

Completion of Phase 2 of Seoul Metropolitan Urban Rail

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Introduction

Since the Seoul Metropolitan Subway (SMS) began operating in 1974 with the opening of Line 1 belonging to the Seoul Metropolitan Subway Corporation (SMSC), the Korean capital has shown a continuing population increase (1.8% in the 1990s) and growth in the number of road vehicles (12.4%). In 1999, the Seoul metropolitan area (11,700 km²) had a population of 21.32 million (46% of the national population of 47.54 million) and 5.14 million vehicles (also 46% of the nation's total of 11.16 million vehicles). As a result, the costs of new infrastructure required to relieve traffic congestion in Seoul and neighbouring Incheon had grown by 15.6% annually from Won1.7 trillion (US\$1 = Won1200) in 1990 to Won5.4 trillion in 1999.

It is estimated that the population of the Seoul metropolitan area will increase to 25.78 million by 2020, with traffic volume rising from 45 million journeys/day in 1999 to 78 million journeys/day in 2020. In 2001, the population of Seoul City alone was 10.33 million and the population density was 17,062/km².

The Seoul metropolitan area has a radial road network with Seoul City at the axis. At the same time, cross-links between the radial roads are poor, causing concentration of traffic in Seoul City. The rail network also falls far short of the needs of the wider region. Road traffic volumes in and out of Seoul are growing by an annual average of 5.8% while the coverage by the railway network is substantially less (41.1 km/1000 km²) than in other large developed cities.

History of Urban Rail Construction

Phase 1 of Seoul Metropolitan Subway

Since work began on Line 1 in 1971,

construction of the Seoul rail network has not followed a coherent long-term plan for a transportation network. Instead, the network has grown piecemeal to meet the needs of population concentration. As a result, there are many winding and circular lines, and some lines are poorly used. For example, the Bundang Line and Ilsan Line belonging to the Korean National Railroad (KNR) only carry some 19% of the transport market.

In addition, building of modal transfer stations requires huge capital but generates relatively low profits, so a coherent pro-active plan has never been developed. Consequently, even when facilities for changing mode between road and rail are built after completion of a line, they are often inadequate, resulting in a transfer rate between private cars, etc., and public transport of less than 1.2%. For example, although there are 69 Park n' Ride facilities, the parking fees are high and the walking distances long, so the usage rate of parking for transfer to rail is only 47%.

The so-called Phase-1 lines are lines 1, 2, 3, and 4. Line 1 was the first subway built in the development of the SMS. Construction began in 1971 and Line 1 opened on 15 August 1974. Line 1 covers the core metropolitan area between Seoul Station and Cheongnyangni Station and connects with KNR's Gyeongin, Gyeongbu, and Gyeongwon lines.

Line 2 was constructed to promote balanced development of Seoul City by

transforming it from a single-core city to a multi-core city. Line 2 is Seoul's only loop line and it starts and ends at City Hall Station. It is also the longest line and carries most passengers.

Line 3 was constructed to supplement the functionality of Line 2 and general use of the subway system by radiating out from the city centre and crossing Line 2. It connects the Ilsan Kyeonggi-do district in north-west Seoul to the Bundang district in south-east Seoul. The line is being extended in stages.

Line 4 was also constructed to supplement Line 2 and to relieve overcrowding and congestion in the city area. It was also extended in stages and passes through the congested city centre district, north of the Han-gang River.

Phase 2 Seoul Metropolitan Rapid Transit

Phase 2 of the Seoul Metropolitan Rapid Transit is composed of lines 5, 6, 7, and 8. These so-called Phase-2 lines were built to address the construction and operational problems of the Phase-1 lines and they present an improvement on Phase 1. Construction on Line 5 began in 1990 and was completed in 1996. It radiates from the city centre to connect the eastern and western sides of the Seoul metropolitan area passing through the Yoido district, which has a high concentration of offices, and extending to Gimpo International Airport.

