

# Transportation Revolution: The Korean High-speed Railway

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## Background to Construction

The background to the high-speed railway initiative in Korea goes back to the 1980s when the country was suffering from serious road congestion caused by a surge in car ownership (17% average annual increase). Significant congestion in the Seoul–Busan corridor led to increased logistics costs and weakened industrial competitiveness. Korea already has a higher proportion of logistics costs to GDP (13.3%) than other advanced countries, creating an urgent necessity to relieve the bottleneck on the Seoul–Busan rail corridor, which contains 73% of the national population and carried 66% of the 7.3 million people riding railways in Korea each day in 1995.

In May 1989, the government took the important decision to construct the Gyeongbu high-speed railway, estimating that passenger and container freight traffic on the new line would increase 1.7 and 3.8 fold by 2011 compared to 1995.

In comparison to a 4-lane motorway or conventional double-track railway, a high-speed railway is most efficient for meeting the needs of long-distance, mass transport. In terms of transport efficiency, such as

operation hours, construction costs, and line capacity, a high-speed railway is two or three times better than a motorway or conventional double-track railway.

The project was launched by constructing a test track between Cheonan and Daejeon in 1992. However, the economic crisis of 1997 forced the government to change its plan by constructing a new line between Seoul and Busan using electrified and upgraded conventional lines between Daegu and Busan by 2004. This is to be followed by construction of an entirely new line between Daegu, Gyeongju, and Busan by 2010. Instead of building new tracks along the entire line, the amended plan adopted phased construction to make best use of the existing Daegu–Gyeongju–Busan tracks.

To maximize the impact of the Gyeongbu high-speed Line construction, the government decided to electrify the main Honam Line (Daejeon–Mokpo) with the two Gyeongbu and Honam main lines to be linked as a new system offering high-speed Korean Train Express (KTX) services (Fig.1).

The government looked at many possible funding sources for the project based on its potential benefits and prevailing financial circumstances. The total cost of

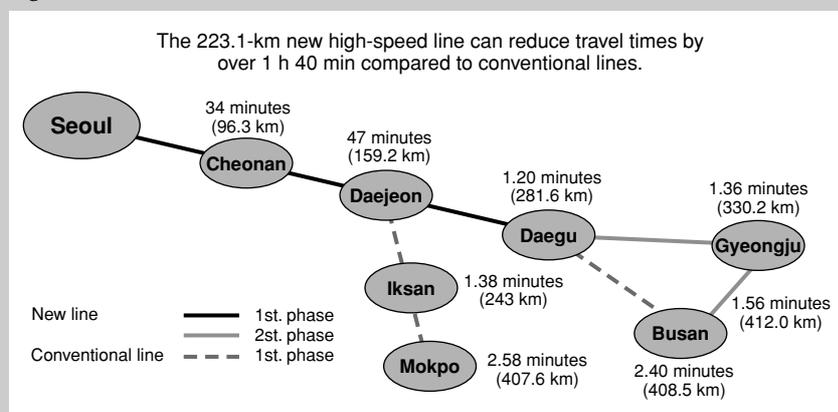
the Gyeongbu high-speed line was estimated to be about Won18.4258 trillion (US\$1 = Won1,162) with some Won12.7377 trillion needed for the first phase. Funds were raised from the government budget (45% and including loans of 10% of the total) and from the budget of the Korea High Speed Rail Construction Authority (KHRC) (credits: 29%; foreign loans: 24%; private funding: 2%). The difficult economic circumstances in Korea at the time required a number of measures to acquire foreign loans. Funding for electrification of the Honam Line was provided entirely by the government.

To hold overall costs to reasonable levels, contracts were made with overseas contractors to provide only core rail systems, such as rolling stock, catenaries, train-control systems (ATC, CTC, SCADA). Other non-core systems such as civil-engineering works, power supplies, tracks, and information systems were handled by Korean companies.

