RISK MANAGEMENT IN A LARGE–SCALE NEW RAILWAY TRANSPORT SYSTEM PROJECT

– Evaluation of Korean High Speed Railway Experience –

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Risk management experiences of the Korean Seoul-Pusan high-speed railway (KTX) project since the planning stage are evaluated. One can clearly see the interplay of engineering and construction risks, financial risks and political risks in the development of the KTX project, which is the peculiarity of large-scale new railway system projects. A brief description on evaluation methodology and overview of the project is followed by detailed evaluations on key differences in risks between conventional railway system and high-speed railway system, social and political risks, engineering and construction risks, and financial risks. Risks involved in system procurement process, such as proposal solicitation, evaluation, selection, and scope of solicitation are separated out and evaluated in depth. Detailed events resulting from these issues are discussed along with their possible impact on system risk. Lessons learned and further possible refinements are also discussed.

Key Words: High-speed railway system, System procurement, Risk management, Korea Train Express, Engineering risks

1. INTRODUCTION

The Korean high-speed railway that connects Seoul and Pusan, KTX (Korea Train Express), started its test run on the 57-kilometer-long test track beginning December 1, 1999 (Figure 1). It is a French TGV-based system (Figure 2), and runs on 412 km long line with four intermediate stations. It will start its first-stage commercial operation in 2004 using a new line and some segments of the existing line and the second-stage revenue operation from the year 2010 on a completely new line. It might be premature to fully analyze risks of the new KTX system, but after eight years of construction and additional years of planning process, it provides enough material and interesting insights on the risk aspects of the project. It is hoped that these valuable experiences will shed lights on similar new large-scale railway projects.

One fleet consists of 20 coaches and will be able to accommodate about 900 persons when it is completed and put in operation in 2004. Careful planning, construction and operation schemes are essential to keep the railway system safe and reliable, considering the large number of passengers on board. The KTX has characteristics that make the project more complex than existing railway projects. It utilizes non-indigenous technology, and therefore foreign system technology should be selected following due process, which put an extra burden on project scheduling and cost control. Because it is a new line construction, combinations of alignment design criteria, system technologies, and station location and the route have to be decided concurrently. This calls for much more complex decision processes involving local governments in addition to the central government. Furthermore, it involves high uncertainties in terms of political risks, in addition to financial and technological aspects. This stems from the long project duration that spans many government administrations and the large project size that encompasses different administrative bodies. Therefore the project called for extensive risk management for successful and safe completion that is much more complex than any other project ever carried out in Korea. To tackle these difficult tasks, the organization in charge of the project completed risk management efforts, with varying degrees of success, at different stages of the project from the inception to now. Also the task should continue until the successful commissioning and daily operation.

This paper evaluates risk management experiences of the Korean Seoul-Pusan KTX project so far since the inception of the project. The next section discusses and defines risk as was used in the paper, followed by the description of historical development of the project. Categorized risk items are discussed based on the KTX experiences, and finally the lessons learned are summarized.

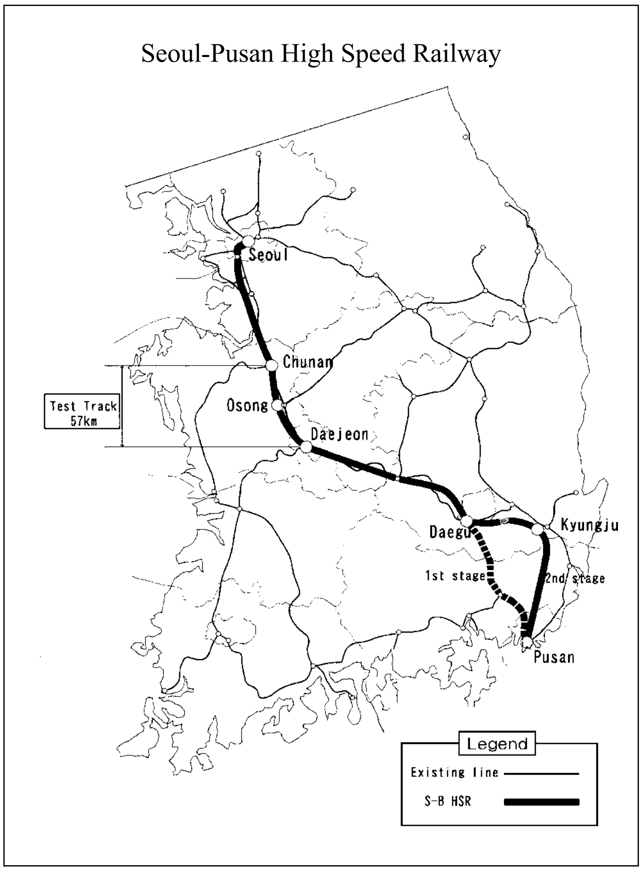


Fig. 1 Route map of Seoul–Pusan High Speed Railway Line (KTX)

