Launch of Korean High-Speed Railway and Efforts to Innovate Future Korean Railway

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Introduction

Korea's high-speed railway (Korea Train express or KTX) celebrated its third anniversary on 1 April 2007, reviving the railway as a serious competitor with automobiles and aircraft in Korea's domestic transport market.

According to a post-launch survey, KTX captured a 56.4% share of all travellers (for all transport modes) on sections longer than 300 km, reaching 60.2% on the Seoul–Busan section. When existing trains, such as the *Saemaul* and the *Mugungwha* were included, railway's share over the same section reached 65.7%. On the other hand, the number of airline passengers has dropped greatly since the KTX opening. For example, on the Seoul–Daegu section, the daily average number of passengers decreased to about 5.5% of the number of passengers before the KTX opening. This effect has been seen before with the opening of shinkansen and TGV services in Japan and France, and is a good example of the market segment in which high-speed railway outcompetes other transport modes, so demand switches from air and the number of railway users increases overall. However, the KTX operational circumstances are fundamentally different from Japan or France because KTX was opened after highway bus services with very competitive fares, comfort, and convenience had already started on the highway network in the Seoul–Busan, Seoul–Gwangju and Mokpo sections. This factor continues to complicate efforts by KTX to expand future passenger numbers, because new national highways, municipal, and local roads are still being expanded strictly in line with the road-centric transportation policy of the high-economic-growth period from the 1960s to 1990s.

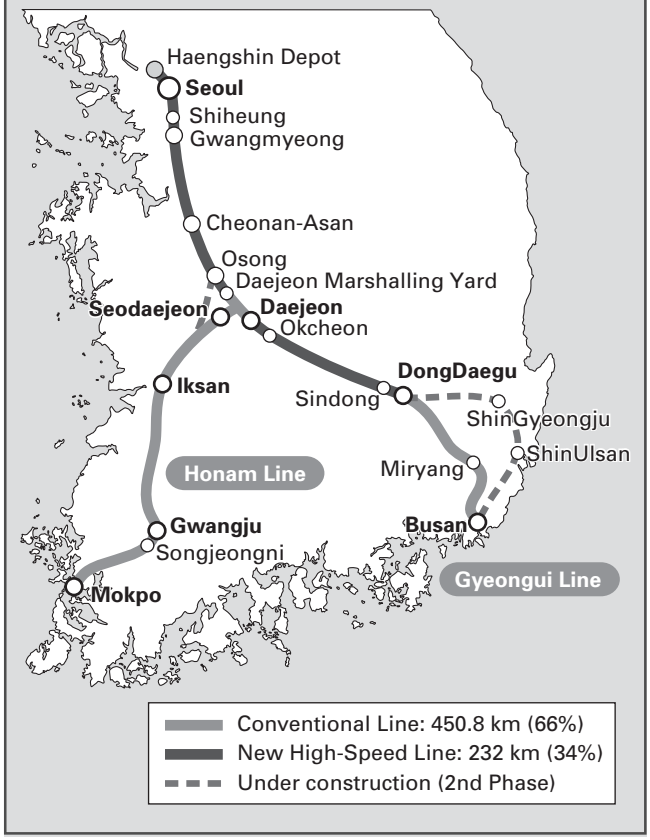
This article has three parts: the first analyzes the effect of the KTX launch from aspects of railway demand and the change in rail's competitive relationship with other transport modes; the second focuses on the current situation of the railway system and the vision to increase the competitive power of Korean Railway after KTX; the third describes the innovation perspectives for Korean railways.

Effects of KTX Launch

KTX was developed to solve transport problems in the Seoul–Busan corridor, which is Korea's key economic zone. The development background was the traffic congestion that accompanied the annual increases in car ownership (up 16% since the mid-1980s) and the resultant increase in distribution costs, which weakened Korea's global competitiveness. After the government decided to build a high-speed line in 1989, construction work started in 1992, and the first section opened in 2004. Due to the impact of the East Asian currency crisis in 1997 on the Korean economy, the initial plan to simultaneously open an all-new Seoul–Busan line was modified and the key features of the first-phase section were electrification, the opening of a new line from Seoul to Daegu (DongDaegu Station), use of the existing line from Daegu to Busan, and the start of train services to Iksan, Gwangju, and Mokpo Stations to spread the KTX effects to the southwest Korean peninsula (Jeolla Province). This was achieved by electrifying the Daejeon–Mokpo section. Following the first-phase opening, KTX services are running over a total of 683 km, comprised of the new 232-km Seoul–Daejeon–DongDaegu section, and 451 km of existing lines. The second phase to be completed in 2010 will link Seoul and Busan over entirely new tracks by constructing a new line in the DongDaegu–Gyungju–Busan section (Fig. 1).