Thirty-four of the 46 TGV-style KTX high-speed train sets were built domestically in Korea based on a technology transfer from SNCF while the other 12 were built in France. Each of the 388-m trains has 20 carriages, including two motorcars, two powered passenger carriages, and 16 passenger cars. Each train has 935 seats, including 127 in first class (three seats per row) and 808 in economy (four seats per row). Operations safety is assured by an onboard computer system (OBCS), fire-detector system, and automatic sensors to detect any malfunctions.

The KTX stations have been designed as futuristic multi-purpose hubs to cater to customers' needs. KTX trains normally stop at Seoul, Gwangmyeong, Cheonan-Asan, Daejeon, Daegu, and Busan, on the Gyeongbu Line, and also stop at Yongsan, SeoDaejeon, Iksan, Songjongri, Gwangju, and Mokpo on the Honam Line. Seoul Station is a five-storey state-of-the-art building, with two floors underground; Yongsan Station is eight-storeys high with

Figure 1 KTX Route





Seoul Station

(Korail)



Gwangmyeong Station

(Korail)



Cheonan-Asan Station

(Korail)

four floors underground. The other stations range in height from two to five storeys, each with different numbers of underground floors. All stations are complete and equipped with fully automated systems using cutting-edge architectural technologies. Reservations, ticket purchases, and ticket issuing are fully automated. Each station has a travel information centre, providing comprehensive information on all transportation modes.

### Efforts for Successful Opening

In January 2004, the Korean National Railroad (KNR) was split into two government agencies: Korea Railroad (Korail) in charge of train operations including KTX services and Korea Rail Network Authority (KR) responsible for building new lines and improving existing network. KTX services run over both newly constructed lines (34%) and existing lines (66%). The tracks total about 661.0 km, composed of 223.6 km of new lines, 422.4 km of conventional lines, and 15 km of connecting lines (Table 1). After the opening of the KTX in 2004, Korail was faced with operating an integrated system between the conventional and high-speed lines, presenting difficulties in timetabling. An important task has been the creation of a secure interface between the different systems. Upgrading and electrification of existing lines was also problematic as was securing time slots for track work on conventional lines without interrupting

regular train services. As a consequence, many of the improvements to the conventional lines were done during the night. Most KTX stations on conventional lines except Gwangmyeong and Cheonan-Asan were remodelled and expanded at night, assuring the same level of train services.

Apart from constructing the high-speed infrastructure, in 1995, KNR initiated across-the-board reforms to develop better human resources for high-speed operations based on a master plan. In 1996, English-language training was provided to all 3500 staff involved in the high-speed operations and an organization was set up to redeploy about 2000 staff to the right locations. In 2002, project management techniques were

incorporated actively into the high-speed operation preparations and all activities were divided into smaller task units under full process management control.

As well as training personnel, KNR made a big effort with pre-opening testing and commissioning to ensure successful operations on opening. This testing and commissioning period showed up many technical problems that were remediated as soon as possible.

Starting with performance-validation tests of the high-speed train sets on the 57.2-km test track in 1999, KNR validated the interface between high-speed rolling stock and rail infrastructure on conventional lines from May 2003.

In January 2004, commercial test runs were started over the whole line under

Table 1 KTX Data

Distance	New line: 223.6 km Connecting tracks: 15.0 km Conventional lines • Gyeongbu corridor: 169.9 km • Honam corridor: 252.5 km
Tunnels	New line: 51 totalling 7.248 km Conventional lines: 36 totalling 10.381 km
Bridges	New line: 104 totalling 89.041 km Conventional lines: 150 totalling 7.608 km
Maximum speed	300 km/h
Gauge	1435 mm
Daily services	122 trains on weekdays 130 trains on weekends
Stations	Gyeongbu corridor (Seoul-Busan): 10 Honam corridor (Seodaejeon-Mokpo): 11
Fleet	46 train sets composed of 920 carriages



KTX train sets at depot

(Korail)



KTX trains at depot

(Korail)

the same conditions as commercial operations. The frequency of test trains was then increased from 70 to 114 roundtrips each day and Korail managed

to stabilize operations by the time each test train had averaged more than 40,000 km. In particular, from 19 to 22 March 2004, Korail put more KTX trains into operation

on conventional lines than on the first day of commercial operations without causing any reductions to conventional train services.

