KNOWLEDGE SHARING PROGRAM

2011 Modularization of Korea's Development Experience

Construction of High Speed Rail in KOREA

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MLTM
Ministry of Land, Transport and Maritime Affairs

KOTI THE KOREA TRANSPORT INSTITUTE

2011 Modularization of Korea's Development Experience:

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Preface

The study of Korea's economic and social transformation offers a unique opportunity to better understand the factors that drive development. Within one generation, Korea had transformed itself from a poor agrarian society to a modern industrial nation, a feat never seen before. What makes Korea's experience so unique is that its rapid economic development was relatively broad-based, meaning that the fruits of Korea's rapid growth were shared by many. The challenge of course is unlocking the secrets behind Korea's rapid and broad-based development, which can offer invaluable insights and lessons and knowledge that can be shared with the rest of the international community.

Recognizing this, the Korean Ministry of Strategy and Finance (MOSF) and the Korea Development Institute (KDI) launched the Knowledge Sharing Program (KSP) in 2004 to share Korea's development experience and to assist its developing country partners. The body of work presented in this volume is part of a greater initiative launched in 2007 to systemically research and document Korea's development experience and to deliver standardized content as case studies. The goal of this undertaking is to offer a deeper and wider understanding of Korea's development experience with the hope that Korea's past can offer lessons for developing countries in search of sustainable and broad-based development. This is a continuation of a multi-year undertaking to study and document Korea's development experience, and it builds on the 20 case studies completed in 2010. Here, we present 40 new studies that explore various development-oriented themes such as industrialization, energy, human capital development, government administration, Information and Communication Technology (ICT), agricultural development, land development and environment.

In presenting these new studies, I would like to take this opportunity to express my gratitude to all those involved in this great undertaking. It was through their hard work and commitment that made this possible. Foremost, I would like to thank the Ministry of Strategy and Finance for their encouragement and full support of this project. I especially would like to thank the KSP Executive Committee, composed of related ministries/departments, and the various Korean research institutes, for their involvement and the invaluable role they played in bringing this project together. I would also like to thank all the former public officials and senior practitioners for lending their time and keen insights and expertise in preparation of the case studies.

Indeed, the successful completion of the case studies was made possible by the dedication of the researchers from the public sector and academia involved in conducting the studies, which I believe will go a long way in advancing knowledge on not only Korea's own development but also development in general. Lastly, I would like to express my gratitude to Professor Joon-Kyung Kim for his stewardship of this enterprise, and to his team including Professor Jin Park at the KDI School of Public Policy and Management, for their hard work and dedication in successfully managing and completing this project.

As always, the views and opinions expressed by the authors in the body of work presented here do not necessary represent those of KDI School of Public Policy and Management.

May 2012

Oh-Seok Hyun

President

KDI School of Public Policy and Management

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Summary

In the 1980s, transportation facilities such as roads and railroads were already crowded due to the rapid industrialization in the country. The investment in roads alone resulted in limitations in coping with traffic congestion. It was expected that, despite the construction of new expressways or the expansion of existing ones, the soaring number of automobiles would increase corridors with traffic congestions. Thus, a necessity was raised to introduce a new transport mode between Seoul and Busan, and a feasibility study results indicated that it would be appropriate to construct exclusive high-speed passenger railway line along the Gyeongbu corridor. For three years, from 1989 to 1991, a technical survey for the Gyeonbu high-speed rail project was conducted by some governmental research institutes and domestic rail technology-related engineering companies. Based on the results of the technical survey, the construction of Gyeongbu high speed railway line started in June 1992.

In the early stages of the KTX project, rail technology levels in Korea were very low. Despite lack of understanding of and experience in high-speed rail technologies, the country went ahead with the project with inadequately prepared design documents or specifications. Also, the type of cars was determined very late, which required overall complementation of the design and caused much confusion and many trial-and-error efforts. Also, due to the economic crisis in the latter half of the 1990s, the original plan to construct high-speed railway line by 2004 was changed to be wholly constructed by 2010 with partial operation of high-speed train from 2004.

High-speed rail projects require highly advanced technologies, are large-scale, and are highly likely to go through technical difficulties and trials and errors and to face various difficulties such as NGO complaints in the process. During the high-speed rail project, construction work was stopped many times, which delayed the project, due to various civil complaints in the process of purchasing land and obtaining approval and controversies over the safety of the tunnels passing through areas adjacent to abandoned mines. Notably, the Gyeongju line had to be changed due to environmental civil complaints over the Mt.

Cheonseong segment and to conserve heritage sites. The Daejeon and Daegu lines, which pass downtown areas, caused conflicts with relevant groups and municipalities. The central government and the Korea High-speed Rail Construction Authority had the patience and wisdom to persuade and negotiate with stakeholders, however, which helped them overcome these problems.

Despite many such difficulties and trials and errors, the project helped enhance Korea's rail technology level as well as the design and construction technology and the country's profile. Based on such a positive assessment of the KTX, Korea is now making efforts in the construction of new KTX lines as well as the speed upgrade of existing railway lines from the maximum speed of 150 km/h to 230-250 km/h.

To successfully implement large-scale projects such as high-speed rail, it is important to improve the impulsion system with the strong backing of the government. South Korea established an exclusive public agency (the Korea High-speed Rail Construction Authority) to implement the project from the beginning, and the related ministry established a special committee for this purpose (the SOC Infrastructure Construction Impulsion Committee). Another factor for the successful operation of KTX is the accumulated operation knowhow of Korea's national rail operator, Korea railroad. Korea railroad is the only agent that runs the national railway network in Korea with over 100 years of railway operation experience, and even before the introduction of KTX, it has experience in the train operation of 90 million train-km.

For the successful implementation of high-speed rail project, it is also necessary to improve the safety and quality standard. During the construction of high-speed railway line in Korea, huge distrust and suspicion toward the safety and quality of the project almost stopped the project. As a measure to reduce the suspicion and distrust on the safety and quality, it is worth considering having internationally renowned organizations participate in the construction project as Korean government adopted.

It is inevitable for developing countries to introduce advanced high-speed rail technologies from foreign countries. In this case, it is highly recommended to set up technology transfer strategies to ultimately secure such technologies. They can thus use the secured technologies in constructing and operating additional high-speed rails and in entering overseas rail markets. In introducing foreign high-speed rail technologies, it is recommended for them to consider the technologies' marketability and development possibilities. Also during the introduction of high-speed rolling stocks from foreign countries, they can benchmark the Korean case in which rolling stock cost was reduced and better terms in technical transfer and financial procurement were achieved through the competition among bidding countries.

To increase high-speed rail demand, it is essential to develop an efficient transfer system between modes, such as buses, passenger cars, subways, and etc. It is recommended to develop a transfer system simultaneously with the opening of a high-speed railway line to

increase the travel demand and the profitability. Also, high-speed rail stations, if constructed far away from downtown areas, will lower accessibility and weaken competitiveness. Thus, construction of the stations in downtown areas should be positively considered.

Although there have been many complaints and difficulties in KTX construction in Korea, these obstacles were wisely overcome, and now the KTX project is recognized as one of the most successful government-run projects. Even though there are some problems raised in terms of the deficits of Korea Rail Network Authority, the KTX project is evaluated to produce many positive effects, such as the drastic enhancement of Korea's railway technology, the improvement of the country's large-scale project management ability, consensus on the necessity of quality management, the acquisition of KTX operation techniques, the establishment of the eco-friendly national transportation system, the promotion of local economy, and improvement of the national image. Also, the Korea's experience in the construction of high-speed rails and enhanced rail technologies should provide it with an engine with which to enter the rapidly expanding global rail market.

Chapter 1

Background

1. Proposal of High Speed Rail as a New Transportation Means
2. Selection of the High Speed Rail as the Optimal Alternative

Background

1. Proposal of High Speed Rail as a New Transportation Means

1.1 Necessity of Drastic Transportation Measures

To support the five-year national economic plan formulated in the 1960s, South Korea pushed to implement policies that bolster transportation capabilities centering on expressways. Thus, road infrastructures such as Gyeongbu and Gyeongin Expressway were constructed, increasing the number of expressways and national roads constructed. Less investment was made, however, in the construction of railroads.

Of the transportation investments made since 1970, road construction topped 50% while railroad construction (except for the extension of railroads to and from harbors and industrial complexes)[1] remained nil. Only double tracks for key railroad lines, electrification of railroads, and alignment improvement of some sections have been conducted. As a result, 92.7% of the passenger transportation was performed by the Gyeongbu Expressway while only 7% of the passenger transportation was performed by railways.

In the 1980s, transportation facilities such as surface roads and railroads were already crowded due to the rapid industrialization in the country. The expanded investment in roads alone resulted in limitations in transportation infrastructure. It was expected that, despite the construction of new expressways or the expansion of existing ones, the soaring number of automobiles would increase zones with traffic difficulties. As of 1982, the key trunk line Gyeongbu Expressway, which was the country's great artery for social and economic activities and the key inland transportation route, serviced 65.8% of the country's population, and 73.7% of the country's GDP was concentrated along its route. Gyeongbu Expressway carried 66% of the total passengers in the country, and 70% of the total cargoes.

1 As of 1975, the length of the national railway was 3,144 km.

Moreover, the average demand of passengers and cargoes was expected to increase by 5.3 and 4.7%, respectively, adding to the country's logistics difficulty. The introduction of new transportation facilities was therefore required.

1.2 Recommendation by Domestic and Overseas Research Institutes to Construct a High Speed Rail

An official discussion on the construction of high-speed rail began in the early 1970s. When the country discussed borrowings from IBRD in 1973, a survey group from SNCF and JARTS researched on measures in 1974, at the request of the bank, to cope with the Seoul-Busan transportation problems.

At that time, South Korea was just finishing the industrial-railway and metropolitan electric-railway projects, and the examiners in both countries who participated in these projects estimated that the existing Gyeongbu railway would have been saturated by the 1980s. They thus proposed the construction of a high speed rail.

About the same time, a group of professors assigned to evaluate the South Korean government's policies proposed a project similar to the one by the French and Japanese survey groups, as a measure to increase the long-term transportation capacity of the Gyeongbu railway.

1.3 Recommendation of Constructing a High Speed Rail to Improve the Gyeongbu Transportation System

It was after KAIST (Korea Advanced Institute of Science and Technology) came up with an independent-research report on "Heavy Freight Transportation System and Transportation Investment Optimization Plan" and proposed the construction of a new railway that the serious discussion of the construction of a high speed rail began. For three years (November, 1978-July, 1981), KAIST conducted a study on the development of a model for estimating the future national transportation demand, assessing the existing transportation facilities, comparing and reviewing plans for increasing transportation capacities, and creating a comprehensive national transportation system. The research report estimated that between 1985 and 1989, the Gyeongbu transportation line, the existing transportation system between Seoul and Busan, would reach a level of transportation difficulty. In particular, it predicted that in the railways, over half of the Gyeongbu transportation line would reach its capacity limit by 1989.

Based on such analysis results, KAIST proposed two alternatives: (1) to increase the transportation capacity of the Gyeongbu transportation line by creating a new double-track electric railway (New Gyeongbu Line) between Seoul and Busan; and (2) to create a high speed passenger railway to improve the efficiency of New Gyeongbu Line.

Based on the research results, the discussion of the necessity of constructing Gyeongbu High speed railcontinued in the 1980s at a more concrete level, and finally, in February 1979, the President ordered the establishment of a long-term transportation measure in relation to the high speed rail, at his new-year inspection tour of the Ministry of Transportation. As such, a full-scale survey on a high speed rail began.

Keenly aware of the necessity of a high speed rail, the South Korean government stipulated the high speed rail plan of establishing a 160-km-long corridor between Seoul and Daejeon in the Fifth Five-Year Economic and Social Development Plan (1982-1986) drafted in June 1981. Later, in the final review of the Fifth Five-Year Economic Development Plan in 1983, the South Korean government changed its plan and decided to conduct a feasibility study on the construction of a high speed rail on the whole corridor between Seoul and Busan within the period of the Five-Year Economic Development Plan.

2. Selection of the High Speed Rail as the Optimal Alternative

2.1 Conducting a Feasibility Study

The Ministry of Transportation conducted the "Review on the Necessity of a Long-Term Transportation Investment on Seoul-Busan Line, and Feasibility Study on Seoul-Busan High-Speed Rail" in two stages, from March 1983 to November 1984.

The first-stage feasibility study (February-August 1983) resulted in the proposal of the construction of a Seoul-Busan high speed passenger rail between 1991 and 1997, considering the future transportation demand, by revising the existing Gyeongbu Line. Based on the necessity of the construction of a Seoul-Busan high speed rail, an economic, financial, and technical survey on the high speed rail plan was conducted as part of the second-stage feasibility study (January-November 1984). The study showed that the transportation demand in Gyeongbu Line would continue to increase and that by the second half of the 1990s, much of the line would experience severe congestion. To expand the transportation capacity of Gyeongbu Line, three alternatives were proposed. The first alternative was to focus on the great expansion of the expressways and the phased supplementation of the existing Gyeongbu railway; the second alternative was to aim at competing the railway and expressway by creating a high speed rail and expanding the required section on the expressway between Seoul and Busan; and the third alternative was to concentrate on railways by creating a high speed rail between Seoul and Busan, promoting the policy of increasing the use of the high speed rail, and minimizing the investment on roads.

A careful review of the three alternatives showed that the third alternative, the railway plan, was better than the second alternative, the expressway-railway plan, considering South Korea's transportation circumstances (As of 1997, the internal rate of return (IRR) for the high speed rail plan was 16.8-18.5% whereas that for the expressway-railway plan

was 16.8%, supporting the superiority of the railway plan). As a result of the feasibility survey, it was proposed that the construction of Gyeongbu High Speed Rail start in 1992 and be completed in 1997.

2.2 Determining the Technical-Survey Policies

After the feasibility survey, the need for constructing a high speed rail quickly expanded and was reflected onto the Fifth Five-Year Economic and Social Development Plan (1982-1986). Thus, the construction of Gyeongbu High Speed Rail was to be started within that period. The soaring demand for the establishment of social-overhead-capital infrastructure in preparation for the 1988 Seoul Olympics, however, led to the conclusion that it would be realistically impossible to secure funding then for the construction of a high speed rail. Consequently, the project was postponed.

It was when the new president who won in the 1987 election made a public pledge to have a high speed rail constructed that the issue of the construction of a high speed rail re-emerged. After the new president took office, the construction of a high speed rail was stipulated in the Sixth Five-Year Economic and Social Development Plan (1987-1991). Accordingly, a technical survey on the construction project was to be conducted, leading to a full-scale presentation of the project.

There has never been any objection to the need for a high speed rail, but transportation-related scholars, in particular, led various discussions then on the timing of the construction, and on the technical issues surrounding the project. Below is a summary of the key debates.

First, there were those who believed that it was premature to construct a high speed rail. At that time, some scholars argued that the speed of the existing trains, led by diesel locomotives, could be increased by up to 200 km only by changing the sections that were expected to become congested into a double-track line, and by renovating the line and track of the existing Gyeongbu Line. The key point of this argument was that the mid- and long-term demand could be covered and the transportation time could be reduced even without promoting the high speed rail, which would require additional lines. Indeed, even those who subscribed to such argument agreed that there was a need to construct a high speed rail, but they argued that it would be more reasonable, considering investment priorities, to first invest in the public transportation system in large cities that were rapidly expanding at that time, using the available funding, rather than to construct a high speed rail, and to expand the arterial roads among regions to cope with the then-upcoming automobile era.

However, in case of the railway, it was analyzed that the Suwon-Daejeon section (125.3 km) had already reached its capacity limit, and even after the increase of the railway expansion after the electrification of the existing lines, the railway would reach its capacity limit by 2000 to 2003. It was determined that while the high speed rail was more expensive to construct compared to the four-lane expressway or a traditional double-line railway, it offered superior transportation efficiency, and therefore, the high speed rail would be constructed.

The second is the issue related to the vehicle type, a technical issue that was debated the most. Some scholars argued that rather than the wheel loader that could be immediately introduced, a magnetic-levitation train, the next-generation type, should be introduced. This debate led to the argument that pending the commercialization of the magnetic-levitation train, which was still being experimented on at that time, the construction of a high speed rail would have to be postponed. Considering the rate of progress of the development of railway technologies, the wheel loader method, which is not only slower than the magnetic-levitation type but also produces much noise and dust, unlike the magnetic-levitation type, would soon be replaced by the latter, and if that happens, the investment made on the wheel loader type would be in vain. Therefore, as the construction of the magnetic-levitation railway was expected to be commercialized within two to three years, or by ten years at the longest, the construction of a high speed rail would have to be postponed accordingly to maximize the efficiency of the investment.

At that time, however, the magnetic-levitation type was being developed only by Japan and Germany, and there were some who were pessimistic about the possibility of its short-term commercialization. Further, the economic performance and transportation capacity of the magnetic-levitation type vis-à-vis those of the wheel loader type had not been confirmed. Moreover, others argued that with regard to the future safety issues of the system, even if the magnetic-levitation type was to be commercialized, the wheel loader type would still be more appropriate. With this, the debate ended.

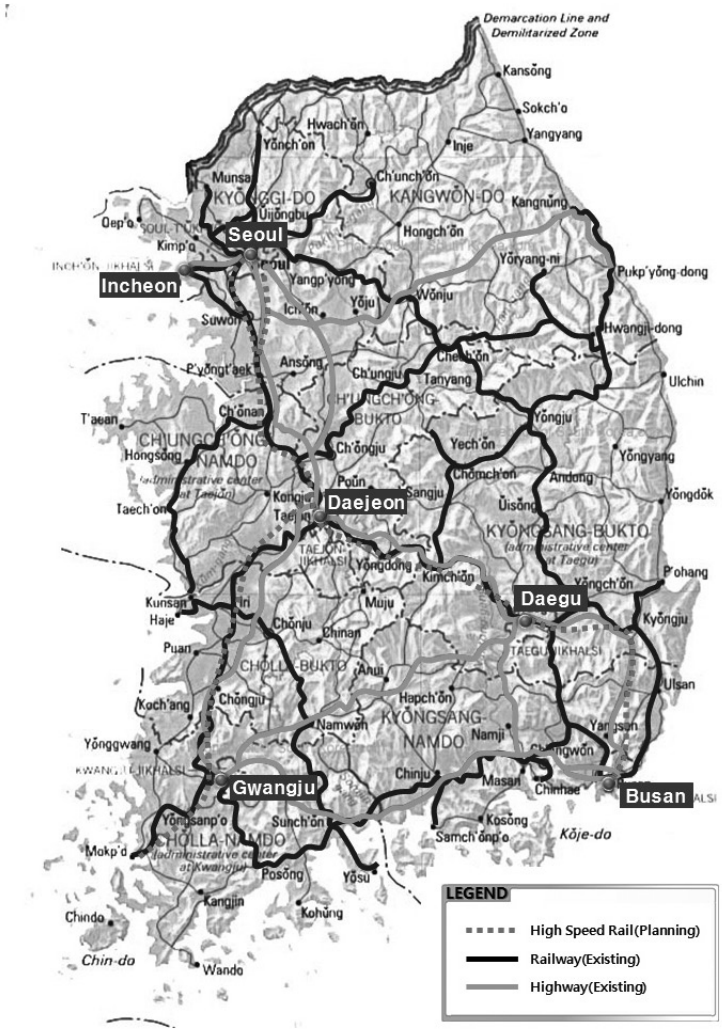
Third, some scholars argued that regardless of the timing or technical aspect of the project, constructing a high speed rail on the Gyeongbu corridor would aggravate the already-concentrated population and industry on the Gyeongbu Corridor. Furthermore, the reduction of the transportation time due to the introduction of a high speed rail would worsen the concentration on the Seoul Metropolitan Area. Such argument was made even more strongly by those who supported balanced regional development based on the case of Japan, to which a high speed rail had been introduced.

Those who supported the construction of a high speed rail, however, argued that if the already-saturated Gyeongbu Corridor suffered from the severer congestions, it would devastate the national economy, or that the development of railway station spheres in the regions where the station of Gyeongbu High speed rail were to be built would lead to balanced development in the regional economy.

Fourth, just before the December 1992 presidential election, the construction of Gyeongbu High Speed Rail was considered a public pledge. Thus, some argued that the fact that the project was being pushed forward although it was not really urgent, or that the construction was to be carried out when the detail design had not been completed and the locations of the underground or on-the-ground stations had not been determined, showed that the project was merely being used for political purposes.

Despite such criticisms, the construction of Gyeongbu High Speed Rail was strongly promoted by the government. For three years, from 1989 to 1991, a technical survey was conducted in relation to the project. Many public and private sectors participated, including concerned national-policy research institutes and South Korean railway-technology-related engineering companies; this technical survey reviewed all the technical conditions related to the construction and operation of a high speed rail, such as the alignment planning, engineering structure, railway tracks, vehicle type, vehicle dynamics, train operation, power transmission and transformation, electric-railway line, signal and communication, and environmental impact, and completed the basic and detail design of the high speed rail. Based on the results of the technical survey, the construction of Gyeongbu High Speed Rail started in June 1992.

Figure 1-1 | Highway and Railway (1988)



Chapter 2

Estabishment of the Project Plan and the Implementation System

1. Establishment of the Project Plan
2. Revision of the Implementation System

Estabishment of the Project Plan and the Implementation System

1. Establishment of the Project Plan

1.1 Execution of the Technical Survey

1.1.1 Overview

On July 15, 1989, two months after the decision was made to include the technical-survey policy for the construction of Gyeongbu High Speed Rail in the Sixth Five-Year Economic and Social Development Plan, the technical survey was started. Performed for three years, until February 1991, the technical survey aimed at studying all the technical aspects of the construction of a high speed rail between Seoul and Busan. The introduction of a high speed rail requires a plan divided into three phases: the basic planning and designing phase, the vehicle system selection and acquisition phase, and the detail design phase for the construction. The technical survey focused on the first phase.

As shown in <Table 2-1>, six companies from 12 areas participated in the technical survey, and the survey examined all matters related to each area. The main contents of the survey included analysis of the transportation demand and economic feasibility, route selection and review of the station location selection alternatives, review of the performance and technical aspects of foreign high speed rails, preparation of a bid proposal (draft) for vehicle type selection, investment and operation plans for the high speed rail, and the basic design in each area, such as civil engineering, electricity, signal, etc.

Table 2-1 | Technical-Survey Service Related Agencies by Area

Area	Service Agency	Remarks
Overseeing the technical services	Korea Transport Institute	
Overseeing the technical areas	Louis Berger Group	U.S. company
Route planning	Yooshin Engineering Corp., KRETA	
Structure	KRETA	
Slope	KRETA	
Station, architecture	Yooshin Engineering Corp., KRETA	
Vehicle structure	Hyundai Precision&Industries Corp.	
Vehicle dynamics	Daewoo Engineering&Construction	
Vehicle operation	Yooshin Engineering Corp.	
Power transmission/ transformation, electric vehicle line	KRETA	
Signaling, communication	Yooshin Engineering Corp.	

Source: Korea Rail Network Authority (2011)

1.1.2 Hosting an International Symposium on the High Speed Rail

Keeping in pace with the implementation of the construction of Gyeongbu High Speed Rail, The Korea Transport Institute, the entity that oversaw the technical-survey services, hosted the one-week "International Symposium on High Speed Rail" from October 16 to 22, 1989. This symposium aimed at establishing national understanding of and a national consensus on the high speed rail project, which was to be accompanied by large-scale investments. It saw the convergence of comprehensive opinions on the technical developments in transportation, industries, and other fields, focusing on the high speed rail project, and collected basic data on selecting the system. Including some 100 foreign specialists in 11 countries, such as France, Japan, and Germany, 630 specialists participated in the symposium. These specialists presented various ideas and opinions on the technical methods involved in the high speed rail, on various issues following the technology transfer, and on policies and operation models, practical-operation experiences, and the magnetic-levitation railway. As such, the symposium produced considerable outcomes in terms of collecting references for creating specifications, establishing contacts with high speed rail specialists in each country, analyzing the characteristics (especially the strengths and weaknesses) of each country's high speed rail system, and forming a national consensus on the high speed rail project.

1.1.3 Basic Direction of the Construction Standard

The design criteria of the high speed rail was set in a way that would make it suit South Korea's topology, by considering the design criteria of the UIC and foreign high speed rail systems, as follows:

- A railway on which diesel locomotives can run by considering the connection with the existing railway;
- A railway that will allow direct operation with the South-North Koreas and the Eurasian railway through China in the future;
- A railway that will allow future speed improvement by considering the global trend of the high speed rail technological development; and
- A railway on which the vehicles from Japan, France, and Germany can be run.

These codes were proposed as the conditions for selecting the vehicle type so that whichever country was chosen to supply the vehicles could take comfort from these codes and would produce vehicles that would be appropriate for South Korea, thus guaranteeing connectivity between the vehicles and railways.

1.1.4 Basic Direction of the Vehicle Codes

The maximum speed of the vehicle on Gyeongbu High Speed Rail was set at 300 km/h because it was determined that this speed was most economical and efficient if there were two to four stations in the 409 km zone between Seoul and Busan. Moreover, the plan was to operate localized vehicles after the technology transfer of one of the three vehicles that had already been developed. The maximum speed of the high speed rail systems that were already in operation was 300 km/h.

Considering the energy consumption, maintenance and repair, and passengers' comfort level while ensuring that the vehicles run at their maximum speed and safely, the high speed rail system followed the construction codes that ensured the construction of a railway system appropriate for the design speed of 300 km/h.

Based on the technological-development trend in the world and the current technological level, high speed vehicles from Japan, France, or Germany, which allow South Korean companies to receive technology transfer by phase, were chosen to improve the South Korean railway vehicle industry, particularly making its technical level reach the global level, and to eventually enable the manufacture of these vehicles in South Korea. Moreover, the vehicle to be chosen should allow few or no issues when connected to the existing railway, and should be suitable for a large amount of transport at a high speed in South Korea, where the land is limited and the population density is very high.

1.1.5 Project Implementation Direction

To cope with the difficulties in maintaining the interface of a high speed rail system, some officials in the National Railroad Association proposed a total system that combines the technologies in all areas while others proposed that these be categorized into core and infrastructure technologies.

Finally, accepting the opinion that the construction could be executed using domestic technologies, civil engineering, tracking, and architecture were to be executed using South Korean technologies while foreign technologies would be introduced as core technologies, such as high speed vehicles, train control, electric-vehicle lines, and train wireless communication, which have yet to be developed in South Korea. Through technology transfer and domestic production, however, it is expected that these technologies will be acquired in the future.

1.1.6 Technical-Survey Results

The results of the technical survey showed that the total transportation increase rate from 1988 to 2028 is expected to be 3.4% for passengers and 2.7% for freight, and that the railway between Suwon and Daejeon would reach the limit of its transportation capacity by 1991. It was also determined that Gyeongbu Expressway was already not performing to its full capacity due to chronic congestion.

When the discount rate was set at 13%, the analysis of the economic performance of the high speed rail project showed good results: 1.55 benefit/cost ratio, 19.4% IRR, and KRW 2.28 trillion net present value. Even at an 18% discount rate, the project is still deemed to be economically sound, with a 1.09 benefit/cost ratio and a KRW 290 billion net present value.

The cost-benefit analysis showed that an annual surplus would result within seven years after the start of the system's operation, and while the maximum accumulated debt in 2001 was to reach KRW 3.9 trillion, this could be adequately paid through the fare revenues during the system's operation.

1.1.7 Selecting the Route

The criteria for route selection were the maximum speed of the train, the location of the station, the environmental conditions, the natural conditions, the level of construction difficulty, the maintenance and repair control, the alignment conditions, and the economic performance.

For the route alternative analysis, a total of 108 alternatives were constructed by combining 12 route alternatives, three station alternatives, and three maximum-speed alternatives. Among these alternatives, 33 alternatives were selected and were broadly evaluated based on (i) convenience (saving time or vehicle/train operation costs); and (ii)

cost (construction cost, high speed rail facility maintenance and repair cost, energy cost, labor cost, etc.). The results showed that at 300 km/h, the maximum speed, the efficiency was better when the number of intermediate stations was smaller (four or less), resulting in the following eight potential route plans:

- Seoul–Daejeon–Daegu–Busan (Jungbu Route, two intermediate stations)
- Seoul–Cheonan–Daejeon–Daegu–Busan (Jungbu Route, three intermediate stations)
- Seoul–Daejeon–Daegu–Ulsan–Busan (Dongbu Route, three intermediate stations)
- Seoul–Cheonan–Daejeon–Daegu–Miryang–Busan (Jungbu Route, four intermediate stations)
- Seoul–Cheonan–Daejeon–Daegu–Ulsan–Busan (Dongbu Route, four intermediate stations)
- Seoul–Cheonan–Daejeon–Gimcheon–Daegu–Busan (Jungbu Route, four intermediate stations)
- Seoul–Cheonan–Daejeon–Daegu–Gyeongju–Busan (Dongbu Route, four intermediate stations)
- Seoul–Cheonan–Daejeon–Daegu–Gyeongju–Busan (in tandem with the Donghaenambu Route Double-Track Project)

Two issues were debated on while selecting the route: (1) whether to straighten the route and minimize the intermediate stations or to maximize the transportation demand and add intermediate stations while lengthening the route; and (2) whether to add Miryang Station [alternative (iv)] or Gyeongju Station [alternative (vii)] if an additional station was to be created.

Considering the scope of the high speed rail construction beneficiary regions and the issues related to the construction technologies resulting from the economic-feasibility analysis, alternative (viii) (Seoul-Cheonan-Daejeon-Daegu- Gyeongju-Busan) was selected in the technical survey in 1990.

1.2 Initial Project Plan

1.2.1 Project Plan

Based on the technical survey conducted beginning in 1989, the basic plan was established, and on June 15, 1990, based on the resolution of the third High Speed Rail& New International Airport Construction Promotion Committee, the basic plan and route of the Gyeongbu High Speed Rail Project were determined and announced, as shown below.

- Route extension: Seoul-Busan, 409 km (tunnels: 42%)
- Maximum design speed: 350 km/h
- Running hours: 90 minutes for the direct operation (101 minutes while stopping at two stations)
- Project term: 1992-1998
- Cost: KRW 5.8462 trillion (KRW 1.2144 trillion for vehicle purchase, as of 1989)
- Usage demand: 218,000 passengers/day
- Financial stability: Annual surplus three years after the opening; accumulated surplus ten years after the opening
- Route: Seoul-Cheonan-Daejeon-Daegu-Gyeongju-Busan (Four Intermediate Stations)

1.2.2 Determination of the Basic Route

For the selection of the route in the basic project plan, the eight potential route plans established in the technical survey were reviewed, and two alternatives-alternatives (i) and (viii)-were short-listed. Alternative (i), which had two intermediate stations (Daejeon and Daegu), offered the straight route. While its running time was shorter, its tunnel extension was longer due to the topology, and compared to the size of the investment, the beneficiary regions were limited. Alternative (viii), which had four intermediate stations, including the Gyeongju and Cheonan stations, offered good financial stability due to its improvement of the high speed rail usage rate as it includes Gyeongju, a major cultural-heritage and tourist attraction, and Ulsan and Pohang, two key industrial areas, as well as Choenan, which has a huge transportation demand. It meant, however, that the route would be slightly diverted. Finally, alternative (viii) was selected as it could increase the high speed rail usage rate.