Thanks to the first phase, Cheonan (Cheonan-Asan Station, 96 km) and Daejeon (159.8 km) are now within 1 hour of Seoul, allowing housing development within a reasonable commuting distance. Travel time from Seoul to DongDaegu was cut by 56%, from Seoul to Busan by 36%, from Seoul to Gwangju by 31%, and from Seoul to Mokpo by 35%. The travel time from Seoul to DongDaegu (282 km) was shortened from 3 hours 3 minutes before KTX to 1 hour 20 minutes, making it the section most noticeably affected by KTX. Despite running over the existing lines south of DongDaegu, the required time from Seoul to Busan was cut from 4 hours 10 minutes before the KTX opening to 2 hours 40 minutes (Fig. 2).

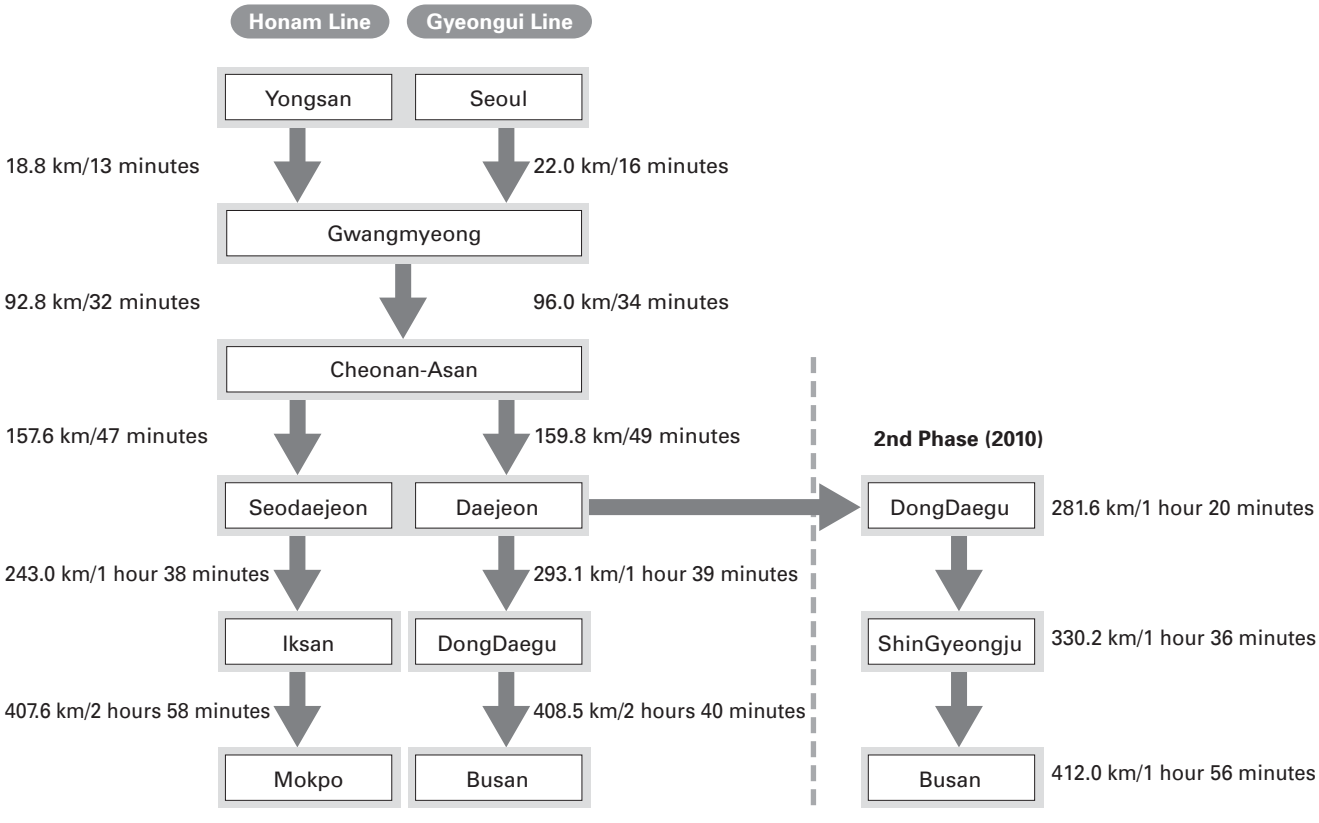
Figure 1 KTX Network



KTX trainsets include two motorcars, two powered passenger carriages, and 16 passenger carriages, with 935 seats per train. The maximum operational speed is 300 km/h. At the opening, there were 128 services, but the number has been increased in response to day-to-day traffic patterns and the increase in the number of Friday users with the spread of a 5-day working week. There are 140–149 services on weekdays and 164 on weekends; the Seoul–Busan section has 104 to 126 runs, or about 75% of the total. At weekends on the Seoul–Busan line, the hourly number of services can reach 3.5 in each direction.

The total number of passengers carried by KTX up to April 2007 exceeded 100 million; at the launch, the daily average number was 72,000, rising to 88,000 in 2005 and passing 100,000 in 2006. At of the end of March 2007, the daily average number of