Creation of the KTX was shared by Korea High Speed Railway (KHSR), which constructed the new high-speed line, and KNR, which electrified existing related lines and brought the high-speed services into operation after completion. KNR emphasized efficient organizational structure and organized many conferences and regular meetings in order to maintain a close cooperative relationship with KHSR. In regard to delivery of the new high-speed train sets from France, KNR took over completely from KHSR in September 2003, which helped accelerate preparations for high-speed operations. Korail also instituted some special task forces, such as the Coordination Office, and Test-run Team for KTX revenue services. Temporary task forces contributed to increased efficiency in preparing for KTX operations, thanks to prompt decisions on problems occurring during the commissioning tests.

Safety is always a top priority in high-speed railway services, so Korail initiated various safety devices, such as high-tech train control systems, together with on-site training programmes for drivers and CTC staff who are closely related to safety. In case of emergencies, contingency plans were drawn up for taking any steps needed to secure safety by strengthening cooperative relationships between related organizations.

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### KTX Services

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The KTX opened up a new era in Korean transport history when it entered revenue operations on 1 April 2004 at a maximum speed of 300 km/h. Since the KTX shares some sections of conventional lines, there were some initial hitches and snags under

actual running conditions. Partly as a result, the train timetable was extensively reorganized around KTX services on the Gyeongbu and Honam lines. Unlike passengers in other countries who experienced sharp reductions in regular train services when new high-speed railway services were launched, Korea repurposed large numbers of non-express trains to the regions where KTX services were not available (Table 2). The first intent was to use 90% of the 46 KTX train sets to maximize availability. However, it took much longer than expected to stabilize the KTX systems, causing the railway authorities to reduce KTX availability to 70% at first and then make gradual increases over time.

There were no serious train cancellations and punctuality (within 10 minutes of on-time service) reached a record 97% for 126 daily roundtrip operations in April 2004 (Table 3). Despite these successes, the Korean mass media found many faults with the many minor problems, especially the narrow seats in economy and the fixed seats that could not be turned to face the travel direction. Many of these problems were due to the focus of efforts on speed and economic efficiency and Korail is now trying to resolve the obstacles in various ways to increase passenger demand.

The KTX fares were determined based on studies by consumer organizations and public opinions collected from public hearings. The basic fares for the Seoul-Busan and Seoul-Mokpo sections are Won45,000 and Won41,400 respectively (Table 4). The fare policy reflects a tapered system in which fares become proportionally cheaper as distance increases. They are set to be 30% cheaper than competing airfares and 35% more expensive than the current *Saemaul* expresses.

To attract more passengers, Korail offers various discounts, including pass discounts (60% for 30 days), reservation

discounts (3.5% to 20%), commuter passes (15% to 30%) and group discounts (10% for 10 people or more). Some discounts vary according to whether the passenger has a Korail Card and when tickets are reserved, etc.

Korail considers punctuality to be one of the most important parameters in evaluating service, and has made a great deal of effort to increase its punctuality levels through preventative maintenance, training KTX drivers and station staff, assigning technical support teams to KTX drivers, making emergency train sets available at short notice at main stations, and deploying special troubleshooting units at rolling-stock depots. These efforts have helped to improve the KTX's punctuality to 98.8% in July 2004.

Although the KTX did not achieve the travel demand anticipated by some expert groups, it still established a world record of carrying 1 million passengers in the first 14 days and 10 million in 142 days. There is some evidence that the recent depressed Korean economy has hindered transfer of

passengers from other transport modes; there are seat shortages during peak hours, especially on weekends, but a lot of seats are empty during non-peak hours. If more KTX train sets could be put into service during high-demand periods, the KTX would be able to play a bigger role in passenger transport.