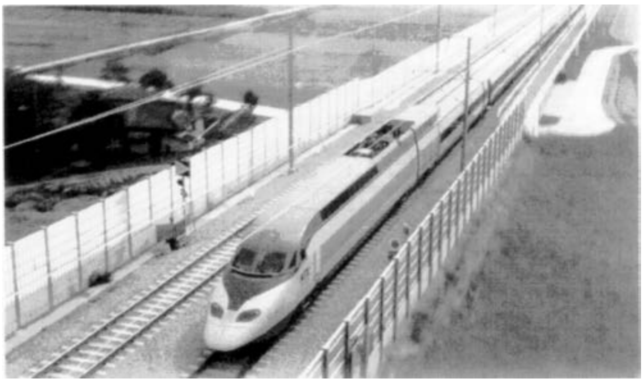


Fig. 2 Rolling stock of KTX

2. RISK ANALYSIS OF NEW RAILWAY SYSTEM PROJECTS

In the context of this paper, risk is defined as the potential for the completed new railway system project being unable to function as intended at the project conception, resulting from uncertainty about the project. It can represent anything from cost overrun, project delay, safe construction and operation, and system integrity. In that sense, it is much broader than financial or safety risks usually considered for projects. Risk assessment and management are difficult and important in large railway projects. It is more so in a railway project with a new system technology. There are, however, not much existing literature dealing with risk management in new high-speed railway system projects, even though there are numerous sources of information for general construction and transport projects.

Risk management on construction projects have received much attention and there are much literature, for example, see Flangagan and Norman[1], Lifson and Shaifer[2], and Skipp[3]. Among these, Skipp[3] concentrates on more detailed topics of ground engineering, and the rest discusses risk management of general construction projects. Taylor[4] discusses risk analysis for pipelines and transport, but it concentrates on ship collision issues. Blockley[5] deals with engineering safety issues extensively. Rhyne's[6] work has more direct relevance to this paper, but relies heavily on the existing operation records for risk assessment, which is not possible with new railway system projects. Risk issues are also addressed from the perspective of system reliability, for example, see Colombo and Bustamante[7] and Henley and Kumamoto[8]. Smith[9], for example, discusses the economic side of risk assessment. Suh and Kwon[10] present local application experiences for highway project economic analysis. The Institute for Urban Transportation[11], Booze-Allen[12], and Abacus Technology[13] all address transit risk management. For more direct relevance to this paper, the seminal work of Touran et al.[14] extensively discusses risk assessment in fixed guideway transit system construction. It, however, mainly focuses on urban transit systems, rather than new regional railway systems projects.

Risks involved in the KTX project can be grouped as technical, financial, social and political in nature. The technical risks include engineering and construction risks, and depend on the technical complexity of the project, which is much higher than those related to conventional railway projects. The financial risk is mainly for cost overrun, and securing funding. Finally, the political risks include the political decision-making process, public perceptions on safety and the project as a whole, and other planning issues such as route and station selection. For the KTX project, all these three risks had a complicating interplay, and usually defied separate analy-

Table 1 Risk categorization for KTX project

Risk Group	1st Tier	2nd Tier	Risks involved with	
			KTX	Conventional rail
Social and Political	Regulatory-Licenses and Permits	Environmental Impact Statement	High	Medium
		Transportation Impact Statement	High	Medium
		Energy Use Assessment	High	Medium
	Technology Transfer		High	NA
	Project Feasibility	Long-term Viability	High	Medium
		Political Situation	High	Medium
	Planning	Reasonableness of Projects Scope, Schedule, Cost	High	Medium
		Technical Constraints	High	NA
		Complexity of Project	High	Medium
	Public Perception on Safety		Higher	High
	Decision Making Process		High	Medium
Engineering/ Construction	Design	Standards/Code	High	Low
		Complexity	High	Medium
		Completeness of Design	High	Medium
		System Integration	High	Low
	Construction/Infrastructure Procurement	Safety Standard	High	High
		Quality Control	High	Medium
		Type of Contract	Medium	Medium
		Contracting Arrangement	Medium	Medium
		Labor	Medium	Medium
	System Procurement	Specification	High	Low
		Scope of Procurement	High	Low
		Procedure of Procurement	High	Low
Financial	Funding	Funding Source	High	Medium
		Inflation	Medium	Medium
		Accuracy of Cost Estimate	High	Low
		Exchange Rate	High	Low
	Joint Venture		Medium	Medium
	Cost Overrun		High	Medium
	Delay Cost		High	Medium

sis. As will be demonstrated later, it is this interplay that can contribute greatly to cost overrun and project delay. Touran et al. [14] identified fifteen risk items for transit projects and grouped those into three broad categories of design, construction and financial risks. They did not explicitly consider social and political risks in their work. For this paper, risks are categorized as shown in the Table 1, explicitly defining social and political risks. The last two columns of the table compare size of risks involved in conventional railway projects with those of the KTX project.

