Application of GIS Technology for Developing Emergency Management System on High-Speed Lines

Sang-Ahm Kim[1] Seon-Ho Hong[2] Jong-Bae Wang[3]

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Abstract

Due to almost all tracks of new Kyoungbu high-speed lines(HSL) consisting of bridges and tunnels, HSR operational safety management is very important factor for passenger safety and preventing catastrophic event. Especially, it is important to approach the scene of the accident and assist in saving lives as soon as possible under emergency conditions. Therefore it is essential to prepare access methods and available resources in advance in order to support emergency correspodances promptly and effectively. This paper persents an application of geographical information system(GIS) for developing emergency management system as well as batabase system on tracks and facilities, electric/communication equipment and safety equipment required to support emergencies. The on-site information on the proximity of HSL is expressed on the numerical map, which can be helpful to call external supports such as medical service, local authorities, police offices, fire brigades, and etc. for the emergency situations.

1. INTRODUCTION

It becomes more and more important problem to manage and operate high-speed railway system (HSRS) for preventing nation-wide disaster as well as reinforcing the passenger safety. Especially contrary to traditional railway almost all tracks of Korean HSRS consist of bridges(27%) and tunnels(46%). Due to the unique feature of the elevated and protected track it is difficult to approach the scene of accident and assist in saving ives under emergency conditions. Therefore it is essential to prepare the access methods and available resources in advance in order to response and support emergencies promptly effectively.

First of all this paper explains the operational safety status in Korea HSL, next presents information management systems which have the database systems for track and facilities, electric/com munication equipment and safety equipment required to support the emergencies on Korean HSL. The practical local information on the accessible roads to high-speed lines was identified on the numerical map and the information system based on GIS was developed for the purpose of the emergency response and its support, which can be helpful to request the external organizations such as local authorities, police offices and fire brigades.

*1 Senior Researcher(PhD), Policy & Operations Research Department, sangahm@krri.re.kr

*2 Senior Researcher(MSc), Policy & Operations Research Department, shhong@krri.re.kr

*3 Safety System Research Group Leader(Ph.D), Policy & Operations Research Department, jbwang@krri.re.kr

2. THE PRESENT STATE OF OPERATIONAL SAFETY FOR KYOUNGBU HSL

HSRS operational safety management is very important part for passenger safety and preventing catastrophic event. The key point in establishing and optimizing effective safety plan is to identify causes and find mitigation methods of the hazards.

(1) The present state of safety equipment and the characteristics of Kyoungbu HSL

The main characteristic of Kyounbu is that most parts of the track consist of bridges(27%) and tunnels(46%), to which high-strength concrete structure and earthquake-proof design were applied. The installation of all electric lines, transformers and other electric facilities were duplicated and ATC/SCADA was adopted for stable supply. And the newest and advanced techniques of TGV operational blocks were adopted to control and monitor the overall HSR system, listed in table 1, which sense and informs mechanical and physical hazards, abnormal weather conditions to secure operational safety and protect equipment and facilities.

(2) The measures to cope with emergency conditions on HSL

As the basic considerations for operational safety on Kyoungbu HSL, the plans for supporting external rescue units and equipment to access the scenes of the accidents for emergency conditions are studied.

Table 1. The status of safety equipment on Kyoungbu HSL

Equipment	Operation procedure	Installation Criteria
Hot-box detector	Warning → signal transmission on train & CTC, determination of speed reduction or emergency stop Simple/examination signal → CTC notification, commander control	Average 30km
Obstacle detector	CTC transmission/caution operation Stop signal transmission to train operated in proximity section Driver examination after train stop	Up and down line, road
Dragging detector	Warning → transmission of stop code → Driver examination after train stop	Depot → main line, Conventional line → HSL entrance point
Weather detector	Warning → CTC transmission → determination of speed reduction or operation stop	Heavy wind, rain and Snow
Train approach detector	Switch on → site PLC → I/O device of machine room → signal light turn-on	Long bridge Turnout
Tunnel warning	Track circuit detection → main controller → modem → site control box → warning signal	All tunnels
Turnout heating	Temperature sensor: auto operation Operation control: remote operation site control: manual operation	Control box
Rail temperature detector	Warning → site control box → repeater → determination of speed reduction or train stop from central system	Track deformation places

1) Identification of the routes accessing the scenes and distribution of the index information for agencies concerned

In case of an accident, it would be difficult for the personnel to access the spot of the accident if he were not the person concerned in corresponding area. Therefore it is very important to identify the

available access routes and notify repair and rescue parties the information in advance. These information consist of the list by conforming local procedure and should be distributed for all agencies concerned.