Since the KTX opening, average daily passenger numbers on both the Gyeongbu and Honam lines have increased about 1.3 fold over 2003 levels. A total of about 22 million people travelled by train on both lines from April to July 2004, composed of about 8.561 million KTX passengers and 13.417 million passengers on conventional trains. As of August 2004, the KTX trains are carrying about 70,000 people a day.

Train operating income has skyrocketed since the KTX launch with ticket sales increasing by 1.9 times compared to the same period of the previous year. Total ticket sales recorded Won363.733 billion for the April-July 2004 period with the KTX yielding Won254.862

**Table 2 Train Operations**

	(Roundtrips)		
	KTX	Conventional	Total
Gyeongbu Line	88-96	92	180-188
Honam Line	34	36	70
Total	122-130	128	250-258

**Table 3 KTX Punctuality (within 10 minutes of timetable)**

	April	May	June	July
Punctuality	97.8%	98.5%	98.8%	98.8%

**Table 4 KTX Fares**

Section	KTX		Air	Ratio (%)
	Business	Economy		
Seoul-Daegu	48,900	34,900	62,000	56%
Seoul-Busan	63,000	45,000	70,500	64%
Seoul-Gwangju	51,200	36,600	62,500	58%
Seoul-Mokpo	58,200	41,400	67,900	61%

**Table 5 KTX Journey Times**

	April 2004	April 2003	Time reduction (him)
Seoul–Daegu	1:39	3:03	1:24
Seoul–Busan	2:40	4:10	1:30
Seoul–Gwangju	2:38	3:53	1:15
Seoul–Mokpo1	2:58	4:32	1:40

**Table 6 Comparison of Key Parameters**

Main Section	KTX/Aeroplane				KTX/Express Bus			
	Journey time (h:min)	Distance (km)	Fare (Won)		Journey time (h:min)	Distance (km)	Fare (Won)	
			First /Business	Standard /Economy			Standard /First	Standard /Standard
Seoul–Cheonan					0:57	1.14	1.87	1.87
Seoul–Daejeon					0:41	1.04	1.76	1.76
Seoul–Daegu	1:15	1.27	0.57	0.53	0:41	0.99	1.65	1.65
Seoul–Busan	1:78	1.26	0.66	0.59	0:48	0.95	1.51	1.51
Seoul–Gwangju	1:88	1.35	0.59	0.55	0:73	1.21	1.75	1.75
Seoul–Mokpo	2:03	1.33		0.57	0:61	1.19	1.70	1.70

**Table 7 Decision Factors When Considering Long-Distance Journey**

	Fare	Journey time	Safety	Accessibility	Comfort	Frequency	Total
Rate (%)	32.8	15.3	22.5	18.5	6.8	4.1	100.0

billion and conventional trains Won108.871 billion. At present, the KTX is earning about Won2.1 billion each day, taking about 52% of the nation's total rail volume and 45% of the total rail operating income.

### Impact of KTX

One of the most remarkable changes occurring as a result of the start of KTX services has been the widespread reduction in travel times. About 70% of the nation is now within 3 hours of the rest of the country, giving time-saving benefits. For example, the travel time from Seoul to Busan was shortened by 2 hours to only 2 hours and 40 minutes while Seoul to Mokpo has been reduced to 2 hours and 58 minutes from 4 hours 32 minutes. The KTX has also extended the

commuting radius around Seoul to 150 to 200 km and it takes just 34 minutes and 49 minutes from Seoul to Cheonan-Asan and Daejeon, respectively (Table 5). The KTX has made a big contribution to increasing transport capacity. Seating capacity grew by 1.67 times on the Gyeongbu and Honam lines from a total of 101,812 seats a day in 2003 to 170,268 seats in 2004 broken down into 114,477 KTX seats and 55,792 non-KTX seats. After only 4 months of KTX operations, it is difficult to assess the changes in transport demand but it seems clear that the KTX trains are taking a growing proportion of the nation's medium- and long-distance traffic. One of the most significant changes is a surge in rail's market share. On KTX routes, the daily number of airline passengers dropped from 21,341 before the KTX opening to 10,934 people. Express long-distance bus traffic also

dropped by 20% to 30%, while that on short-distance routes (100 km or less) increased by about 20%. These figures clearly indicate that the Korean transportation network is becoming railway-centric.