Table 2-2 | Comparison of Two Short-Listed Route Alternatives in the Basic Plan

Review \ Alternative		Alternative (i) Seoul-Daejeon-Daegu-Busan	Alternative (viii) Seoul-Cheonan-Daejeon-Daegu-Gyeongju-Busan
Topology	Distance	387 km	409 km (changed to 412 km)
	Tunnel	48%	42%
Running time		Direct: 1 hour 26 minutes (two stops: 1 hour 37 minutes)	Direct: 1 hour 30 minutes (two stops: 1 hour 41 minutes)
Transport demand		192,000 passengers/day	218,000 passengers/day
Cost		KRW 4.4267 trillion	KRW 4.6318 trillion
Financial stability		Annual surplus: after five years Accumulated surplus: after 13 years	Annual surplus: after three years Accumulated surplus: after ten years
Characteristics		Shortest-distance route Limited beneficiary regions considering the investment size	Will accommodate the Cheonan and Gyeongju tourists Will improve the usage rate Needs to divert a bit

Source: Korea Rail Network Authority (2011)

Note: Additional KRW1.2144 trillion for vehicle purchase

1.2.3 Station Locations

In the process of determining the stations, the locations were a delicate issue, where the local governments' and residents' interests showed sharp conflicts. Some local governments or residents did not want the route to include their region due to the noise or environmental pollution that may be caused by the high speed rail and the damage to various resources, including cultural assets, that may be caused by the construction of the station and the route. Most of them, however, admitted that establishing a station in their region would promote the development of their local economy. Some key issues that were debated when the locations of the stations were being selected were the formation of strong bases for creating and developing new cities, convenience in the use of the system in the city (Seoul), the underground stations and their construction cost (Daejeon and Daegu), and the effect of the construction on the region's cultural assets (Gyeongju).

1.2.4 Design Criteria

One important task in constructing the country's first high speed rail was the creation of design criteria. For this, the government referred to the design criteria of the UIC and other countries and sought the help of foreign and South Korean specialists and technical teams.

It is noteworthy that in setting the goal of cultivating technical competency through the project, the project selected a core-method code, which meant that the government chose to introduce only the core technologies from the advanced countries and to promote the use of the South Korean technologies for the other aspects of the project, instead of the total-method code, based on which all the required technologies would come from the advanced countries and South Korea would only manage the project.

1.3 Revisions of the Project Plan

Since the determination of the basic plan in 1990, the Gyeongbu High Speed Rail Project has gone through two major revisions. The main reasons for the revisions were as follows: (1) after the construction of the test zone, it was determined that the cost would increase considerably if the original route plan would be followed; (2) there were consistent local complaints regarding the basic plan; and (3) the unit price increased due to the construction delay. Besides such big changes, other minor design changes caused by local complaints and changes in construction technologies continued throughout the term.

1.3.1 First Revision of the Project Plan (June 1993)

The initial cost of the project was KRW 5.8462 trillion, based on the constant market price from 1989 to the early 1990s. This cost calculation, however, was based on the method of adding extra cost by a fixed rate to the existing railway construction cost due to the limited data available on the high speed rail construction, and therefore, it was somewhat unreasonable from the beginning to consider this cost accurate.

For example, in the 1990s, the sub-base course construction was estimated to be 1.4-1.5 times the unit cost of the existing line while the tracking was estimated to be the same as that of the pole railing for the existing railway. Also, the average unit price of Shinkansen in Japan, TGV in France, or ICE in Germany was applied to the cost of the signal communication facilities. Therefore, more accurate cost estimation had to be done when the actual construction had progressed to a certain point. It was after 1993, when the Cheonan-Daejeon Test Zone (57.2 km) was completed, that the actual and realistic estimation of the construction cost became possible.

a. Necessity of revising the plan

The construction cost of the high speed rail project, confirmed by the detail design and actual construction of the sub-base course construction, tracking, and signal communication facilities, was considerably higher than the originally estimated cost. Additionally, the marked increase of the construction cost, including the labor and material costs, from the time when the basic plan was drafted became a key reason for the drastic increase of the overall cost. To resolve the two issues regarding the basic plan (the error in the estimation and the market price increase), the first revision of the plan was carried out.

The problem did not end there. Besides simple errors in the estimation, the revision of the plan itself was inevitable. The total route length increased from 409 km by over 13 km due to the diverting route to Osong Station (4.9 km), the diverting route due to the protection of cultural assets in Gyeongju (7.1 km), and the diverting route due to the city plan in Yangsan Zone (1.3 km), all of which were not considered in the initial plan.

As such, considering the overall changes that were made to compensate for the errors in the estimation, the reflection of the market price increase, and the extension of the route, the total cost was re-estimated to be KRW 12.1743 trillion, over twice the original cost estimated, if the original construction term was to be maintained so that the project would be completed in 1998. In the revised cost, 81.8% of the increase was from the changes that were made to compensate for the errors in the estimation and the reflection of the market price increase while 18.2% was from the increase in the investment cost due to the increase in the capacity. Accordingly, as the revision was being made, further revisions were made on some zones, and reasonable adjustment of the construction term and confirmation of the station locations were done to maximize the cost savings.

b. Key revised contents

The focus of the revision was the plan to cut down the investment cost. First, it was planned that the underground facilities be constructed on the ground, and maximum use of the existing facilities was planned. Accordingly, a revision was made in the underground zone plan between Seoul and Gwangmyeong Station and between Seoul and Susaek Station. The issue of the railway capacity due to the revision (Seoul-Siheung, 17 km) was to be resolved by reducing the services in the existing railway (Saemaeul and Mugunghwa) and freight trains. To handle the trains at Seoul Station, the central station for the project, the starting and ending trains were to be also allotted to Gyeongmyeong Station, located in the outskirt of the Seoul Metropolitan Area, and to cope with the limitation of the railway capacity between Seoul and Susaek Station (8 km), the adjustment of the block section was considered (reducing the block section from 800-1,300 to 500 m). Besides Seoul, the original underground-section plan in Daejeon and Daegu was converted into a ground-level plan, and by postponing the construction plan of the vehicle maintenance depot, the total investment cost was reduced from KRW 12.1743 trillion to KRW 10.74 trillion. To alleviate the annual investment load, which increased along with the increase of the total project cost, the construction term was extended for three more years, and therefore, it was planned that the project be completed by 2001. Cheonan-Daejeon Test section, however, was to be completed by 1997, and Seoul-Daejeon Zone, by the end of 1999, so that as of 2000, the high speed rail could be commercially operated. In the revision, every effort was made to follow the original objectives of the plan.

1.3.2 Second Project Revision (July 1998)

a. Necessity of the revision

After the first revision of the plan in 1993, further revision of the cost and term was inevitable due to the underground construction in Daejeon and Daegu, the changes in the plan due to local complaints (e.g., the changes in the Gyeongju route), the market price increase, and the changes in the design. Accordingly, the government proposed a draft on the revision of the basic plan in November 1997. While the talks between the concerned organizations were in progress, some drastic changes occurred in the project implementation environment, such as the 1997 foreign-exchange crisis and the establishment of a new government in 1998, which led to the full revision of the project.

In April 1998, after the establishment of a new government, a joint-force task team consisting of the Ministry of Construction and Transportation, KTX, and Korea National Railroad was formed to review the cost and the project. Also, an assessment advisory committee consisting of 24 specialists in economics, journalism, transportation, and civil engineering, among others, conducted an in-depth analysis of the project, and after the feasibility assessment and advisory meetings, the Social-Overhead-Capital Construction Implementation Committee revised the basic plan on July 31, 1998, considering the dire economic conditions then.

b. Key revised contents

The key contents of the second revision maintained the framework of the original plan in consideration of the consistency of the government's policies and the transportation issues regarding Gyeongbu Line, while aiming to adjust the cost and the completion time by dividing the whole section into sections in the first and second phases in consideration of the then dire economic conditions. Accordingly, the original completion date for the whole section, 2000, was revised so that the first-phase project would complete the new high speed railway between Seoul and Daegu and transform the existing railway between Daegu and Busan as well as the downtown section in Daejeon and Daegu and the section between the two cities: into an electrical railway and would complete the project by April 2004. The second-phase project would create a new high speed rail between Daegu and Busan, transform the downtown of Daejeon and Daegu into an underground railway, use the existing railway between Seoul and Gwangmyeong Station, and create a diverting route in the Sangni Tunnel section, which had been controversial as the original plan was to go through a closed coal mine. As such, the project should have been completed by 2010.

Converting the original plan into a two-phase plan was strongly based on the dire condition of the government's budgets, which made it impossible to concentrate government investment on the project in 2000, as stipulated in the original plan.

Another reason for the revision was that the estimated total cost doubled from KRW10.74 trillion, the cost estimated in the first revision (June 1993), to KRW18.4358 trillion in 1998, combining the costs of the first-and second-phase projects. Due to the huge increase in

the cost, even if the investment would be made as planned in the yearly investment plan, the project would never be completed by 2000, as projected. Also considered was the dire economic condition at the time, which made additional financial investment impossible. Thus, within the scope that the budget allowed, the Seoul-Daegu section was to be completed and operated in the first phase by 2004, and the completion of the project was to be postponed to 2010.

As the project plan was changed into a two-phase plan, some of the civil complaints were resolved. Particularly, the underground route in Daejeon and Daegu was pushed to the second-phase project while the original plan was maintained, whereas the Gyeongju route was determined to be the final alternative, which was the Hwacheonri section. Also, for the Sangni section, the route that diverts from the unstable ground region due to the mining was determined and completed in the first-phase project. The Seoul Station-Gwangmyeong Station section, however, would use the existing route, as confirmed in the first revision.

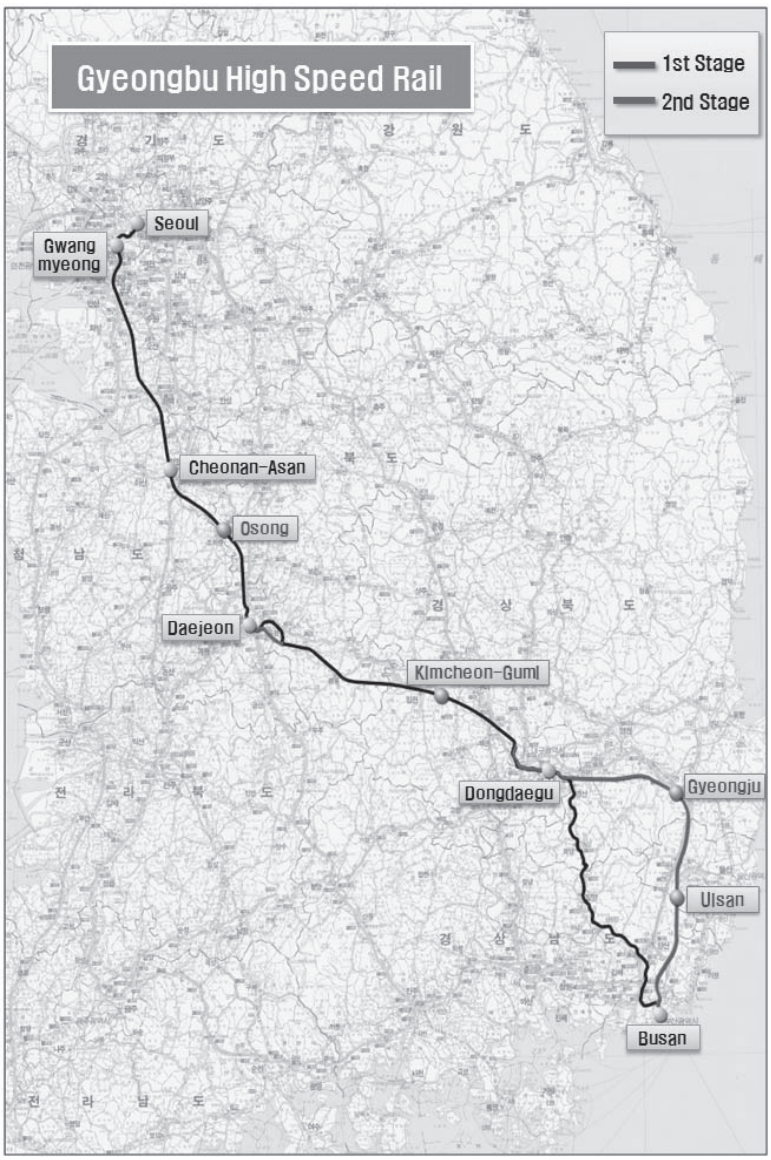
Table 2-3 | Comparison of the Revisions of the Basic Project Plan

Category	Basic Plan Established (June 14, 1990)	First Revision (June 14, 1993)	Second Revision (July 31, 1998)	
			First Phase	Second Phase
Route	Seoul-Cheonan-Daejeon-Daegu-Gyeongju-Busan	Seoul-Cheonan-Daejeon-Daegu-Gyeongju-Busan	Seoul-Cheonan-Daejeon-Daegu -Busan	Seoul-Cheonan-Daejeon-Daegu-Gyeongju-Busan
Distance	409 km	430.7 km	409.8 km	412 km
Term	Aug. 1991-Aug. 1998	June 1992-May 2002	June 1992-April 2004	May 2004-Oct. 2010
Cost	KRW 5.8426 trillion	KRW 10.74 trillion	KRW 12.7377 trillion	KRW 5.6891 trillion
Stations	Seoul, Cheonan, Daejeon, Daegu, Gyeongju, Busan	Seoul, Gwangmueong, Cheonan, Daejeon, Daegu, Gyeongju, Busan	· Gwangmyeong, Cheonan, Daejeon, Daegu, Busan · Seoul Station: Using the existing Seoul Station and the expansion of Yongsan Station	Gwangmyeong, Cheonan, Daejeon, Daegu, Gyeongju, Busan

Category	Basic Plan Established (June 14, 1990)	First Revision (June 14, 1993)	Second Revision (July 31, 1998)	
			First Phase	Second Phase
Running time (Seoul-Busan)	101 minutes	124 minutes	160 minutes	116 minutes
Speed	350 km/h (max. design speed)	300 km/h (max. running speed)	300 km/h (max. running speed)	300 km/h (max. running speed)
Vehicle arrangement	46	46	46 (foreign: 12; domestic: 34)	46
Budget plan	-	· Government funding: 45% · Other funding: 55%	· Government funding: 45% · Other funding: 55%	-
Major revisions	-	· Renovating and using the existing ground- level Seoul, Daejeon, and Daegu Station · Using the existing Gyeongbu Line between Seoul and Anyang · Creating a new station for Gwangmyeong	· Electrifying and using the existing line for the sections of Daegu and Daejeon as well as the Daegu-Busan section · Using the existing railway between Seoul and Gwangmyeong	· Constructing a new railway between Daegu and Busan · Constructing Gyeongju Station · Constructing an underground railway that will pass through Daejeon and Daegu downtowns

Source: Korea Rail Network Authority (2011)

Figure 2-1 | The Route of Gyeongbu High Speed Rail



2. Revision of the Implementation System

2.1 Implementation Organizations

The most representative implementation organizations for the Gyeongbu High Speed Rail Project are the Ministry of Construction and Transportation's High Speed Rail Construction Planning Team, the High Speed Rail Construction Headquarters at Korean National Railroad, Korea High Speed Rail Construction Authority, and Social-Overhead-Capital Construction Implementation Committee.

The Ministry of Construction and Transportation's High Speed Rail Construction Planning Team oversaw the establishment, revisions, and management of the pertinent law, the establishment (revision) and announcement of the basic plan, determining and planning other key policies related to the high speed rail project, approving of the project execution plan, managing the High Speed Rail Construction Review Committee, carrying out other supporting functions for Korea High Speed Rail Construction Authority, guiding and supervising Korea High Speed Rail Construction Authority, and mediating and adjusting the tasks between Korean National Railroad and Korea High Speed Rail Construction Authority.

The High Speed Rail Construction Headquarters at Korean National Railroad was commissioned by Korea High Speed Rail Construction Authority to conduct the repair and electrification of the existing railway and facilities in the project.

Korea High Speed Rail Construction Authority not only conducted the execution of the project but also performed the role of the project owner by establishing the execution plan and supplying funding.

The Social-Overhead-Capital Construction Implementation Committee reviewed and mediated the key policies (basic plan, fund supply, etc.) in relation to the construction of the high speed rail, and oversaw the task cooperation among the concerned departments, organizations, and local governments.

2.1.1 High Speed Rail Construction Planning Team (Ministry of Construction and Transportation)

• History

- April 30, 1994: The High Speed Rail Division (temporary organization) was established (eight people)
- May 1, 1996: Reorganized into High Speed Rail Propulsion Team (nine people)

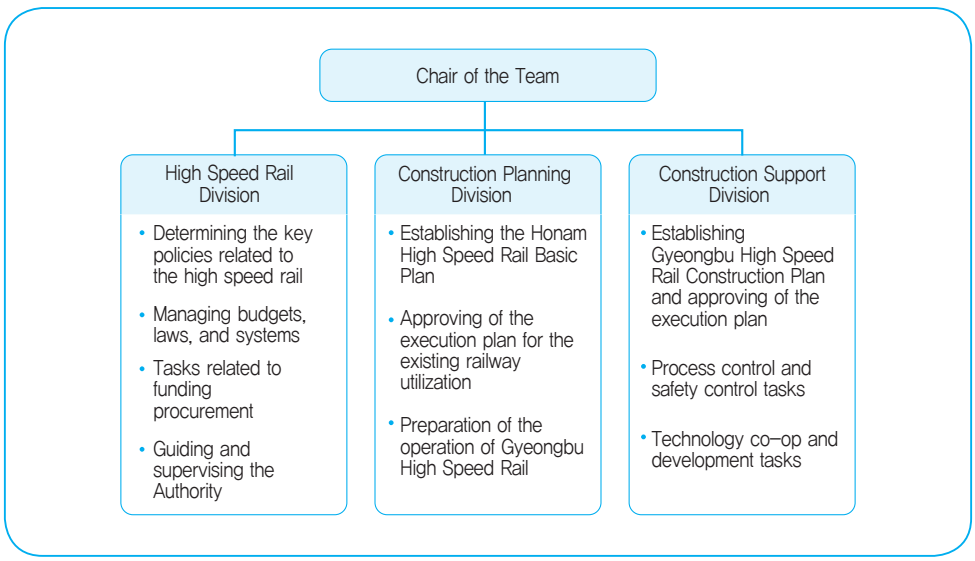
- June 29, 1996: Reorganized into High Speed Rail Department (official organization) (12 people)
- November 23, 1996: The High Speed Rail Construction Planning Team was established (22 people in two divisions)
- September 3, 1997: The Construction Planning Division of the Ministry of Construction and Transportation's High Speed Rail Construction Planning Team was expanded (29 people in three divisions)

• Tasks and functions

- Establishing and adjusting the high speed rail plan and policies
- Establishing and adjusting the investment and funding supply for the project
- Guiding and supervising High Speed Rail Construction Authority

• Organization and personnel (three divisions)

Figure 2-2 | Three Divisions of High Speed Rail Construction Planning Team



2.1.2 High Speed Rail Headquarters (Korean National Railroad)[2]

• History

- December 1989: The High Speed Rail Construction Task Force (High Speed Rail Planning Team) was established.
- December 1994: The High Speed Rail Operation Preparation Team was established.
- July 1996: The Technology Promotion Management Team was reorganized into the High Speed Rail Management Team.
- July 1997: The High Speed Rail Training Division was established within Korean National Railroad Officials Training Center.
- August 1998: The High Speed Rail Management Team was renamed High Speed Rail Project Management Team; the High Speed Rail Operation Management Team was established.
- July 1999: The High Speed Rail Headquarters was established (one chair, 76 people in five divisions, and 20 teams).
- January 2000: The High Speed Rail Construction Project Office was established within the Headquarters (one chair, 118 people in six divisions, and 22 teams).

• Tasks and functions

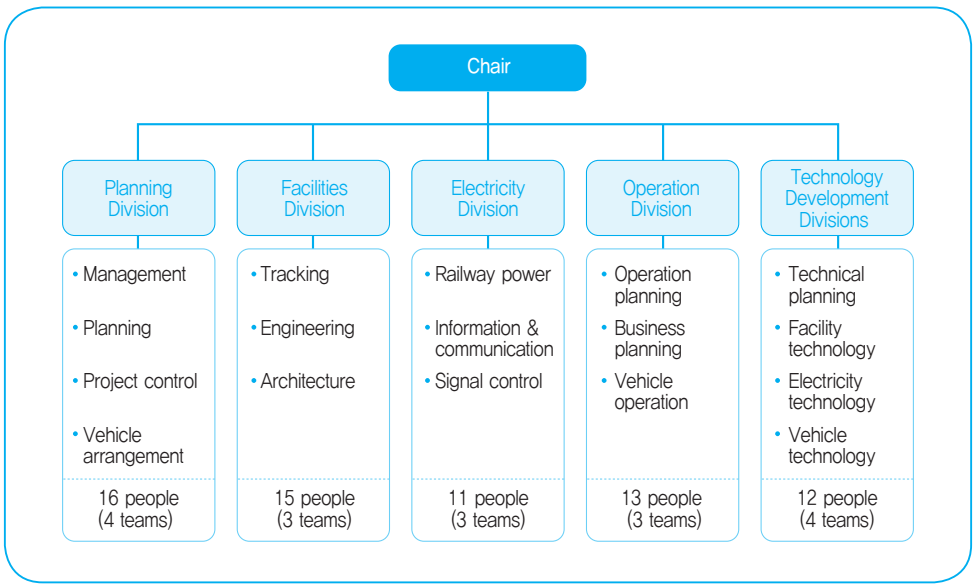
- Systematic execution of the budget and process control for railway system maintenance and repair tasks (including the electrification of the existing railway) in the High Speed Rail Construction Project
- Formulating design, construction, and maintenance/repair plans in the facilities and electricity areas related to the project
- Preparing for the operation of the high speed rail
- Systematic promotion of the railway technology development

• Organization and personnel

- High Speed Rail Headquarters (68 people in five divisions, and 17 teams)

2 Having supervised the construction and operation of the railway system, the Headquarters was divided into Korean National Railroad Facilities Authority, which oversees the railroad facilities, and Korean National Railroad, which manages the operation, according to the National Railroad Industry Restructuring Plan (2004).

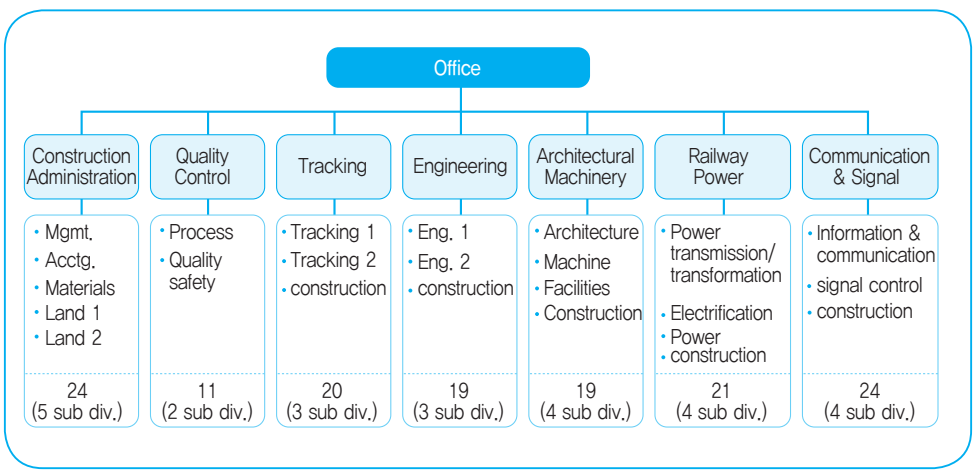
Figure 2-3 | High Speed Rail Headquarters



※ Not including the regular personnel at the branch offices and the dispatched vehicle management team (T/F)

- High Speed Rail Construction Office (one chair, 182 people in seven divisions, and 25 subdivisions)

Figure 2-4 | High Speed Rail Construction Office



2.1.3 Korean High Speed Rail Construction Authority

• History

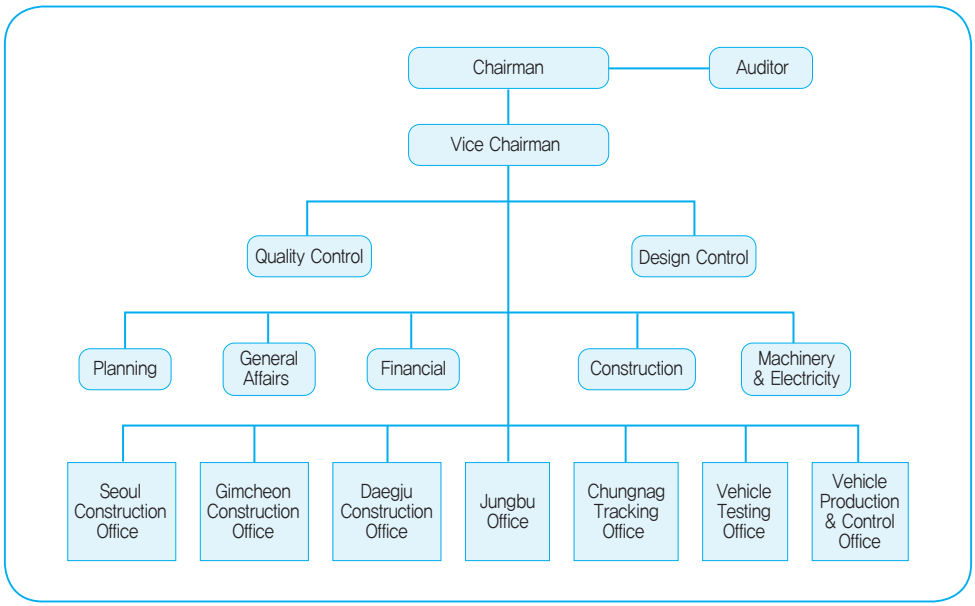
- July 1989: The High speed rail&New International Airport Construction Implementation Committee&Task Committee were established.
- Implementation Committee: 17 members, excluding the Minister of Economic Planning Board (Chair)
- Task Committee: 22 members, excluding the Vice Minister of Transportation (Chair)
- December 1989: The Task Force Team was established (54 KORAIL employees).
- February 1991: The High Speed Rail Project Planning Team was established (140 people).
- December 1991: Korea High Speed Rail Construction Authority Act (Act No. 4456) was enacted.
- March 1992: Korea High Speed Rail Authority was established (seven headquarters, 379 people).

• Tasks and functions

- Constructing the high speed rail
- Carrying out the high speed rail station spheres and neighboring-zone development project
- R&D and survey of high speed rail technologies

• Organization and personnel (five headquarters, two divisions, seven offices, 776 people)

Figure 2-5 | Organization and Personnel of Korean High Speed Rail Construction Authority



2.1.4 Social-Overhead-Capital Construction Implementation Committee

• Establishment Grounds

- Provision on the High-speed Electric Rail and New International Airport Construction Impulsion Committee (Presidential Decree No. 12762 enacted on July 24, 1989)
- Amendment of the Provision on the SOC Infrastructure Impulsion Committee (Presidential Decree No. 15173 partially amended on November 23, 1996)

• Goal

- Reviewing and adjusting the basic plan and key policies on the construction of high speed rails, new international airports, and new harbors

• Functions

- Issues related to the establishment of the construction basic plan for high speed rails, new airports, and harbors
- Issues related to the key policies related to the construction of high speed rails, new airports, and harbors as well as construction funding procurement
- Issues related to interdepartmental cooperation with regard to the construction of high speed rails, new airports, and harbors

• Organization (30 people, including the chairman and vice chairman)

- Chairman: Minister of Planning and Budgeting
- Vice chairman: Minister of Construction and Transportation, Minister of Maritime Affairs and Fisheries
- Members: Ministers of Public Administration and Security, National Defense, Agriculture and Forestry, Commerce, Industry and Energy, Information and Communication, Environment, Science and Technology, and Office for Government Policy Coordination; Presidential-Secretariat Economic-Division secretary; Director of Forest Services; Director of Korean National Railroad; Seoul Metropolitan City Mayor; mayors of metropolitan cities; governors; Chairman of Korean High Speed Rail Construction Authority; Chairman of Incheon International Airport; and others related to the issues to be reviewed and appointed by the chairman

* Task Force Committee (30 people, including the chairman and vice chairman)

- Chairman: Vice Ministers of Construction and Transportation, Maritime Affairs, and Fisheries
- Vice chairman: Director of the Conveyance Policies Office at the Ministry of Construction and Transportation, Director of Planning and Management at the Ministry of Maritime Affairs and Fisheries
- Members: Ministers of Strategy and Finance, Public Administration and Security, National Defense, Culture and Tourism, Agriculture and Forestry, Commerce, Industry and Energy, Information and Communication, Environment, and Science and Technology; Office of Planning and Budgeting; Office of Government Policy Coordination; Office of Forest Services; Korean National Railroad; Presidential Secretariat; directors of Seoul City and the other concerned cities and provinces; National Railroad Authority; Vice Chairman of Incheon International Airport; and those appointed by the chairman

2.2 Relevant Laws

2.2.1 Provision on the High-speed Electric Rail and New International Airport Construction Impulsion Committee

The provision on the High-speed Rail and New International Airport Construction Impulsion Committee was enacted in 1989 to deliberate on and coordinate the basic plan and important policies for the construction of the high-speed rail and new international airport. This Act defines the committee's functions and composition, its working committee composition, and other necessary matters concerning its operation (in November 1996, the provision name was changed to "Provision on the SOC Infrastructure Construction Impulsion Committee.").

2.2.2 The Korea High-speed Rail Construction Authority Act

The Korea High-speed Rail Construction Authority Act was enacted in 1991 to establish the Authority so as to efficiently construct the high-speed rail with a view to expanding the rail transportation networks, in a bid to enhance public transportation convenience and to help promote national economic development. This Act defines the Authority's business scope, officer composition/qualifications, financing methods, collection of service fees, and other overall matters related to the operations of the Authority.

2.2.3 The High-speed Rail Construction Promotion Act

The High-speed Rail Construction Promotion Act was enacted in 1966 to define matters necessary for the early construction of the high-speed rail so as to efficiently implement the high-speed rail construction project. This Act defines the term of the high-speed rail, the formulation of the basic plan for the high-speed rail construction, implementers of the high-speed rail construction project and supervision thereof, designation of the prearranged areas for the project, and other matters concerning the construction of the high-speed rail.

Table 2-4 | Laws Pertaining to the High-Speed Rail

Relevant laws	Purpose	Outline	Date of enactment
Provision on the High-speed Electric Rail and New International Airport Construction Impulsion Committee	To deliberate on and coordinate the basic plan and important policies for the construction of the high-speed electric rail and new international airport	Define the committee's function, composition, and working committee composition, and other matters necessary for the operation of the committee	July 24, 1989
Korea High-speed Rail Construction Authority Act	To establish the Korea High-speed Rail Construction Authority so as to efficiently construct the high-speed rail with a view to expanding Korea's rail networks	Define the business scope, officer composition and qualifications, financing methods, collection of service fees, and other overall matters necessary for the operation of the Authority	December 27, 1991
High-speed Rail Construction Promotion Act	To define matters necessary for the early construction of the high-speed rail so as to efficiently implement the high-speed rail construction project	Define the basic plan and the execution plan for the high-speed rail construction, the project implementers, supervision of the project, the Act's correlation with other laws, designation of the prearranged areas for the rail, and other matters concerning the construction of the high-speed rail	December 31, 1996

Note: See the Appendix for the full text.