Line 6 connects Seoul's north-east and

Seoul Metropolitan Urban Rail Lines

	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8
Operating length (km)	7.8	60.2	35.2	31.7	52.3	35.1	46.9	17.7
No. of stations	9	49	31	26	50	38	42	17
No. of trains	160	834	480	470	608	328	496	132
Time between departures (min)	RH 3.0 NH 4.0	2.5	3.0	2.5	2.5	4.0	2.5	4.5
Construction cost (Won100 million)	330	10,712	10,304	8,315	30,253	25,496	27,851	8,502
Construction period (years)	1971-74	1978-84	1980-85	1980-85	1990-96	1994-2000	1990-2000	1990-99

Note: RH = Rush hour, NH = Non-rush hour

Comparison of Phase 1 and Phase 2 Urban Rail Construction

	Phase 1 Subway	Phase 2 Subway	Notes
Gauge			Standard
Power	1500 Vdc Overhead	1500 Vdc Overhead	
Track bed	Gravel	Concrete in all areas	
Platform length	205 m	Lines 5, 6, 7: 165 m Line 8: 125 m	Reduction of 40–80 m
Carriage size (m)	3.2 W x 4.5 H x 20 L	3.2 W x 4.0 H x 20 L	Height reduction of 50 cm
Control operation	Lines 1, 2: ATS Lines 3, 4: ATC (2 staff)	ATC/ATO (1 driver or unmanned)	Shift from semi-automatic to fully automatic
Rolling stock	Lines 1, 2, 3, 4: 10 cars	Lines 5, 6, 7: 8 cars Line 8: 6 cars	
Power control	Line 1: Resistance control Lines 2, 3, 4: Chopper control	VVVF control	Prevention of overheating, reduced energy
Carriage body	Steel	Light SUS	Increased life cycle, reduced maintenance
Ventilation	Line 1: Natural ventilation Lines 2, 3, 4: Semi-forced ventilation (Forced intake, natural output)	Forced ventilation (forced intake and output)	
Station air-conditioning (%)	8.4	100	

north-west districts and forms the basis of a transfer system connecting all lines passing through the city centre. Completion of Line 6 established a web-like rail network in the metropolitan area. Line 7 links Uijongbu City with south-east Seoul via north-east Seoul and south of the Han-gang River. It runs broadly parallel and inside the southern part of Line 2 and relieves congestion at Sindorim and other Line-2 stations and also absorbs some of the traffic demands of KNR's Gyeongin Line.

Line 8 links Seoul's more highly populated residential areas of Gangdong Gu, Songpa Gu, and Songnam City, increasing accessibility from Seoul to various metropolitan sub-centres and facilitating smooth access to Seoul for citizens of Songnam City. Services operate with just six carriages per train, the smallest train set of any metropolitan line. After construction of Line 8, Seoul's financial resources were considered inadequate for further development, which has been limited to just the first stages of Line 9.

The total construction costs Phases 1 and 2 are estimated at Won120 trillion. A boom in subway construction financed by the national government also took root in larger regional cities. As a result, the prevailing opinion today is that the burden

on central government is too heavy. From 1991, the government contributed 30% (25% in Seoul) towards the cost of constructing subway systems by regional autonomous bodies. Then this amount was increased to 50% (40% in Seoul) from 1998. However, more recently and in order to discourage construction of economically non-viable subways, the government is starting to refuse financial support if the local government does not bear at least 50% of the construction costs. The government is also understood to be actively encouraging investment participation from the private sector.

Differences between Phase 1 and Phase 2 lines

The Phase-2 lines were built to overcome the shortcomings of the Phase-1 lines. All track beds were built with concrete to eliminate dust generation, improve the underground environment and reduce the maintenance costs. Construction costs were pared down by lowering internal ceilings, reducing carriage height, and shortening station and platform lengths. Moreover, labour costs were cut while raising safety by changing from semi-automatic to automatic driving operation. The ratio of motorized to trailing cars in train sets was revised and the minimum

time between departures was improved from 2.5 minutes to 2 minutes to increase capacity. The control system was upgraded from chopper control to variable voltage variable frequency (VVVF) inverter control for improved braking and better passenger comfort. This change also extended the inspection interval, reducing manpower and repair costs. Moreover, the weight saving helped cut energy costs. The carriage body material was changed to SUS 301L in order to cut weight, extend service life, eliminate painting and reduce repair costs.

All underground stations were fitted with air conditioning to maintain reasonable temperatures in the tunnels. Forced ventilation was chosen to improve air circulation in main tunnels.

