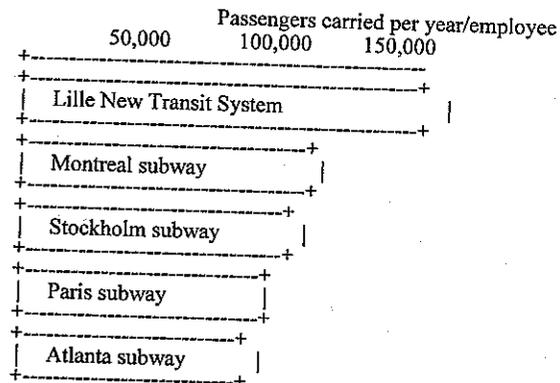


Figure 2: Comparison of Operational Efficiency

Although the new transit system has relatively less capacity than existing subway systems, the fully automated system shortens headway and can compensate for its smaller carrying capacity by running more frequently. Seoul and Pusan's subways operate at headway of 150 seconds but Lille's VAL and Berlin's M-Bahn operate at headway of 60 seconds, and Vancouver's Skytrain operate at headway of 75 seconds.

Passenger Aspects

The new transit system's significant benefits for passengers are shorter waiting times at stations and an overall reduction in travel time. Due to its tighter turns and steeper gradients, it can serve passengers even to the shortest destinations. In the case of constructing large railroad networks, it can easily connect with existing subways. New transit system can make up for the weak points of existing subway functions by improving accessibility to facilitate shifting of automobile users to mass transit. Finally, guideway types of new transit system with rubber tires and linear induction motors can reduce environmental pollution such as noise and vibration.

Developing the New Transit System in Korea

Shortage of Transportation Facilities and Transportation Problems

In 1995, the number of automobiles in Korea had already passed 8 million and the projected number of automobiles by 2001 is 14 million, which means one car per household. Due to Korea's limit on usable land and resources, the road expansion rate is only 1.5% in developed urban areas. In order to overcome the urban transportation problems, subway construction projects are being processed, but remarkable financing requirements make it difficult to expand subway networks. In Seoul, construction costs for the subway system has increased from US\$31.3 million/km in the '80s to US\$48.1 million/km in the '90s. The average travel speed of vehicles in Seoul and Pusan is estimated to be 10 km/hour in 2001. Thus, development of a new transit system as an alternative of mass transit is required.

Table 3: Rates of Road Expansion and Increase in Cars in Major Cities (1986- 2001)

City	Seoul	Pusan	Taegu	Kwangju	Taejeon
Rate of Road Increase (%)	1.29	1.17	3.37	2.11	1.67
Rate of Car Increase (%)	13.8	13.3	17.8	15.5	17.6

Increasing the Efficiency of Transportation Investment

In order to construct a comprehensive transportation system, multilateral investments and management policies for roads (passenger car and bus), subways, and new transit systems are required. The new transit system will help to overcome the limitations of existing transportation modes. Elevated structural construction can reduce land compensation and civil costs.

New Financing Scheme for Transportation Investment

Recently, the Korean government has enacted the "Regulation of Promoting Investment of Private Sector to Social Overhead Capital" to raise investment funds and technological improvements in transportation facilities by actively encouraging participation by private sectors. It has been decided that constructing the new transit system through private sector's participation is necessary to construct large fixed guideway networks to provide connections between central cities and satellite cities in major metropolitan areas of Korea.

Development Plan for the New Transit System in Korea

Followed by a feasibility study in 1993, the Korea Transport Institute has completed a master plan for constructing the new transit system in Seoul and Pusan. With a total length of 191 km, the construction of the expected new transit system will take five years for completion and the total construction cost is estimated at US\$4.6 billion. However, most of projects shown in Table 4 were postponed due to the financial problems.

Table 4: Prospects of Developing New Transit System in Korea

Projects	Construction Period	Route length (Km)	Stations	Project Cost (Million US\$)
Seoul--Hanam	1995 to 2000	18.65	20	409
Pusan--Kimhae	1995 to 2000	26.00	16	615
Seoul--Uijongbu	1995 to 2000	14.85	16	300
Suwan-Bundang-Yongin	1step : 1995 to 1999 2step : 2000 to 2004	35.40	15	885
Masan-Changwon-Jinhae	1998 to 2011	48.20	61	1,205
Mikum-Kuri-Sangbang-Hoeki	-	15.96	14	399
Sihug-Puchon	-	6.75	6	169
Yangsan	1996 to 2000	10.30	5	258
Pusan station-TaeJongDae	1996 to 1999	11.25	16	281
Solak Mountain-Sokcho city	1995 to 1998	6.30	6	158
Total	-	190.81	-	4,679

Development Policy for the New Transit System

The development policy for constructing and establishing a comprehensive transportation system requires feeder systems with each travel mode in order to

provide convenient transferring systems. Also, maximum travel effectiveness should be obtained under limited fund, and for these purposes, mass transit priority policy should be implemented. Rearrangement of road systems and rail transit systems is necessary to respond to the increasing travel distances, population mobility, and urbanization started by large-scale housing development and new town development. It is necessary to clearly define the function of the new transit system and adjust the function of each travel mode in the mass transit system. Table 5 shows a concept plan of role sharing of modes in the mass transit system, including new transit system.