Chapter 3

Key Project Issues

1. Design Criteria and Detail Design
2. Introduction of the Project Management System
3. Vehicle Type Selection and Contract Conclusion
4. Technology Transfer and Localization
5. Development of the High Speed Rail Technology
6. Selection of the Construction Companies and Construction of the Test Railway Section
7. Preparation for the Opening and Operation of the High Speed Rail System
8. Financial Procurement

Key Project Issues

1. Design Criteria and Detail Design

1.1 Establishment of the Design Criteria and Basic Design

The Gyeongbu High Speed Rail Project was a good opportunity to notch up South Korea's construction technology in terms of both the size and content of the construction. Therefore, the South Korean government propelled the project by focusing on the independence of the country's high speed rail technology and the production of railway technicians. Accordingly, from the planning phase, the government made sure that South Korean technical experts would lead the project, but foreign technical teams were encouraged to handle the technology areas that South Korea was lacking in to ensure the technical stability and reliability of the high speed rail. South Korean technologies were also used in the civil-engineering, tracking, and architectural issues so that in the future, South Korea would be able to construct a high speed rail system using its own technology.

The detailed design for the sub-base course construction was performed by specialists from 14 South Korean technical-service companies, and in the designing process, academic scholars and specialists joined the force so that the design would conform to the design criteria of UIC and foreign high speed rail systems.

The dynamic safety review of the extensions, structures, and forms of the sub-base facilities and structures, such as the bridges and tunnels, designed by South Korean specialists was commissioned to and performed by renowned foreign specialists.

After the first-phase design and the second-phase dynamic safety review, a comprehensive safety review of the technical connectivity between the core equipment (e.g., the TGV vehicles in France, the actual vehicle to be introduced) and the sub-base course facilities was performed by a special technical team of SYSTRA (formerly SOFRERAIL), a high speed rail company affiliated with SNCF in France.

1.1.1 Establishment of the Design Criteria

Some 300 South Korean and foreign specialists joined forces to create the design criteria for the Gyeongbu High Speed Rail System that are suitable for South Korea's topology, using the design criteria of UIC and foreign high speed rail systems.

Considering the connecting operation between South Korea and its neighboring countries (China, North Korea, Russia, etc.), the UIC code, the standard load applied worldwide, was set as the design load.

a. Establishment of the construction code

The High Speed Rail Construction Code on Railway and Structures for the Construction of a High Speed Rail was established on December 28, 1991 in relation to the track gage, curve and slope, construction limitations, distance between the centers of the tracks, formation level, and track. The code was first used in the detail design and test railway sections.

b. Creating the standard specifications

With KSCE as the main contractor, 134 specialists participated in creating eight standard specifications, including the steel bridge and composite bridge design standard specifications, for the high speed rail system for 10 months, from November 13, 1990 to September 12, 1991. Shown below are the high speed rail design criteria of other countries at that time.

Table 3-1 | Design Criteria for the Foreign High Speed Rail Systems

Category	South Korea: KTX	Japan: Shinkansen	France: TGV	Germany: ICE	Spain: AVE
Max. speed	300 km/h	260 km/h	320 km/h	300 km/h	250 km/h
Min. radius of curve	7,000 (400 m)	4,000 m	6,000 m	7,000 m	4,000 m
Max. grade	25‰	15‰	25‰	12.5‰	12.5‰
Width of formation level	14.0 m	11.6 m	13.6 m	13.7 m	13.3 m
Distance between the centers of tracks	5.0 m	4.3 m	4.5 m	4.7 m	4.3 m
Section area of the tunnel	107 m^2 (75m^2)	60 m^2	100 m^2	82 m^2	74 m^2
Design load	HL load (UIC load)	NP load	UIC load	UIC load	UIC load

Source: Korea Rail Network Authority (2011)

1.1.2 Basic Design

Through the preliminary measurement of the optimal alternative and the reviewed alternatives, the total sizes of the facilities for engineering, bridges, stations, tracks, buildings, electricity, vehicle depots, and other sites were roughly determined, and the total project cost and term were calculated.

1.2 Detail Design

The detail design of the sub-base facilities for Gyeongbu High Speed Rail was performed from June 1991 to August 1998 by dividing the Seoul-Busan section into 14 construction sections based on the results of the technical survey (Korea Transport Institute) and the standard specifications (KSCE). The Cheonan-Daejeon section (57.2 km) was selected as the test line, and to ensure that the construction would begin in 1992, the detail design of the fourth and fifth construction sections was performed first. The detail design of the power facilities was performed by dividing the facilities into six sections for the power transmission/transformation facilities, two sections for the electric railways, three sections for the electric-power distribution facilities, and one section for the remote-control facility.

In the detail design process, as much advice as can be gathered from specialists in various fields, and foreign technical information, was utilized. As for the key structures such as bridges and tunnels, international specialists and technicians from the country that would supply the trains participated in the review of the technologies and the selection of new technologies.

2. Introduction of the Project Management System

2.1 Background

As the Gyeongbu High Speed Rail Project was a compound project that would entail a large investment cost, a scientific and systematic management technique was required for the effective implementation of the project. Also, the fact that the locations of the project were distributed all over the country and that the project would be executed through technical cooperation with France and required the control and management of various state-of-the-art technologies, a large number of staffs, various materials, equipment, and data made the introduction of a reasonable project management system even more urgent. At that time, however, there was no specialist or organization that had the capacity or experience of managing a large project like the High Speed Rail Project. Thus, all the specialists agreed that the introduction of a foreign-project management technique was absolutely necessary.

Although some project management systems were introduced to some projects in the early 1970s in South Korea, they were mostly in the infant stage. In the 1980s, a South Korean technical team carried out a nuclear-power-plant construction project under a project management system. A foreign company was the main contractor, however, while

the South Korean company participated only in some areas, thus acquiring some process control and cost management techniques under the project management system.

After the 1990s, computers became widely distributed in South Korea, and there was an increase in the number of large-scale projects, such as nuclear-power-plant construction projects. Accordingly, the people's recognition of the need for project management rapidly increased. Since then, the South Korean companies already led technological development and utilization and received technical advice from foreign companies only in the areas where the South Koreans' technical know-how was lacking. As such, South Korea began to accumulate technologies on project management systems.

Accordingly, on September 26, 1992, the selection guideline for the project management service company was determined, and on November 23, 1992, a proposal request was sent to seven foreign service companies, including Bechtel. After the receipt of proposals from three companies (Bechtel, Louise Berger, and Parsons Brinkerhoff), on December 19, 1992, the proposal made by Bechtel was selected, and a contract was concluded.

The contract with Bechtel started as one for simple advisory service and expanded to project management services in 1997.

2.2 Bechtel's Project Management Services (1993-2001)

• Bechtel's role

○ Establishing the infrastructure required for executing an international-grade large project

- Negotiations for core system contract and international loan contract, etc.

○ Theoretical and practical support according to the introduction of a project management method

- Developing various procedures, systems, the basic-process chart, and the management guideline process charts

○ Proposing the direction of and alternatives to key decisions through various advising activities on construction, supervision, and quality control

○ Support on various coping methods and capacities under an international contract

- Creating international contracts, RFPs, RFP evaluation, and measures for various claims, etc.

○ Acquiring an international credit standing for Gyeongbu High Speed Rail of Korean High Speed Rail Construction Authority

- Contributing to the convenience in attracting funds from foreign financial markets, and to the reduction of the financial costs

• Outcomes of the services

1) PMAS (Project Management Advisory Service) (April 1993-September 1997)[3]

○ Established the project management system by introducing a systematic process and cost management system

○ Reduced the budget by establishing an effective strategy when negotiating for a core system contract

- Initial price suggested by France: about USD 4 billion→final contract: USD 2.14 billion (saved USD 1.86 billion)

- Established an effective exchange risk avoidance management system (saved about KRW 4.3 billion)

○ Led to a reasonable contract with foreign companies on the train wireless system and construction supervision

- Price suggested by Motorola: about USD 98 million→final contract: USD 83.5 million (saved about USD 14.5 million)

○ Design and quality control

-Reduced the term by introducing new methods (PSM method and waterproofing systems)

2) PMS (Project Management Service) (December 1997 – January 2001)[4]

○ A total of 62 ideas on method changes were proposed when the basic plan was revised in July 1998, and 53 ideas were reflected onto the revision, which reduced the cost by about KRW 160 billion.

A. Core contract claim negotiations on the compensations due to the change in the vehicle supply schedule

○ France requested for USD 193 million→negotiated at USD 57.9 million (saved USD135.1 million)

B. Established a comprehensive project management system by developing project management procedures and expanding the electronic system

C. Offered training programs for project management techniques and technical documents

○ 2,187 employees received 62 training programs; 176 technical documents, including standard waterproofing codes and structural calculations

D. Contributed to the acquisition of ISO 9001 and KSA 9001 certifications (May 2000)

3 It was a simple advisory contract without concrete responsibilities, and at the owner's behest, Bechtel supported the owner's decision-making process by offering its opinions, advice, and suggestions.

4 A contract under which Bechtel was to perform the services either in cooperation with or on behalf of the owner, and was to take responsibility for the outcomes

Table 3-2 | Conditions of the PMS Contract

Category	Phase 1	Phase 2	Phase 3		Phase 4
			Original	Revision (May 24, 1999)	
Type	PMAS		PMS		
Term	04/16/93-04/15/95	04/16/95-09/30/97	12/01/97-11/30/99		12/01/99-11/30/01
Amount	$20.35M	$34.92M	$82M	$41.6M	$57.63M
Executed amount	$12.71M	$21.32M	-	$36.77M	-
Labor	Max. 20	Max. 36	37-120	Max. 87	Max. 85
Methods	Review at the behest of High Speed Rail Authority Offering advice Supporting the decision-making process		Creating an integrated organization with the Authority Managing the co-op projects Participating in the decision-making process		

Source: MLTM (2010)

2.3 Establishing an Independent Project Management System (2002-2005)

After completing the project management contract with Bechtel, the Authority established the system for producing specialists by having a specialist service provider train its project management staff with theories and electronic education to enable them to perform independent project management tasks. After January 2004, a new organization (Korean National Railroad Facilities Authority) that integrated the construction area of the high speed rail system and the existing railway system was established, which created a need for various project management methods for projects in various sizes and formats. In 2004, the project management system was revised, and in 2005, the comprehensive project management system was completed.

3. Vehicle Type Selection and Contract Conclusion

3.1 Overview

One of the core tasks of the Gyeongbu High Speed Rail Project was the selection of the vehicle type and technology transfer. The task for selecting the vehicle type began by sending the RFP to three countries -Japan, France, and Germany -on August 26, 1991.

3.1.1 RFP

a. Objective and basic direction

The objective of the RFP was to receive reliable proposals on the technology, technology transfer, funding, and price for the construction of the Gyeongbu High Speed Rail System, and to select among the proposals the best vehicle type.

The scope of the RFP included vehicles with a maximum speed of 300 km/h, and electric car lines and ATCs that required state-of-the-art technologies. The target countries were France, Germany, and Japan, which owned high speed rail technologies. Each system proposal was reviewed, and the best proposal was selected based on compatibility, transport capacity, high-speed capability, stability, technology transfer, and localization.

Further, the RFP requested that each proposal stipulate the best foreign-funding-supply conditions that would facilitate the procurement of the funding required for the acquisition of vehicles and core equipment, and it was determined that the vehicle type would be finalized through the negotiation process after reviewing the proposals.

(1) Procedure

The first draft of the RFP was created based on the results of the technical survey and the basic design, as requested by KORAIL and performed by Korea Transport Institute, among others (July 1989-February 1990).

The International High Speed Rail Symposium was held in Seoul on October 16-22, 1989 and about 100 foreign specialists and 531 South Korean specialists. Referring to the technical trends determined in the symposium, Korea Transport Institute, Yooshin Engineering Corp., KRETA, Hyundai Precision&Industries Corp., Daewoo Engineering&Construction, and Louise Berger (USA), among others, created and reviewed the RFP.

The creation of the RFP for vehicle introduction, however, underwent various trial-and-error periods until it was completed and sent out, due to the lack of technical information on the high speed rail system.

(2) Evaluation standard and method for the proposals

Out of the total score of 30,000, the evaluation standard divided each proposal into four areas (cost, technology, technology development, and sales), each of which was given

a total score of 7,500. The four areas were subdivided into 300 subcategories, and to ensure the objectivity and fairness of the evaluation, an evaluation team consisted of 50 reviewers in three teams of specialists in High Speed Rail Construction Authority, as well as South Korean and foreign specialists, was established.

The evaluation method assessed the proposals by comparing their characteristics based on an inclusive scoring system. In particular, the method used both a qualitative assessment method that evaluated the technical performance and characteristics subjectively, and a quantitative method that, based on the proposed price, analyzed and evaluated the economic performance of each proposal by considering the financial condition, foreign-exchange rate, market price increase rate, etc.

(3) Evaluation participant organizations

- Korea High Speed Rail Construction Authority
- Five South Korean organizations: Korea Transport Institute, KIMM, KERI, Korea Ratings, and Shin&Kim
- Foreign organization: International Overseas Bechtel, Inc.

(4) Evaluation items by area

- Finance (eight items): Credit rating, total loan, amount of interest, redemption period, warranty period, capitalization of construction interest, exchange risk hedge, other special conditions
- Rolling stock (60 items): Vehicle system, noise&vibration, vehicle structure, amenities, seats, operating-room facilities, air-conditioning system, truck&comfort, brake device, current collector, propelling device, controlling device, services&others
- Catenary (11 items): Dynamic performance, electric characteristics, reliability, safety characteristics, installation condition, installation services, training plan, testing&test-driving plan, parts/tools/other equipment, maintenance&repair plan/services, basic&detailed designs
- ATC (15 items): Headway, speed control phase, interface to the train, reliability, usability, maintenance&repair, safety, installation condition&services, training plan, testing&test-driving plan, operation&maintenance/repair guidelines, parts/tools/equipment, maintenance/repair plan&services, basic design&supervision
- Connecting devices (IXL; 10 items): Electric-train devices, ground-signaling device, reliability, maintenance&reparability, safety, basic design&supervision, installation condition&services, training plan, testing&test-driving plan, parts/tools/equipment, maintenance/repair plan&services
- CTC (eight items): Auxiliary devices to the computer, resistance force to defects, software, central-control-room&display device, installation labor, training plan, testing&test-driving plan, parts/tools/equipment, maintenance/repair plan&services

- QA/QC (18 items): Quality control plan, organization, design control, guidelines, procedures&drawings, operation-storing-loading&control, materials&equipment control, special-process control, investigation, test control, testing, inspection&states, quality program records

- Technology transfer (33 items): Full-scope license, foreign-market sales rights, system engineering, conditions, vehicles, electric-car line, signal facilities design, automatic-train-control device, train concentration control device, connecting device, signal facilities, testing&test driving, signal facility installation services

- Localization (28 items): Vehicles, electric-car line, testing&test driving, installation of signal facilities, automatic-vehicle-control device, central-concentration control device, connecting device

- General&special conditions (48 items):

  ■ General conditions: General responsibilities (dispute mediation, etc.), design&manufacturing (guaranteeing the patents, etc.), installation&maintenance/ repair (contractor's installation services, etc.), contractor responsibility (contract&defect warranty, etc.)

  ■ Special conditions: Compensation for deferment, insurance conditions, joint surety of the contractor

- Project experiences (three items): Project execution capacity, experience in high speed rail construction, funding sources

- Scheduling (60 items): Contract scheduling, project objectives scheduling, scheduling-related data submission, production scheduling, detailed scheduling, 90-day scheduling, six-week scheduling, schedule adjustment, schedule meeting, progress reports, project management plan, administrative/mediation/technical/ industrial/quality/ purchase/operation management

3.1.2 First-Phase Proposal Evaluation

a. Evaluation process and overall opinions

Following the government's high speed rail project policies, High Speed Rail Construction Authority sent out the RFP to three countries -France, Germany, and Japan, which own high speed rail technologies -on August 26, 1991, and received the initial proposals on March 31, 1992 from three consortiums: GEC-Alsthom (France), Siemens AG Transport Group (Germany), and Mitsubishi (Japan). Despite the difference in the method and characteristics, the vehicle systems proposed by the three consortiums were determined to be suitable for the Gyeongbu High Speed Rail System in terms of technology and performance. Most of the contents of the proposals, however, such as the price, technology transfer and localization conditions, and scheduling, did not meet South Korea's expectations, and South Korea

requested the first supplement proposal (April 28, 1992), notifying that if the supplements do not meet its expectations, the priority of negotiation would not be determined, and the bid will be opened to other companies.

The supplementary proposals showed that while Alsthom in France was somewhat superior to the other companies in terms of financial conditions, technological development, control plan, and qualifications, Siemens in Germany was superior in terms of economic performance and overall technological aspects. While Mitsubishi in Japan was considered superior in terms of price conditions and scheduling, its proposal did not meet South Korea's expectations. Therefore, South Korea changed its policy to generate intense competition among the companies, and to drastically improve the level of the proposals.

Having submitted a report on such circumstances to the Social- Overhead-Capital Construction Implementation Committee, the Authority proposed the holding of simultaneous and multiple-party negotiations with the three countries as a measure. After the approval, the Authority officially notified the three companies of the initiation of simultaneous, multiple-party negotiations with them, the negotiation organization of South Korea, and the schedule on June 10, 1992.

b. Negotiation and evaluation results

The evaluation of the initial and supplementary proposals showed not only that the proposed content by area was well below South Korea's expectations but also that the proposing companies kept one another in check while maintaining their own stance. To cope with such circumstance and to drastically improve the level of the proposals so as to conclude the contract with a better price and better conditions, South Korea changed its strategy into simultaneous and multiple-party negotiations, which could lead to intense competition among the three companies.

As such, South Korea set the optimal negotiation goal and detailed negotiation plans by area, and the Authority held negotiations with South Korean and foreign specialists by area. Moreover, to ensure an efficient negotiation process, the Authority first underwent training sessions from KEPCO, which acquired extensive experience in international negotiations during the nuclear-plant construction projects, and from the Bechtel staff, who were international negotiation and contract specialists.

The vehicle negotiation was conducted by phase and area. The topics in the first-phase negotiation included the financial conditions, the technical aspects related to the performances of various equipment, state-of-the-art technology transfer and localization, contract conditions, and other sales area. The topics in the second-phase negotiation, on the other hand, focused on relating all the conditions to the price, with the primary objective of reducing the price.

(1) First-phase negotiation targets:

- Financial conditions: Stable procurement of project funding through a long-term loan with low interest by setting the target values on the overall loan conditions, such as the total amount of loans and interest rate, as well as the deferred term related to the export finance and commercial loan
- Technical areas: Leading to the construction of a low-maintenance/repair cost system that offers the best performance, and selecting the vehicles and amenities that are suitable for South Korea's circumstances
- Technology development: Ensuring the transfer of all the technologies, including and especially the state-of-the-art core technologies, to South Korea, to enable the construction of localized high speed trains therein, and minimizing the technology transfer cost related to the transfer process; ensuring that 44 vehicle groups, excluding the two sample vehicle groups, would be assembled in South Korea so that South Korean companies could participate as actively and intensively as possible in the vehicle manufacturing process
- Sales: Setting the target values on various responsibilities and obligations related to the project in such a way that the results would be beneficial to South Korea, and planning the scheduling so that each process proposed by South Korea would not pose any problem or give rise to any issue

(2) Second-phase negotiation targets (price):

- Setting the target price for all expenses related to the project, and encouraging each company that submits a proposal to competitively approach the target price; minimizing the factors contributing to future cost increases, such as market price increases

3.1.3 Second-Phase Proposal Evaluation

Through the first-phase negotiation by area with the three companies from June 16 to September 30, 1992, their technical level could be compared and verified, based on which South Korea requested the firm price by setting the work scope.

On September 30, 1992, the revised proposals from the three companies were received, and the second-phase proposal evaluation was carried out on October 10-29. The evaluation team, consisting of a total of 53 reviewers -29 from the Authority evaluation team, 21 from Bechtel, and three from Shin&Kim -evaluated the proposals based on the same method as in the first-phase evaluation, which was to score the proposals by area and to sum up the scores.

While the three companies proposed a firm price, it was very high based on the adjustment of the work scope and the foreign-exchange rates. They also continued to avoid

technology transfer, and the numbers of assemblies in South Korea were below what had been originally requested. Particularly in terms of core-technology transfer, while they granted the right to manufacture and sell vehicles, the target sales regions were restricted or required advance approval -all of which did not meet the expectations of South Korea at all. Even with regard to South Korean localization, they proposed a plan based on their own production price rather than one based on which the localization could be calculated, resulting in an extremely low reliability of the proposals.

a. Evaluation results

For the evaluation results for each area (i.e., cost, technology, technology development, and sales), out of 30,000, Alsthom in France scored 20,030; Siemens in Germany 19,983; and Mitsubishi in Japan 19,151. All the scores were about 63% of the total score.

b. Second-phase negotiation

Based on the price proposed by Mitsubishi, South Korea wanted to encourage Alsthom and Siemens to reduce their prices, and to compare and evaluate the further-reduced price proposals, but due to the unstable political circumstances at that time (presidential election, etc.), the negotiation became stagnant, and each company sat on the table with less enthusiasm.

Thus, the South Korean government changed its negotiation tactics to make them more realistic and concrete. First, it collected and analyzed the information on the actual transaction price of foreign high speed rail vehicles so as to estimate the price appropriate for Gyeongbu High Speed Rail, and in the negotiation, it focused on the difference between the estimated and proposed prices. Second, by comparing the proposed prices and the proposed supply amounts, it encouraged the reduction of the unit prices and the amounts of supply of the parts that were excessively overestimated (training cost, provisional parts, translation and interpretation services charges, and other labor fees). Third, it urged the three companies to participate in the negotiation of those parts that had not been agreed upon with greater enthusiasm (guaranteeing the system performance, core-technology transfer, localization, etc.), and explained the conditions by comparing them to those of the other companies so as to instigate a sense of competition among them. Finally, recognizing that the three companies were predicting the level of the proposal among themselves and attempted to adjust their proposal just below those of the two other companies and within the smallest scope so as to have the upper hand in the negotiation, the South Korean government advocated a strong policy against such tactic, announcing that it would exclude the company whose level of proposal is the lowest among the three companies, so as to urge them to participate in the negotiation with greater enthusiasm.

3.1.4 Third-Phase Proposal Evaluation

Having received the third proposals on December 10, 1992, the South Korean government evaluated the proposals on December 16. The evaluation team consisted of 51 reviewers -20 from the Authority's evaluation team, 19 from Bechtel, and 12 from specialist organizations and law firms -and the evaluation method was the same as that in the second-phase evaluation.

The third-phase evaluation and negotiation focused on the price. To encourage drastic price reduction from the three companies, the negotiation team adjusted the scope of some work and alleviated the overall conditions to the level of the custom of international trade, but the three companies could not meet the target price of the negotiation team. Nevertheless, the three companies sufficiently understood the request of the negotiation team and reviewed their first price revision and considerably lowered it.

As for technology transfer and localization, the three companies conducted practical negotiations with a South Korean company to accommodate the requests made by the negotiation team, and calculated and presented the localization price based on the estimates proposed by the South Korean company. As for the basic contract, general contracts, and some parts related to technology transfer, the negotiation team made some progress: it succeeded in concluding complete technology transfer and proposed a plan to establish a joint-investment company for the production of parts that require high-level technology.

The price proposed by all three companies, however, exceeded the target price (USD2.7 billion). While the price proposed by Mitsubishi was within the target price based on a simple comparison, if the standardization cost, financial and operational costs, and the costs of other economic performances were to be considered, it would have been higher than the price proposed by Alsthom. Furthermore, all the three companies excluded the core technology from the technology transfer.

Furthermore, the number of key assembly groups in South Korea was between 28 and 30, and the participation rate of South Korean companies was low (between 29.1 and 35.7%). Moreover, the technology transfer contracts concluded with South Korean companies were inadequate, and the proposals on the contract conditions and scheduling were not satisfactory. All these made the negotiation team feel that the request for additional proposal revisions was inevitable.

3.1.5 Fourth-Phase Proposal Evaluation

The fourth-phase proposals were requested on December 23, 1992, received on January 11, 1993, and evaluated and negotiated on January 12-30, 1993. All the three companies proposed prices that were between 10.4 and 26.9% lower than the prices in the second-phase proposals, and between 1.9 and 11.1% lower than the prices in the third-phase proposals, at USD 2.5 billion (Mitsubishi), USD 2.7 billion (Alsthom), and USD 2.94 billion (Siemens), getting closer to the negotiation team's target price.

The three companies, however, were still reluctant about the technology transfer of core technologies, and as for the localization proposal, the number of assembly groups in South Korea was merely around 31, and the participation ratio of the South Korean companies to the total proposed amount of the price remained at around 38%. Meanwhile, it was determined that the financial burden of South Korea needed to be minimized, and accordingly, another revision was requested to maximize the competition in the less-satisfactory areas and to encourage the submission of better proposals that would be more in keeping with the national interest.

3.1.6 Fifth-Phase Proposal Evaluation

As a consequence of the first to fourth proposal evaluations, some progress was made in the price and core technology. The overall conditions, however, did not meet the negotiation team's expectations. As such, the fifth-phase proposals were requested on February 3, 1993, were received on February 22, and were evaluated and negotiated on March 4-31, 1993.

The fifth-phase proposal evaluation focused on improving the less-satisfactory conditions in finance, localization, and technology, and on reducing the proposed price. In the review of the revised proposals, it was determined that the terms of repayment, such as the interest rate or contracted charges, were much improved, although there were some differences among the companies. In terms of technology transfer, the proposals extended the scope of free technical training and support as well as offered detailed technological-development plans. Some or all of the items excluded from technology transfer were removed, and the number of assemblies in South Korea or the localization ratio was also greatly increased.

3.1.7 Sixth-Phase Proposal Evaluation (Final Evaluation)

After reviewing the investment cost and construction process of the Gyeongbu High Speed Rail Construction Project on June 14, 1993, the South Korean government decided to revise some parts of the basic plan, such as the production process, vehicle supply schedule, and project scope.

To acquire better conditions and technologies, the final evaluation was conducted by a vehicle negotiation team consisting of specialists from the Authority and in various fields. The South Korean negotiation team consisted of 57 members (the Authority, Shin&Kim, Korea Development Bank, Foreign Exchange Bank, and Bechtel) while the French negotiation team consisted of 70 members.

After the contract negotiations for vehicle introduction and core technology that lasted for about eight months, the negotiation team announced the results on April 18, 1994. Below are the results of the negotiations for key issues, such as technology transfer and localization, as well as for technological issues, including warranty, thorough test drive, improvement of passenger facilities, and comfort of use.

- Price: USD 2.1016 billion (an about 43% reduction from the highest proposed price)
- Unprecedented technology transfer and localization of over 50% of the production cost
- Securing the right to supervise High Speed Rail Construction Authority in all technology transfer and localization processes
- If the localization failed to meet the goal, 20% of the rest of the amount will be paid as penalty.
- Reduction of the technology transfer fees: Free prepaid technical fees; sales technical fees reduced from 2.5 to 2%
- Securing the manufacturer's production, testing, sales, and world market advancement rights (except for the European and North American markets, on which further negotiation is required)
- Guaranteeing the Authority's right to use the already-developed technologies and ownership of the new technologies developed during the project
- Guaranteeing the performance for two years after the acquisition, and a five-year warranty after the contract for unpredictable defects
- Individual and joint responsibilities among consortium-participating companies over all the tasks performed
- Drastic improvement of various other contract conditions, operation experiences, and scheduling

3.1.8 Concluding the Contract

a. Negotiations for the contract

- Technical issues:
  - ○ Quality control: Based on ISO 9000, achieving the target quality of the related companies under the responsibility of the contract
  - ○ Data and drawings control: Conforming to the new design and revised contract conditions
  - ○ Running speed: Running speed of a normal-functioning train – 300 km/h; brake safety speed – 330 km/h
  - ○ Training: Testing, test driving, operation, and inspection training
- Offered by the contractor:
  - ○ Vehicle arrangement: 20 vehicles for one group (two power trains + two power passenger vehicles + 16 general passenger vehicles)
  - ○ Noise level of passenger vehicles: below 66-75 dBA

○ Environmental noise: Less than Lmax. 93 dBA (measured at 25 m from the noise source)

○ Air conditioner

○ Passenger information: 16-inch video monitors installed

○ Public phone: Six phones per group

○ Operational software: Offering operational codes; offering the source codes for the software required for entering the variables

○ Exterior design: Electronic calculation and wind tunnel test

○ Offering design software

- Technology transfer and localization

○ Offering the full-scope license: Offered to all the three South Korean companies in charge of manufacturing the vehicles

○ Sales regions: World market (further negotiations for EC and North America)

○ Calculation code for the localization rate: Domestic price to the total production price (excluding buy-backs)

○ Approval of the technology transfer contract: Concluding the technology transfer contract among the companies over the vehicle parts, which takes effect after the approval by the Authority

○ Next-generation R&D technologies: Participating in the co-research on France's next-generation high speed rail technology (350 km/h), aerodynamic technology while the vehicle is at a stop, and ten other research topics

○ Technology transfer among the companies: Executed according to the technology transfer contract by the transfer company

○ Intellectual copyrights:

· Contractor's ownership of the already-developed intellectual properties: Authority's non-exclusive right to use the intellectual properties for the high speed rail project and within South Korea

· Ownership of the intellectual properties after the contract: Authority owns the patents, and the contractor owns the non-exclusive right to use the intellectual properties

○ Guaranteeing the execution of the project

- Guaranteeing the execution of the contract

○ 10% of the total amount of the contract

○ Warranty over defects

E. Deposit: 5% of the total amount of the contract

F. Warranty period: 24 months after the acquisition, or 12 months after FSC (full-system commissioning), whichever comes later

○ Repayment of deferment

G. Rate: 0.05% of the item; 0.1% per day after FSC

H. Max. amount: 5% of the total amount of the contract

- Scheduling

○ The vehicle delivery schedule should conform to the total project plan or construction plan.

○ South Korean and foreign delivery level: CFR or FOB price

b. Concluding the contract on the introduction of vehicles and core system

On June 14, 1994, about two months after the announcement of the negotiation results, the contract on the introduction of vehicles and core system was concluded. The price and supply scope in the contract sealed between the owner, High Speed Rail Construction Authority, and the supplier, Korea TGV Consortium, are shown below.

(1) Price

- Total amount of the contract: USD 2.1016 billion (about USD 1.682 trillion)
- Foreign tasks: FFr 6.009542 billion
- Domestic tasks: USD 1.069843

(2) Supply scope

- Design of 46 groups of rolling stock (basic, detailed, and production designs), manufacturing, delivery of the completed vehicles, testing and preparation for the operation
- Design (basic and production designs) of the catenary, manufacturing, material supply, supervision of the installation and detailed design, testing and preparation for the operation
- Technical data, training and technical support for the technology transfer of the French company, the contractor, and over 50% of the localization of the equipment production price
- Training, testing and test driving, creating operation and maintenance/repair guidelines, supplying the provision parts and maintenance/repair tools, establishing and executing the maintenance/repair plan (for two years), offering various services, etc.