As shown in Table 1, some factors have more profound impacts on KTX than on conventional railway projects. For example, technology transfer is a major concern for the KTX project, but it is not much of concern for conventional railway projects that utilize already localized technologies. Also system procurement procedures do not pose too much of a challenge for conventional railway projects, but it is a major hurdle to overcome in the KTX project. Risks for finances and duration of the project are usually analyzed with some kind of probabilistic tool, such as the Monte Carlo simulation.

This can be done, for conventional railway project, using existing database of cost and duration. But for the KTX project, it is very difficult to do the same, because there are no reliable historical data.

3. MAJOR MILESTONES OF THE KTX PROJECT

To understand the arguments of this paper, it is helpful to have some background information on the Seoul-Pusan high-speed railway project. Therefore, project milestones are presented first with their historical backdrop. The web site operated by the Korea High Speed Railway Construction Authority* will be very valuable in understanding the current status of the project.

3.1 From conceptual planning to groundbreaking

General Background: A general description of high-speed railway in Korea's national development can be found in Suh[15]. In 1984, feasibility for the construction of a high-speed railway system was studied as one measure of expanding the transportation capacity of the Seoul-Pusan corridor. A subsequent study was initiated in 1989 and lasted until January of 1991 to develop preliminary engineering plans. In the study, engineers from high-speed railway operating countries were excluded in the study process to make the system selection process more 'objective'**. Alignment and station location alternatives were identified and analyzed. Drafts of request for a proposal (RFP) for the system procurement were developed for various scenarios. Feasibility of the high-speed railway system was re-evaluated in the second phase study along with the national high-speed railway network[16]. The study recommended a 409 km*** long alignment with four intermediate stations and a maximum operation speed of 300 km/h. A systematic approach employed in the study to analyze various combined alternatives routes, traffic and railway system was introduced[17]. Total project cost was estimated to be 5.8 trillion won****, of which 4.6 trillion was for infrastructure, and 1.2 trillion won for rolling stock.

* http://www.khrc.or.kr/

** This was one of the vital decisions made by the Korean government that has had long-lasting impact on the project progress.

*** This was the original route, and extended later in piecemeal fashion to 426 km and changed back to 412 km.

**** 800 won = $US 1 in 1989, now exchange rate is about 1,200 won = $US 1.

Organization: A Special Committee* headed by the prime minister was formed to deal with various policy measures regarding the high-speed railway project and the Incheon International Airport project in July 1989. In March of 1992, the Korea High-Speed Railway Construction Authority (KHRC) was instituted with about 400 people as a field agency for high-speed railway construction. Figure 3 shows the organizational chart of the KHRC as of 1999.

Construction: A groundbreaking ceremony for the test-track segment of 57 km connecting Chunan and Daejeon was held in June 30, 1992. It was only one year after the start of the detailed design, and eight months after issuing the RFP, for which the proposal was received in January 1992. The system was not decided yet; therefore, the strategy taken was to proceed with alignment design utilizing design variables that could be common denominators of the three high-speed railway systems being considered**. Table 2 shows major design criteria of the system.

3.2 First amendment of the master plan (1993)

One year after the groundbreaking ceremony, the master plan for the high-speed railway was greatly modified in June 1993. Important items of notice were:

- Cost of the project increased to 10.74 trillion won (1993 price) from 5.8 trillion won (1988 price).

Table 2 Major design criteria

Description	Design Criteria
Maximum Operating Speed	300 km/h
Design Speed	350 km/h
Standard Radius	7,000 m
Track Centerline Spacing	5.0 m
Maximum Grade	15 ‰
Standard Design Load	LS-22
Tunnel Cross Section	107 m^2
Total Line Length	411 km
Earthwork	119.59 km (29%)
Bridge	152.73 km (37%)
Tunnel	138.68 km (34%)
Grade by Percent	100%
Less than 5 ‰	191.74 km (47%)
5 to 10‰	96.06 km (23%)
10 to 15‰	123.20 km (30%)

* Steering Committee of the High Speed Railway and the Incheon International Airport Construction

** This was also a very important decision that had a profound impact on the system configuration and construction.

- An additional station at the outskirts of Seoul was added (South-Seoul station): total number of stations became five.
- The commissioning date was postponed from 1998 to 2001* (First Phase with shared ROW with conventional railway between South-Seoul and Seoul main station)
- Second Phase with the new dedicated segment between South-Seoul and Seoul station will be opened in 2010.
- All intermediate stations will be built at street level instead of underground.