passengers was 103,000. According to the statistics by section, there were 85,300 passengers on the Seoul–Busan section, and 17,500 on the Seoul–Mokpo section, demonstrating the large difference in passenger demand. This is explained by the nature of the local economies and population size in the areas that the lines pass through. Moreover, there are more competitive highway buses running over the same section as the Seoul–Mokpo line, limiting increased demand for the high-speed railway. On the other hand, although the daily average number of KTX passengers

Figure 2 Distance and Time of KTX Stations from Seoul



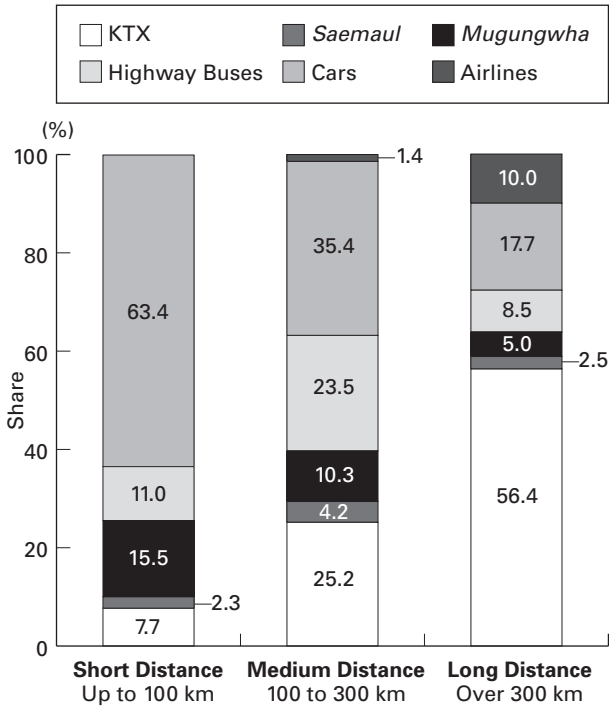
(based on totals for 3 months from January to March 2007) is about 34% of total passengers using the national main-line railway network (excluding metropolitan and regional lines), KTX has about 66% of the total income, showing that KTX has the potential to improve Korean Railway's future profitability.

Among KTX passengers, 74% are company workers and 13.2% are self-employed. By age and gender, men in their thirties in specialist/management positions with a high educational background (college graduate or higher) form the largest passenger group. For travel purpose, business totalled 58.3% on weekdays and private 64.7% on weekends. The number of season-ticket users has increased every year (by 10,000 in 2005 and 2006), from 10,000 at the start. In particular, the number has increased in the Cheonan and Daejeon areas, which can be reached from Seoul in less than 1 hour. For Cheonan, 37% of passengers using the KTX are commuters.