(3) Key contract conditions

- Mediating disputes: Based on the mediation regulations of Korea Commercial Arbitration Board, both parties appoint one arbiter each, and the third-party arbiter is appointed by Korea Commercial Arbitration Board.
- Task outcomes: The Authority owns the copyrights.
- Inspection and testing: The Authority reserves the right to review, request proof for, attend to, and reject the tasks or delivered goods if these do not conform to the contract provisions.
- Right to audit: The Authority owns the rights for claims and cost reimbursement, and reserves the right to investigate if the target localization has been achieved.
- Interface management: The interface management responsibilities shall be shared by the contractor and the concerned companies, and shall include the related tasks.
- Intellectual copyrights: Securing the Authority's right to use the already-developed intellectual properties as well as the right to own the intellectual properties developed during the project
- Contractor's liability for reparation: Within 10% of the total contract amount against the direct damages or claims that may arise during the project
- Right to cancel tasks: The Authority reserves the right to stop some or all of the related tasks.

c. Sealing the contract on the introduction of public loans

Another important task of the Authority was to supply a large amount of the fund for acquiring vehicles and core equipment through a long-term and low-interest loan. It was partly because of France's extensive financial offer that the Authority selected France (TGV) as its "prioritized negotiating partner." To initiate the loan based on such a financial offer, the South Korean government established the 1994 Public-Loan Introduction Plan, with the South Korean government as the loaner, and acquired the National Assembly's approval for such on December 16, 1993.

Even after the approval by the National Assembly, the South Korean government was not satisfied with France's final, sixth-phase proposal. Thus, for additional improvement of the financial conditions, it entered into a financial negotiation with Indosuez Bank for five months, from January 1994. After agreeing on the loan term sheet, the two parties signed the contract on May 27, 1994. Later, on August 12, the loan contract was sealed between 25 loan bank associations, including Indosuez Bank, and the former Ministry of Finance, which represented the South Korean government. As the outcome of the two-year-and-a-half-long negotiations, this contract allowed a total of USD2.337 billion worth of loans for introducing vehicles and core equipment by way of the export credits guaranteed by COFACE and the export-tied loan, which was connected to the export credits, as one

package. This allowed the South Korean government to acquire stable, long-term, low-interest funding in terms of interest rates and loan terms, which played the decisive role in establishing the infrastructure of the Gyeongbu High speed railConstruction Project.

<Progress>

- August 26, 1991: The RFP was sent out to France, Japan, and Germany.
  - ○ The South Korean government would be the loaner and guarantee the payment of part of or the whole proposed loan amount.
  - ○ The loan would be used to cover 100% of the vehicles and core equipment costs and the other domestic costs.
- July-August, 1993: Ministry of Finance's opinions on the Authority's foreign-loan plan
  - ○ The foreign loans, out of the loans for the vehicles and core equipment costs would be obtained as public loans, but a plan was required to minimize the contract charges.
  - ○ The localization cost was a kind of cash loan, and since after August 1986, foreign loans have been restricted under the foreign-investment policy. To obtain foreign-currency domestic loans, it was necessary to provide various plans for the use of the loan.

Table 3-3 | Key Loan Conditions Agreed upon by the National Assembly

Category	Export Finance	Tied Loan	Remark
Amount	USD 1,915 million	USD 825 million	
Interest rate	CIRR	Libor + 0.75 (average)	
Terms	18 years (including 8 years deferment)	15 years (including 8 years deferment)	

Source: Korea Rail Network Authority (2011)

- August 20, 1993: Final finance proposal by Alsthom, France, which was selected as the prioritized negotiation partner
- September 10, 1993: During the meeting with the Vice Prime Minister and the Ministers of Finance and of Transportation after the meeting with the Minister of the

Economy, it was determined, as a policy, to proceed with obtaining public loans also to cover the localization costs.

- September 24, 1993: Submitted a public-loan application to the Ministry of Finance
  - ○ Loaner: South Korean government
  - ○ Project owner: Korean High speed railConstruction Authority
  - ○ Estimated loan amount: USD 2.74 billion
  - ○ Projected loanees: International loaning team, including Indosuez Bank in France
- December 16, 193: The original motion on the introduction of public loans was passed at the National Assembly's 165th general meeting, with the conditions below.
  - ○ The government would stipulate the early-repayment and cancellation rights on the loan contract, and report every three years to the National Assembly if early repayment and cancellation would be necessary, which the National Assembly may review.
- August 12, 1994: The public-loan contract was concluded.
  - ○ Loaner: Minister of Finance
  - ○ Loanees: 25 South Korean and foreign financial institutes, including Indosuez Bank (seven South Korean and 18 foreign institutes)
  - ○ Loan amount: USD 2.337 billion (USD 1.617 billion exports finance; USD 722 million tied finance)
- August 26, 1994: The public-loan subcontract was sealed between the Ministry of Finance and the Chairman of the Authority, based on Article 26 of the Foreign Investment Act.

Table 3-4 | Final loan Conditions

Category	Exports Finance	Tied	Remark
Contrast amount	USD 1.617 billion	USD 720 million	
Interest rate	6.25% confirmed based on CIRR	Libor + 0.57%	
Terms	10-year redemption by installment (8 years deferment)	7-year redemption by installment (8 years deferment)	
Charges	Management charges: 0.4% Contract charges: 0.28% per year	Management charges: 0.7% Contract charges: 0.3% per year	
Capitalization	Interest and insurance premium	Interest	
Usage	Foreign-equipment purchases, exports insurance premium, interest and market price increase during the construction	Advance, South Korean equipment purchases, interest during the construction	

Note: Based on the vehicle contract results on June 14, 1994, the loan amount was reduced from that agreed upon by the National Assembly.

Source: Korea Rail Network Authority (2011)

d. Concluding the train wireless communication system supply contract

It was originally planned that the train wireless communication system would be established by the exclusive proposal together with the core system, and all three countries proposed the wireless communication system that was in use in their own country. This equipment, however, was old and in the analog format, and the proposed amount was too high. Thus, the negotiation team asked for the proposal of a frequency-sharing method based on digital technology, but no proposal was satisfactory. Thus, the train wireless communication system was separated from the core system and was ordered independently. After the call for project proposals in the newspapers in 10 countries, including the U.S., U.K., and Germany, seven companies from the U.S., France, Germany, and Switzerland showed interest in participating in the project.

As of May 1994, the deadline for the proposals, only two companies in the U.S. submitted proposals, which were reviewed by a committee consisting of scholars and researchers in South Korea and abroad. As a result, Motorola was chosen as the prioritized negotiation partner, and after negotiations with the company, the negotiation team concluded a contract with it on April 22, 1995, at about USD 83.4 million, which was 38.5~53.8% lower than the amount indicated in the high speed rail proposals. The performance of the resulting system was superior to, and its functions were more diverse than, those in the previously proposed systems. As such, the negotiation team was able to integrate wireless communication systems in all areas of the high speed rail system, resulting in efficient operations.

<Basic Conditions of the Train Wireless System>

- Efficient support of the centralized control system for all trains
- Securing the communication zone in over 98% of all the system zones
- Securing sufficient data and voice communication capacities between land and trains
- Securing the reliability through the establishment of a no-barrier system by doubling the principal equipment and parts
- Zero-disturbance system insusceptible to electromagnetic waves caused by high-voltage lines around the railway
- The central command center can perform surveillance and control functions of the land and train systems
- Allowing emergency calls, general calls, and group and individual calls, and allowing the setting of calling priorities
- Allowing handover at a high speed (over 300 km/h)

4. Technology Transfer and Localization

The agreement between both parties on the technology transfer and localization through the six-phase negotiation, and the resulting contract, were smoothly executed in the construction of Gyeongbu High Speed Rail and the vehicle production process. As a result, before April 2004, when the first stage of Gyeongbu High Speed Rail opened, all the agreements were realized as planned.

4.1 Vehicle Production

According to the contract, the initial 12 groups of vehicles out of the total of 46 groups would be produced in France and assembled in South Korea while the rest of the 34 groups would be produced and assembled in South Korea. The initial 12 groups of vehicles were produced in 10 factories in France, Belgium, and the U.K. from 1995, and were brought to South Korea from 1998, and after the assembly, vehicle tests, and test drives, they were introduced to Korean National Railroad Authority for two years, from 1999.

Rotem, Inc., the largest South Korean railway vehicle producer, began producing the vehicles that were planned to be produced in South Korea, manufacturing and assembling the locomotives, passenger and locomotive-passenger vehicles, and joint rings. These vehicles were produced in phases beginning in 2001, for two years, and were gradually brought into Korean National Railroad Authority by 2003.

4.2 Technology Transfer

The technology transfer related to vehicles concerned all the parts and auxiliaries required for the production of vehicles, electric-car lines, and train control, and the agreement was for the contractor to offer technical data consisting of a total of 29 items as well as 350,000 technical documents, and to train and provide support for 2,000 technicians. Such technology transfer contract subsequently proceeded without any problem, and the letter of the agreement in all the items that confirmed the official completion of the technology transfer between the company that offered the technology and each company that was to receive the technology transfer was submitted to the South Korean government on December 29, 2003.

Table 3-5 | Progress of the Technology Transfer

Category	Plan	Outcome	Ratio (%)
Technical data	352,145 sheets of technical data	353,370 sheets of technical data	100.3
Technical training	1,120 people	1,194 people	106.6
Technical support	892 people	1,027 people	115.1

Source: Ministry of Construction and Transportation, KICTEP (2007)

4.3 Progress of the Vehicles and Parts Localization

The localization of the vehicle-related parts was divided into vehicle production and assembly, electric-car lines, and train control. In the first phase of the localization, two groups of sample vehicles manufactured by Alsthom in France were brought to South Korea and were reassembled and subjected to a factory test drive, employing the services of the technical personnel trained in France, through which the South Korean technicians could acquire group assembling and testing skills. This was completed in 2001.

In the second-phase localization, ten groups of vehicles produced in France were brought to South Korea, and using the acquired assembling and testing techniques in the first-phase localization and with technical support from Alsthom, the locomotive and locomotive-passenger vehicles were connected, and vehicles and trucks were assembled, group-assembled, and tested at the factory by 2001.

In the third-phase localization, parts were produced, and after passing the performance inspection through individual tests, such parts were manufactured and installed on the vehicles that were also manufactured in South Korea. In this phase, KTX No. 13, the first vehicle produced in South Korea, was completed in 2002, and in 2003, KTX No. 46, the final group of South-Korean-made vehicles, was completed, signaling the completion of the localization of the vehicles. As such, five years after the production of two sample train sets, South Korea achieved a 93.8% localization ratio.

The localization of electric-car lines was also divided into two phases. The first phase involved the localization of parts like clips and stress cones that were required for the Cheonan-Daejeon zone, the test zone, by 1999, and the second phase involved the completion of the localization of the electric-car lines, clips, and stress cones that were to be used in the zones other than the test zone by 2001. The localization of train control also proceeded in two phases. The first phase involved the completion of the localization of ATC devices (railway line facilities, detectors, etc.), IXL devices (relays, frames, power devices, input/output devices, etc.) that were to be used in the test zone by 2000. The second phase involved the completion of the localization of ACT devices (top parts of the vehicles, interiors, railway line facilities), CTC devices (command console, computers, LAN facilities, software), and IXL devices (electronic-connection devices, display panels, railway line converters, software) that were to be used in the zones other than the test zone.

The actual localization ratio of the vehicles, electric-car lines, and train control devices through technology transfer according to the localization contract was 55.4% at the end of November 2003, exceeding the target ratio in the contract (50%).

Table 3-6 | Localization Outcomes of the Vehicles and Parts

Category		Localization Scope
Vehicles (~10/2003)	1st Phase (two sample train sets)	Reassembling, testing, and test driving of two sample train sets (KTX 1, 2) in South Korea
	2nd Phase (10 train sets)	Assembling, testing, and test driving of train sets (KTX 3-12), and manufacturing joint rings in South Korea
	3rd Phase (34 train sets)	Reassembling, testing, and test driving of 34 train sets (KTX 13-46) in South Korea
Electric-car line (12/1996-12/2001)	1st Phase (sample line section)	Localization of primary and secondary parts, small steel parts
	2nd Phase (sections except the test section)	Localization of all parts (excluding the items that offer no economic value)
Train control device (03/1995-10/2003)	1st Phase (testing section)	Introducing foreign materials; some parts are assembled in South Korea
	2nd Phase (Gwangmyeong-Daegu)	Manufacturing basic parts; assembling and testing key parts

Source: Ministry of Construction and Transportation, KICTEP (2007)

5. Development of the High Speed Rail Technology

5.1 G7 High Speed Rail Technology Development Project

5.1.1 Overview

The High Speed Rail Technology Development Project, one of the Pioneering Technology Development Projects (G7) promoted by the Ministry of Science&Technology, was participated in by various government departments, including the Ministry of Construction and Transportation as the center and the Ministry of Commerce, Industry, and Energy and the Ministry of Science and Technology as its partners, and led by Korean Railroad Research Institute, the project was participated in by 4,934 researchers from 129 organizations (82 companies, 18 research institutes, and 29 universities) from December 1996 to October 2002. The final goal of the project was "to develop the Korean High Speed Rail System with the maximum operational speed of 350 km/h and while securing core technologies." A total of KRW 210.1 billion (KRW 105.2 billion from the government and KRW 104.9 billion from the private sectors) was invested in the project.

The project was largely divided into two parts. The first part promoted the project through analysis and design while the second part promoted it through manufacturing, testing, and results evaluation.

Table 3-7 | Milestones of the Korean High Speed Rail Technology Development Project

1st Phase (12/96-10/99)	- Determining the next-generation South Korean system specifications and detailed design - Manufacturing the sample vehicle and developing the first sample of the signal device - Developing an original design technology and producing technical personnel - Developing a railway line structures design technology
2nd Phase (11/99-10/02)	- Developing an independent 350 km/h testing evaluation technology and creating and test driving the sample vehicle - Acquiring the original design technology and independent system engineering technology - Developing an independent railway line structure design technology

Source: Ministry of Construction and Transportation, KICTEP (2007)

The High Speed Rail Technology Development Project concentrated on overcoming the technical issues due to the increase in the vehicle operation speed compared to KTX, on the existing high speed rail system, and on acquiring an exclusive technology.

- Improving the pulling force and reducing the vehicle air resistance
    - ○ Developing a large-capacity main power converter, induction motor, and transformer
    - ○ Applying the air-resistance-reducing structure to the lower part of the vehicle
    - ○ Developing lightweight vehicles (the main body and devices)
    - ○ Minimizing the air resistance of the front part of the vehicle
- Driving safety
    - ○ Analysis of the vehicle fatigue strength
    - ○ Developing a lightweight body and revision of the vehicle frame structure
    - ○ Characteristics analysis and development of a suspension device for high-speed operation
- Braking system
    - ○ Additional development of an eddy current braking device
    - ○ Developing and implementing wheel and ventilation discs
- Collector and signal devices
    - ○ Developing the vehicle/line interface and dynamic characteristics analysis, and a collecting device
    - ○ Developing new line system design and materials according to the speed improvement
    - ○ Establishing a compatible signal system (developing automatic train control, concentrated train control, and an electronic-tied device)
- Environmental measures
    - ○ Developing various devices and technologies for reducing noise (vehicle body and truck, etc.)
    - ○ Developing an absorptive technology for improving the tracking performance (fixing tools, dust proofing materials, slab tracking, etc.)
    - ○ Developing a technology for tunnel and bridge characteristics analysis and measures
    - ○ Establishing an electromagnetic-effect analysis and impact assessment system

Table 3-8 | Core Technologies of the Korean High Speed Rail System

Category	Korean High Speed Rail System (G7 Project)	KTX	Remark
Max. operation speed	350 km/h	300 km/h	
Front	South Korean	TGV	Aerodynamic design
Body	Aluminum	Mild steel	Material technology
Pulling motor	Induction motor	Synchronous motor	
Main power converter (power device)	IGCT	GTO	
Pressure control system	Pressurization system	Ventilation openings	
Braking system	Friction, regeneration, eddy current	Friction and regeneration	

Source: Ministry of Construction and Transportation, KICTEP (2007)

5.1.2 Outcomes of the G7 Project

Through the G7 Project, a high speed rail system with the highest speed of 350 km/h was manufactured using South Korea's domestic technology. The following is a summary of the project's key outcomes.

Table 3-9 | Key Outcomes of the G7 Project

Category	Research Contents
System engineering	- Establishing system engineering management and technical systems - Performing comprehensive control and test driving/inspection/ assessment based on the testing and assessment plan - Completing system performance assessment and performance assessment technology - Reviewing the performance of the comprehensive test-driving system, and establishing the measurement system - Developing a sample signal control product, and integrated testing - Developing an integrated signal control system simulator and an electric/ electronic environmental assessment and measurement system - Developing a railway line structure performance improvement technology and a test-driving performance assessment technology - Reviewing the performance and safety of railway line structures based on test driving
Vehicle system and parts	- Establishing a vehicle system engineering technology system - Establishing a vehicle system and parts assessment plan, setting the assessment standards, and confirming the specifications - Developing and assessing the sample vehicle system and parts - Completing and manufacturing the detailed design of the vehicle system and electronic components - Optimized design of the vehicle system, and completing the sample vehicle production - Establishing a plan for the integrated vehicle electrical-system test, revising and diagnostic control plan - Carrying out a performance test of the sample vehicle - Supporting the integrated test driving and testing/assessment

Source: Ministry of Construction and Transportation, KICTEP (2007)

5.2 High Speed Rail System Technology Development Project

5.2.1 Overview

The High Speed Rail System Technology Development Project was conducted in tandem with the G7 Project, whose goal was to establish a stable, reliable, and safe system from the Korean High Speed Rail System developed in the G7 Project. The term of the project was planned to be five years, from December 2002 to October 2007, and the total budget for the project was KRW45.7 billion (KRW 35.3 billion from the South Korean government and KRW 10.4 billion from the private sector).

Below are the key research topics for the project:

- Stable and practical technology development by acquiring the reliability of the Korean High Speed Rail System
- Technological development of an integrated passenger-freight transportation system
- Establishing a high speed rail system that meets both the safety and performance standards
- Developing South Korea's own multiple-propulsion system technology

For the effective promotion of the research, the project was divided into two parts: (1) reliability and safety system development, and (2) system stabilization.

5.2.2 Progress of the project

The project was led by the Ministry of Construction and Transportation, and research institutes, including Korea Railroad Research Institute as the main research body, were selected based on eight objectives. The project started in December 2002 and went on for five years, and the two objectives -development of a high speed rail performance standard and safety system, and development of a high speed rail vehicle development system -were completed in the fourth year while the rest of the six objectives were pursued until the fifth year.

The maximum speed of the high speed rail system developed by the G7 Project was 350 km/h, which was faster than 300 km/h of the existing KTX, and the new high speed rail system started to operate in March 2010.

Table 3-10 | Key Research Topics by Objective

Objective	Key Research Topics
Integrating and overseeing the high speed rail technology development	- Controlling and overseeing the high speed rail technology project - Overseeing the procurement of maintenance/repair parts - Controlling and adjusting the subcategory task schedules
Development of the technology for improving the reliability and operational efficiency of the high speed rail system	- Acquiring a reliability assessment technology - Establishing a comprehensive measurement system - Integrating and commercializing development S/W - Technical survey of the high speed rail integrated transport system - Integrated transport system design, implementation and feasibility analysis - Developing an operational-efficiency infrastructure technology
Development of the high speed rail performance standard and safety system technology	- Analysis of cases in foreign countries on the high speed rail performance standard and safety system - Producing a draft on the performance standard and safety control system - Reviewing the technical aspects of the draft, and collecting opinions on it - Establishing the South Korean high speed rail performance standard - Establishing the South Korean high speed rail system safety control system - Legislating the performance/safety standards
Development of structure technology of the high speed rail vehicle system	- Analyzing the sample vehicle parts performance test, and establishing measures - Technical support for the test driving of the vehicle system - Establishing the vehicle system development structure - Establishing the quality control of the vehicle system
Development of stability technology of the high speed rail vehicle system	- Stabilization test for vehicle system stabilization - Vehicle system maintenance/repair - Revised design for practicality - Practical system development and performance assessment - Establishing a vehicle system maintenance/repair system
Development of control system stabilization technology of the high speed rail system	- ATC/CTC/IXL stabilization and reliability test - Producing and analyzing train-control-related hazards - Analyzing the safety requirements and plan - Establishing a safety inspection system - Related H/W and S/W development - Life cycle stability analysis

Objective	Key Research Topics
Development of the high speed rail track structure stabilization technology	- Development of a track structure safety improvement technology - Study on the commercialization of the developed products, including high-speed turnout - Development of a parts reliability tracking technology
Development of a South Korean multiple-propulsion system technology	- Analysis and confirmation of the multiple-propulsion system application plan - Selection of the multiple-propulsion system capacity and characteristics analysis - Characteristics analysis and test assessment of the multiple-propulsion system - Test driving and assessment of the developed system

Source: Ministry of Construction and Transportation, KICTEP (2007)

A high speed rail system with the maximum speed of 430 km/h (HEMU-400X) is currently being developed. As the operation stability test was successfully completed in October 2011, it is projected that the developed system would go through performance and stability assessment via test driving in 2012.

6. Selection of the Construction Companies and Construction of the Test Railway Section

6.1 Selection of the Construction Companies

For the bidding method for selecting a contractor for the Gyeongbu High speed rail Project, pre-qualification (PQ) was chosen so that only qualified companies could participate in the bidding. In addition, the open-competition principle was used for those who were selected via PQ, and considering various conditions, one construction zone was set to be around 10 km to promote clear construction and to accumulate technical experience.

6.1.1 Bidding Process

To have a healthy and excellent contractor who would use advanced construction equipment and highly skilled personnel to complete the project within the given term, and who would conduct international-level quality control and process control, the PQ system was used as a bidding process for all the bidding participants. While allowing a joint-venture contract to extend the bidding opportunity to small and middle-sized companies, and for technology accumulation, measures were also implemented in the bidding process to prevent poor construction due to a joint-venture contract by only small and middle-sized companies.

6.1.2 Improvement of the Bidding Process

The second project plan revision in September 1997 strengthened the qualifications of the contractors and limited the number of joint-venture contractors. Specifically, the revision plan allowed the participation of companies that had little experience in bridge and tunnel construction and that had few contract limits, and allowed up to five companies to submit a joint-venture contract, which might lead to poor construction (35 companies in 16 construction zones). Thus, the revised plan raised the contract amount limit to KRW400 billion from KRW 35 billion. Further, the number of companies in a joint-venture contract was adjusted from five to three companies, and priority was given to companies that had acquired ISO quality certification.

6.2 Commencement of the Test Railway Section

In March 1992, Korean High Speed Rail Construction Authority, which was to lead the project, was established, and the practical procedure for the commencement of the project began. On June 30, 1992, the groundbreaking ceremony on the test railway section [the first four construction zones (39.6 km) among the seven test railway sections] was held.

A test section was constructed because the high speed rail system had trains running over 300 km/h, and because the system was a state-of-the-art technology that was to be implemented in South Korea for the first time. Therefore, it was necessary for the project to go through sufficient performance and safety tests before the commencement of the construction in all the sections. The Cheonan-Daejeon section was selected as the test section because this region had various topological characteristics, such as tunnels, bridges, and earthworks, which were required for the test. Moreover, while the region was relatively close to Seoul, there were no large cities nearby; as such, it would be less affected by the noise and vibration generated in the test operation.

7. Preparation for the Opening and Operation of the High Speed Rail System

7.1 Completion of the First-Phase Construction Project, and Execution of a Commercial Test Run

7.1.1 Completion of the First-Phase Construction Project

Since after the target process was completed in 2001 and 2002, in the first half of 2003, the construction of all facilities, including the sub-base course, tracks, and power facilities, was completed, and from May, the high speed vehicle was placed in the Gyeongmyeong-Cheonan zone for the performance of a facility performance test. Moreover, the substation at Busan Vehicle Depot, the final substance in the first-phase zone, successfully started receiving electricity on October 1, 2003, and all the seven substances that were to offer

power to high speed vehicles, and the supporting facilities, were ready for operation. Thus, the power supply preparation for the 409.8-km-long first-phase section was completed.

Meanwhile, Seoul Station started its operation on November 28, 2003 to prepare for the official opening in April 2004, and the construction of Cheonan-Asan Station was finalized at the end of 2003 and was completed towards the end of March 2004, after continuous performance testing and supplementary construction of passenger facilities. Towards the end of April of the same year, Gyeongmyeong Station was also completed. The revision of Busan, Daejeon, and Dongdaegu Stations was completed towards the end of September 2003.

The final KTX No. 46 was shipped out on November 28, 2003, and since October 17 of the same year, an integrated test drive in cooperation with KORAIL had been conducted between Seoul and Busan.

7.1.2 Completion of the Test Drive, and Execution of a Commercial Test Drive

After their acquisition, the high speed rail vehicles were subjected to an integrated test to confirm the comprehensive performance of the system. The integrated test was performed to verify various performance issues of each system (e.g., vehicle, track, power, signal, communication, CTC) while the test vehicle was running on the railway where it was to operate, to discover and address any potential problem in advance.

The integrated test, targeting all the railway sections, was performed in tandem with the train operation time and energy consumption. The Gyeongmyeong-Bukdaejeon section (135.6 km), including the test railway section, underwent the running test at 300 km/h from July 18 to August 14, 2003, and the test drive was extended to the Daejeon-Daegu section from October to November 7 in the same year.

The test drive on the Daejeon-Daegu zone measured the truck vibration acceleration of the KTX vehicle, the derailing rate of the electric railway line, the performance of the power supply system, and the wireless communication system while increasing the speed in six stages, from 60 to 300 km/h. The running test at 300 km/h on November 7, 2003 satisfied all the standard values and was completed.

After completing the running test between Daejeon and Daegu, the KTX test drive that had been performed only between Seoul and Daejeon was extended to Seoul and Daegu until the end of 2003. From January 2003 until the official start of the service, a commercial test drive was performed, which assumed normal business operations, with the staff onboard.

7.2 Preparation for the Official Start of the Service

7.2.1 Organization of the Preparation for the Integrated Operation

As the high speed rail should be differentiated from the then-existing railway operation system as it is operated by a state-of-the-art system and requires higher service quality, the South Korean government established the "Integrated Operation Preparatory Plan" in December 2001 for the preparation for the official opening of the service, and for the subsequent operations. The preparatory plan was divided into seven propulsion fields, each of which was assigned to the Ministry of Construction and Transportation, KORAIL, and Korean High Speed Rail Construction Authority.

Table 3-11 | Key Issues of the Integrated-Operation Preparatory Plan

Category	Unit Task
Operation organization and personnel training	Construction of the operational organization | Personnel training and control
Operation system and business strategy	Reorganization of the operation system and regulations | Establishment of an integrated train operation plan | Establishment of an integrated information system | Establishment of safety and security measures | Establishment of a tied-transport system | Securing the operation facilities and operating amenities | Establishing marketing strategies | Developing auxiliary-profit projects | Strengthening the international cooperation
Test driving	Test drive of individual systems | Integrated test operation | Organization of the test operation and control agency
Maintenance/ repair	Maintenance/repair of high speed trains | Maintenance/repair of infrastructure facilities
Transfer and acquisition	Data control and transfer | Transfer/acquisition of assets and debts
Preparation for the official start of the service	Final checkup before officially starting the service | Notice of confirmation of the official service start date | Formulating the opening-ceremony plan

Source: Korea Rail Network Authority (2011)

As of the end of January 2002, an integrated operation organization began operating as a manager had been assigned for each operation preparation field, to regularly check the status of the preparation. In August of the same year, the High speed rail Operation

Preparatory Task Force Team (team leader, a secretary, one administrative officer, two six-grade officers, two dispatched staff members from KORAIL, and one dispatched staff from the Authority) was expanded and reorganized for the preparation for the operation.

7.2.2 Concluding a Business Agreement between the Authority and KORAIL

In June 2003, in the process of preparing for the start of the operation of the High Speed Rail System, the Railroad Industry Structure Reform Management Act was established, which effectively separated the construction and operation subjects. The Authority and KORAIL thus concluded a business agreement in September of the same year for the opening and operation of the High Speed Rail System. The basic issues of the agreement were the spot acquisition before the legal transfer and acquisition of the operational assets, the transfer of the right to use the High Speed Rail System facilities and assets, and the support of the Authority by dispatching technical personnel to KORAIL in preparation for the opening of the service.

7.2.3 Preparation for the Operation by Area

a. Operating staff training and management

To recruit talented workers who could operate the state-of-the-art high speed rail system, and to produce elite operation specialists trained through systematic educational programs, an operating-staff training program was developed.

Based on Article 18 of the Korean High Speed Rail Construction Authority Act, a high speed rail operation organization was established in KORAIL. Among the total of 3,039 operational workers (estimation by KORAIL as of December 2000), 2,259 workers completed the theory and simulation training program by the end of December 2002, and 80 high speed train engineers and 84 high speed rail maintenance/repair engineers received OJT.

Since after the conclusion of the core training contract in June 1994, particularly since 1996, the Authority had offered domestic and overseas training programs to the operation, central command, and other related staff, and the planned 320 staff members completed the training. Since August 2002, the Authority had conducted OJT for KORAIL's train engineers, CTC operational staff, and train attendants, completing the practical training for 4,044 workers by August 2003.

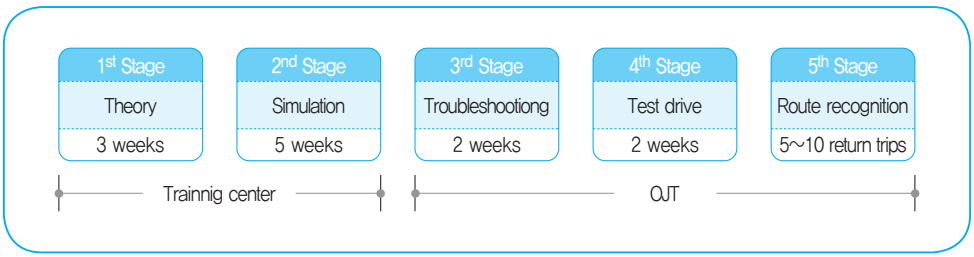
b. Producing high speed train engineers

The high speed train engineers were selected among KORAIL's train engineers with at least five years' experience, based on the aptitudes and health conditions. The selected engineers were trained by 20 training staff who had received dispatch training in France.

The high speed train engineer training program was systematically designed to consist of

theories, practical training, and test driving, and it took at least five months for it to produce one train engineer. Specifically, the training program consists of three stages, with theory training in the first stage, simulation-based training in the second stage, and troubleshooting training in the third stage, all of which were given at the training center. Later, in the fourth and fifth stages of the program, the trainee engineers were subjected to test driving and route recognition training, respectively.

Figure 3-1 | The Five Stage of the High Speed Train Engineer Training Program



Existing route recognition : 13 return trips by zone (137 hours)/per engineer (October-November 2003)
High speed rail route recognition : 4 return trips by zone (50 hours)/per engineer (October 2003-March 2004)

During the theory training, the trainee engineers learned various operation regulations and theories related to the high speed train operation, and during the simulation-based training, they underwent simulated-driving tests on a simulator vehicle that offered operation conditions almost the same as those of the actual vehicle. Later, through the test driving of the actual vehicle, the trainee engineers received static-and dynamic-troubleshooting training and finally completed the high speed rail route recognition and simulation training.

c. Test drive, maintenance/repair, and transfer/acquisition

To cope with any potential issue during the actual operation of the system, test driving and various facility inspections were performed, and various systems were established by March 2004.