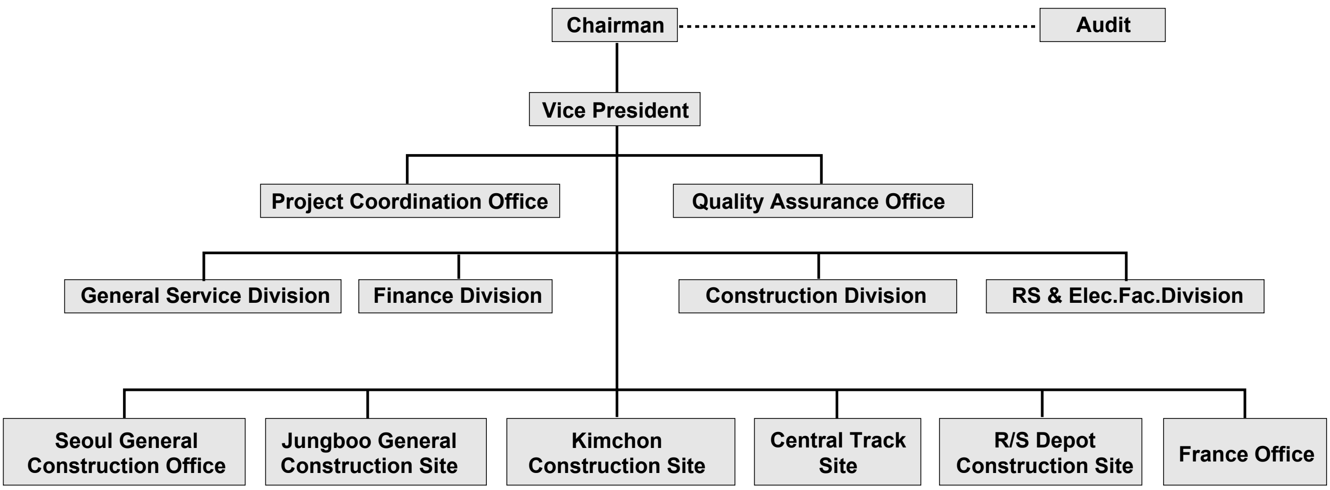
More than 80% of the cost increase was attributed to price increases for the past three years. The remaining 20% was loosely attributed to a 13 km increase in alignment length and building requirements. The length of the line increased from 409 km to 421.7 km. The cost increase not only accounts for price increases during the past four years, but also includes additional changes resulting from the design variables. Design speed, tunnel cross section, and route length are only some examples. Therefore it is not wise to directly compare those two figures. However, many experts believe that the initial cost and opening year estimates were too optimistic while considering ideal conditions, and that the new cost estimate was based on too aggressive design concepts.

Regarding rolling stock, the TGV consortium was selected as a priority negotiation partner in August 1993, and after almost one year, the contract for rolling stock procurement was signed in June 1994. Figure 4 shows the organization of the TGV consortium.

3.3 Second amendment of the master plan (1998)

In the revised master plan announced in 1998, a phased construction and commissioning scheme was utilized. For the first phase, the total line length will be 409.8 km. The new line being 222.1 km long and the improved existing KNR line being 187.7 km long. Even though the maximum speed is 300 km/h, the average speed will be about 150 km/h. Once the second phase is completed, the total line length will be 412 km and travel time is expected to be 116 minutes with an average speed of 213 km/h. For the completed alignment, 111 km will be at-grade comprising 27%, 112 km will be viaduct, comprising 27%, and 189 km will be tunnels comprising 46%. A total of 46 train sets are expected to operate on the line. About 74% of the rolling stock will be manufactured locally.

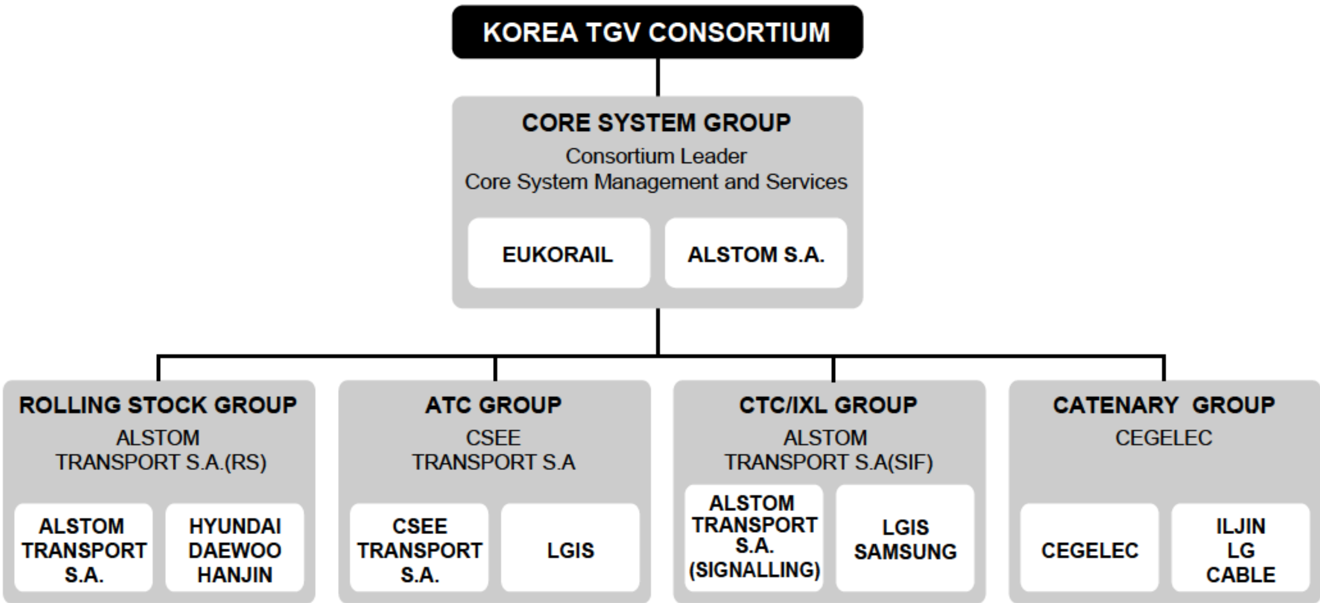
The project cost was announced to be 18,435.8 billion won, and for the first phase, 12,737.7 billion won at the 1998 price. Of the total cost, the central government will be responsible for 45%, of which 35% is equity participation and 10% is a loan to KHRC. The remaining 55% will be financed by KHRC. 29% will be by bond, 24% by foreign loans in the format of supplier's credit, and 2% by private capital. Table 3 shows the funding scheme for the project.