Performance

Passenger ridership

Construction of the Seoul metropolitan subways has been successful from the perspective that passenger cars play a smaller role in the city's transportation, decreasing from 19.6% in 1999 to 15.4% in 2002). At the same time, the metropolitan railways' share has increased from 33.8% in 1999 to 37.8% in 2002. On the other hand, persistent debt and recently exposed safety inadequacies are serious problems.

In recent years, lines 1 to 4 have shown annual increases in passenger ridership; in 2002, they carried a total of 1.44 billion passengers. Line 2 had the largest share (690 million passengers) while the relatively shorter Line 1 passing through the city centre carried 170 million passengers, posting the smallest numbers for lines 1 to 4.

In 2002, lines 5 to 8 showed a drop in passengers over the previous year, transporting 910 million passengers. Lines 5 and 7 did well, transporting 350 million and 320 million passengers, respectively;

Passengers/Fare Revenue of SMSC

Year	Lines	Passengers (1000)		Revenues (Won million)	
		Total	Daily average	Total	Daily average
2000	Total	1,369,719	3742	520,303	1422
	Line 1	176,766	483	55,101	151
	Line 2	656,567	1794	253,928	694
	Line 3	237,669	649	96,451	263
2001	Total	1,415,738	3879	578,219	1585
	Line 1	174,660	479	59,860	164
	Line 2	676,270	1853	282,798	775
	Line 3	259,142	710	109,363	300
2002	Total	1,439,716	3944	579,635	1588
	Line 1	171,061	469	59,269	163
	Line 2	692,766	1898	285,528	782
	Line 3	265,142	776	108,769	298
	Line 4	310,747	851	126,069	345

Passenger/Fare Revenue for SMRT

Year	Lines	Passengers (1000)		Revenues (Won million)	
		Total	Daily average	Total	Daily average
2000	Total	719,528	1966	187,203	511
	Line 5	403,692	1103	103,350	282
	Line 6	9,179	62	2,597	18
	Line 7	208,268	569	55,570	152
2001	Total	1,024,863	2808	281,935	772
	Line 5	424,583	1163	114,963	315
	Line 6	137,251	376	38,039	104
	Line 7	354,232	970	98,890	271
2002	Total	911,363	2998	247,367	814
	Line 5	354,463	1166	94,819	312
	Line 6	144,351	475	38,927	128
	Line 7	318,914	1049	88,200	290
	Line 8	93,635	308	25,421	84

Line 6 continued to show increased performance, transporting 140 million passengers.

In total, in 2002, lines 1 to 8 carried 2.35 billion passengers—a relatively slight decrease compared to the 2.42 billion passengers carried in 2001. Nevertheless, the 2002 result is still good compared to the 2.09 billion passengers in 2000.

Commercial performance

Along with the increased numbers of passengers, lines 1 to 4 showed increases in fare revenues, producing a combined total of Won580 billion in 2002. At Won290 billion, the income from Line 2 was exactly half the total of the four lines combined. Line 4 yielded the next highest

income of Won130 billion, but this was less than half the income from Line 2.

The combined total transport income from Lines 5 to 8 in 2002 was Won250 billion, which is still less than half the combined income from lines 1 to 4. Income from lines 5 and 7 was relatively high, each producing Won95 billion and Won88 billion, respectively.

Issues

Standardization

When KNR's Gwachon Line opened in 1994, there was at least one operating accident every day. This drew attention to the problems of safety and maintaining

and repairing rolling stock. Some problems could not be dealt with quickly due to shortcomings in technology and manpower, and variations in rolling stock even within one line. To solve these problems, the government promoted standardization of metropolitan rolling stock from 1995 and a system was put in place by 2000.

Nevertheless, safe operations could not be guaranteed by standardization of rolling stock alone, so standardization is being expanded to include other systems, such as signalling, tractive power supplies, track construction, etc. Domestic signalling technology is still weak and the ability to analyze accidents and develop solutions is still insufficient. Since most signalling systems in the urban network are of foreign manufacture, the time required to recover from an accident is sometimes delayed until foreign parts can be obtained. Costs are high too.