In addition, the routes to access the entrances to HSL should be drawn up and distributed to related rescue bodies for emergency conditions, indices to inform the data be marked below the signposts of available roadways to access HSL lines. The index system informing access routes to HSL need to have the unique characteristic that identifies reference locations classified by line sections which distinguish left and right sides of each line, mark available traffic means(ex. by car, on foot, etc)

2) Prior Decision of the possibility to restore servicec and preparation of scenarios

In case of an accident on double track line, it is very important to decide whether single line operation is possible or not. So various scenarios must be prepared in advance.

Safety facilities(double track, equipment to travel in opposite direction on track or crossings) is applied to where accident had been frequently occurred. In case of interruption PC TO decide applicability of the equipment operation scenarios and notifies to related agencies like CTC.

3) Call for the supports of external agencies and the development of S/W

In case of an accident, a designated personnel has responsibilities to restore services and connect external agencies concerned. According to the accident condition if there are fatalities, local or doctors are requested under the responsibility of commander. In case there is human damage including fatality, major injury and natural death, grade-crossing accident by illegal act having the matter of fleeing concern, intentional or criminal act, police officers are requested. For the purpose of above mentioned, some softwares should be developed to refer the entrances, phone numbers of emergency agencies, police and city-hall officers by assigning accident spot and line name.

(3) The present state of development of information management systems for HSL-related facilities

At present, for railway safety an integrated equipment management system had been developed and is under operation in Korea National Railroad. Additionally various management systems for computerization of each management work were also developed and is under operation. For example, in case of railway tunnels database systems has been implemented for inspections, maintenance recording, managing drawings and changes of facilities and other related information. In this systems it is possible for user to inquire & search changes classified by locations and form Raster I/O format so that it can manage drawings & pictures information.

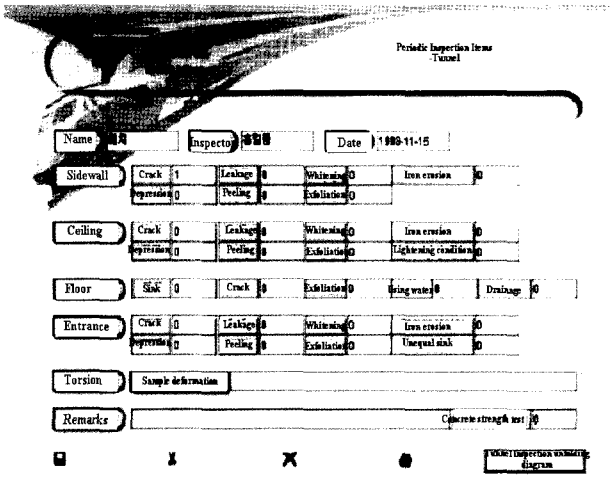

Figure 1. Korean Railway Tunnel Management System

3. DEVELOPMENT OF INFORMATION SUPPORTING SYSTEM FOR ENSURING HSL OPERATIONAL SAFETY

Newly constructed HSL has many safety systems in various aspects. However, as a good reference, the

counter plan for an accident in France, which introduced high-speed train and safety system ahead of us, shows us a lot. An information providing system integrated to various information such as geographical position, analysis on an access plan to some location and available facilities and cooperating body should be developed in Korea for the purpose of immediate understanding of situation and effective deployment of emergency service in case of an accident. Information integrating function of information proving system that is related to safe operation of high-speed train can make numerical map and statistical data of HSR safety facilities more systemized when they are managed in database. That is, attribute information such as diagram, distance, maintenance quality and authority in charge, should be integrated and managed.

(1) Application of numerical map

① Extracting properties and configuring layers

Property data that can be extracted from numerical map are based on many layers. In case of road, classes of roads such as express way, high way, regional way and road, name of road and number of road are computerized as name of railway is also computerized. Facilities and buildings are categorized to school, hospital, police station, public offices and etc. Its possible to acquire types and names of them and its integrated to diagram information as table 2.