Source: Korea High Speed Railway Construction Authority, 1999

Fig. 3 Organization chart of the Korea High Speed Railway Construction Authority

* Total construction period was regarded to be seven years.



Source: Korea High Speed Railway Construction Authority, 1999

Fig. 4 Organization of Korea TGV consortium

Table 3 Funding scheme for the Phase 1 Seoul-Pusan High Speed Railway

(In constant value as of Jan. 1, 1998 , Unit: Billion won)

Classification	Original Plan(6.14.93) Amount	%	Revised Plan(7.31.98) Amount	%	Amount Changed
Gov't Contribution	4,833	45	5,732	45	899
Subsidy	3,759	35	4,458	35	699
Loan	1,759	10	1,274	10	200
Financing by KHRC	5,907	55	7,005	55	1,098
Local Currency Bonds	3,331	31	3,668	29	337
Offshore Financing	1,978	18	3,075	24	1,097
Private Capital	598	6	262	2	(336)
Total	10,740	100	12,737	100	1,997

The chart shows a detailed comparison of the revised and original funding plan of Phase I: funding scheme for Phase 2 will be the same

Source: Korea High Speed Rail Construction Authority, 1999

4. MAJOR RISK MANAGEMENT ISSUES

Two amendments to the master plan, as explained before, of KTX themselves represent major risk management efforts. More interesting lessons, however, can be obtained by looking into individual risk items. As was discussed previously, there will be many different ways to categorize risks, and some subjectivity will certainly play a part in the process. They are confined to a small number of important categories as shown in Table 1, and an effort is made to explain most of the issues within them. Specific risk items that might be of general interest, not country specific, are chosen for wider audiences.

4.1 Social and political risks

4.1.1 Regulatory risks

Regulatory risks represent all the uncertainties in obtaining licenses and permits in time. They include Environmental Impact Statement (EIS), Transportation Impact Statement, Site Impact Analysis, and Energy Use Certificate for Korean case. Noise, vibration and dust from the KTX posed special problems in the course of EIS stage. Adverse effects of KTX right-of-way that divides existing villages also caused stiff opposition from local people, and required building extra pathways. As can be seen in the route near Kyungju, the route passing through the archaeological site posed a special challenge to the project. The Ministry of Culture (MOC) usually has different priorities concerning building transport infrastructure and conserving historical sites.

4.1.2 Technology transfer

From the outset of the project, the second important objective of the KTX project was identified to be providing impetus in advancing local railway systems technology. Therefore, technology transfer schemes have received high priority in the project development. The Ministry of Science and Technology and the Ministry of Industry and Resources played a big role in developing technology transfer schemes. Also their objectives usually do not coincide with those of the Ministry of Construction and Transportation (MOCT).

Development of the detailed technology transfer scheme put extra strain on the project budget and duration. Design technology received less emphasis than rolling stock technology, but later experiences demonstrated that system integration technology was very important technology to be transferred, and infrastructure design technology, with which local engineers felt comfortable, was also important.

4.1.3 Project feasibility

One should be prepared to deal with political influences when working with such a large project that encompasses 70 percent of the national population. It is generally understood that route and station selection will be influenced somehow. The timing of certain important milestones will be influenced, such as the groundbreaking and opening, etc. Usually, the impact of the influences is hard to evaluate as being positive or negative. It is a matter of “value” which engineers and planners do not have at their disposal.

With the Seoul-Pusan high-speed railway project, many issues influenced by political interest were outstanding. The top-level decision maker is the president, of course. Since the start of the construction, three presidents have dealt with the project. Their tenure is five years. The timing choice of RFP issuance and groundbreaking seemed to have a clear political implication of the then-outgoing president. Even though the new government actually signed the legislation in 1994, the previous government already arranged the fundamental policy. This critical political decision put many engineers, planners, and government officials in agony. The decision impacted the system procurement decision and selection of design variables.