One notable change in other transport modes since the KTX opening is the decrease in airline passengers over the same section. The same phenomenon has also been seen before in Japan and France, demonstrating some commonality between high-speed railways around the world. The effect was greatest with the first-phase opening from Seoul to Daegu where the daily average number of airline passengers dropped sharply from about 4,000 before the KTX opening to about 220 in 2006. On the Seoul–Busan section, the average daily number of airline passengers halved from about 14,300 (about 5.2 million annually) before the KTX opening to about 7,360 (2.68 million annually) in 2006. The lower decrease on the Seoul–Busan section compared to the Seoul–Daegu section is due to the fact that the train is currently operating on the electrified existing Daegu–Busan section and takes 2 hours 40 minutes, while air travel is only about 1 hour. The effect of KTX on the airlines is also conspicuous on the Seoul–Gwangju section where a limited time improvement was achieved by electrifying the existing line rather than constructing a new line; following the opening, airline passengers decreased by about 40%.

The KTX has been promoted as a good medium- and long-distance mode. Seen by market segment, it has secured 7.7% in the short-distance market up to 100 km, 25.2% in the medium-distance market from 100 to 300 km, and 56.4% in the long-distance market over 300 km. Role-sharing inside the railway is also being explored. For example, the existing *Mugungwha* and *Saemaul* services, occupied 2.3% and 15.5%, respectively, in the 100-km market, 4.2% and 10.3% in the medium-distance market from 100 to 300 km, and 2.5% and 5% in the long-distance market over 300 km, (Fig. 3). It is thought these trends can be used as fundamentals for planning role-sharing with existing lines to expand future KTX passenger numbers.

Figure 3 Importance of KTX in Long-Distance Travel



On the Seoul–Busan section, KTX is estimated to have a 60% or higher share of all travel and adding the shares (5.5%) of the existing *Saemaul* and *Mugungwha* trains shows the strong impact of the railways on Korean economic activities (Table 1).

Table 1 Modal Share between Seoul and Busan

Section	Classification	Cars	Buses	Airplanes	Railways				Total
					Total	KTX	*Saemaul*	*Mugungwha*	
Seoul	Passengers	3,082	1,912	6,837	22,666	20,768	814	1,084	34,497
Busan	Share (%)	8.9	5.5	19.8	65.7	60.2	2.4	3.1	100.0

To increase future KTX demand, KORAIL, is actively promoting marketing based on maintaining a high on-time service ratio and minimizing system problems. These efforts include: introducing a Yield Management System to maximize train operation income; ensuring stable passenger demand through group contracts with businesses; and cutting the operation costs by promoting a distribution channel. In addition, efforts are being made in both technology development and operations to maintain competitive power. The next part explains the current situation of the railway R&D projects promoted in cooperation with railway industries, research institutes, and operation authorities, centered on the Korea Railroad Research Institute (KRRI).

Railway R&D Projects

While preparing the KTX launch, Korea promoted a project to localize the imported French high-speed railway system with the aim of developing a domestic high-speed railway system running at speeds up to 350 km/h. The project started in 1996, and finishes this year (2007).

The technical aspects of the system are described below. The maximum speed is 350 km/h with 15% less drag than the KTX to be achieved by designing an aerodynamic train nose. Extruded-aluminum passenger carriages cut weight compared to steel carriages. The propulsion and control systems use an independently developed induction motor and Integrated Gate Commutated Thyristor (IGCT) with European Standard TCN system for train control diagnostics. Compatibility with the KTX and standardized components is also key.

Main developments include: a cab in each powered carriage; a motor block as the main power control unit; a 350-km/h class pantograph; an aerodynamic nose design; an ergonomically designed drivers cab with digital displays of train and operations information; induction motors; high-capacity lightweight transformers; and an auxiliary block. Passenger carriages feature air-spring secondary suspension, brake control unit, pressurization, eddy-current braking, and comfortable but safe lightweight passenger seat.

Fifteen rounds of incremental speed tests from 60 km/h to the final speed of 350 km/h were used to confirm the safety of carriages and infrastructure. The top-speed test in December 2004 marked 352.4 km/h and analysis demonstrated that carriage safety (UIC 518), ride quality (UIC 513R deluxe rolling stock level), and current-collecting performance (BS EN 50119) all satisfy international standards.

Korean High Speed Train at Gwangmyeong Station

Currently, stability and reliability tests are ongoing. They include performance verification, improvement, and stabilization of each unit; reliability management of carriages and infrastructure; failure management for better reliability; and compatibility tests in preparation for actual deployment. A total of 357 tests had been performed by the end of December 2006 with a total distance travelled of 164,000 km.