As for the test drive, the Authority conducted and completed a performance and design verification test on the individual systems (high speed trains, electric railway lines, power, signal, etc.) in the test section from December 2002. In March 2003, the vehicle acquisition test was conducted, and it was completed by the end of January 2004. The test drive on the connectivity between the high speed train wheels and the railroad in the existing railway section was successfully completed (January-June 2002), and in March 2003, when the existing railway renovation project had been completed, the full-scale test was conducted. Further, in October 2003, an integrated test was conducted, where the dynamic connectivity between the individual systems and the high speed trains was inspected and revised. The test was completed at the end of January 2004.

7.2.4 Supporting Tasks for the Preparation for the Official Start of the Service

a. Establishment of a joint regular inspection system among the concerned organizations

As the first-phase Gyeongbu High Speed Rail Construction Project progressed as planned, the official start of the service was set to April 2004. Thus, the Ministry of Construction and Transportation, the Authority, and KORAIL established a joint regular inspection system. Targeting the wide-scale promotion of the safe operation and high-quality passenger services of the high speed rail system, the three organizations held a joint inspection meeting to inspect the progress of the project and test drive plans, and discussed the related key issues and various alternatives of each organization.

The Authority made an early transfer of the high speed rail assets and the maintenance/repair tasks of the facilities in new railway zones to KORAIL, and dispatched its special task force to KORAIL to support the official start of the system operation, which helped in the successful opening of the high speed rail system.

For the final inspection before the official start of the service, the Ministry of Construction and Transportation organized the Opening Task Force in May 2003, and the Authority also established the Opening Preparatory Team for thorough post-event management through the systematic integration and adjustment of the opening-related preparatory tasks. In June of the same year, KORAIL organized and used the Integrated High Speed Rail Operation Preparatory Center for checking potential issues, making final adjustments, and providing measures.

b. Installation and operation of the Opening Preparation Status Room

In August 2003, to promote the successful start of the service, the Authority monitored the status of KORAIL's opening preparations and provided the necessary measures to address the various problems that were discovered through the field checkups and inspections by installing and operating the Opening Preparation Status Room.

7.2.5 Establishment and Execution of Safety Measures in Prearation for the Opening

a. Comprehensive facilities inspection by foreign specialists

(1) Goal

The High Speed Rail Construction Project consisted of a complex system in which various technologies in sub-base courses, tracks, power, communication, signal, vehicles, etc., are integrated. During the construction, various entities in design, inspection, and construction promoted systematic quality control activities that met the ISO 9001 standards, ensuring good quality through preventive training and inspection activities. In addition, the

continuous test driving in the test zone between Cheonan and Daejeon enabled sufficient inspections of the performance of the high speed rail facilities and vehicles.

To increase the South Korean people's trust, however, in the preparation for the opening of the first-phase business section, the South Korean government came up with a comprehensive inspection plan, to be executed by a foreign inspection specialist organization. After the conclusion of a contract with SYSTRA (France) for this purpose, a three-month comprehensive inspection was conducted from September 23 to the end of December 2003.

Consisting of nine members, including specialists in each related area and special UIC members, the inspection team conducted a comprehensive inspection of the performance and safety of the facilities (earthwork, tracks, electric railway lines, control, and communication) and the vehicles, using the same inspection method that was implemented for France's high speed rail system.

(2) Inspection results

The results of the inspection showed that the quality of the sub-base course, track, and other facilities was good. Not only were they constructed based on the exact guidelines regarding the design, construction, test, and test drive stages; their quality was comparable to that of any European high speed rail system that was already in operation. Moreover, the system facilities, such as the power, signal, and communication, were excellent in terms of the production and purchase processes, and the field construction status was considered appropriate. After taking a KTX train ride, the team concluded that the train was very stable dynamically, and that there is likely to be no problem that could affect the system's commercial operation starting in April 2004. The team, however, presented a total of 21 recommendations, 16 improvement measures to be made before the official opening of the service, and five required for the future maintenance and management. The Authority completed all the recommended measures by March 26, 2004, before the opening.

b. Safety checkup

The first-phase Gyeongbu High Speed Rail section that opened in April 2004 is 409.8 km long, and about 19% of the zone consists of tunnels (52 tunnels, 76.4 km). There are three tunnels (26.4 km) that are over 5 km long: Iljik Tunnel (10.3 km) from Gyeongmyeong to Asan in Gyeonggi; Hwashin Tunnel (6.3 km) in Yeongdong, Chungbuk; and Hwangak Tunnel (9.9 km) between Yeongdong, Chungbuk and Kimcheom, Gyeongbuk. Moreover, five out of the total of six stations are on the ground while Gyeongmyeong Station is on the semi-basement.

The railway construction for KTX and high speed trains was designed and executed based on France's standards, and their safety was achieved through thorough vehicle tests and test drives. Before the first-phase opening of the system, however, the South Korean government established safety measures by area, and conducted safety checkups with the current vehicles, particularly on the structures and safety facilities, to ensure complete stability.

(1) Fire drill with the current vehicles by independent specialists

The passenger interior materials in all KTX vehicles are of A1 grade, the highest quality material grade under France's industrial code (NFF-16101), and have been designed with nonflammable and nontoxic materials to prevent fire. Each item was tested by an official fire-testing agency, and after the testing and confirmation, was used in the production.

In particular, the South Korean government conducted a fire test on KTX vehicles on March 11, 2003, with KORAIL, Rotem, and EUKORAIL officials attending. At the fire test, an about-900ºC flame thrower was used to set on fire the passenger floor materials, walls, ceilings, curtains, and seats, to measure the self-extinguishability and the degree of smoke creation. The results showed that all the materials were self-extinguishable and created little smoke, thus posing no threat of fire. Another actual fire test was conducted outside Goyang Vehicle Depot, which proved the excellent fireproof quality and self-extinguishability of KTX materials. Furthermore, various fire detection and alarm equipment were installed in the vehicles to address any potential threat.

(2) Station fireproof measures

All the fireproof facilities in the stations were designed and constructed based on the firefighting plan and facility standards set by a special firefighting agency. Gyeongmyeong Station, however, installed on the semi-basement, may pose a fire threat. To remove all threatening elements, the South Korean government had a special service agency review an evacuation plan in the event of a fire by commissioning "Firefighting Research," and took precautionary measures for unexpected fires by inspecting the flow of smoke in the event that a fire breaks out, via computer simulation.

(3) Tunnel firefighting measures

For the firefighting facilities in the tunnels, emergency lights, exit lights, evacuation passages (1.7 m wide), and handrails were installed in all the tunnels to facilitate the passengers' evacuation. To enable communication via cell phones in emergency cases, antenna cables and wireless phones were installed. Evacuation passages were also installed in the long tunnels (over 5 km).

In addition, for the easy passage of emergency and firefighting vehicles in case of fire, each tunnel was equipped with an access road and a vehicle return road, and for fire direction in KTX vehicles, vehicle axle temperature detectors were installed outside the railway.

(4) Sub-base structures safety inspection

To ensure the safety of the high speed rail, a comprehensive safety inspection of the constructed structures was conducted by WJE (USA) between June 1992 and April 26, 1996. The results showed that 39 structures required partial reconstruction; 109 structures required minor repairs for small cracks, etc.; around 200 structures required surface finishing improvement; and the other 583 structures required no repair. Overall, WJE found no structural-safety issue.

In addition, the South Korean government commissioned Korea Infrastructure Safety Corporation to conduct regular safety inspections for the structures constructed between April 27, 1996 and April 30, 1998, and Korea Infrastructure Safety Corporation and seven other organizations to conduct regular safety inspections for the structures constructed between May 1, 1998 and April 30, 1999. These regular inspections revealed no structural cracks or leakage, and that over all, all the structures were safe and appropriately constructed based on the design specifications.

The sub-base structures had been built in sequence since 1999 and in compliance with Article 6 of the Special Act on Facilities Safety Management, defect inspection and thorough checkup were conducted every six months to verify the safety conditions of the structures. In particular, the Authority headquarters and KCQR, which were registered as safety inspection agencies, and two other agencies, conducted thorough checkup and defect inspection of the structures in the prioritized zone (Seoul-Daegu) in preparation for the official start of the service. The results revealed no structural issues, but minor recommendations were made, such as the repair of small cracks and surface finishing, which were undertaken based on the repair specifications.

(5) Tracking test and inspection to ensure high-quality service

As the tracking construction in the first-phase Seoul-Daegu zone proceeded as planned, a tracking inspection test in tandem with a 300 km/h acceleration test for the KTX vehicle was conducted in the already-completed zones. This test used the ultrasound detection car that examined in detail the condition of the rail, and the self-propelled track inspection car that accurately measured the precision of the tracking slopes in millimeters. Under warranty and by the supervision of the French technical team, which oversaw the supervision of the said zone, the inspection was conducted error-free.

The results of the track inspection test on the first-constructed test zone, which was conducted by international track specialists from five countries, including France, in May 1999, showed that the Gyeongbu High Speed Rail track satisfied the precision level and performance required for a high speed rail system.

In November 1999, just before the service opening of the test zone, an inspection was performed on the performance, safety, and connectivity of the track, the electric railway lines, and the train control facilities, as well as on the vehicles between Cheonan and Daejeon, the 34.4 km zone. The results showed that the Gyeongbu High speed rail track had world-class quality.

The safety and quality of the Gyeongbu High Speed Rail structures were confirmed through various inspections, from the design stage, and in the construction stage, experienced foreign consulting companies such as DEC in Germany and SYSTRA and INGEROP in France participated in the process as inspectors, and oversaw the construction process to acquire the highest possible quality, which bolstered the construction technology in South Korea.

Also during the construction, safety inspection was conducted by an official agency every year, and all small defects that were discovered were immediately addressed. Moreover, after the construction, thorough checkup and defect inspection were conducted every six months to reconfirm the safety condition of the structures.

Considering that the track construction was the first and largest mechanized construction that was ever attempted in South Korea, the construction went through technical reviews by foreign technical teams from the design to the construction and final-inspection stages, to acquire the highest possible quality. As a result, Gyeongbu High Speed Rail acquired a level of safety and quality that would allow it to compete with the best railway systems in the world.

8. Financial Procurement

8.1 Financial-Procurement Plan

The budget finalized on July 31, 1998, was KRW 12.7377 trillion, based on the first-phase project plan (1992-2004). To procure the budget, the South Korean government and the Authority established the financial-procurement principle while concluding the first revised plan in 1993. According to such principle, the South Korean government would provide 45% of the total budget while the Authority would provide the rest (55%). The financial support was divided into the investment by the Authority and the financial-loan projects while the self-procurement consisted of issuing bonds, foreign loans, and private financing.

The budget finalized in the second-phase project plan (2002-2014) was KRW 7.9454 trillion, and as of 2007, considering the practical railway management, the government's financial support and the Authority's self-procurement ratios were adjusted to 50 and 50%, respectively.

Table 3-12 | Gyeongbu High Speed Rail Budget Plans

(Unit: KRW 100 million as per the basic plan)

Category	Total	Government			Authority			
		Subtotal	Investment	Loan	Subtotal	Foreign loan	Bonds, etc.	Private financing
Total	202,939	93,998	79,025	14,973	108,941	30,750	75,568	2,623
1st Phase	127,377	57,320	44,582	12,738	70,057	30,750	36,684	2,623
2nd Phase	75,562	36,678	34,443	2,235	38,884	-	38,884	-

Source: MLTM (2010)

8.2 Financial-Procurement Performance

8.2.1 Government's Financial Support

The government's financial support was about KRW 620 billion per year from 1992 to 1999, and since after 2000, about 40% of the yearly financial support was offered as a financial loan through the Transportation Project Special Accounting. As a result, since after 2000, the financial investment was reduced to KRW 370 billion per year whereas the financial loans increased to about KRW 250 billion per year. This shows that while the government's financial support was around KRW 620 billion per year, about the same as that before 1999, the responsibility of the Authority increased as the government used the loan method rather than investing on the project, partly due to the financial difficulties that the government was experiencing after the onset of the foreign-exchange crisis. As a result, the government's investment represented 30% of the total budget while the financial loan represented 15%.

8.2.2 Issuing Bonds

Among the self-procured financing by the Authority, the owner of the construction project, issuing bonds took the largest share of the financing plan (29%). The bond issuance maintained the objective of the original plan, which was active financing through the public-funding management fund and the bonding market for the shortage. As a result, the original bonding issuance plan at KRW 3.6648 trillion successfully supplied KRW 3.8097 trillion through the acquisition of the public-funding management fund, and the rest of the KRW 2.9 trillion through the bonding market, as of April 2004. A larger amount of bonds than as planned was issued because the Authority had to supplement the shortages in foreign loans and private funding, and also because the Authority had to renew the fund due to the redemption of the five-year matured bond.

8.2.3 Foreign Loans

Representing as much as 24% of the total budget, the foreign loans introduced USD 2.364 billion in 1994 from 25 international loan consortiums, including Calyon (formerly Indosuez) Bank in France, as public loans by the South Korean government. Of such amount, USD 2.11745 billion was used by the Authority for purchasing vehicles and core equipment, as a type of sub-loan.

In the 2000s, the international interest rate decreased, and the initial loan conditions (interest rate: 6.25%) were worse than the conditions for new bonds or foreign-currency loans. Thus, the Authority stopped the withdrawal of the exports finance on July 25, 2003 and introduced foreign funds through foreign-currency loans (USD 45 million) and foreign bonds (USD 140 million) as part of the Authority's effort to reduce the repayment after the start of the railway service by procuring the funding with better conditions.

Table 3-13 | Conditions for Public-Loan Introduction

Category	Exports Finance	Tied Finance
Contract amount	USD 1617 million	USD 720 million
Interest rate	6.255% based on CIRR	Libor+0.57%
Term	10-year installment, with 8 years deferment	7-year installment, with 8 years deferment
Charges	Management charges: 0.4% Contract charges: 0.28% yearly	Management charges: 0.7% Contract charges: 0.3% yearly
Capitalization	Interest and insurance premium	Interest
Usage	Foreign-equipment purchase, exports insurance premium, interest and market price increase during the construction	Prepayment, purchase of South Korean equipment, interest, etc. during the construction

Source: Ministry of Construction and Transportation, KICTEP (2007)

8.2.4 Private Funding

Due to the postponement of the station construction after the opening of the first-phase section in 2004, or the revision of the original plan, where the existing stations were decided to be used, it was difficult to promote private-funding projects whose main target was constructing new stations. In the case of Gyeongmyeong Station, the only newly constructed station, as it was built in the development restriction zone, the subsequent private funding was restricted. In relation to the development of Daegu Station in the second-phase project, private-funding projects are being promoted, and it is expected that other types of private funding will be possible for the other stations, through the development projects of railway station spheres.

Table 3-14 | Funding Procurement Plans and Outcomes of Gyeongbu High Speed Railway (Phase 1)

(unit: KRW 1 billion)

Category	Total Budget	'92-'99	2000	2001	2002	2003	2004
· National budget	5,732	2,634	790	833	737	608	394
-Investment	4,458	2,634	590	601	457	151	232
-Financial loan	1,274	-	200	232	280	457	162
· Self-procurement	7,006	2,609	1,001	1,457	1,085	646	607
Total	12,738	5,243	1,791	2,290	1,822	1,253	1,000

Source: Ministry of Construction and Transportation, KICTEP (2007)

8.3 Future Repayment Plan and Measures

Based on the KORAIL structural reform after the start of the railway service, the construction and operation of the national railway system were separated (2004-2005), and the repayment of the funding procured for the construction of the high speed rail was separated into the railway operation and facilities, each of which is being repaid under the responsibility of KORAIL and the Authority. Among the debts related to the high speed rail, those related to the operation, including the vehicles (about KRW 4.3 trillion as of 2004), were transferred to KORAIL, which repays them through its operational income, whereas the facilities debts, including the railway, etc. (about KRW 6.8 trillion as of 2004), are being repaid by the Authority, which receives the facility usage fees from KORAIL. Thirty-one percent of the high speed rail income is applied to the fees for the use of the high speed rail that KORAIL, the railway operator, pays the Authority, the facility manager. In 2010, however, the railway usage income of the Authority was KRW 210.6 billion, less than half of the interest in the same year (KRW 462.7 billion), making it impossible for it even to repay the interest.

Chapter 4

Difficulties in the Process of Executing the Project

1. Key Factors in the Poor Performance of the Project
2. Overcoming the Difficulties

Difficulties in the Process of Executing the Project

1. Key Factors in the Poor Performance of the Project

1.1 Excessive Civil Complaints and Regional Self-centeredness

While the construction of the test section (Cheonan-Daejeon) began on June 30, 1992, some presidential candidates made a public pledge to stop the project completely amid the heated presidential election in December 1993, and in the middle of the turnover of power, some argued that the construction should be transferred to the next government. Moreover, many problems began to emerge due to the insufficient preliminary surveys, lack of experience in high speed rail projects, and lack of technical know-how and means. As a result, the Gyeongbu High Speed Rail Project was on the verge of being completely dismantled. The mass media questioned South Korea's poor infrastructure construction conditions in relation to the collapse of Seongsu Bridge in 1994 and that of Sampoong Department Store in 1995, and also strongly questioned the safety of Gyeongbu High Speed Rail, whose full-scale construction had just begun. Every day, the mass media reported on the feasibility and even possible dismantlement of the project.

Meanwhile, the construction progressed little, and the impact of the collapse of large-scale structures increased the nation's sense of insecurity against various structures. The progress of the construction was even further delayed as the structural safety became more important than the progress of the construction and the continuous revisions of the construction plan. In particular, even the Jangjae-ri site, where the groundbreaking ceremony was to be held, was not purchased, and the ceremony was held at a leased site. As such, land purchase and the subsequent compensation issues were not progressing as smoothly as planned. Furthermore, the residents of the areas neighboring the construction zones continued to raise civil complaints, and the worsening regional self-centeredness stopped almost the whole construction.

In fact, an official of a service company at the construction site admitted that it took them almost a year to finish even just the groundwork of a government-owned river. The difficulties in relation to land purchases and civil complaints were evidenced by the long sighs of the then Authority's staff who was in charge of the construction.

Later, the land compensation issues were somewhat resolved, and the construction resumed. As Alsthom in France, however, was selected as the supplier of the vehicle system, the construction had to be stopped in the process of reviewing the technical connectivity between the vehicle characteristics and the sub-base course and safety, and in the process of revising the design. This could be considered a trial-and-error process borne by the inexperience of the South Korean government in the high speed rail project. In other words, although the design and construction of the structures should be preceded by the selection of the high speed rail vehicle system, the design and some construction actually started before a decision was made regarding the vehicle system to be adopted, consequently resulting in the project's inefficiency as the whole design needed to be revised.

In addition, the lack of geological and topological surveys on the regions where the trains would pass, the insufficient discussions among the concerned organizations in relation to cultural assets, the civil actions of the residents in relation to the railway station sphere development and land compensations, and the continuous civil complaints of and demands by the local governments and residents for the power transmission lines and transformer facilities to be moved as these might hinder the local development and lower the land price all effectively led the construction project towards a dead end.

The cultural-assets issue that emerged when the South Korean government started the construction of Osong Tracking Depot without an excavation survey on the cultural sites to be affected by the construction became a national debate, particularly in relation to the Gyeongju route. That is, the Ministry of Transportation and Construction argued that the original route should be followed due to the tremendous expenses that would be incurred on account of the construction delay caused by doing otherwise, and due to the additional funding required by the construction of a different route. Further contributing to the construction inefficiency was the Ministry of Culture&Tourism's argument that the route should never pass Gyeongju so that the cultural assets in Shilla's old capital would be preserved. The debate became even more intense when Federico Mayor, then Director-General of UNESCO, in his visit to South Korea, said that it would be difficult for Gyeongju to be designated as a world heritage site if the high speed rail would pass through the city.

The debate on the Gyeongju route, whose construction had started, as regards cultural-assets protection later developed into a very complicated situation as those who were involved in the debate argued even more vigorously in defense of their respective stance. Further, the voice of each local government added to the regional self-centeredness, and the debate on the Gyeongju route made many people worry about the possibility that the other regions that had been confirmed to be made part of the railway system as well, as routes, would also enter into the debate.

Besides, according to the media in 1996, there were more than ten major civil complaints that could affect the process and term of the construction: those regarding the location of Seoul Central Station; the installation of Gyeongmyeong Station; the early installation of Osong Station; the underground work for the Kimcheon-passing route; the underground work for the Yangsan-gun-passing route; the underground work near Beomeosa; the installation of Bujeon Station, Busan Vehicle Depot, and Seoul Vehicle Depot; and the request that the station names be changed.

Such civil complaints and controversies took a turn when the South Korean government proposed solutions for them and announced that it would prove the safety of the construction through a safety inspection by an independent agency, and if problems were discovered, the concerned structures would be rebuilt.

Subsequently, WJE, a U.S. safety inspection agency, conducted a safety inspection of the 92 structures built between June 1992 and April 1996. While this inspection demonstrated the determination of the Authority, the owner of the project, to eliminate not only poor construction but also the makeshift construction custom, the Authority's public pledge not to repeat the trial-and-error process in the continuance of the project when the inspection was announced to the public led the South Korean people to consider the Authority a hotbed of poor construction. Consequently, the Authority came to face even more difficulties.

1.2 Route Change

1.2.1 Change in the Gyeongju route

Since after the South Korean government announced in June 1992 that it selected the route that passes through the downtown of Gyeongju and would build Gyeongju Station on the northern field 5 km south from the downtown, objections to this decision by the cultural, religious, and academic fields had been expressed due to the belief that it would directly and indirectly damage not only the cultural relics and sites in Gyeongju but also the landscape of Mt. Namsan in Gyeongju.

At that time, the Ministry of Construction and Transportation and the Authority proposed a plan to change the station from the northern field to Ijori (10 km south from the downtown) in October 1995, and another plan not to develop the railway station after the joint survey in the same year, to protect the cultural assets and landscape in Gyeongju.

The Ministry of Culture and Tourism, however, and the religious and academic professionals, opposed the aforementioned plans due to the insufficient measures therein to protect the region's cultural assets, arguing in favor of the original route as the construction inefficiency and investment cost would damage the landscape and cultural atmosphere of the 1,000-year-old capital and would risk damaging the cultural assets therein. This made the gap between the two parties even wider.

Thus, the Ministry of Construction and Transportation proposed alternatives that included extending the underground section to 8.4 km (from 3.5 km) as a revision of the Hyeongsan River route, and moving the station from the downtown of Gyeongju to Ijori, 10 km south from the downtown, but failed to reach an agreement on such matters.

Towards the end of April 1996, the Office of the Prime Minister led a joint field survey with the Ministry of Construction and Transportation and Ministry of Culture and Tourism, participated in by the staff of both departments and by independent cultural-assets, urban-planning, and transportation reviewers who had been recommended by the opposing party.

The basic stance of the government on the Gyeongju route was to minimize the damage that it would cause to the atmosphere and to the cultural assets that might be buried therein, and to proceed with the project without any more hitches, and at the same time, to consider the transportation convenience of the residents in Gyeongju, Ulsan, and Pohang in selecting the location of the route and the station.

Based on the government's principle, the joint survey team completed a joint report, based on which the Prime Minister led a series of meetings with the Minister of Economy, Culture and Tourism, and with the Minister of Construction and Transportation, leading to an agreement.

Based on what was agreed upon, the government determined and announced a new Gyeongju route in January 1997. The changed route was determined based on the consideration that it would minimize the damage to the cultural assets in Gyeongju, and would have technical and economic feasibility. Further, it was decided that the location of the station would be placed within the administrative section of Gyeongju City.

1.2.2 Route Change of Sangni Tunnel Section

The construction of Sangni Tunnel Section started on May 8, 1995, but a survey on the nationwide unused or abandoned mines through the National Assembly inspection of the government offices revealed a web-like empty space in the upper/lower parts and at the side of the tunnel, which is 25 m long and has a 50 m 3 capacity. Consequently, the issue of the safety of the high speed railwas raised. This space was an abandoned mine shaft from the mining work in Sambo Mine, which produced zinc for 40 years, since 1956. At that time, 298 m of the 2.1-km Sangni Tunnel had already been dug.

To establish a fundamental measure for ensuring Sangni Tunnel's safety, the South Korean government commissioned Professor Kirschke and his team in Germany to conduct a preliminary safety assessment. As a result, the team recommended a reinforcement plan of some sections through the visual observation of the floor plan of the abandoned mine and ore. Later, in November 1996, Korea Resources Corporation commissioned a ground safety assessment and international services.

After a series of assessments, on October 19, 1996, the Authority's board of directors decided to change the route, and after the feasibility survey for the selection of a new Sangni Tunnel route, the Authority commissioned Korea Transport Institute to conduct the work. The detoured route was determined on March 14, 1997.

1.2.3 Change in the Method of Passing the Downtown of Daejeon and Daegu

In June 1991, to minimize the running time of the high speed rail, a plan to construct an underground route for Daejeon and Daegu downtown sections proposed based on the results of the technical survey. The main objective of such plan was to overcome the reduction in speed (120 km/h) due to the severe slopes (1 site R = 100 m; 13 sites R = 600 m), the difficulty in creating an interchange due to the existing roads (20 sites in Daejeon and 17 sites in Daegu), the damage to the urban landscape, environmental issues like noise or vibration, and excessive obstacles in residential areas.

To reduce the investment cost, however, in June 1993, the underground plan was changed into the on-the-ground plan after the Social- Overhead-Capital Construction Implementation Committee agreed to do so. The total amount saved by the revision was KRW 403.3 billion, which is consisted of KRW 225.3 billion (from KRW 646.2 billion to KRW 420.9 billion) in Daejeon and KRW 208.2 billion (from KRW 945.3 billion to KRW 737.1 billion) in Daegu.

Besides the economic reasons, the on-the-ground construction would offer easy benefits such as construction, a reduced construction term, easy connectivity and transfer to the existing railway, disaster prevention, environmental maintenance, lower facilities and maintenance/repair costs, and easy recovery in case of accidents.

The continuous civil complaints from the residents and local governments regarding the environmental damages (e.g., noise, vibration), however, as well as the worsening division of the downtown, resulted in the decision to revert the construction back to underground work in April 1995. Later, in 2001, due to the question raised by the local government with regard to the underground passage, the construction was finalized as on-the-ground work in August 2006. As such, the continuous revisions of the Daejeon and Daegu downtown section construction could not be completed in 2004, the target first-phase opening of Gyeongbu High Speed Rail. The latter is thus expected to be completed in 2014.

1.2.4 Change in the Bridge Type

The detailed design standard of the high speed rail was created by South Korean specialists from July 1987 to February 1991, by referring to the public-design data of the high speed rails in France, Germany, and Japan. Later, in June 1991, the design was commissioned to 14 South Korean specialist companies, which designed the upper structure of the bridges based on PC box.

Four test zones started to be constructed in June 1992, but due to the first project revision in June 1993, which was reviewed and agreed to by the Social-Overhead-Capital Construction Implementation Committee based on the socioeconomic situation in the country then, the bridge structure was changed from PC box to PC beam as part of the plan to effect maximum cost savings (first format change). Later, in August 1993, after the selection of Alsthom in France as the prioritized negotiation partner, the dynamic behavior of the bridges was reviewed for the inspection of the bridges' safety at high-speed operation. Although the results showed that there were no issues in deflection or vibration, it was recommended that the stiffness of the structures in the Rahmen and PC beam bridges be reinforced to reduce the vehicle's vibration and to promote the passengers' comfort. Accordingly, considering the long-term stability improvement and maintenance/repair aspects of the structures, the bridge type was reverted back to the continuous PC box structure from PC beam in August 1995 (second format change).

As such, the Gyeongbu High Speed Rail Project went through various technical conflicts because of the minimal experience of the South Korean technical team in designing high speed rail systems and because the design was started before selecting the vehicle format. The bridge type was finally changed to PC box considering long-term stability and convenience of maintenance and repair.

1.2.5 Environmental Civil Complaints Concerning Mt. Cheonseong

Environmental civil complaints concerning Mt. Cheonseong, which Gyeongbu High speed rail passes through, were raised in 2001 by Monk Jiyul, who requested that the construction be completely stopped. In November 2004, the Busan High Court dismissed the injunction filed by Monk Jiyul on the construction on the following ground: "The probability of environmental encroachment of the tunnel construction on the high mountains and swamp areas is considerably low, and the tremendous interest of the public cannot be disregarded on account of the environmental-encroachment disadvantage that has considerably low probability."

Monk Jiyul protested against the court's decision and appealed the case to the Supreme Court. He also went on a hunger strike, discrediting the review by the specialists appointed by the Ministry of Environment and the High Court's decision.

The Authority agreed to the conduct of a joint environmental-impact survey in February 2005, upon the request of Monk Jiyul, to end the distrust of the tunnel construction in relation to environmental issues, and to save lives. As such, the construction was stopped for three months, during the survey period (August 30-November 29, 2005).

The joint survey was conducted by a joint survey team consisting of 14 specialists from each party in five areas (underground water, geophysical prospecting, geological structure, rock mechanics, and ecosystem), and the results were announced to the media on February 28, 2006 and were submitted to the Supreme Court, where the appeal was pending litigation, on March 14, 2006.

As for the appeal for the issuance of an injunction to the Authority for the stoppage of the construction, the Supreme Court determined on June 2, 2006 that "there is no basis for the encroachment of environmental interest raised by environmental organizations and others," which effectively ended the five-year-long conflict between the government and environmental organizations concerning Mt. Cheonseong. The litigation, however, resulted in an increase in the construction cost and in a delay in the construction term.

<Progress>

- 11/13/01: Gyeongbu High Speed Rail route plan review was requested.
- 03/07/03: The President ordered the review of the route.
- 10/15/03: Monk Jiyul requested for an injunction to stop the construction (the so-called "Korean Salamander Lawsuit").
- 11/27/03: Sub-base course construction began on Mt. Cheonseong (Yeonhyo Tunnel).
- 04/08/04: The injunction request was dismissed in the first trial; the decision was appealed to the High Court (04/16/04).
- 08/09/04: The Yeonhyo Tunnel excavation was started.
- 08/26.04-11/29/04: The Mt. Cheonseong construction was stopped (three months).

· Monk Jiyul went on a hunger strike for 58 days; the construction was stopped as per the agreement between the Authority and Monk Jiyul, pending the completion of the Busan High Court proceedings.

- 11/29/04: The Busan High Court dismissed the appeal; the construction resumed.
- 12/06/04: The decision was appealed to the Supreme Court.
- 02/03/05: The Authority and Monk Jiyul agreed to conduct a joint environmental -impact survey.
- 08/30/05-11/29/05: The survey was conducted. (The tunnel construction was stopped for three months.)
- 02/28/06: The survey results were announced.

· While the survey team agreed that there would be specific environmental impacts on four areas (underground water, geography, rock mechanics, and geophysics), there were differences in the detailed contents of the survey results. The survey team showed different opinions about the ecosystem.

- 03/14/06: The survey report was submitted to the Supreme Court.

- 06/02/06: The Supreme Court dismissed the appeal.

2. Overcoming the Difficulties

2.1 Conducting Safety Inspections and Establishing Measures to Prevent Poor Construction

2.1.1 WJE's Safety Inspection

A series of large-scale disasters, such as the collapse of Seongsu Bridge and of Sampoong Department Store in 1994 and 1995, respectively, led the South Korean people to develop an extreme distrust of the South Korean construction industry. In such a situation, a question was raised concerning the safety of the Gyeongbu High Speed Rail Project, a large national project. Furthermore, the continuous revisions of the bridge designs, and the consequent reconstruction and structural reinforcement, required the inspection of the structures and the verification of their safety by specialist organizations.