The choice of the route passing Kyungju was not solely based on economic efficiency after all. After much debate, trouble, and recent changes on the alignment passing Kyungju, that route will not be realized until the year 2010. The route that will be used for the time being was the route advocated over the Kyungju route by many engineers and planners during the initial study. One can only hope that the decision makers must have had better insights for the “value” of society.

4.1.4 Planning

With the system selection, changes in route, alignment and cost, and the revised master plan, the system configuration in 1993 became much different from the original system configuration of 1989. Even after 1993, many incremental and piecemeal changes happened continuously to the system. The original travel time of 90 minutes for the express service became 160 minutes as of 1999. Will the demand remain the same with the increased travel time? How about financial viability when the cost is more than doubled? Fares need to be increased to maintain financial viability, but increased fares will reduce the demand according to the demand’s price-elasticity. If the high-speed railway system is going to share the right-of-way with the existing railway, what will happen to the much touted expected capacity expansion? What will be the impact of the recent economic crisis on the demand and economic and financial viability? Ongoing checks about these issues will clearly be a planning function.

4.1.5 Public perception on safety

The stellar safety record of Japanese and French high-speed railway systems was much advanced as one of the supporting arguments for the KTX project from the outset. Possibly out of this trust, high public perception on safety also played a critical role in project progress, usually in a negative way. The route on the Sangri tunnel was re-routed to detour nearby old mines, despite advice from experts against the detour. The detour added at least three extra years to the project duration. The public has different views on risks than engineer. Engineer has better information, and knows risk more objectively. But public and political bodies have more simplistic view on risks, and it is very difficult to control. When there is some incident in the construction site, media hype and public perception usually prevailed over engineering judgment, and added extra unnecessary burden on the project cost and duration. This was especially true with the case when the media reported some problems with the already constructed structures at the end of 1996. It almost stopped the project for more than one year. After that incident, foreign supervision teams were mobilized in a much broader scale.

4.1.6 Decision making process

The organizational chart of the KHRC is shown in Figure 3. The division of labor of government agencies regarding high-speed railway is as follows: KHRC is in charge of construction; Korean National Railway (KNR), operation; and MOCT, overall coordination and policy-making. More important organizational issues stem from the structure and responsibility of KHRC and the relationship of KHRC with MOCT. The other issue is the effectiveness of the Special Committee as the final decision making body regarding the high-speed railway project. It can be said that the agency that decides on important issues should have an appropriate responsibility too. If possible, when multiple agencies will be involved, each agency's responsibilities should be clearly defined at the start of the project.

Depending on the country, a committee has different powers of authority. Looking back at past experiences, one might argue about the authority of the Special Committee of the Seoul-Pusan high-speed railway project. The Special Committee has twenty-five members including all the government ministers whose job function has any connection with the high-speed railway project. The committee is the final decision-making body regarding the high-speed railway and Incheon Airport project. The committee approved a route plan that includes the original Kyungju route in 1990, and reconfirmed it in 1993. But, in 1995, the Ministry of Culture, whose minister is a member of the committee, asked to relocate the Kyungju route for historic site preservation reasons. The Kyungju route eventually was relocated in January 1997. There has been no newly discovered historic artifacts or sites from 1993 to 1995. Apparently it will be the desire of everyone involved in the project to have a solid decision making body that has the final say.

4.1.7 Central-local government cooperation

At the time of writing this paper, the location and development method of the new main station in Seoul is still not officially decided. MOCT prefers the existing Seoul station, while Seoul city government likes to use the high-speed railway as leverage to develop the area around Yongsan station, which Seoul city advocates for the main station. This factor contributed to delays in the project's progress. The issue of station location and approach methods was common to all the city governments involved. Their requirements are all the same – build an underground approach and station. These problems could have been solved fairly easily by developing cost share principles and adhering to them, but what actually happened was indecision because of political concerns. For example, changes in station type of Daegu and Daejeon were first underground, then above ground, finally becoming underground again in 1989, 1993, and 1995 respectively. The first decision to have underground stations was based on the city government's influence. Those changes were hardly based on engineering judgment. The cost sharing scheme and service contract concept could have solved the problem more easily.

4.2 Engineering and construction risks

4.2.1 Design

Standard and Code: Design and construction codes are very important in railway system development. It is especially so in a new line with new system technology. Scope, content and structure of codes are very important. Existing design codes and construction specifications can be upgraded or are to be developed from scratch. Blockley[5] discusses many aspects of developing codes with respect to engineering safety.

Korean code regarding high-speed railway was developed before specific system technology was selected. If one accepts the fact that the code does specify 'minimum', the code based on the common denominator of Japan, France, and Germany should not pose special problems. As shown in Table 2, the design parameters of KTX demonstrate this conservative approach. The major philosophies in developing design variables were:

- Diesel locomotive should be able to run on the new line;
- Provide room for speed improvement;
- Can accommodate rolling stocks of Japan, France, and Germany.