The KTX has also made a significant contribution to decentralization by increasing the number of people commuting by train between the regions and large cities. In addition, several urban renewal programmes around KTX stations are bringing a breath of fresh air to real-estate markets as accessibility to KTX stations becomes a critical factor in seeking new business. Moreover, high-speed services coupled with the nationwide introduction of a five-day working week are helping to promote tourism, particularly in local cities.

From the environmental aspect, the KTX is playing a significant role in helping to reduce CO<sub>2</sub> emissions as the KTX takes more passengers from automobiles and aeroplanes.

### How to Maximize High-Speed Rail Transport Demand

The total number of passengers on the Gyeongbu and the Honam lines since the opening is estimated at 310,000 passengers per day, of which about 70,000 are KTX passengers. The number of KTX passengers is fewer than anticipated possibly due to the Korean economic downturn and objections that conventional train users have against new high-speed rail. To overcome these factors and create increased demand for high-speed trains, it is necessary to promote their competitive advantages over other transport modes, such as lower fares than air and shorter journey times than cars and express buses (Table 6). One report shows that people consider the fare and safety as the most important factors in choosing their means of long-distance transport (Table 7).

As a part of the preparations for becoming a public enterprise in 2005, Korail plans to increase the daily frequency of KTX runs by 10% from the current 122 roundtrips to more than 142. By analyzing its operations performance, Korail will concentrate on KTX operations during daytime peak hours to maximize demand and customer convenience.

As high-speed rail becomes the central mode of the nation's transportation system and helps improve economic and cultural standards, there will be ever more demand for it. To meet this demand, the nation's conventional lines will see increasingly widespread electrification. When all the existing major lines have been electrified, more high-speed rail services will be phased in using direct connections to maximize operational efficiency.

Korail is pushing to establish strategies to increase the Korean Customer Satisfaction Index (KCSI) up to the level of airlines, with KTX transport volume up to 35%, and sales revenue up to 20% by activating KTX-related businesses. To reach these goals, Korail has established several staged tactics in the fields of merchandising, sales management, transport etc. In this respect, Korail intends to promote to use of economy class at considerably discounted fares and to provide quality service for business customers. Korail is also adopting a market-oriented rate system to overcome the limitations of the current fixed rate system and become more competitive than other transportation modes. Ticket discounts of 30%–70% have been available to different groups since 23 August 2004 and Korail is expecting to see a 25% increase in KTX passengers as a result.

In the meantime, development of the HSR350-X next-generation Korean high-speed train has been under way since 1996. It is designed to provide more operational flexibility and efficiency. A successful test run at 300 km/h was made



KTX train running on bridge

(Korail)

in September 2003 and the HSR350-X will be entering revenue service within 2 or 3 years after systematic test runs, safety checks and inspections. The new design also features seats that can be turned to face both travel directions, which are so favoured by Korean passengers. To expand high-speed rail services nationwide, Korail is proceeding with on-schedule construction of the second phase of the Gyeongbu high-speed line and will also focus on building a more-efficient railway network connecting high-speed and conventional lines. Furthermore, Korail will invest more resources in development of high-level technologies to become a world-leading railway company.

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### Being the Best

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Building the KTX has been one of the greatest Korean engineering works and the 1 April 2004 opening has seen a rail renaissance with renewed competitiveness recovering the losses to other modes in the last three decades. The KTX will enhance the nation's competitive edge through decreased logistics costs, helping to bringing a prosperous future. Following massive restructuring, Korail will become a public enterprise in 2005 with an anticipated increased share of the transport market and reinforced competitiveness. ■



#### Kim Chun-Hwan

Mr Kim is General Director of High-speed Rail Headquarter at Korail. After graduating in engineering from Seoul National University, he joined Suncheon Regional Railroad Office as a Safety Officer. He then joined KNR Headquarters, working on high-speed rail. He also has a master's degree from the University of Nottingham in railway operations and management.