Having realized that the South Korean people's trust in the construction project urgently needed to be regained, the Authority decided to conduct a safety inspection of the structures that had been built between June 1992 (the start of the construction) and April 26, 1996. At that point, the overall progress of the construction project was 8.3%, and that of the test zone between Cheonan and Daejeon was about 60%. As such, the Authority sent a safety inspection request to Bechtel in the U.S., SYSTRA in France, DEC in Germany, and WJE and FKC in the U.S. Among them, four companies submitted a proposal, and after a thorough review of the proposals by the selection committee consisting of specialists in various fields, WJE, which had extensive experience in safety inspections (about 4,000 cases) and in repair and reinforcement work worldwide, was chosen as the best company to conduct the inspection.

a. Target structures for the safety inspection

· One construction section between Seoul and Cheonan (2-1 construction zone) built between June 1992 and April 26, 1996, and the whole test line section between Cheonan and Daejeon

  ○ Total length: 61 km; 1,012 sites

  ○ Bridges: 32.5 km (37 bridges)

  ○ Tunnels: 14.7 km (15 tunnels)

○ Earthworks and culverts : 13.8 km (72 earthworks, 18 culverts)

· Contractor: WJE (Wiss, Janney, Elstner Associates, Inc., USA)

· Terms and cost:

○ First inspection: 08/01/1996-01/31/1997 (six months); USD 2,828,535

○ Second inspection: 08/01/1997-01/31/1998 (six months); USD 1,070,0002)

b. Results

The results showed 200 sites for field revisions, 190 sites for repair, 39 sites for partial reconstruction, and 583 sites for no repair. The field revision (200 sites) and repair (190 sites) posed no structural safety issues as they involved minor defects that might have been caused by the carelessness in the construction, such as in the surface finishing, small cracks due to drying shrinkage, pockmarks, and inappropriateness of construction joints used. As a measure for the partial reconstruction (39 sites), the bridge bearing in rail format in 35 sites was exchanged in the future maintenance and repair, and for the bridge slab in the rest of the four sites, patching repair was requested.

2.1.2 Establishing Poor-Construction Preventive Measures

The reasons for poor construction and delay in the schedule of Gyeongbu High Speed Railway Project were, first, the lack of preparation in design documents and specifications, and second, the lack of understanding in safety and accuracy due to the nonexistence experience in high speed railway construction. Also several incidents of the stoppage of the construction forced the project to focus mostly on meeting the construction deadlines, and consequently, quality of the construction was neglected. This resulted in a series of long-lasting side effects, such as the mass media's hastily written articles that scandalized problems, and apathetic social atmosphere, the nation's indifference of and misunderstanding in safety.

But the project overcame such difficulties through the safety inspection conducted by WJE, and could learn from the experience that the construction of a high speed railway would require comprehensive quality and construction management.

The recommendations by WJE as a result of the safety inspection it conducted showed that most of the issues resulted from the poor management of the construction. The various defects and problems that had been identified were thoroughly reviewed and addressed so that no identical issues would appear in the future. Moreover, the quality control and field inspection tasks were strengthened to ensure the safety of the construction, and the Safety Control Promotion Plan was established to ensure better safety based on the provision of technical support for and the reinforced supervision of the construction.

2.2 Design Verification and Supplementation

After WJE's safety inspection, the safety issues of structures due to the South Korean construction industry's custom of "build first, repair later" or the careless management of construction projects emerged. This became an opportunity to change such practices and to reform the industry to raise its competency level to that in advanced countries.

To regain the people's trust in the safety of the country's structures, and to obtain technical connectivity between the TGV vehicle system and the core system, the Authority commissioned SYSTRA, an affiliate company of SNCF, to conduct a full-scale design inspection of the sub-base course, track, and structures of Gyeongbu High Speed Rail. The design review by SYSTRA, which had extensive experience in high speed rail design and construction projects, was conducted into two phases (first phase: 09/1994-05/1995; second phase: 05/1996-08/1998). In the first phase, the contractor reviewed the sub-base design standard and test line zone design, and in the second phase, it conducted a detailed review of the areas that were not looked into in the first phase, and created a design drawing for the PC box bridge standardization. The Authority had a SYSTRA technician stay in South Korea during the review, who undertook the task cooperation and technology transfer.

Thanks to the design review, the construction project acquired external reliability and ensured the structural safety of the sub-base structures, and the implementation of the detailed top structure design in the standard format could improve the constructability and could reduce the construction cost by about 5%. Furthermore, the South Korean technical team acquired advanced high speed rail construction know-how and accumulated related advanced technologies as South Korean technologies, which became the driving force for performing high speed rail projects not only in South Korea but also in other countries.

2.3 Execution of a Complete-responsibility-based Management System

For safe operation at the maximum speed of 300 km/h, Gyeongbu High Speed Rail should be thoroughly constructed, with the highest quality, safety, and process control, but with the lack of experience in such projects and the fact that the vehicle type had not been decided, the Authority conducted the design based on the UIC standard, and ordered the construction. As a result, the lack of quality consciousness of the contractor, and the low management level in South Korea, in the initial project implementation period, among others, resulted in poor construction.

Accordingly, to fundamentally resolve the problem of poor construction, the Authority initially commissioned SYSTRA to review and revise the design, and then implemented the contractor-named construction project system to develop quality consciousness on the part of the contractor.

In addition, the Authority implemented the complete responsibility-based management system in all the construction zones, and hired specialists from foreign supervision companies, such as DEC in Germany and INGEROP in France, to conduct verification and inspection tasks with the South Korean supervision team, and to address the technical shortage. The complete responsibility-based management system is the system where a supervision specialist company (1) verifies if a construction project with a total cost of over KRW5 billion or with a total floor area of over 10,000 m^2 conforms to its design and related documents; (2) offers technical guidance; and (3) plays the role of a quality control, construction, and safety control supervisor.

2.4 Establishing the High Speed Rail Quality Control System

To ensure the perfect construction and high quality of the high speed rail, the contractor, the supervising team, and the Authority maintained separate quality control organizations, and to systematically perform self-inspections, tests, and reviews to prevent the emergence of quality-related issues, they established a quality control system. The contractor acquired the testing lab and quality control organization appropriate for the quality control system so that during the construction, it would assume responsibility for the project through voluntary quality control activities. The Authority exercised joint supervision with DEC or INGEROP, which had experience in high speed rail projects and contributed to the acquisition of high quality by supplementing the South Korean supervision team's supervision techniques. In particular, the issues by phase that should be verified were recognized and divided into attending and inspection points, and were thoroughly controlled. The partially completed structures were also verified through tests and inspections.

Based on the main quality control system, any issue pointed out to the contractor was divided according to their level of seriousness, and QDNs or NCRs were issued so that the contractor could take the necessary measures. The Authority (the headquarters, the construction testing center, and the office), on the other hand, regularly conducted inspection tests on the quality of the materials and on the construction condition at the sites, to maintain thorough and strict quality control.

Furthermore, the quality control staffs of Bechtel, who had extensive experience in the management of large-scale projects, were dispatched to the headquarters and construction sites and performed quality supervision activities to ensure the highest quality. Finally, the self-established quality control department of the contractor conducted inspections of and tests on (first-phase inspection) the tasks performed by the construction division based on the IPT, and submitted the results of such inspections and tests to the Authority. The supervising team, for its part, verified and inspected (second-phase inspection) by process phase if the contractor conducted the quality inspection tasks based on the inspection plan.

Even the structures built with such systematic quality control system were subjected to safety inspection by an independent safety inspection agency, which thoroughly verified the safety conditions of all the structures to prevent poor construction and to reconfirm the quality of the project.

2.5 Public Promotion of the High Speed Railway System

In order to resolve the issues related in the construction process of Gyeongbu High Speed Railway and the nation's concern over the poor construction, it was necessary to conduct a series of public promotion that could have the publiuc understand that the construction was being performed safely and establish the public's understanding and trust for the project in relation to various economic, social and cultural effect of the construction on the country that were to be expected after the completion as a new transportation means in the 21st century. In particular, for a large national project like Gyeongbu High Speed Railway Project, the public understanding and cooperation are more important than anything else, and to draw the public support by informing people of its benefits was essential in promoting the project. As a result, various public promotion activities were proactively conducted.

The project conducted indirect public promotion activities using mass media between 1992 and 1996, which were limited in offering general information of the current status of the project and the introduction of the construction sites. After 1997, the validity, necessity or effectiveness of the construction was neglected and the public opinions of the mass media and people on the project were largely negative. For the Corporation, this period was important to conduct public promotion strategies to correct such negative views. Accordingly, the project executed direct and proactive public promotion activities led by its PR team between 1997 and 1998.

Since after 1999, the project conducted public promotion activities that presented a long-term and ambitious vision to make the nation feel safe and expect for the future high speed railway system. Around the test-drive between Cheonan and Daejeon section in December 1999, the project conducted a series of direct and experiential events through the mass media, publication of PR materials, and test-drive events. Such events that proposed the vision targeted the competitive marketing against various other types of transportation means that would emerge along with the completion of the project.

Chapter 5

Evaluation and Implications

Evaluation and Implications

1. Evaluation

1.1 Major Achievements

1.1.1 Enhancement of Rail Technology Competitiveness and Preparation of the Export

One of the major achievements of the high-speed rail project was to build up Korea's technological experience in applying foreign technologies locally and overcoming the corresponding challenges. This experience helped advance Korea's local rail technology. In the first stage of the project, the country depended on foreign technology, but the second stage (April 2004-November 2011) was carried out by the local technical team, thus upgrading Korea's rail technology to the world-class level. The localization of Korea's high-speed rail technology helped reduce the budget for the project, created jobs, and enabled local construction firms and architectural designers to participate in the construction of the high-speed rail of Taiwan, among other overseas projects.

By securing high-speed rail technologies, Korea has drastically improved its overall architectural design capabilities in conventional rails, subways, light rail, and other means of public transportation. This is expected to improve technologies in related fields. Aerodynamic technologies can be used to design the bodies of high-speed vehicles such as aircraft, cars, and guided missiles. Car body sealing and pressure wave prevention technologies, which are designed to prevent passengers from suffering from ringing in the ears, are being used to design aircraft, submarines, etc. Computer control and self-examination technologies are being used in the industrial equipment automation, industrial robot, and demand-based semiconductor industries. Total treatment technology using computers promotes the development of the software and information industries. Large-capacity power transformation and gate control technologies are being used for home

electronic products, industrial power transformation, robots, etc. Lightweight and high-strength new material technologies are expected to be used in the development of lightweight automobiles and other materials.

1.1.2 Improvement of Project Management Capabilities

The High-speed Rail Construction Authority introduced and applied its project management skills to systematically and efficiently manage the large-scale high-speed rail project. In the early stages of the project, with the help of Bechtel of the U.S., the local technical team managed the project. After the project management agreement expired, however, the Authority educated its employees on how to manage the project by themselves, fostered experts, and built up the Authority's managerial capabilities.

In the second stage, the Authority developed a 3-D project management system dubbed "GPMS," which combined sophisticated information and GIS technologies. The Authority patented GPMS locally, and thereby upgraded its project management skills and earned project management orders for China's rail projects, which enabled it to advance into global markets.

In the supervision field, the Authority executed a total responsible supervision system across the entire process of high-speed rail production. Experts from a foreign supervisory firm were commissioned for the project, and the local supervisory team coordinated with the foreign experts, which enabled the Authority to enhance its supervisory capabilities.

1.1.3 Raising Awareness of Construction Work Quality Management

Various defects due to poor construction management were detected in the safety inspection of the high-speed rail project, which led to stronger quality management and field inspection. A quality management system was developed to systematically perform self-inspection and examination as well as tests to proactively prevent quality problems. To secure the safety of the construction works, measures for safe management were devised. As such, the high-speed rail construction project improved relevant practices of the local construction industry and advanced the domestic supervisory and oversight system. Currently, the Authority's construction quality management is cited as the best of its kind.

1.1.4 Securing of High-speed Rail Operation Technologies

The high-speed rail is a culmination of cutting-edge sciences and technologies, and its service is an innovative product that calls for a change in the management mindset. Thus, all the processes for the preparation and operation of the high-speed rail drastically advanced rail operation technologies.

Working manuals for new fields were drawn up, and for the smooth operation of the high-speed rail, four-step assessment criteria and other scientific maintenance and repair skills were introduced. A proactive repair system based on data analysis and prior detection of lowered performance was developed. Also, the localization of the operating equipment helped reduce maintenance costs; cut labor costs with the management system automation; and improved customer management skills. These are also among the effects of the high-speed rail construction.

1.1.5 Changes in the National Transportation System and Social and Economic Effect

a. Changes in the national transportation system

High Speed Rails have higher energy efficiency and are more cost-effective than private cars, aircraft, and other means of transportation, and also help reduce travel time and costs. There was a drastic change in transportation ratios among cities that had high speed railway stations. Rail passengers have increased, and passengers of private cars, express buses, and aircraft have decreased. There was also a notable change in air travel demand. In the case of the Seoul-to-Daegu segment, the high-speed rail reduced air travel demand, which led to the closure of such air travel route in 2007.

Table 5-1 | Mode Share between Vehicles after the Opening of the High-Speed Rail

(Unit: %)

Description	Seoul-Busan (424 km)		Seoul-Daegu (293 km)	
	2003	2008	2003	2008
Auto	14.0	5.4	41.1	32.0
Express Bus	7.6	7.5	13.7	6.3
Rail	29.3	63.3	26.5	61.7
Air	49.1	23.8	18.7	0.0
Total	100	100	100	100

Source: KORAIL Research Institute (2009)

Figure 5-1 | Mode Share in the Seoul-Busan Corridor

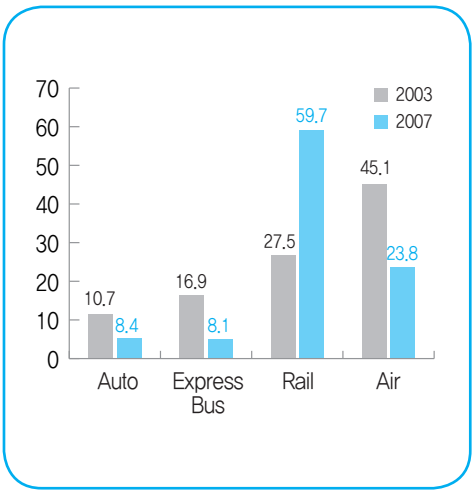
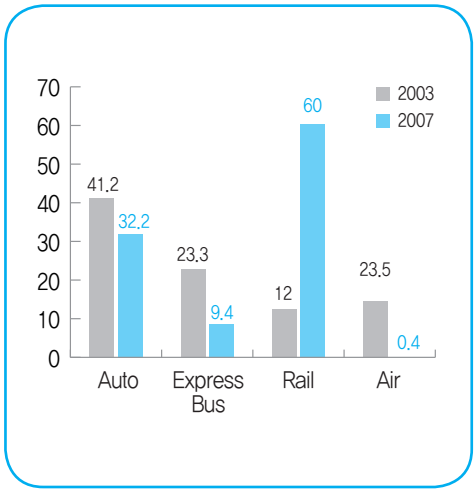
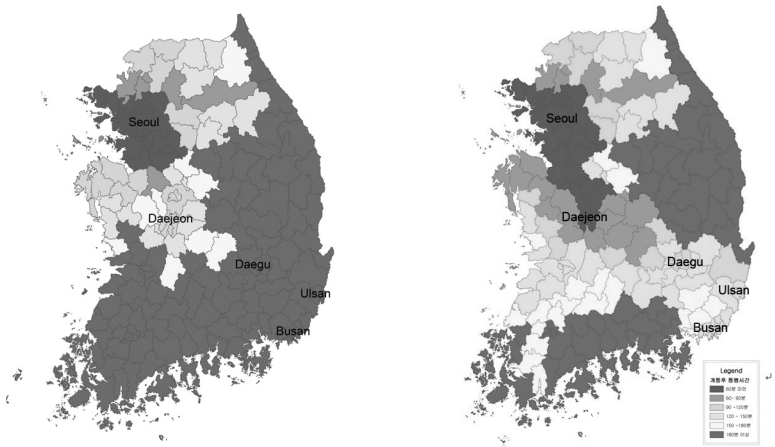


Figure 5-2 | Mode Share in the Seoul-Daegu Corridor



The opening of the high speed railway reduced the transportation time amongst major cities down to two hours (Seoul-Busan: from 4 hours and 30 minutes to 2 hours and 18 minutes). In the future, it is expected that the establishment of a KTX high speed railway network that connects all regions in the country within one hour will remove the gap between Seoul and local regions by integrating the country into one zone.

Figure 5-3 | Comparison of the Transportation Time before and after the Opening of Gyeongbu High Speed Railway (From Seoul)



<Before the opening of KTX> <After the opening of KTX>

b. Social and economic effect

The change in the carriage ratios between vehicles led to economic and environmental benefits such as lower petroleum energy consumption, CO_2 emissions, and environmental pollutant discharge. KORAIL (2009) forecasted the effects of the operation of the high-speed rail as an energy cost reduction of KRW 297.4 billion and an environmental cost reduction of KRW 118.3 billion in 2008.

Table 5-2 | Reduction in Energy and Environmental Costs due to the Gyeongbu High-Speed Rail

(Unit: KRW)

Region	2004	2005	2006	2007	2008	Total
Reduced energy costs	1,900	2,883	2,947	2,974	2,974	13,678
Reduced environmental costs	789	1,178	1,195	1,183	1,183	5,529

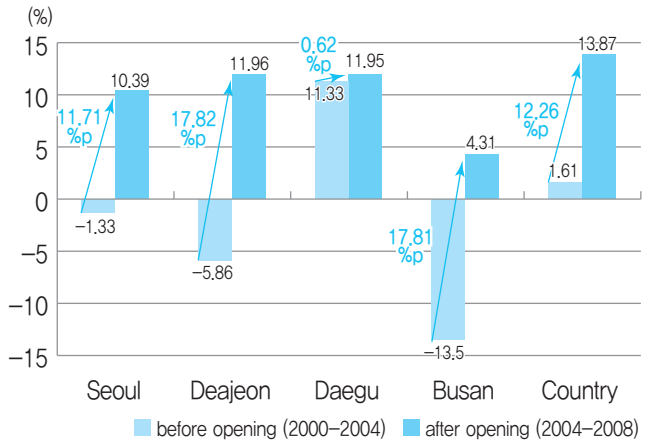
High-speed rail stations are the so-called KTX economic zones where people, capital, and technology gather, prompting them to emerge as regional transportation and business hubs. Thanks to the opening of KTX, both physical and psychological distance to local cities has decreased, and consequently, there is a growing tendency in considering local cities as places for hosting international summits, conventions, and seminars.

Table 5-3 | International Conventions Held in Cities that have a KTX Station

Region	2003	2004	2005	2006	2007	2008	Average annual increase ratio
Seoul	158	164	155	191	171	193	4%
Busan	19	27	49	82	78	143	50%
Daegu	8	13	11	15	20	16	15%
Daejeon	14	10	7	18	18	53	31%

The tourism industries in these cities have also been positively affected by KTX. The sales from tourist accommodation facilities in Busan and Daejeon have greatly improved after the opening of KTX, showing that the influx of tourists in these cities has been active. While it may be unreasonable to explain such a result only from the effect of KTX, it is expected that the improvement of the city image due to the increasing number of international conventions held and the reduction of the transportation time will increase the demand on leisure and tourism activities in the local regions, thus, activating the local economy.

Figure 5-4 | Changes in the Ratio of the Sales from Tourist Accommodation Facilities before and after the Opening of KTX



On the other hand, the concentration phenomenon toward Seoul that local cities had been worrying about before the opening of KTX was shown to be unclear. In the medical industry, the opening of KTX affected people's movement toward Seoul for the use of medical services. However, the transportation from Seoul to KTX cities was larger than that from KTX cities to Seoul.

Table 5-4 | Trends in the Number of Days of Using Medical Facilities in Other Regions

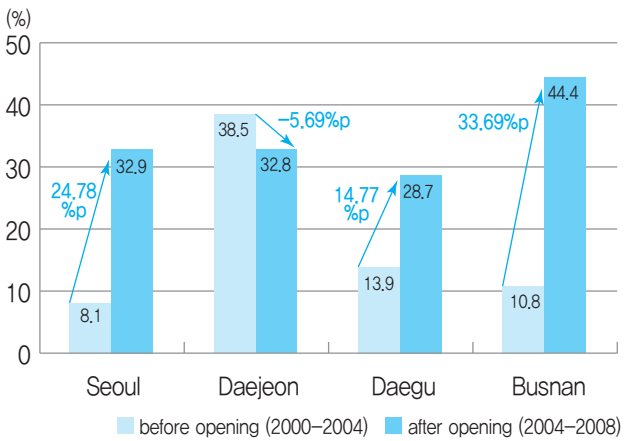
Category	2003	2004	2005	2006	2007	2008	2009
Seoul → 4 Cities	895	953	1,037	1,273	2,643	3,556	3,785
4 Cities → Seoul	1,236	1,315	1,452	1,656	2,067	2,361	2,536

Note: The 4 cities are Busan, Daegu, Daejeon and Ulsan.

The wholesale and retail sales increase ratio also showed little difference among KTX cities. The sales in Seoul increased by 24.78% while those in Daegu and Busan increased by 14.77% and 33.69%, respectively. While those in Daejeon decrased by a small margin, the increase ratio is still very high, and the much-worried phenomenon of the concentration toward Seoul is not observed so far. Still some local cities argue that the opening of KTX

fortified the concentration to Seoul and weakened the competitiveness of local cities. In fact, when they first opened the high speed railway system, Japan also experienced the concentration to Tokyo in the beginning of the opening.

Figure 5-5 | Changes in the Wholesale and Retail Sales Increase Ratios before and after the Opening of KTX



1.2 Downsides

1.2.1 Lower demand than expected

The high-speed rail demand, as of 2010, was 112,000 passengers a day, which is half of the expected 226,000 passengers a day under the second revised plan (1998). One of the reasons for this lower demand is that while the revised basic plan forecasted the Seoul-to-Busan travel time as 116 minutes (2-station stoppage), the current running time is 145 minutes. In the future it is expected that once the downtown section high speed railway construction in Daejeon and Daegu is completed, the travel time will be close to the original goal. Also, basic data for demand estimation were not adequately accumulated, which made it impossible to accurately forecast the demand.

Table 5-5 | Travel Demand for the High-Speed Rail

(Unit: 1,000 people/day)

Description	2004	2005	2006	2007	2008	2009	2010
Demand forecast	149	159	171	183	196	211	226
Actual demand	54	88	99	101	102	101	112

Moreover, a considerable number of rail passengers are transferring to the high-speed rail, whereas new passengers represent 40% of the total number of high-speed rail passengers.

Table 5-6 | Travel Demand for the High-Speed Rail and the Conventional Rail

(Unit: 1,000 people/day)

Description	2002	2003	2004	2005	2006	2007	2008	2009	2010
KTX	-	-	49	80	90	92	93	92	99
Conventional rail	172	165	138	116	111	108	112	109	116
Total	172	165	188	196	201	200	205	201	215

Such a lack in demand for KTX affects the transportation profits. KTX maintains a profitable operation and expects to further increase its operating revenues whereas the conventional rail losses drastically increased from before the commencement of KTX, due to which KORAIL has been posting a deficit of over KRW 500 billion in the passenger category each year, and the overall passenger profits show a deficit of KRW 200 to 300 billion. If the KTX demand had increased to the originally estimated level, the profitability of KORAIL's passenger operation must have hugely been improved.

Table 5-7 | KORAIL's Passenger Carriage Revenues

(Unit: KRW 100 million)

Description	2002	2003	2004	2005	2006	2007	2008	2009	2010
KTX	-	-	-2,169	1,394	2,336	2,555	2,836	2,495	3,202
Conventional rail	-400	-1,365	-2,610	-4,472	-4,636	-5,452	-6,194	-5,642	-5,245
Total	-400	-1,365	-4,779	-3,078	-2,300	-2,897	-3,358	-3,147	-2,043

Note: Excluding the multi-regional electric rail and logistics revenues
Source: KORAIL (each year)

However, the KTX fares in Korea is very low compared to that in Japan, France or Germany, and it is difficult to raise the fares. Considering the low fares flexibility of KTX demand, it is expected that the increase in the fares will promote its profitability.

Table 5-8 | Comparison of Each Country's Railway Fares

Category	Zone	Vehicle	Fare	Distance	Simple comparison		Comparison by PPP		
					Fare per km (Won)	Fare level *Korea = 100	PPP index per GNI	Fare weight per GNI	Fare level *Korea = 100
Korea	Seoul-Busan	KTX	51,200 Won	409 km	125	100	$28,120 (31,803 K Won)	0.39%	100
Japan	Tokyo-New Osaka	Shinkansen	¥14,050 (171,691 won)	553 km	311	248	$35,200 (31,803 K won)	0.78%	198
France	Paris-Lyon	TGV	¢70.0 (106,990 won)	429 km	249	199	$34,400 (38,906 K Won)	0.64%	163
Germany	Frankfurt-Munich	ICE	¢91.0 (139,087 won)	400 km	348	277	$35,940 (40,648 K won)	0.86%	217
China	Guangzhou-Wuhan	Wuguang	490 yuan (81,193 won)	1,068 km	76	61	$6,020 (6,808 K won)	1,12%	283

Note: As of March 30, 2010 (However, the fare in China is based on the second-level seat at the time of the opening of the high speed rail in December 2009.)

KORAIL makes much effort to resolve such deficit issues, such as creating efficient management and improving profitability, and thus, after 2008, the deficit is on the decrease. But to reduce a large amount of deficits, it is necessary to make the management more efficient and create new transportation demand. KTX demand is a key factor in the profitability of KORAIL, the operating body, and the return of KORAIL Network Authority's investment. Therefore, it is necessary to promote the project based on more careful demand estimation when conducting the high speed rail project.

1.2.2 Increased construction debts

The Korea Rail Network Authority (Korea Network) depends on rail ussage fees collected from KORAIL for its revenues. Its rail usage fees account for 31% of its operating profits, and its 2010 rail usage fees for KTX amounted to KRW 210 billion. Its rail usage fees for four years, from their 2004 commencement to 2010, amounted to KRW 1.24 trillion, of which Korea Network used KRW 446.50 billion, excluding the maintenance cost of KRW

793.4 billion paid to KORAIL, to repay its debt of KRW 446.5 billion. The rail usage fees that it used to repay its debts is just 19% of the interest on the KTX construction cost. In other words, the rail usage fees that Korea Network charges to KORAIL do not even pay the interest of the funding that it procured for the construction of KORAIL. The accumulated debt of Korea Network consists of the internal procurement cost for the construction and the interest and amounts to 12.707 trillion won as of 2010. Since the accumulated debt continues to increase, the financial condition of Korea Network will be worsened if the operating income from KTX does not increase.

The main reason for the increase of the Korea Network's debt is that the rail usage fees that it receives from KORAIL is low. It is believed that this is due to that the KTX demand is lower than the estimated demand, and that the rail usage fees are set too low to 31% of the KORAIL operating income. Another reason is the low fee level of KTX. Although such low fees may worsen the financial condition of Korea Network and KORAIL, it may, on the other hand, be a positive thing for the users who can receive quality services at a low fee. Also, it is determined that the deficit issues of Korea Network are a peculiar situation of Korea, not a general issue for all the other countries. In other words, the increase in the rail usage fee will be able to improve the yearly accumulated deficits.

In a bid to improve its financial structure, Korea Network is striving to reduce its construction project costs, to develop rail station spheres, and to generate revenues through supplementary businesses. And it is asking KORAIL to increase the rail usage fees, which currently does not even pay the interest.

Table 5-9 | Korea Network's Accumulated KTX Debts

(KRW: 100 million)

Description	2004	2005	2006	2007	2008	2009	2010	Total
Rail usage fees (A)	1,056	1,598	1,821	2,006	2,004	1,808	2,106	12,399
Maintenance costs (B)	1,178	1,712	1,630	802	889	781	942	7,934
Debt repayment (C = A-B)	-122	-114	191	1,204	1,115	1,027	1,164	4,465
Interest cost (D)	2,003	2,764	3,084	3,555	3,305	4,111	4,627	23,449
Deficit (D-C)	2,125	2,878	2,893	2,351	2,190	3,084	3,463	18,984
Accumulated debt[5]	56,446	62,899	69,530	80,908	94,245	107,338	127,070	-

Source: Korea Rail Network Authority

5 Debts for financing the KTX construction costs and the interest cost deficit

1.2.3 Accessibility Problems in Some Stations and Untimely Aetup of Transfer Systems

KTX stations in some cities were constructed far away from downtown areas to conserve heritage sites and due to opposition to train passage through downtown areas. Such accessibility problems led KTX to lose in competition with other means of transportation, thus inconveniencing KTX passengers and reducing demand and profitability.

The reason for such phenomena is because Korea Network focused mainly on the construction of KTX and showed less interest in connecting transportation means. As such, the scope of the connecting transportation network construction, the responsible party, the standard for the connecting network, and the distribution of the investment were not clearly presented. The Ministry of Land recognized the inefficient transportation facility investment, which results in the lack of the connecting network among key nodes, such as railway stations, harbors, national industrial complexes, and tourist complexes, and causes disservice zones, and to improve the situation, proposed a basic plan on establishing a connecting transportation system and renovates the overall connecting transportation system. Particularly, it promotes the complex transfer centers that link various public transportation means, such as KTX stations, conventional rail stations, subway, buses and light-rails, and is making effort in establishing KTX stations as the hub of local economic development, such as urban development and industrial promotion projects centered on KTX stations.

2. Implications

The Gyeongbu KTX construction project began in June 1992 and entered the first stage of its operation on April 1, 2004. The second stage began on November 1, 2010, and the full operation will be launched in 2014. This project is the largest state project so far, accomplishing remarkable technical achievements in the rail history of South Korea.

In the early stages of the KTX project, local technical foundations, particularly rail technology levels, were very low. Despite lack of understanding of and experience in high-speed rail technologies, the country went ahead with the project with inadequately prepared design documents or specifications. Also, the type of cars was determined very late, which required overall complementation of the design and caused much confusion and many trial-and-error efforts. On the other hand, due to the foreign currency crisis in the latter half of the 1990s, the original plan to install new tracks for KTX across all the sections was changed in the first and second stages. These trial-and-error moves enabled the country to accumulate new technologies and knowhow, and to be equipped with advanced rail construction capabilities.

The construction work was stopped many times, which delayed the project, due to various civil complaints in the process of purchasing land and obtaining approval and controversies over the safety of the tunnels passing through areas adjacent to abandoned

mines. Notably, the Gyeongju line had to be changed due to environmental complaints over the Mt. Cheonseong segment and to conserve heritage sites. The Daejeon and Daegu lines, which pass downtown areas, caused conflicts with relevant groups and municipalities. The central government and the Korea High-speed Rail Construction Authority had the patience and wisdom to persuade and negotiate with stakeholders, however, which helped them overcome these problems.

Despite many such difficulties and trials and errors, the project helped enhance Korea's rail technology level as well as the design and construction technology throughout the industry and the country's profile. Also, the country's experience in the construction of high-speed rails and enhanced rail technologies should provide it with an engine with which to enter the rapidly expanding global rail market.

Based on South Korea's experience in the construction of high-speed rails, some tips to developing countries on the implementation of high-speed rail construction projects are proposed, as follows.