But one has to consider what is the price of being conservative. This has been one of the hot issues argued from the start of the project.

Complexity and System Integration: To carry out a large-scale railway project that uses non-indigenous technology, one usually employs outside help. The question to ask is the scope and timing of outside assistance. With the Seoul-Pusan high-speed railway project, American engineers were mainly utilized in the initial phase of the project. Engineers from the three countries that have high-speed railways were intentionally excluded at the initial stage. It is very difficult to decide the pros and cons of each approach, but it is good to have someone who can give a more "objective" opinion. Also, once the system is selected, engineers from the system provider should participate in the project.

4.2.2 Construction and infrastructure procurement

When the system procurement strategy was considered, the infrastructure procurement strategy was also considered concurrently. One can use turnkey procurement over conventional procurement approach. The risk involved in turn key projects is well summarized in the Booz-Allen[12]. The Korean government took a conventional approach over turnkey, and willingly took more risk in favor of more project control.

The Program Manager body was proposed at the initial study phase, but was not accepted. Program Manager was recommended as one means to reduce risks involved in the project development. Experts from countries with high-speed railway operations, and other countries were recommended to fill the positions along with local experts. In the second amendment of 1998, one can see the budget allocated for the Program Manager.

4.2.3 Systems procurement procedure and timing

If one had to choose the most important cause of all the problems, the system procurement method and its timing is it. This is the precursor to all subsequent issues. This is the oldest cause and has the most far-reaching impact. One way or another all other issues have some relevance to this factor.

The most fundamental paradigm in railway system planning is that one has to consider alternatives that are combination of system technology, route and transportation demands. This is because these factors have something to do with the remaining factors. For example, systems technology decides the operating speed, design variables and capacity of the technology. These in turn impact cost, route, and transportation demands. Also, the route has a far-reaching impact on station-to-station travel time, and this will impact transportation demand. Therefore it would not be wise to separate the aforementioned three factors. But as explained earlier, the system for the Seoul-Pusan high-speed railway was officially selected in 1994, which was two years after construction began in 1992. It would not be fair to say that the engineers who participated in the technical study of 1989 and drafted the RFP did not know the consequences of this. They had suffered from the should-have-been-avoided burden of doing extra work on the preliminary engineering study for all three target-systems.

What is included in the system procurement package is also very important. With the Seoul-Pusan high-speed railway project, it should be understood that the “mix-and-match” concept was attempted, apparently, without much success. So called “high-tech” railway systems, whether they may be automated guided transit (AGT) or high-speed railway, are known for being difficult to understand by people other than engineers and the system suppliers. One can see that a certain system supplier can have a monopoly where the system they are supplying is concerned. For example, it is becoming very difficult for one to bring a control system from one system and use it in another system. Usually the “mix-and-match” scheme does not apply itself well to these high-tech systems. In the RFP, system providers were asked to submit proposals on rolling stock, automatic train control, catenary, with some degree of interface engineering. The KHRC called those systems the “Core” system. It was the wishful thinking at that time that with some minor help with the interface assurance, local engineers could handle the infrastructure. There had been very serious and long debates on the pros and cons about the procurement method. The idea of procuring partial systems finally prevailed. Eventually designs done before the system selection underwent reviews by TGV engineers. In short, the “mix-and-match” attempt for the high-tech railway system has high risks and is not for the faint-hearted. Total system procurement approach is the path to take, with the option of selectively choosing the final components for actual purchase. One has to decide what should be purchased after first seeing what is involved in the system.

4.3 Financial risks

Financial risk analysis for transit project received much interests. Turan et al.[14], Abacus Technology[13], and the Institute for Urban Transportation[11], for example, discussed financial risks involved in transit projects. As was stated before, these risk analyses are based heavily on probabilistic approaches, which usually were not an available option for the new KTX project. At the initial planning stage, sensitivity analysis was carried out for key variables.

4.3.1 Funding scheme

Securing sound funds for the project is very important. The funding scheme itself has a bearing on the project’s progress. At the initial planning, the possibility of employing Build-Operate-Transfer scheme was studied, but discarded because it was decided to have too much inherent risks. The availability of adequate capital and at an appropriate time is critical for project implementation.

Accuracy of cost estimates is a very important issue, but in retrospect the initial costs estimates, which were based on the average of published cost of Japan, France, and Germany, did not give satisfactory estimates. The cost of rolling stock was off by about 60 million won.

Table 4 Unit cost change

(Unit: million won/km)

	1993	1998	Percentage Change
Land (1000 m^2)	52	49	94.5
Roadbed	12,640	18,827	148.9
Track	570	859	150.5
Building (1000 m^2)	1,165	1,605	137.7
R/S (Fleet)	26,400	43,821	165.9
Depot (1000 m^2)	304	265	87.0
Electrification	1,693	2,299	135.8
Communication	981	1,201	122.0
Signaling	915	902	98.5
Design	322	619	192.3
Supervision	127	1,019	803.0
Miscellaneous	291	105	35.9
Program Manager	157	598	380.2
Research	224	165	73.5

Table 4 shows changes in unit cost between 1993 and 1998 cost estimates. Inflation contributed to about 15 percent of the total cost increase.