Table 5: A Concept Plan of Role Sharing of Mass Transit System

Travel Mode	Function	Service Type	Role
Subway	major transit	trunk line service	- major corridor in service in large cities
Bus	supporting transit	connection to subway and circulation	- connection between residential area - connection between residential area and district centroid
Taxi	short distance assistant transit	connection to other mode	residential areas and mass transit network connection
New Transit System	major transit and feeder transit	feeder line and connection with subway	connection between central city and satellite city
		circulation of trunk line and assistant trunk line	major corridor in medium and small cities
	paratransit	demand responsive high level of service	connections between major activity centers

Tasks for New Transit System Development

Planning and Construction Aspect

The new transit system should maximize connectivity with existing railroad, subway, and road systems by considering future transportation networks and

construction plan. In order to maintain the profits in operation, the route should be chosen to maintain enough travel demand during both peak hours and all day. Also, major trip generating facilities should be placed near routes and comprehensive land use policies should be considered very carefully.

The performance specification of the transit system needs to be provided by considering transportation and geographic conditions of target area. The RFP (request for proposals) will be made based on performance specification. In order to minimize land compensations, maximum use of public owned lands for the construction of the new transit system is needed.

Financing Aspect

It is difficult to construct and operate the new transit system exclusively by the private sector without intervention by the public sector for ensuring public interests. Therefore, it is desirable to proceed under a joint venture system with private and public agencies working together on the construction of a new transit system. With the assumption of no financial support from central government and considering the current fare levels of public transit, operating profits would be relatively low. Therefore, funds must be sought through innovative strategies. Attracting private funds for public projects makes it possible to supply transportation services efficiently and reduce the burden of government in large-scale investment.

Technology Aspect

Technology transfer of a new transit system from foreign companies to domestic companies by individuals is not a good approach. Introduction of new technology by government is desirable for maintaining efficient management of technology transfer in the future.

Case study: Developing New Transit System in Pusan

Background

Kimhae City, a satellite city of Pusan, has a relatively high potential for development in the northwest area of Pusan. There are only two transportation corridors, local road #14 and Namhae Expressway, in this area. These two major roads are insufficient to handle the rapidly increasing travel demands and this

generates serious traffic congestion. As part of constructing rail transit network plan for the Pusan metropolitan area, the construction of new transit system in Pusan-Kimhae corridor is proceeding in order to tackle the regional traffic congestion problem.

Construction Plan

The route of the new transit system connecting Kimhae and Pusan consists of 16 stations with a total length 26km.

Time schedule for implementing the project is as follows:

Basic design and detail design: 1995 - 1996 (18 months)

Land acquisition and compensation: 1996 (6 months).

Construction and test track operation: 1997- 2000 (4 years).

Opening: 2001

The estimated cost of the project is shown in the following table.

Table 6: Costs of Project
(Millions of US\$)

Design Cost	Land Compensation Cost	Civil Construction Cost	Rolling Stock Cost	Total
19.5	25.0	382.4	187.8	614.7

Difficulties in Processing Project

The major difficulties in processing this project are financing and choosing an appropriate implementation body for the project.

Government Subsidy

In most countries, government subsidies for urban railroad construction

amount to over 50% but in Korea, subsidies provided by the governments come around to 40-50% according to "Urban Railroad Act" only for subway (metro), not for new transit system.

Subsidiary Development Revenues

The "Regulation of Promoting Investment of Private Sector Act" prevents the scale of housing development in subsidiary developments from exceeding 100% of total construction costs, which causes difficulties in project financing.

Sink Investment

From the total project cost of US\$614.7 million, supposing that 40% is invested from private and public sectors, initially, the private sector cost burden from private will be \$196.8 million and public investment will be \$49.3 million. This may restrict the willingness of private sector to participate in the project.

Selecting Implementation Body

Selecting an implementation body for the project could be delayed due to different interests among different participants. At the earliest moment, vehicle system and implementation body for the project should be selected for basic and detail design.

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Socioeconomic, Land Use and Travel Patterns of Shanghai

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Introduction

Shanghai is a very important city in eastern China and also a major commercial and industrial center of the nation. It is located at the mid-point of the East China Sea's coastline, and near the outlet of the Yangtze River, the longest river and the most important inland waterway in China. Shanghai was developed as a trading center as early as the 1850s due to its prime location. In the early 1920s, Shanghai had already become a modernized international city. Today, Shanghai is a municipal district with an area of 6,340 square kilometers and with more than 13 million residents.

Shanghai is situated on the Yangtze Delta, which provides a large flat area for the city to expand. There are two rivers cutting through the downtown area: the Wusong River to the north and the Huangpu River to the east. Before World War II, the city had expanded to the north of the Wusong River. In the last few decades, the city has expanded to the west of the city along several external corridors. The area east of Huangpu River, now called Pudong New District, was identified in early 1990s as the most important urban development project in eastern China. Many infrastructure projects, commercial, industrial and residential areas have been or are being developed there.

Due to economic reform, Shanghai has experienced tremendous economic growth in the past decade. Numerous urban development projects have been implemented. Following the economic growth and the extensive urban

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