High-speed rail projects require highly advanced technologies, are large-scale, and are highly likely to meet with technical difficulties and trials and errors and to face various difficulties such as NGO complaints in the process. To be successful, it is important to improve the impulsion system with the strong backing of the government. South Korea established an exclusive public agency (the Korea High-speed Rail Construction Authority) to implement the project from the beginning, and the related ministry established a special committee for this purpose (the SOC Infrastructure Construction Impulsion Committee). Also one of the reasons for the successful operation of KTX is Korea Network's accumulated operation knowhow. Korea Network is the only agency that runs the national railway system in Korea with over 100 years of railway operation experience, and even before the introduction of KTX, it has experience in business extension of 3,000 km as well as the operation railway system of 90 million train-km. These organizations and government-wide efforts enabled Korea to successfully complete the large-scale project. Nonetheless, the country met with many difficulties in the process, which delayed the project. It is necessary to establish a dedicated organization and government-wide measures as well as to improve the safety and quality issues during the construction of KTX. Because the huge distrust and suspicion toward the safety and quality of the project during the construction almost stopped the project. As a plan to reduce the suspicion and distrust on the safety and quality, it is necessary to consider having internationally renowned organizations participate in the construction project.

It is inevitable for developing countries to introduce advanced high-speed rail technologies from foreign countries. It is strongly recommended to ultimately secure such technologies under a technology transfer strategy. They can thus use the secured technologies in constructing and operating additional high-speed rails and in entering overseas rail markets. In introducing foreign technologies for high-speed rail systems as well as cars and to benefit from technology transfer, they must consider the technologies'

marketability and development possibilities. Also during the introduction of a foreign vehicle system, it is necessary to benchmark the cases in which vehicle cost was reduced through the competition among bidding countries and negotiations led to better terms in technical transfer and financial procurement.

In the case of South Korea, the high-speed rail construction costs were financed by the central government and the government-controlled Korea Network, which helped ease the financial difficulty. Developing countries may have difficulty financing the project, however, and may opt to choose a private-capital-backed project. The private-capital-backed project requires a prudent decision on the minimum revenue guarantee. Under MRG, the government will compensate for lower-than-planned operating revenues; but given the uncertainty of demand forecasts, it is necessary to take careful consideration in introducing the MRG system. In the case of South Korea, the central government pays a huge amount of compensation to private operators under the MRG system in a number of projects on light-rails and toll roads.

For South Korea, the construction of the high-speed rail was financed by the central government, but the operating losses of the Korea Network are increasing each year. Such debts due to the high speed railway construction should be eventually borne by the central government, and this point should be heeded. In other words, developing countries should base their high-speed rail projects on well-founded plans hinged on accurate demand, selection of operation segments, and the feasibility of the project, to reduce government risk. The benefits of high-speed rail construction projects may offer huge socioeconomic benefits vis-à-vis costs, but may not guarantee profitability. On the other hand, a private-capital-backed project will entail many difficulties in purchasing land and compensating for them, and in coping with various civil complaints. To activate private-capital-backed projects, the government should address various complaints of various NGOs and municipalities in addition to purchasing land and compensating for them.

To increase high-speed rail demand, it is essential to develop systems for easy passenger transfer to other means of transportation (buses, taxis, and subways). South Korea was focused more on the construction of a high-speed rail than on the development of transfer systems. Thus, some high-speed rail stations are experiencing low demand. Developing countries must develop transfer systems simultaneously with their opening of a high-speed rail to increase the high-speed rail demand and the improvement of profitability. Also, high-speed rail stations, if constructed far away from downtown areas, will lower accessibility and weaken competitiveness. Thus, construction of the stations in downtown areas should be positively considered.

Although there have been many complaints and difficulties in KTX construction in Korea, these obstacles were wisely overcome, and now the KTX project is recognized one of the most successful government-run projects. There are some problems raised in terms of the debuts of Korea Network. However, the KTX project affects positively in Korea, such as the drastic enhancement of Korea's railway technology, the improvement of the

country's large-scale project management as well as consensus on quality management, the acquisition of KTX operation techniques, the establishment of the eco-friendly national transportation system, the promotion of local economy, and improvement of the national image. Based on such a positive assessment of KTX, Korea is now making effort in the construction of new KTX lines as well as the renovation of existing lines into expressways (150 km/h→230-250 km/h).

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Appendix 1. The High-speed Rail and Its Plan

1) Overview of the Gyeongbu High-speed Rail Operations

Table A-1 | Operations Overview (as of 2011)

Category	Description
Commencement date	• 1st stage (Seoul-Daegu): April 2004 (Downtown areas in Daeju and Dajeon, and electrification of the existing Daegu-Busan segment) • 2nd stage (Daegu-Busan): November 2010 (Construction of new tracks between Daegu and Busan, and use of the existing rails in the downtown areas in Daejeon and Daegu) • Full operation (downtown areas in Daejieon and Daegu): scheduled for 2014
Length	• Seoul-Busan: 423.8 km - New high-speed rail tracks: 346.4 km (as of 2011) - Existing tracks: 77.4 km (Seoul-Siheung, and downtown area segments in Daejeon and Daegu)
Frequency	• 59 frequencies during weekdays, and 77 frequencies during weekends
Max. speed	• 300 km/h
Stations	• Seoul, Gwangmyeong, Cheonan and Asan, Osong, Daejeon, Gimcheon (Gumi), Dongdaegu, Singyeongju, Ulsan, and Busan
Running time (Seoul-Busan)	• Non-stop: 2 hours and 13 minutes • Stopping at 5 stations: 2 hours and 42 minutes

Table A-2 | Fares (as of 2011)

(Unit: KRW)

Description			Seoul-Daejeon (159.8 km)	Seoul-Daegu (293.1 km)	Seoul-Busan (423.8 km)
Weekdays (Mon.-Thu.)	Special room	Adults	30,000	53,800	72,500
		Children	19,300	34,600	46,600
		Elderly	23,600	42,300	57,000
	Regular room	Adults	21,400	38,400	51,800
		Children	10,700	19,200	25,900
		Elderly	15,000	26,900	36,300
	Seat unavailability / free seat	Adults	20,300	36,500	49,200
		Children	10,100	18,200	24,600
		Elderly	14,200	25,500	34,400
Weekends (Fri.–Sun.)	Special room	Adults	32,100	57,500	77,700
		Children	20,600	36,900	49,900
		Elderly	25,200	45,200	61,000
	Regular room	Adults	22,900	41,100	55,500
		Children	11,400	20,500	27,700
		Elderly	16,000	28,800	38,800
	Seat unavailability / free seat	Adults	21,800	39,000	52,700
		Children	10,900	19,500	26,300
		Elderly	15,300	27,300	36,900

Table A-3 | Travel Demand

(Unit: 1,000 people/year)

Description	2004	2005	2006	2007	2008	2009	2010
KTX carriage demands	19,791	32,104	36,017	36,709	37,417	36,823	40,765

2) Plan for the High-speed Rail Construction

A. Honam High-speed Rail

○ Projected segment: Osong-Mokpo (231 km)

○ Project period: 2006-2017

- 1st stage: Osong-Gwangju (Songjeong-ri; 182.3 km, scheduled for completion in 2014)

- 2nd stage: Gwangju (Songjeong-ri-Mokpo: 48.7 km, scheduled for completion in 2017)

○ Project cost: Total of KRW 11.272 trillion (including a car cost of KRW 753.5 billion)

○ Stations for stoppage: Osong, Gongju, Iksan, Jeongeup, Gwangju, and Mokpo

○ Project history

- Apr.-Oct. 1990: Feasibility study of the Honam high-speed rail (KORAIL)

- Sep. 1994-Dec. 1997: Survey to devise a basic plan for the Honam high-speed rail (KORAIL)

- May 2001-Nov. 2003: Commissioning of the survey and research to devise a basic plan for the Honam high-speed rail (Ministry of Construction and Transportation)

- Apr. 2006: Commissioning of the complementation of the survey and research to devise the basic plan for the Honam high-speed rail (Ministry of Land, Transport, and Maritime Affairs)

- Nov. 2006: Basic design of the Honam high-speed rail construction project

- Nov. 2008: Completion of the basic design of the Honam high-speed rail roadbed, and commencement of the execution design

- Apr. 2009: Approval of the execution plan for the Honam high-speed rail

- Apr. 2009: Issuance of notice on a change in the basic plan for the Honam high-speed rail

- Aug. 2009: Approval of the first change in the execution plan for the Honam high-speed rail project

- May-Dec. 2009: Start of construction of 19 roadbed segments in the Osong-Gwangju (Songjeong-ri) route

B. Seoul Metropolitan (Suseo-Pyeongtaek) High-speed Rail

○ Project purpose

- Even after the opening of the Gyeongbu KTX line, the Seoul-Siheung segment (17 km) of the Gyeongbu Line is being used jointly in the high-speed rail, regular rail, freight trains, and Seoul metropolitan subways, due to which it has reached

its capacity limitations. Measures are needed to address the corresponding bottlenecks.

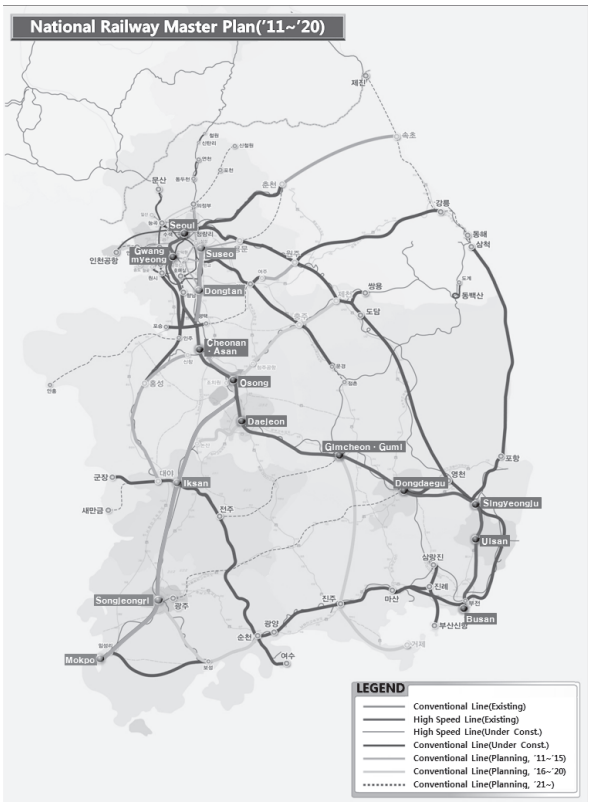
- Also, the starting and ending stations in the Seoul metropolitan area should be distributed to Suseo Station, so as to diversify the rail operation patterns. To create 5 million potential passengers in Gangnam and Gang-dong in Seoul as well as in southeastern Gyeonggi, the Suseo-Pyeongtaek high-speed rail project is being constructed.

○ Projected segment: Suseo~Pyeongtaek (60 km)

○ Project period: 2011-2014

○ Project cost: KRW 3,723.1 billion

Figure A-1 | National Railway Master Plan ('11~'20)



Appendix 2. Progress of the High Speed Rail Project

1) Key Process History

Year	Project History
06/14/90	⟨Basic plan confirmed⟩ Four stations to be completed: Absorbing the transportation demand in the Ulsan·Pohang region and Cheonan, close to the capital region; Gyeongju and Cheonan Station would increase the high speed rail usage rate.
06/10/92	⟨Detailed plan confirmed⟩ Main line Service line at the vehicle depot
06/14/93	⟨First revision of the plan⟩ Realistic project cost, term extension, and cost savings
04/25/95	⟨Daejeon-Daegu downtown zone plan revised⟩ Hindering urban development due to noise, vibration, and city division into two (on-the-ground (93)-underground work)
06/05/96	⟨Selecting a new route (68 km) in Gyeongju⟩ Minimizing the damage to cultural assets; considering technical and economic feasibility; Gyeongju Station shall be built within the city limits
02/25/97	Route change of the Sangni Tunnel zone, in which an abandoned mine was discovered
07/31/98	⟨Second revision of the plan⟩ To minimize the initial investment cost, the plan was conducted in the first and second phases; early opening of the services in Busan by converting the existing line into an electrified line
11/07/03	⟨Additional policy on intermediate stations⟩ At the Ministers' meeting on the economy, Osong, Kimcheon, Gumi, and Ulsan were added as intermediate stations for expanding the beneficiary regions.
08/23/06	⟨Third revision of the plan⟩ Three more regions (Oseong, Kimcheon-Gumi, Ulsan) were added as intermediate stations; the Daejeon-Daegu downtown route was changed to on-the-ground work; reflecting the vehicle repair facilities, etc.
10/26/07	⟨Fourth revision of the plan⟩ In preparation for the future Bujeon intermediate station, the minimal infrastructure facilities cost was reflected on the total cost.
06/24/09	⟨Fifth revision of the plan⟩ The Daejeon-Daegu downtown route construction term was changed (12/2010 → 12/2014)

2) Detailed Progress History

Year	Project History
12/73-06/74	• The construction of a new railway system in Gyeongbu was proposed (International Bank IBRD) - Survey team: SNCF survey team, Japan Foreign Railway Technical Cooperation Team
11/78-06/81	• The construction of a new railway system in Gyeongbu was proposed. - Services: KAIST (led by the Ministry of Transportation)
06/81	• Reflecting Seoul-Daejeon (160 km) on the high speed rail plan (1986-1989) - Fifth Five-Year Economic and Social Development Plan (1982-1986)
03/83	• Revised to determine the construction after the feasibility survey of Gyeongbu High Speed Rail - Fifth Five-Year Economic and Social Development Plan revised
03/83-11/84	• Seoul-Busan long-term transportation investment and high speed rail construction feasibility survey - Results: By early 1990, the railway and expressway in Gyeongbu would have reached their capacity limits, and the acquisition of a new transportation facility should focus on a railway-based plan, which offers better economic value.
05/08/89	• Determining the Seoul-Busan high speed rail construction policy (about 380 km) - Operation speed over 200 km/h; term: 08/91-08/98 (seven years); cost: KRW3.5 trillion (national budget)
07/89-02/91	• Technical survey (KORAIL)
10/16/89-10/22/89	• International High Speed Rail Symposium (Seoul) - Participated in by 631 specialists (100 from 10 foreign countries, including Japan, France, Germany, and USA)
06/14/90	• Project plan and route determined - Route: Seoul-Cheonan-Daejeon-Daegu-Gyeongju-Busan; four intermediate stations (Cheonan, Daejeon, Daegu, Gyeongju)
03/91-04/92	• Aerial photograph measurement of the optimal route (width on both sides: 200 m)
06/03/91	• Sub-base course detail design service for Seoul-Busan began
08/26/91	• The RFP for vehicle format selection was sent out to Japan, France, and Germany (deadline: 01/31/92).
06/10/92	• The detailed route was determined. - 04/30/92: Reflecting the issues discussed at the seventh Implementation Committee meeting

Year	Project History
06/30/92	• The construction of the test line (Cheonan-Daejeon) began. The sub-base course was constructed using South Korean technology. To meet the completion goal (1998), the construction was started before the vehicle format was determined
06/14/93	• The High Speed Rail Construction Plan was revised. - Cost: KRW 5.8462 trillion (1998) to KRW 10.74 trillion (1993) - Term: 1992-1998 to 2001 (Seoul-Daejeon: 1999) - Financing: 45% from financing support; 55% self-procurement * The project was revised. - Daejeon and Daegu Downtown section construction were changed to the ground level; the suspension of the bridges was changed to PC beam - The Anyang-Seoul-Susaek underground route was revised to use the existing line.
08/20/93	• The prioritized negotiation partner for the vehicles was selected (Alsthom in France).
06/15/94	• The vehicle introduction contract was concluded. - Owner: the Authority; supplier: Korea TGV Consortium - Contract amount: About USD 2.1 billion (initial proposal: about USD 3.7 billion)
08/12/94	• A contract on the introduction of a public loan amounting to USD 2.3037 billion was concluded. - Loan line: 25 financial institutes (South Korea: 7; foreign: 18)
04/25/95	• The Daejeon-Daegu section revised into an underground route. - Considering the noise, vibration, and environmental impact of the vehicle operation as well as the division of the city, the residents requested that it be changed into an underground route.
06/05/96	• A new route that would pass through Gyeongju (68 km) was determined. - Electrified line of the existing Gyeongbu railway between Daegu-Busan; the normal high speed rail operation in the whole Seoul-Busan zone by 2002
08/01/96	• Structural-safety inspection was conducted by WJE (USA). - Structures built between 06/92 and 04/25/96 (USD 2.83 million; about KRW 2.4 billion)
02/24/97	• A change was made in the Sangni Tunnel route, which was to pass through an abandoned mine.
04/14/97	• The results of WJE's safety inspection were announced.
09/08/97	• The project revision draft was announced, and a public hearing on it was held.

Year	Project History
11/14/97	• The project revision draft was discussed with 24 concerned organizations. (The implementation of the revised project plan was postponed due to the worsening economic conditions then, such as the foreign-exchange crisis.) * Project plan review results: - Cost: KRW 10.74 trillion to KRW 17.5028 trillion - Term: 05/02 to 05/11 - Economic performance: B/C 1.55 to 1.22 - Financial health: Surplus seven years after the opening → 11 years after the opening; debt repayment: 17 years after the opening → 29 years after the opening
04/03/98	• The policy of reviewing the project plan was determined. - A joint-review team, private economic-performance analysis team, and evaluation advisory committee consisting of specialists in various fields were organized for the review of the project plan.
07/08/98	• The revised project plan draft was discussed with 24 concerned organizations.
07/31/98	• Project plan revision was decided. - Cost: KRW 10.73 trillion → KRW18.4358 trillion (first phase: KRW12.7377 trillion) - Project method: Two-phase process - Term: 06/92-05/02 to 04/04 (second phase: by 2010)
07/18/99	• Official name of the High Speed Rail - KTX: "Korea Train Express"
11/22/99	• The KTX noise limit was determined (in agreement with the Ministry of Environment). - Noise measurement: Leq (equivalent sound level); test line: 65-70 dB; other sections: 63-68 dB; 15 years after the opening: 60-65 dB
12/16/99	• Test drive of Gyeongbu High Speed Rail (L = 34.4 km) - speed: 200 km/h
11/13/00	• The test line section (57.2 km) was completed; test drive at 300 km/h
11/27/00	• The second-phase project started early with the approval of the President (04-→02).
12/01/01-09/31/03	• Review service on the plan for the Daejeon and Daegu downtown route
06/18/02	• Second-phase section: Three sub-base course sections began construction.
07/18/03	• An underground route for Daegu was proposed.

Year	Project History
11/07/03	• The construction of additional intermediate stations was decided at the Ministers' Meeting for the Economy - Osong, Kimcheon-Gumi, Ulsan; part of the installation cost was to be paid by the concerned local governments
11/14/03	• The government's policy on the construction of additional intermediate stations was announced.
12/31/03	The first phase of the Gyeongbu High Speed Rail Project was completed.
04/01/04	• The first-phase section of the project was opened for services.
05/12/04	• On-the-ground construction for the Daejeon downtown route was proposed.
04/04 – 12/04	• Services for the establishment of the Gyeongbu High speed rail Intermediate Stations Basic Plan
11/16/04	• On-the-ground construction of the Daejeon downtown route was proposed again. - An on-the-ground route that uses the existing railway, with the renovation of the railway as a precondition
03/16/05 – 05/05	• Discussion on the second-phase project revision
12/12/05	• The draft of the plan for the revision of the second-phase project was submitted to the Social-Overhead-Capital Construction Implementation Committee.
07/21/06	• The written decision of the Social-Overhead-Capital Construction Implementation Committee on the second-phase project was requested.
07/21/06-08/14/06	• The written decision of the Social-Overhead-Capital Construction Implementation Committee on the second-phase project was submitted to the minister and chairman.
08/23/06	• Written decision of the Social-Overhead-Capital Construction Implementation Committee on the second-phase project: - Cost: KRW 5.6981 trillion to KRW 7.19 trillion (national budget: 35-50%) - Term: 2004-2010 to 2002-2010 - Daejeon-Daegu downtown route (underground to on-the-ground level) - Intermediate stations: Daejeon, Dongdaegu, Gyeongju, Osong, Kimcheon•Gumi, Ulsan
10/26/07	• Written decision of the Social-Overhead-Capital Construction Implementation Committee on the second-phase project - Cost: KRW 7.19 trillion to KRW 7.2136 trillion (national budget: 50%) - Revision: Reflecting the minimal infrastructure facilities cost for the future installation of the Bujeon intermediate station on the total cost

Year	Project History
06/18/09	• Written decision of the Social-Overhead-Capital Construction Implementation Committee on the second-phase project - Cost: KRW 7.2136 trillion to KRW 7.5562 trillion (national budget: 50%) - Revision: Extension of the Daejeon-Daegu downtown route construction term (12/2010-12/2014)
11/20/09	• Adjustment of the total cost that reflects the new installation cost for a connecting line between Gyeongbu High Speed Rail and Donghae Nambu Railway - Total cost: KRW 7.5562 trillion to KRW 7.9454 trillion - Cost for the installation of the new connecting railway: KRW 173.5 billion; reflecting the detail design result: KRW 215.7 billion

Appendix 3. Relevant Laws

1. Regulation on the High-speed Rail and New International Airport Construction Committee

(Enforced on July 24, 1989) (Presidential Decree No. 12762 enacted on July 24, 1989)

Article 1 (Purpose).

Under this regulation, the High-speed Rail and New International Airport Construction Committee ("the committee") shall be established to deliberate on and coordinate the basic plans and major policies for the construction of a high-speed rail and a new international airport in Korea.

Article 2 (Function).

The committee shall deliberate on and coordinate the following matters.

1. Matters concerning the formulation of a basic plan for the construction of the high-speed rail and the new international airport.
2. Matters concerning major policies for the construction of the high-speed rail and the new international airport.
3. Matters concerning the introduction of technologies necessary for the construction of the high-speed rail and the new international airport, and concerning the development of relevant domestic technologies.
4. Matters concerning the financing of the construction of the high-speed rail and the new international airport.
5. Matters concerning inter-ministerial cooperation in the construction of the high-speed rail and the new international airport.
6. Matters that the Chairperson will propose as part of the agenda regarding the construction of the high-speed rail and the new international airport.

Article 3 (Composition).

1. The committee shall consist of up to 25 persons, including one Chairperson and one Vice-chairperson.
2. The Chairperson shall be the Minister of Economic Planning of Korea, and the Vice-chairperson shall be the Minister of Transportation.
3. The members shall be the Minister of Home Affairs, the Minister of Finance, the Minister of National Defense, the Minister of Agriculture and Fisheries, the Minister of Commerce, the Minister of Energy and Resources, the Minister of Construction, the Minister of Communications, the Minister of Science and Technology, the Seoul Mayor, the Forest Service Commissioner, the Minister of Environment, the Korea Rail President, the Economic Secretary of the President, and the Administrative

Coordination Office Head, as well as personnel with ample knowledge and experience in relevant areas who shall be appointed by the Chairperson.

Article 4 (Duties of the Chairperson and the Vice-chairperson).

1. The Chairperson shall represent the committee and supervise its affairs.
2. The Vice-chairperson shall assist the Chairperson, and shall act as the Chairperson when the Chairperson is incapacitated.

Article 5 (Meetings).

1. As deemed necessary, the Chairperson shall convene meetings of the committee, and shall preside over such meetings.
2. The committee meeting shall start with the attendance of the majority, and shall make resolutions with the concurrence of the majority of the attendees.

Article 6 (Hearing of Opinions).

As deemed necessary, the committee may hear the opinions of relevant public officials and experts in deliberating on and coordinating the matters stipulated in Article 2.

Article 7 (Moderator).

1. The committee shall appoint one moderator to handle its administrative affairs.
2. The moderator shall be appointed by the Minister of Transport from among the officials of the Ministry of Transport.

Article 8 (Working Committee).

1. The committee shall establish a working committee to conduct a working review of its deliberation and coordination matters, as well as of its assigned matters.
2. The working committee shall consist of fewer than 30 members including one Chairperson and two Vice Chairpersons.
3. The working committee Chairperson shall be the Vice-minister of Transportation, and the Vice-chairpersons shall be the Head of the Planning and Coordination Office under the control of the Ministry of Transport and the Vice-president of the Rail Service.
4. The working committee shall consist of relevant bureau directors from the Ministry of Economic Planning, Ministry of Home Affairs, Ministry of Finance, Ministry of National Defense, Ministry of Agriculture and Fisheries, Ministry of Commerce, Ministry of Energy and Resources, Ministry of Construction, Ministry of Transportation, Ministry of Communications, Ministry of Science and Technology, Seoul City, Forest Service, Ministry of Environment, and Korea Rail, as well as of second- and third-grade officials in charge of transportation at the Presidential Secretariat (including second- or third-grade special officials), second- and third-

grade reviewers in charge of transportation at the Administrative Coordination Office, researchers from relevant research institutions, and experts in relevant fields as appointed by the Chairperson.

5. Matters concerning the working committee, such as its operation, and the establishment of subcommittees shall be determined by the Chairperson of the committee through a resolution by the committee.

6. Articles 4-6 shall apply to the working committee, with modifications as deemed necessary.

Article 9 (Operation of Working Members and Dispatch of Relevant Officials).

1. To support the work of the committee, as deemed necessary, its working members shall hold office at the Ministry of Transport and Korea Rail.

2. As deemed necessary to the conduct of the work of the working members of the committee, the Minister of Transport and the president of Korea Rail may request the dispatch of officials from relevant administrative agencies, and of officials and employees from relevant corporations or research institutions, to the working group.

Article 10 (Minutes).

The committee and the working committee shall keep minutes of their meetings.

Article 11 (Allowances, etc.).

Allowances and trip expenses may be paid to non-public-officials in the committee and the working committee, and to relevant specialists and working group members in these committees, within the budget scope.

Article 12 (Detailed Operational Rules).

As deemed necessary, matters outside this Decree shall be decided on by the Chairperson through a resolution by the committee.

2. The Korea High-speed Rail Construction Authority Act

(Enforced on March 1, 1992) (Act No. 4456 enacted on December 27, 1991)

Article 1 (Purpose).

This Act establishes the Korea High-speed Rail Construction Authority ("the Authority") to efficiently construct the high-speed rail with a view to the expansion of rail transportation networks, in a bid to improve transportation convenience and to help promote a healthy national economic development.

Article 2 (Definition).

A high-speed rail under this Act is a rail wherein a train can run at over 200 kph on its major segments, and that the Minister of Transportation designates as such along with a public notice.

Article 3 (Corporate Entity). The Authority shall be a corporation.

Article 4 (Establishment).

1. The Authority shall be established with an establishment registration in its main office location.
2. The establishment registration details under Section 1 shall be described as follows:
   1.1. Purpose;
   1.2. Name;
   1.3. Main office, branches, and sub-branches;
   1.4. Names and addresses of officers; and
   1.5. Method of public announcement.
3. Regarding the Authority registration, except for its establishment registration, the provision on foundation and corporation registration under the Civil Act shall apply with modifications as deemed necessary.

Article 5 (Office).

1. The main office of the Authority shall be defined in its Articles of Association.
2. As deemed necessary, the Authority may establish branches or sub-branches according to its Articles of Association.

Article 6 (Articles of Association).

1. The Articles of Association of the Authority shall stipulate the following details:
   1.1. Purpose;
   1.2. Name;
   1.3. Location of the main office;

1.4. Matters concerning works and their execution;

1.5. Matters concerning assets and accounting;

1.6. Matters concerning officers and employees;

1.7. Matters concerning the board of directors;

1.8. Matters concerning the amendment of its Articles of Association; and

1.9. Matters concerning public announcements.

2. In amending its Articles of Association, the Authority shall obtain prior approval from the Minister of Transportation.

Article 7 (Projects).

The Authority shall perform the following projects to achieve the purpose stipulated in Article 1:

1. Construction of the high-speed rail;
2. Construction of the high-speed rails of foreign countries;
3. Research, development, and survey of high-speed rail technologies;
4. Projects to develop high-speed rail station spheres and the areas surrounding the high-speed rail;
5. Projects annexed to Paragraphs 1 to 4; and
6. Projects commissioned by the government.

Article 8 (Officers).

1. The Authority shall have the following officers: 10 directors (including one president and two executive vice-presidents) and one auditor.
2. Upon the recommendation of the Minister of Transportation, the president shall be appointed and dismissed by the President of Korea.
3. The auditor shall be appointed and dismissed by the Minister of Transportation.
4. The executive vice-presidents and directors shall be appointed and dismissed by the president of the Authority subject to the approval of the Minister of Transportation.
5. The term of the /president, executive vice-presidents, and directors shall be three years, and the term of the auditor shall be two years.

Article 9 (Limitation of the Representative Rights of the President).

With regard to matters wherein the interest of the Authority and that of the president conflict with each other, the president shall not represent the Authority, and instead, the auditor shall represent the Authority.

Article 10 (Appointment of a Proxy).

The president may, according to the Articles of Association of the Authority, appoint a proxy from among the employees of the Authority, who will have the authority to engage in trials and other matters of the Authority.

Article 11 (Duties of Officers).

1. The president shall represent the Authority and supervise the works of the Authority.
2. The executive vice-president shall assist the president, and one of them shall be the/ acting president according to the Articles of Association when the president is incapacitated.
3. The president shall divide the works of the Authority according to its Articles of Association, and if the president and the executive vice-presidents are all incapacitated, an officer shall be an the acting president according to the priority stipulated in the Articles of Association of the Authority.
4. The auditor shall audit the works and accounts of the Authority.

Article 12 (Reasons for Disqualification of Officers).

The personnel described below shall not be eligible to become officers of the Authority:

1. A person who is not a South Korean national;
2. A person who is not reinstated after declared incompetent, quasi-incompetent, or bankrupt;
3. A person who is sentenced to imprisonment or higher punishment, and whose sentence ended less than two years ago or whose sentence was lifted less than two years ago; and
4. A person who is disqualified or whose qualifications are suspended according to laws or the court's decision.

Article 13 (Limitation of Multiple Jobs of Officers and Employees).

The officers and employees of the Authority shall not engage in businesses for profit other than their jobs. Officers shall not engage in other jobs without the approval of the Minister of Transportation, and employees shall not engage in other jobs without the approval of the president of the Authority.

Article 14 (Board of Directors).

1. The Authority shall establish a board of directors to resolve important matters of the Authority.
2. The board shall consist of the president, executive vice-presidents, and directors.

3. The president shall convene board meetings and shall be the chairperson of the board.

4. The board shall decide on matters by approval of the majority in meetings attended by the majority of all the members.

5. The auditor may attend board meetings and state his/her opinions thereat.

Article 15 (Appointment and Dismissal of Employees).

The employees of the Authority shall be appointed and dismissed by the president of the Authority according to its Articles of Association.

Article 16 (Free Lending of State-owned Properties etc.).

1. As deemed necessary for the efficient performance of the projects of the Authority under Article 7, the government may, notwithstanding the State-owned Property Act, lend state-owned properties to the Authority for free, or allow it to use and benefit from them.

2. The Authority may, notwithstanding the provision on the state-owned properties, construct buildings or permanent facilities in the sate-owned properties that are lent to it for its use and benefit under Section 1.

3. Necessary matters concerning conditions and procedures for the approval of lending or the use and benefit under Section 1 shall be defined by Presidential Decree.

Article 17 (Sublease of State-owned Properties etc.).

1. As deemed necessary for the efficient construction of the high-speed rail, the Authority may sublease the state-owned properties that are lent to it for its use and benefit under Article 16.