4.3.2 Joint venture/development

As can be seen in the Table 3, the percentage of private funds reduced from 6 percent to 2 percent. Amount of money that can be mobilized with a joint venture is heavily dependent on the general economic situation. Considering the recent economic crisis Korea has experienced, it should be understood as one of the KHRC's efforts to reduce funding risk. Risks involved with joint ventures are basically the risks of the economic situation.

4.3.3 Cost overrun

Cost overrun can also be categorized as an engineering/construction risk. Average costs of the KTX project component showed a wide discrepancy between estimated and actual figures. Also input cost increases over the years explained much of the portion of cost overrun experienced. For example, during the 1989 to 1993 year period, labor cost increased about three-fold, and material costs, ready-mix concrete for example, increased by 40 percent. During the same period, GNP inflator for the construction sector rose about 90 percent. This increase in unit cost accounted for about 82 percent of the cost increase in 1993 amendment. The remaining 18 percent was attributed to the change order resulting from the route length increase.

4.3.4 Delay cost

Delay cost also can be discussed under engineering/construction risk. The original commissioning date of 1998 was delayed to 2002, and now 2004 is set for the first-stage operation. Various factors contributed to this delay. According to KOTI[18], system selection, relocation of the route around Sangri tunnel, re-routing of Kyungju segment, station location and ground/underground issues in Seoul, Daegu, and Daejeon, location of train depot were identified as the major causes of delay. They delayed the project for almost four years. The delay caused cost increases in addition to social opportunity costs. Direct project cost increase caused by project delay is about 25.5 percent of the total cost overrun experienced between 1993 and 1997. One can see objectively, how much project delay has a damaging effect on project cost control.

5. LESSONS LEARNED

The KTX project development was reviewed. Major risk factors were evaluated based on the experiences from the initial planning stage to the test run stage. Until the commissioning in 2004, there should be continued efforts of risk management to ensure safe and reliable high-speed railway. The complexity of the project does not permit an easy understanding of all the risks involved, but at least some of the salient factors could be evaluated. Some of the lessons learned by evaluating the risk management efforts for the KTX project are summarized below.

A new railway system project is very complex, and every effort should be exercised not to complicate it by adding more project goals. Technology transfer, regional development and other secondary objectives should remain as secondary. If the project goal is not concrete and simple, many different decision bodies approach the project with different and often conflicting goals. This is very harmful to the cost and duration control for the project. It is also very important to have realistic scope, schedule and cost estimates. Sometimes, as shown in the KTX project, project development can be seriously distorted by efforts to make up for the delay caused by external reasons, such as delay in system procurement. Also technology transfer should be focused on system integration, rather than rolling stock only. There are many system specific technologies to be transferred for successful implementation. Those technologies are not always available publicly. Inviting experts from the country that has operation experience, with responsible charges from the initial stage of the work, may contribute to reduce project risks in a high-speed railway project.

It is usually believed that taking a conservative stance can reduce project risks. But the risk reduction is not automatic, and also sometimes there are heavy costs involved with being too conservative. The initial design standards of KTX that were believed to be a superset of available high-speed railway systems, could accommodate all three high-speed railwayway systems. But after the system selection, designs went through extensive design review process. Of course, the review called for some redesigns, and caused project delay. Change of bridge type from PC-BOX to PC-Beam, and back to PC-Box demonstrated the importance of sound engineering codes and standards.

Even with all the issues addressed, there will still be remaining risks. It is the inherent characteristic nature of risks. Uncertainty cannot be eliminated by one-time risk management procedures, rather it should be on-going efforts. In this sense, having a good Program Manager team and good organization body to constantly monitor risk items and address them is vital to successful project development. Usually probabilistic risk analysis and management is not very successful with a new railway project, especially with a system that uses new technology. Probability can be developed with historical data, but it is not the case with the first high-speed railway project in the country. Experience with existing railway is helpful, but not sufficient. Social and political risks are higher with a new railway system compared with the existing railway project. Major project delay was consistently caused by some social and political reasons, for example, system procurement, route relocation, and station location and type. Therefore it is mandatory to consider combined effects of social and political risks, engineering risks, and financial risks. In this sense, totalistic or systematic approaches are strongly advocated, instead of a partial or piecemeal approach. It will be helpful to identify effects of each major decision on project risk. If one is not careful, it will be very difficult to isolate causes of specific risks, and address them. For example, the decision to procure only the 'Core' system caused high risks, while conservative design variable lowered them. But one can only observe the combined effects of those decisions. Probabilistic risk assessment using the Monte Carlo simulation is readily available, and is a good tool for financial risk assessment. It, however, is not good enough to address combined effects of political, engineering, and financial risks. An integrated management scheme should be developed. More systematic approaches should be developed and tested for future application.

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