New carriages for this project were chosen by bidding in 2006 for operations on the SeoDaejeon–Mokpo Line (2009) and the Iksan–Suncheon Line (2010) (Table 2). Additionally, domestic development of a tilting train (Tilting Train eXpress: TTX) is being promoted to increase speeds on existing lines to 200 km/h. The main contents include development of a new carriage design, infrastructure improvements such as electronic signalling, and maintenance technology. A prototype carriage using a new-materials-based design is undergoing running trials to be followed by comprehensive testing to verify and improve reliability.

Table 2 Comparison of HSR350x and KTX

Main Item	Korean High-Speed Railway (HSR350x)	KTX
Maximum speed	350 km/h	300 km/h
Number of seats	366 (2 motor cars, B passenger carriages)	935
Car body	Aluminium	Steel
Motor	Induction	Synchronous
Power switching	IGCT	Thyristor
Brakes	+ Eddy current	Friction/Electrical

Prototype of Tilting Train eXpress at Osong Site

Towards Innovation of Korean Railways

The last part of this article describes the innovation perspectives of Korean Railways. Innovation means developing railways as an alternative mode in the urban, regional, and national transportation network, based on rail's strengths and advantages against other transport modes in the long term.

The KTX will play an important role in future innovation by realizing the potential of Korean Railways to support inter-urban services. The direct impact of KTX on helping to increase numbers of train passengers is significant because Korean Railways has been seen as a declining industry. However, the poor competitiveness was the direct result of lack of investment. As one index of this losing fight, from 1971 to 2004, the lengths of highways and local roads grew by 4.24 and 2.39 times, respectively, while railways decreased by 0.98 times, preventing improvements in operation speeds. Following the increase to 140 km/h in 1985, operation speeds did not increase for about 20 years until the KTX opening. Excluding the Seoul–Busan and Seoul–Mokpo sections, operating speeds stayed at about 90 to 120 km/h. This prevented railways competing with faster and more flexible private cars and express buses on highways. In this context, the direct impact of KTX shows that railways could be an alternative transport mode when new technologies are applied. This rediscovery of rail's potentials is the basis of future innovation.

Since the KTX project, Korean researchers have been preparing R&D projects to localize the newest railway technologies to meet the specific needs of Korea. This is partly based on our KTX experience, where insufficient consideration of cultural factors caused some problems and an additional costs. This was a good lesson on the need to understand the direction of a railway R&D project. In particular, a supplier-led system of technology development does not necessarily help increase customers in a competitive market. In providing new technologies, it is important to analyze passengers' profiles, such as socio-professional category, as well as railway usage habits, including ride frequency, period, and purpose. As the only general railway institute in Korea, KRRI recognizes the importance of developing technologies required by Korean society and promoting their use.

The structural reform of Korean Railways, separating operations and infrastructure, also constitutes a good foundation for further innovation. As in the other countries, structural reform is expected to reinforce specialties and responsible management while clarifying the role between government and operator. It also helps guarantee consistency between national railway development plans and technology development schedules.

Growing environmental awareness in Korea, in the context of global debates on climate change, will solidify the social necessity for the development of railways as a more-environment friendly transportation system. But there are some obstacles to establish a more-environment friendly transportation system where the characteristics of each means of transportation are fully considered. First, if Korean railways lose competitiveness because of insufficient governmental investment compared to roads, it is hardly possible for the Korean government to invest more in railways than roads, meaning that the present situation would continue. To face this problem, it is necessary to perform various studies on the socio-economic impacts of railways and on the methodologies to internalize external costs in infrastructure projects. Efforts to enhance efficiency in planning and construction inside the railway are also needed. Second, countermeasures to face inconveniences in railway utilization are also needed. Dealing with this will require defining problems caused by Korea's rapid growth in car ownership. Some items are structural, such as the current form (design) of the private-car based transport network makes it difficult to use railways (or public transportation in general). Other items are psychological, such as the resistance of freedom-loving car users to use railways. However, recent efforts in Seoul to redistribute former road space to pedestrians will make it possible to harmonize transport and land-use policies, allowing railways to demonstrate their future importance whereby the urban, regional and national railway systems developed by KRRI will lead to innovation of Korean railways.

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