Safety

There is some indication that government standards on urban railway safety will be strengthened after the tragic Taegu subway fire in February 2003. The old regulations only applied to new rolling stock and safety weaknesses in old rolling stock were left unaddressed. Some experts have previously pointed out the inadequate ventilation for emergencies and the worsening air pollution in the underground network. However, there has been no systematic response from the government yet.

After the Taegu fire, there are plans for a revised safety standard that will apply to all rolling stock in operation. For example, safety training in simulated real situations will be strengthened. The Subway Safety Task Force created by the government after the fire has collected and analyzed cases from both home and overseas, including Japan. Apart from this, the task force, together with the Korea Railroad Research Institute (KRRI), has

carried out performance tests on various materials, including trial tests in actual subway stations. After conducting seminars and public hearings in order to gather opinions, the task force will draft Comprehensive Metropolitan Rail Safety Measures reflecting the test results.

Operational debt

Huge losses are recorded each year by the SMSC and SMRT, making it hard to see the construction of Seoul's metropolitan rail system as an economic success. Both corporations would be hard pressed to survive without financial support from the Seoul municipal government, and neither is able to secure funds for new investment from operating income. As a result, the Phase-3 construction plans are on hold.

The losses occur because operating expenses are greater than operating income. Moreover, interest on loans comprises a large part of non-operating expenses. Increasing fares and cutting costs are both being considered as a solution but possible fare increases are very limited due to their impact on the consumer price index. Two alternative approaches could be considered—increasing passenger ridership by improving services, and maximizing non-transport revenues from secondary and incidental businesses. A more realistic approach, might be cutting costs by expanding private consignment and streamlining operations.

Differences between operating bodies

The large number of bodies operating Seoul's metropolitan rail network is another source of inefficiency. Although cooperation is being gradually achieved, it is not yet at the level where a unified timetable can be drafted. One possible approach to reducing losses might be merger of the various organizations.

The losses posted by the SMSC and SMRT

have lead to the problematic situation where the Seoul municipal government is forced to subsidize payment of both capital and interest on loans owed by the two operators. At the end of 2001, the current capital and interest owed by the SMSC was Won3.4 trillion, meaning that the corporation will have to repay hundreds of billions of won each year until 2008. Estimates conclude that SMSC's loan burden will only decrease after 2009, when it will have to repay some Won18 billion annually.

In the case of the SMRT, the current combined total of capital and interest owed at the end 2002 was Won2.2 trillion. Although this amount is decreasing year by year, it still has to repay several trillion won each year.

If we examine the state of the two corporations' expenses, we see that the personnel expenses of the SMSC in 2002 amounted to Won460 billion, and the personnel expenses of the SMRT amounted to 250 billion. If we divide these amounts by the number of employees, we find that this amounts to Won46.38 million/employee for SMSC and Won38.34 million/employee for SMRTC. Since the average family income

(employee payment base) for 2000 in the Seoul metropolitan area was Won17.7 million, these averages are quite high. In the case of the SMSC, personnel expenses accounted for 53.2% of operating costs, while they account for 35% of SMRT's operating costs. Clearly efforts should be made to reduce personnel expenses at least in the case of the SMSC.