2. In subleasing the properties under Section 1, the Authority shall obtain prior approval from the Minister of Transportation. This shall likewise apply to a revision thereof.

3. In approving the sublease under Section 2, the Minister of Transportation shall have prior consultation with the head of the central administrative agency that lends the relevant state-owned property or that allows it to be used by the Authority for the Authority's benefit.

4. Article 16, Sections 2 and 3 shall apply to the subleased state-owned properties under Section 1, with modifications as deemed necessary.

Article 18 (Succession to the High-speed Rail etc.).

1. The Korea Rail Corporation, established according to the Korea Rail Corporation Act, ("Korea Rail Corporation"), shall, according to the Korea Rail Corporation Act, take over the rights to properties and facilities and the operation thereof that are acquired in connection with the high-speed rail constructed under Article 7, and with the projects for the development of the high-speed rail station spheres and the

areas surrounding the high-speed rail ("the assets"), as well as to debts related to the relevant assets ("the debts") when all the projects end. Assets not directly needed for the works of the Korea Rail Corporation shall be owned, however, by the state according to the Presidential Decree.

2. When the Authority intends to transfer the assets and debts under Section 1 to the Korea Rail Corporation, it shall prepare transfer-related documents and obtain approval thereof from the Minister of Transportation.

3. The time for the Korea Rail Corporation to take over the assets and debts under Section 1, as well as the method of evaluation thereof, the evaluation base date, etc., shall be determined by Presidential Decree.

Article 19 (Financing etc.).

1. The operation and projects of the Authority shall be financed as follows:

   1.1. Through investment by the government or other parties;

   1.2. Through funds raised from the issuance of high-speed rail construction bonds;

   1.3. Through proceeds from the operation of assets;

   1.4. Through borrowings (including foreign borrowings and materials); and

   1.5. Through other revenues.

2. Necessary matters concerning the provision, management, and use of the government's investment fund under Section 1, Paragraph 1 shall be determined by Presidential Decree.

Article 20 (Projects on the Development of a Railway Station Sphere etc.).

1. In performing projects to develop the high-speed rail station spheres and the areas surrounding the high-speed rail, as deemed necessary for promoting the construction of the high-speed rail, the Authority may perform housing development projects according to the Housing Land Development Promotion Act. In this case, in applying the Housing Land Development Promotion Act, the Authority shall be regarded as included in the category of implementers of housing land development projects under Article 7 of the same Act.

2. The scope of the rail station spheres and their surrounding areas under Section 1 shall be determined by Presidential Decree.

Article 21 (Collection of Service Fees etc.).

1. The Authority may collect service or use fees from those who use the facilities that it manages.

2. Necessary matters concerning the collection targets, the collected amount, and the

collection procedure with regard to the collected service or use fees under Section 1 shall be determined by the Transportation Ministry Decree.

Article 22 (Investments etc.).

1. As deemed necessary for the efficient performance of its projects, the Authority may make monetary or material investments in projects under each Paragraph of Article 7.
2. Necessary matters concerning monetary or material investments under Section 1 shall be determined by the Presidential Act.

Article 23 (Purchase of Land etc.).

1. To achieve the purpose stipulated in Section 1, the Authority may purchase or sell necessary lands or fixtures on the relevant land.
2. As deemed necessary for the performance of the projects under Article 7, the Authority may expropriate or use the land, properties, or rights under Article 2 of the Land Expropriation Act.
3. The Land Expropriation Act shall apply to the expropriation or use of lands under Section 2.

Article 24 (Borrowing of Funds etc.).

1. As deemed necessary for the performance of the projects under Article 7, the Authority may, with the approval of the Minister of Transportation, borrow funds (including foreign funds and the introduction of foreign materials). This shall likewise apply herein.
2. In approving the borrowings under Section 1, the Minister of Transportation shall have prior consultation with the head of the relevant central administrative agency.

Article 25 (Issuance of Bonds for the High-speed Rail Construction etc.).

1. To finance the projects under Article 7, the Authority may issue high-speed rail construction bonds ("the bonds").
2. In issuing the bonds under Section 1, the Authority shall obtain approval thereof from the Minister of Transportation. In this case, the Minister of Transportation shall have prior consultation with the head of the relevant central administrative agency.
3. The government may guarantee the repayment of the principal of the bonds issued by the Authority.
4. The government may help in the payment of some of the costs incurred for the Authority to pay for the interest on its issued bonds.
5. The extinctive prescription of the bonds shall be completed in 5 years for the principal, and in 2 years for the interest, from the repayment date.

6. Other necessary matters concerning the issuance of bonds shall be determined by Presidential Decree.

Article 26 (Approval of the Project Plan etc.).

The Authority shall prepare the business plan and budget plan for each fiscal year according to the Presidential Decree, and obtain approval thereof from the Minister of Transportation. This shall likewise apply to revisions thereof.

Article 27 (Submission of the Settlement Statement).

The Authority shall prepare a statement of settlement of revenues and expenditures in each fiscal year, have it examined by certified public accountants, and submit it to the Minister of Transportation by the end of February of the next fiscal year.

Article 28 (Fiscal Year).

The fiscal year of the Authority shall be the same as that of the government.

Article 29 (Disposition of Surplus).

The Authority shall dispose of the surplus shown in its settlement statement for each fiscal year, if any, with the following priorities:

1. Covering of the deficit carried over from the previous term;
2. Facility reserve fund defined by the Presidential Decree; and
3. Payment to the state coffers.

Article 30 (Request for Provision of Data).

As deemed necessary for its works, the Authority may request relevant administrative agencies, or other institutions and organizations related to the high-speed rail, to provide necessary data.

Article 31 (Accounting Provision of the Authority etc.).

The Authority shall determine matters concerning its organization, accounting, human resource affairs, and remuneration, and obtain approval thereof from the Minister of Transportation. This shall likewise apply to revisions thereof.

Article 32 (Guidance and Supervision).

1. As deemed necessary for the guidance and supervision of the Authority, the Minister of Transportation may require the Authority to report its works, accounting, and properties, or may order his/her officials to inspect the Authority's books, files, facilities, and other properties.
2. If the report or inspection under Section 1 reveals illegality or improprieties, the Minister of Transportation may issue a corrective action order to the Authority.

3. The officials who will perform the inspection under Section 1 shall carry a certificate representing their authority and show it to the relevant personnel.

Article 33 (Confidentiality).

The Authority's officers or employees or personnel, and those engaged in the design, construction, improvement, or repair of the high-speed rail facilities under agreements with the Authority or who are employed for such works shall not leak confidential business information that they may come to know.

Article 34 (Ban on the Use of Similar Names).

Entities that are not the Authority by this Act shall not use the name Korea High-speed Construction Authority or similar names.

Article 35 (Application of Other Laws with Modifications as Deemed Necessary).

Except as stipulated in this Act, the provision on foundations and corporations under the Civil Act shall apply to the Authority, with modifications as deemed necessary.

Article 36 (Legal Function as Public Officials with Regard to the Application of Punishment).

When applying Articles 129-132 of the Criminal Act, the Authority's officers and employees shall be regarded as public officials.

Article 37 (Punishment).

Violators of Article 33 shall be penalized with up to two years imprisonment or with a fine of up to KRW 2 million.

Article 38 (Fines).

Violators of Article 34 shall be fined up to KRW 2 million.

3. High-speed Rail Construction Promotion Act

(Enforced on April 1, 1997) (Act No. 5250 enacted on December 31, 1996)

Article 1 (Purpose).

This Act defines necessary matters concerning the early construction of a high-speed rail in Korea, so as to efficiently implement the high-speed construction project with a view to coping with the rapidly increasing traffic demand and boosting Korea's economic development.

Article 2 (Definition).

The terms of this Act shall be defined as follows.

1. "High-speed rail" refers to a rail wherein a train can travel on major legs at over 200 kph, and that the Minister of Construction and Transportation has designated as such, along with a public notification thereof.
2. "High-speed rail facility" refers to each of the following facilities:
   - 2.1. Tracks of the high-speed rail (including facilities annexed to the tracks) and station facilities (including the transfer facilities stipulated in Article 2, Section 3 of the Urban Traffic Improvement Promotion Act, which shall likewise apply hereunder);
   - 2.2. Car maintenance depots, track repair bases, and car detention facilities designed to repair and maintain cars and tracks of the high-speed rail;
   - 2.3. In the high-speed rail, transformers, power transmission lines, and other power facilities, as well as rail communication facilities and train control facilities;
   - 2.4. Facilities needed to link the operation of the high-speed rail to that of other rails;
   - 2.5. Facilities to develop, test, and research on high-speed rail technologies; and
   - 2.6. Facilities to construct, maintain, and repair the high-speed rail, as designated by the Presidential Decree.
3. "High-speed rail construction project" refers to the following projects:
   - 3.1. Construction projects for facilities under Paragraph 2;
   - 3.2. Residential facilities and convenience infrastructure construction projects for those who will lose their residential areas due to construction projects under Paragraph 2; and
   - 3.3. Construction projects for public facilities, military facilities, or communal buildings (excluding high-speed rail facilities) that shall be installed under Article 16, Section 1.

Article 3 (Formulation of a Basic Plan for the High-speed Rail Construction).

1. As deemed necessary for the construction of the high-speed rail, the Minister of Construction and Transportation shall formulate the basic plan for the high-speed rail construction ("the basic plan") according to the Presidential Decree.
2. In devising the basic plan under Section 1, the Minister of Construction and Transportation shall have prior consultation with relevant mayors or provincial governors ("mayors and governors") and with the heads of relevant central government agencies, and shall have the plan reviewed by the High-speed Rail Construction Impulsion Committee as designated by the Presidential Decree ("the impulsion committee").
3. The Minister of Construction and Transportation shall notify the public of the basic plan devised under Section 1 according to the Presidential Decree, and shall send the plan to the mayors and governors for public disclosure thereof over a period of more than 20 days.
4. The basic plan shall include the following matters:
   - 4.1. Regarding the prearranged area for the construction of the high-speed rail, its characteristics, traffic situation, and forecasts of traffic demand;
   - 4.2. Evaluation of the economics, feasibility, and other aspects of the high-speed rail construction;
   - 4.3. Sketchy route maps;
   - 4.4. Construction period and financing measures;
   - 4.5. Approximate construction costs and mid- and long-term fund operation plans;
   - 4.6. Building of transportation systems linked to other means of transportation;
   - 4.7. Countermeasures against earthquakes;
   - 4.8. Plan for securing and fostering high-speed rail operations manpower; and
   - 4.9. Other matters deemed necessary by the Minister of Construction and Transportation.
5. Sections 2 and 3 shall apply--with modifications as deemed necessary--to revisions of the basic plan devised according to Section 4. This shall exclude the revision of light matters stipulated in the Presidential Decree.

Article 4 (Implementer of the High-speed Construction Project).

1. The high-speed rail construction project shall be performed by the Korea High-speed Rail Construction Authority established according to the state or the Korea High-speed Rail Construction Authority Act. If, however, the construction of the high-

speed rail shall be performed under the Private Capital Attraction Promotion Act Concerning SOC Infrastructure, the person designated in the Act shall implement the project.

2. As deemed necessary for the efficient implementation of the high-speed rail construction project, the Minister of Transportation and Construction may allow an administrative agency, a government-invested institution, etc., other than the persons designated in Section 1, to perform part of the project according to the Presidential Decree.

Article 5 (Designation of Prearranged Areas, etc.).

1. In implementing the high-speed rail construction project, the Minister of Construction and Transportation may designate prearranged areas for the high-speed rail construction ("prearranged areas") or change the designated prearranged areas.

2. In designating or changing the prearranged areas under Section 1, the Minister of Construction and Transportation shall have prior consultation with the relevant mayors and governors and the heads of relevant central administrative agencies, and shall have the corresponding results reviewed by the impulsion committee.

3. The Minister of Construction and Transportation shall notify the public of the designated or changed prearranged areas under Section 1, according to the Presidential Decree.

4. The Minister of Construction and Transportation shall cancel the prearranged or changed areas designated under Section 1 if the project has not commenced within 5 years of such designation or change.

Article 6 (Limitations of this Act).

1. Those who intend to change the shape and quality of land, construct buildings, install facilities, collect soil and gravel (including sand, which shall likewise apply hereunder), or conduct other acts as designated by the Presidential Decree in the prearranged areas, shall obtain approval thereof from the competent mayor, county governor, or district office head (i.e., the autonomous district office head, which shall likewise apply hereunder). This shall equally apply to a change in approvals.

2. Notwithstanding Section 1, those who have already embarked on the construction of the project upon the designation or notice of the prearranged areas according to the relevant laws, and who have already obtained approval and permission concerning the change in the land shape and quality, construction of buildings, installation of facilities, or collection of soil and gravel (including occasions when no such approval or permission is required according to the relevant laws), may implement such project after reporting it to the mayor, county governor, or district office head according to the Presidential Decree.

3. Section 1 shall not apply to acts necessary for military operations. This shall not

apply, however, when the safe operation of the high-speed rail is hampered, or when permanent buildings or facilities need to be installed.

4. The mayor, county governor, or district office head may order the violators of Section 1 to restore the original state.

5. In accordance with the Administrative Vicarious Execution Act, the mayor, county governor, or district office head may execute necessary action against those who have been given the order according to Section 4 but who have failed to perform their duty.

Article 7 (Approval of the Execution Plan).

1. The high-speed rail project implementers under Article 4 ("the project implementers") shall devise an execution plan for the high-speed rail construction, specifying the project size, outline, period, financing, and other matters stipulated in the Presidential Decree ("the execution plan"), and shall obtain approval thereof from the Minister of Construction and Transportation. In this case, as deemed necessary for the efficient implementation of the high-speed rail construction project, the project implementers may devise execution plans according to segments or facilities within the scope of the basic plan.

2. In devising the execution plan under Section 1, the project implementers shall reflect the results of their environmental impact evaluation, traffic impact evaluation, and survey of cultural heritage situations in the plan.

3. The Minister of Construction and Transportation shall publicly announce the execution plan--if approved under Section 1--according to the Presidential Decree, and shall send copies of relevant documents to the heads of relevant local governments.

4. The heads of local governments who have received copies of relevant documents under Section 3 shall take necessary action, including land registration notice approval application under Article 13 of the Urban Planning Act, if the relevant documents include matters that need urban planning decisions. In this case, the project implementers shall submit documents necessary for the issuance of land registration notices to the heads of local governments.

5. In revising matters included in the execution plan as approved under Section 1 and designated by the Presidential Decree, the project implementers shall obtain approval thereof from the Minister of Construction and Transportation. In this case, Sections 1-4 shall apply, with modifications as deemed necessary.

Article 8 (Relations to Other Laws).

1. If the execution plan has been approved according to Article 7, it shall be regarded as among the following approvals, permissions, decisions, reports, designation, licenses, consultations, agreements, liftings of designations, and deliberations being

done ("approval, permission, etc."). If the approval of the execution plan has been publicly announced, the following approvals, permissions, etc. shall be regarded as publicly announced according to relevant laws:

1.1. Consultation on or approval of the installation of public facilities etc. according to Article 20 of the Act on the Utilization and Management of National Land, land transaction approval according to Article 21-3 of the same Act, and reporting of land transaction agreements according to Article 21-7 of the same Act;

1.2. Permission for a change in the land shape and quality according to Article 4 of the Urban Planning Act, decision on urban planning according to Article 12 of the same Act (limited to the facilities under Article 2, Section 1, Paragraph 1, Subparagraph B of the same Act), designation of the urban planning project implementers under Article 23 of the same Act, and approval of the execution plan for the urban planning project under Article 25 of the same Act;

1.3. Permission for the occupation or use of public waters under Article 4 of the Public Waters Management Act;

1.4. Licensing of the reclamation of public waters under Article 4 of the Public Waters Reclamation Act, the of the execution plan under Article 9-2 of the same Act, and consultation on or approval of the plan under Article 29 of the same Act;

1.5. Consultation with or approval by the management office under Article 6 of the River Act (limited to the approval of the implementation of river projects under Article 23 of the same Act, and to the approval of river occupation etc. under Article 25 of the same Act);

1.6. Consultation with and approval by the Road Management Office under Article 8 of the Road Act (limited to the public announcement of road recognition under Article 19 of the same Act, decisions on road areas under Article 25 of the same Act, approval of the implementation of road projects for entities other than the management office under Article 34 of the same Act, and occupation of roads under Article 40 of the same Act);

1.7. Consultation with the Park Management Office under Article 50, Section 1 of the Natural Park Act (limited to approval of the occupation and use of parks under Article 23 of the same Act, and to approval of acts inside the protected park areas under Article 25 of the same Act);

1.8. Approval of diverted use of agricultural land under Article 36 of the Agricultural Land Act;

1.9. Deliberation on traffic impact assessment under Article 13 of the Urban Traffic Improvement Promotion Act;

1.10. Permission of lumbering, etc. under Article 14 of the Land Erosion and Collapse

Prevention Work Act, and lifting of the designation of erosion prevention areas under Article 20 of the same Act;

1.11. Permission for and consultation on diverted use of preserved forests under Article 18 of the Forest Act, lifting of the designation of security forests under Article 57 of the same Act, permission for lumbering of trees inside security forests under Article 62 of the same Act, permission for lumbering of trees under Article 90 of the same Act, and approval of quarrying under Article 90-2 of the same Act;

1.12. Approval of general waterworks projects under Article 12, Section 1 of the Water Supply and Waterworks Installation Act, and approval of exclusive waterworks installation under Articles 36 and 38 of the same Act;

1.13. Consultation on and approval under Article 3 of the Sewerage Act, approval of the implementation of public sewerage projects under Article 13 of the same Act, and approval of the occupation of public sewerages under Article 20 of the same Act;

1.14. Approval of the installation of electric facilities under Article 29 of the Electric Power Business Act, and approval or reporting of project plans for self-use electric facilities under Article 32 of the same Act;

1.15. Approval of the construction of factories, etc. under Article 13 of the Act on Industrial Deployment and Construction of Factories (limited to factories that are directly needed for the high-speed rail construction project and that are constructed during the construction period);

1.16. Deliberation by the construction committee under Article 4 of the Construction Act, approval of construction under Article 8 of the same Act, reporting of construction under Article 9 of the same Act, approval of the construction of temporary buildings under Article 15, Section 1 of the same Act, and consultation on construction under Article 25 of the same Act;

1.17. Approval of acts inside the grassland creation area under Article 8 of the Grassland Act, and approval of or consultation on diverted use under Article 23 of the same Act;

1.18. Deliberation by the Construction Technology Deliberation Committee under Article 5 of the Construction Technology Management Act;

1.19. Agreement on the approval of construction, etc. under Article 8 of the Firefighting Act, permission for the installation of factories, etc. under Article 16, Section 1 of the same Act, and reporting of the construction of firefighting facilities under Article 62, Section 1 of the same Act;

1.20. Approval of access to protected areas or military facilities under Article 7 of the Military Facility Protection Act, and consultation on approvals by the relevant administrative office under Article 10 of the same Act;

1.21. Approval of the relocation of tombs under Article 16, Section 2 of the Act on Burial, Tombs, etc.;

1.22. Non-approval of the establishment of mining rights under Article 29 of the Mining Business Act, and cancellation of mining rights or reduction of mine blocks under Article 39 of the same Act;

1.23. Approval of the construction of private roads under Article 4 of the Private Road Act;

1.24. Approval of land acquisition under Article 10 of the Housing Land Ownership Limitation Act;

1.25. Approval or reporting of waste treatment facilities under Article 30 of the Waste Management Act;

1.26. Reporting of the installation of sewage disposal facilities under Article 9, Section 2 of the Act on the Disposal of Sewage, Excrement, and Livestock Wastewater, and reporting of the installation of sewage disposal tanks under Article 10, Section 2 of the same Act; and

1.27. Approval or reporting of the installation of discharge facilities under Article 10 of the Clean Air Conservation Act, Article 10 of the Clean Water Conservation Act, and Article 9 of the Noise and Vibrations Regulation Act, and approval of the design and construction of self-prevention facilities under the proviso of Article 12 of the Clean Air Conservation Act and the proviso of Article 12, Section 1 of the Clean Water Conservation Act.

2. In approving the execution plan that includes one of the matters stipulated in each paragraph in Section 1, the Minister of Construction and Transportation shall prepare relevant documents submitted by the project implementers and shall have prior consultation with the heads of relevant administrative agencies. In this case, the heads of the relevant administrative agencies shall provide their opinions within the period designated by the Presidential Decree for such a request.

Article 9 (High-speed Rail Construction Review Committee).

1. To deliberate on important matters concerning architectural technologies, construction technologies, and the traffic impact of the high-speed rail construction project, the high-speed rail construction review committee ("the review committee") shall be established under the control of the Minister of Construction and Transportation.

2. In approving the execution plan that includes Paragraphs 9 and 16 of Article 8

(excluding the approval of the construction of temporary buildings under Article 15, Section 1 of the Construction Act) or matters in Paragraph 18, the Minister of Construction and Transportation shall have prior consultation with the review committee.

3. The review committee shall have up to 100 members, including the committee chairperson, and these members shall be appointed by the Minister of Construction and Transportation from among those described below:

   3.1. Fourth-grade or higher officials related to the high-speed rail construction project in the relevant central and local administrative agencies and local governments;

   3.2. Officers of public organizations and research institutions; and

   3.3. Personnel with ample knowledge and experience in high-speed rail construction, civil engineering, and environment protection, as defined by the Minister of Construction and Transportation.

4. As deemed necessary, the Chairperson may form and operate subcommittees by field according to the agenda for the review committee's deliberation of relevant matters.

5. Necessary matters concerning the composition, functions, and operations of the review committee under Section 1 shall be defined by the Presidential Decree.

Article 10 (Special Cases Concerning the Promotion of the High-speed Rail Construction Project and the Improvement of the Quality Thereof).

1. Under each of the following circumstances, the relevant high-speed rail facilities shall not be governed by Articles 39 and 40 of the Construction Act, Article 44 of the same Act, Article 17, Section 1 of the Firefighting Act, and Article 30, Section 1 of the same Act:

   1.1. In the event that special technologies or special machines, which were admitted by the Minister of Construction and Transportation after undergoing the review thereof by the review committee, are used; and

   1.2. In the event that the structures and types of high-speed rail facilities are admitted by the Minister of Construction and Transportation to be equivalent to the criteria for firefighting, accident prevention, fire prevention, and escape stipulated under relevant laws, after they are reviewed by the review committee.

2. In placing orders for the construction of the high-speed rail facilities with diverse functions and characteristics, such as high-speed rail stations, the project implementers may place a combined order for all such facilities according to the Presidential Decree, if any, if separate individual orders are difficult due to the nature of the construction work or to the technical inseparability of the construction, electricity, and electricity and communication works.

3. The project implementers may, notwithstanding Article 20 of the Act on the Industrial Deployment and Construction of Factories, install, expand, or relocate to the production facilities various materials necessary for the high-speed rail project that are admitted by the Minister of Construction and Transportation as directly necessary for the high-speed rail construction project in the prearranged areas or surrounding areas. In this case, the relevant production facilities for the construction materials shall be limited to those that are installed for the construction works during the construction period.

Article 11 (Access to and Use of Land, etc.).

1. Regarding investigations and surveying or implementation of the high-speed rail construction project with a view to the drawing up of the execution plan, as deemed necessary, the project implementer may access third-party land or temporarily use third-party land as material accumulation sites, passages, or temporary roads. Notably, as deemed necessary, the project implementer may change or remove bamboos and trees, soil, and other obstacles from such land.

2. Article 5, Sections 2-7 of the Urban Planning Act, and Article 6 of the same Act, shall apply to Section 1 with modifications, as deemed necessary.

Article 12 (Expropriation of Land, etc.).

1. In implementing the high-speed rail construction project, as deemed necessary, the project implementers may expropriate or use the land, properties, or rights ("land, etc.") stipulated in Article 2 of the Land Expropriation Act.

2. When the execution plan is approved or publicly announced, it shall be regarded as the project admission and the issuance of the notice of the project admission under Article 14 of the Land Expropriation Act and Article 16 of the same Act, and an application for a decision may, notwithstanding Article 17 of the Land Expropriation Act and Article 25, Section 2 of the same Act, be made within the project implementation period stipulated in the execution plan.

3. The central land expropriation committee shall be the competent land expropriation committee for the decision-making on the expropriation or use of land, etc. under Section 1.

4. The Land Expropriation Act shall apply to the expropriation or use of land under Section 1, with modifications as deemed necessary, except otherwise stipulated in this Act.

Article 13 (Limited Disposition of National and Public Lands, etc.).

1. Land owned by the central government or local governments, that is situated inside the prearranged areas, and that is necessary for the high-speed rail construction project, shall not be sold or transferred for purposes other than the implementation of the high-speed rail construction project.

2. The properties located inside the prearranged areas and owned by the central government or by local governments may, notwithstanding the State-owned Property Act, the Local Finance Act, and other laws, be sold to the project implementers on a negotiated contract basis. In this case, regarding the disposition of the use or sale of the relevant property, the Minister of Construction and Transportation shall have prior consultation with the heads of relevant administrative agencies.

3. Upon a request for consultation according to the second part of Section 2, the heads of relevant administrative agencies shall take necessary measures such as the disposition of the use and sale within 90 days of their receipt of the request.

4. Regarding state-owned properties that are intended to be sold to the project implementers under Section 2, but the management offices of which are not known, the Minister of Finance and Economy shall, notwithstanding other laws, be responsible for their management and disposition.

Article 14 (Confirmation of the Completion of the Construction).

1. After completing the construction work in the high-speed rail construction project, the project implementers shall, without delay, submit a construction work completion report to the Minister of Construction and Transportation, and shall obtain confirmation of their construction work completion from the minister. In this case, the Minister of Construction and Transportation may request that the inspection necessary for the confirmation of the construction work completion be conducted by heads of relevant central administrative agencies, local governments, government-invested institutions, and the Korea High-speed Rail Construction Authority, research institutions, or other specialist institutions.

2. Upon the receipt of an application for confirmation of construction work completion under Section 1, the Minister of Construction and Transportation shall, in the event that the works are admitted as implemented as approved after the confirmation of the construction work completion, issue a certificate of construction work completion to the applicant, and shall send the relevant documents to the relevant administrative agency if the completed facility is a building.

3. When the project implementers are issued a certificate of construction work confirmation under Section 2, it shall be taken to mean that the construction work completion has been inspected or the construction work completion has been approved under the relevant project, in line with the permissions and approvals under each paragraph in Article 8.

4. The project implementers shall not, before being issued a license for the confirmation of their construction work completion under Section 2, use the lands and facilities created or established under the high-speed rail construction project, except when

the use thereof before the construction work completion is approved by the Minister of Construction and Transportation.

5. As deemed necessary for the efficient implementation of the high-speed rail construction project, the project implementers may apply for the confirmation of their construction work completion according to individual segments or facilities within the scope of the execution plan.

Article 15 (Ownership of Facilities, etc.).

1. The lands or facilities that are created or established under the high-speed rail construction project shall, upon their completion, be owned by the state, except with respect to the lands and facilities that are defined by the Presidential Decree.
2. The Minister of Construction and Transportation may allow the project implementer of the facilities owned by the state under Section 1 to use and profit from the facilities for free within his total project investment costs according to the Presidential Decree.
3. If the project implementer is the Korea High-speed Rail Construction Authority and an implementer of a private-capital-attracting infrastructure facility project according to the Private Capital Attraction Promotion Act, the ownership of the lands and facilities that are created or installed under the high-speed rail construction project shall, notwithstanding Sections 1 and 2, be determined by the respective Korea High-speed Rail Construction Authority Acts and the Act on Private Capital Attraction Promotion for SOC Facilities.
4. The calculation method for the total project cost under Section 2, and the period of the use of the facilities for free, shall be determined by the Presidential Decree.

Article 16 (Installation of Replaced Public Facilities, etc.).

1. The Minister of Construction and Transportation may, if there are public facilities, military facilities, or communal buildings (excluding high-speed rail facilities, which shall be referred to as "public facilities" herein) that are incorporated into the sites under the high-speed rail construction project and that are designated by the Presidential Decree, upon the application by the management office or owner of the public facilities, allow the project implementer to install public facilities etc. that will replace the existing facilities (which shall be referred to as "replaced public facilities etc." herein).
2. In allowing the project implementer to install the replaced public facilities etc. under Section 1, the Minister of Construction and Transportation shall specify this fact in his/her approval of the execution plan under Section 7 according to the Presidential Decree.
3. When the replaced public facilities etc. have been given a confirmation of completion under Article 14, notwithstanding the State-owned Property Act, Local Finance Act,

and other laws, the existing public facilities etc. shall be owned for free by the project implementer, and the replaced public facilities etc. shall be owned for free by the central government and the local governments or the owners of the existing facilities.

4. With regard to the registration of the replaced public facilities under Section 3, the approval of the execution plan, or the approval of the revision thereof and the confirmation of the construction works, shall replace the documents that prove the registration causes according to the Realty Registration Act.

Article 17 (Supervision).

1. Under the following circumstances involving the project implementer, the Minster of Construction and Transportation may cancel the permission or approval granted under this Act, or give orders to suspend or change the construction works, or to reconstruct, change, or relocate the facilities or properties:

   1.1. In the event that the project implementer obtained the permission or approval using illegal methods under this Act;

   1.2. In the event that the project implementer violated this Act or the orders or dispositions made under this Act; and

   1.3. In the event that due to a change in circumstances, it is impossible for the project implementer to continue implementing the high-speed rail construction project.

2. With regard to the dispositions or orders made under Section 1, the Minister of Construction and Transportation shall notify the public of the corresponding results according to the Presidential Decree.

Article 18 (Reporting, Inspection, etc.).

1. As deemed necessary for the implementation of this Act, the Minister of Construction and Transportation may require the project implementers to submit necessary reports on the high-speed rail construction project, or to submit relevant data. Also, the minister may order relevant officials to access the offices, workplaces, or other necessary places of the project implementers so as to inspect the works concerning the high-speed rail construction project.

2. Officials who inspect the works concerning the high-speed rail construction project under Section 1 shall show a certificate of their authority to the relevant personnel.

3. Necessary matters concerning the certificate under Section 2 shall be determined by the Construction and Transportation Ministry Decree.

Article 19 (Commissioning of the Land Purchase Project, etc.).

1. The project implementers may commission land purchase work, loss compensation

work, and relocation measure projects under the high-speed rail construction project to the heads of competent local governments according to the Presidential Decree, or to government-invested institutions according to the Basic Act on Government-invested Institution Management.

2. The fees for the commissioning of land purchase work, loss compensation work, and relocation measure work under Section 1 shall be determined by the Presidential Decree.

Article 20 (Penalties).

1. Those who shall fail to obtain approval under Article 6, Section 1, or who shall obtain approval by illegal methods, shall be sentenced to up to one year imprisonment or fined up to KRW 5 million.

2. Those who shall be involved in each of the following circumstances shall be fined up to KRW 3 million:

   2.1. Project implementers who, without justifiable reasons, refused to perform their duties under Article 11, Section 1;

   2.2. Those who violated orders given under Article 17, Section 1;

   2.3. Those who failed to submit reports or data under Article 18, Section 1, or submitted false reports or data; and

   2.4. Those who refused to receive inspections or hampered inspections under Article 18, Section 1.

Article 21 (Joint Penal Provision).

If the corporate representative, the corporation's or individual person's proxy, or a worker or employee has violated the acts under Article 20 with regard to the corporation's or individual person's works, the violator shall be punished and a fine shall be imposed on the corporation or individual person under this Article.

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