Attracting private investment capital

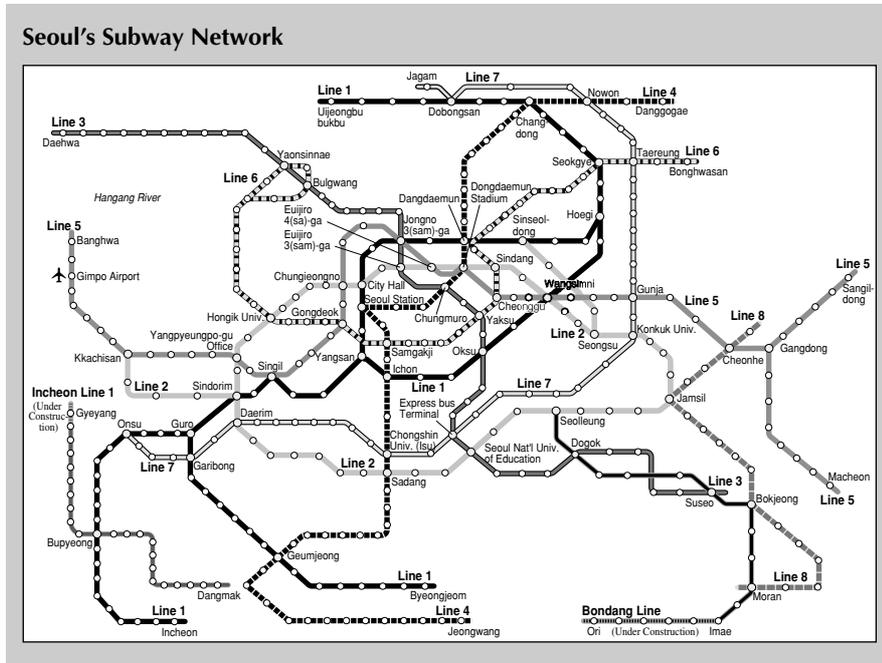
In the early 1990s, the national government recognized the need to introduce light-rail systems. A government 1993 survey examined the suitability of light rail in the metropolitan area between Seoul and Hanam. To overcome the difficulty of securing funds and the need for indirect private funding to construct existing types of subway systems, the government decided to actively promote construction of light rail as an opportunity for private-sector investment, allowing utilization of private sector initiative and technical know-how. However, metropolitan rail systems require both huge initial capital investment in infrastructure and rolling stock, as well as huge amounts of

Metropolitan Rail Operators

Lines	Operators
Lines 1, 2, 3, 4	SMSC
Lines 5, 6, 7, 8	SMRT
Line 1 Transfer points: Gyeongwon Line, Gyeongin Line, Gyeongbu Line City Centre: Cheongnyangni–Wangshimni–Yongsan Line 3 Transfer points: Ilsan Line, Bundang Line Line 4 Transfer points: Gwacheon Line, Ansan Line	KNR
Bupyeong Station Transfer Incheon Subway Line 1	Incheon Metro

Current Status of the Metropolitan Rail Operators

	SMSC	SMRTC
Started operations	Sep 1981	Mar 1994
No. of employees	9871	6426
No. of trains	1944	1564
Lines	1, 2, 3, 4	5, 6, 7, 8
Track length (km)	143.1	152.0



metropolitan area, plans are in place to operate express EMUs on the 481 km of tracks in the 13 municipal districts along seven of the 10 main access routes into Seoul. High-speed DMUs will be operated along the other three main access routes. Plans are also in place to improve the speed of current rail operations from 30 to 40 km/h to 50 km/h or more by 2020.

According to the government's plan, Won45.4 trillion will be spent to expand the rail network, with another Won500 billion to be spent on construction of the transfer centres. The national government will contribute 47% of the cost, the regional autonomous bodies (including Seoul municipal government) will contribute 19.15%, and private-sector investment will contribute 14.4%.

In the area of operations, it appears that fares will become more diversified. Bigger discounts will be available to passengers transferring between transportation mode and a system of day passes and weekly season tickets may be introduced, allowing greater freedom to passengers.

additional investment for operations, etc. Moreover, compared to other investments such as roads, return on the investment takes relatively long and there are unknown risks, such as introduction of overseas technology. As a result, private investors tend to avoid investment in rail. Therefore, to assure profitability for the private sector, the government is currently reviewing an approach under which it would bear the basic infrastructure costs. In addition, in order to reduce the risk burden related to purchase of overseas technology, the government is promoting development of domestic light rail rolling stock and systems technology.

transportation in the national capital. According to this plan, rail's share of transport (including light rail) will increase from 20% in 1999 to 40% in 2020. To achieve this, the government intends to add 1000 km to the current rail network by completing an X-shaped network linking the major residential areas around Seoul. It also intends to construct 11 more modal transfer centres along the 10 main transportation routes approaching Seoul City. In the mid- to long-term, these changes are intended to support economic activity in the west-coast region and prepare for eventual unification of North and South Korea.

To accommodate the need for speed-up required by the expansion of the Seoul

Future Direction

Metropolitan transportation issues have come to the fore due to the rapid growth of the Seoul metropolitan area. In response, the government established the Metropolitan Transportation Network Plan in 2001 as a means to effectively and systematically deal with the problems of



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