Table 2. Layers in numerical map

Scale : 1/5,000			
Category I	Category II	CategoryIII	Contents
Railway	Track	Road (actual width)	Not-classified, regular railway, special railway, tunnel, subway
		Track (on map)	Not-classified, double track, station
	Railway facilities	Bridge	Not-classified, bridge, overbridge
		Convenience Facilities	Not-classified, platform, roof, ventilation, entrance & exit

② Linking diagram information with layers

While all the natural features on the earth expressed on 1/5,000 scaled numerical map are the essential elements to construct high-speed railway information system, all the contents are not necessary in utilization of data. For example, not-classified elements, double tracks and stations in railway related category of table 2 have not much relation with the present construction stage of the system. On the other hand conventional line, railway facilities and related cycles are the essential elements. As for contour lines the data required for decision of overall shape of natural features, they are expressed at 5m intervals in 1/5,000 scaled map. But we decided that it is effective to optimize the interval to the 100m to improve the screen disposal performance at searching. Among the buildings and facilities the data like public offices, hospitals and schools can be applied for mobilization at emergency conditions. Table 3 shows geometrical information and usages being constructed in high-speed information supporting system.

Table 3. Geographic information and its applications

Geographic information	Usage
Track data	Conventional rail network,
Road data	National or local road data extraction for analyzing accessibility at emergency conditions
Buildings/facilities	Identification of available public offices, schools and hospitals at emergency conditions
Waterways data	Status on the piers at bridge
Tributary data	Ancillary roles for interconnection information between road and high-speed line
Geographic data	Auxiliary use of geographic and altitude data around HSL
Administrative boundary	Linking management authorities with facilities and roads related HSL

③ Linking maintenance information for facilities

For complete implementation of safety management system for high-speed train, information on various facilities such as specification, managing

authority, how to manage, manufacturer or construction company name, method of construction, date of construction and periodic check-up should be added and integrated. Especially, securing the accuracy and reliability through GPS measurement and GIS analysis that is integrated to geographical information rather than kilometer post should be taken in consideration.

While putting the above considerations together there are so many information in 1/5,000-scale map, mid-classified data and the data expressed by center line other than actual width especially for railway and road are requested for constructing this system. Exactly the method to utilize the data as natural features is necessary other than to express as map. As the above mentioned it is necessary to select and reprocess the essential data.

(2) Calculation of coordinates of specific facilities by measuring GPS signals

In case of specific facilities, the locational coordinates are to be calculated by measuring on the sites. For example, weather detection equipment have been managed by kilometer post based on neighboring topographies and meteorological observations for several years. To obtain coordinates of these specific facilities, GPS was used for easy access to sites and measured on the second order triangular point (1 place), the third order triangular point (1 place) and the first order triangular point (1place) in the test track being operated.

Measuring was performed when the test train was in operation. Sine the accessible time was limited, three-dimensional coordinates of weather sensing equipment was calculated from a temporary datum plan near motor way. For an additional installation or a transfer of weather sensing equipment, a comprehensive consideration through GPS measurement and GIS analysis should be taken.

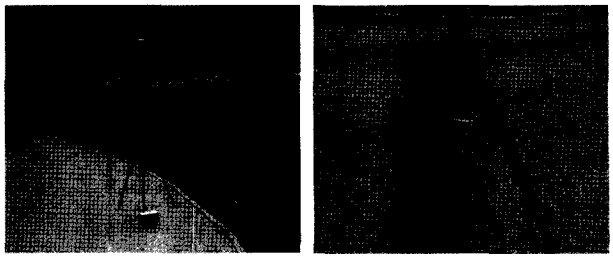

Figure 2. Measurement of GPS coordinates of weather equipments for preliminary management system

(3) Implementation of GIS based Information Supporting system

Information supporting system that had been developed in this research is based on GIS and use software tool for general purpose considering end-user and operating environment. Above mentioned tool is Visual Basic 6.0 and ESRIs MapObject 2.0 to interconnect between geographical and property information. Geographical information were constructed by CAD and Geomenia, property information were constructed by MSAccess. NT Server 4.0 was used as operation system for working in Windows environment. Main functions of developed information supporting system are as follows.

- ☐ Function of quick viewer using GIS (magnification of a map, traveling and scale-down
- ☐ Function of screen control by scale, searching locations by (conversion) kilometer post
- ☐ Function of selection and search by users input area(boxes, circles and polygons)
- ☐ Function of search and modification of related agencies like safety facilities, infrastructures and agencies concerned

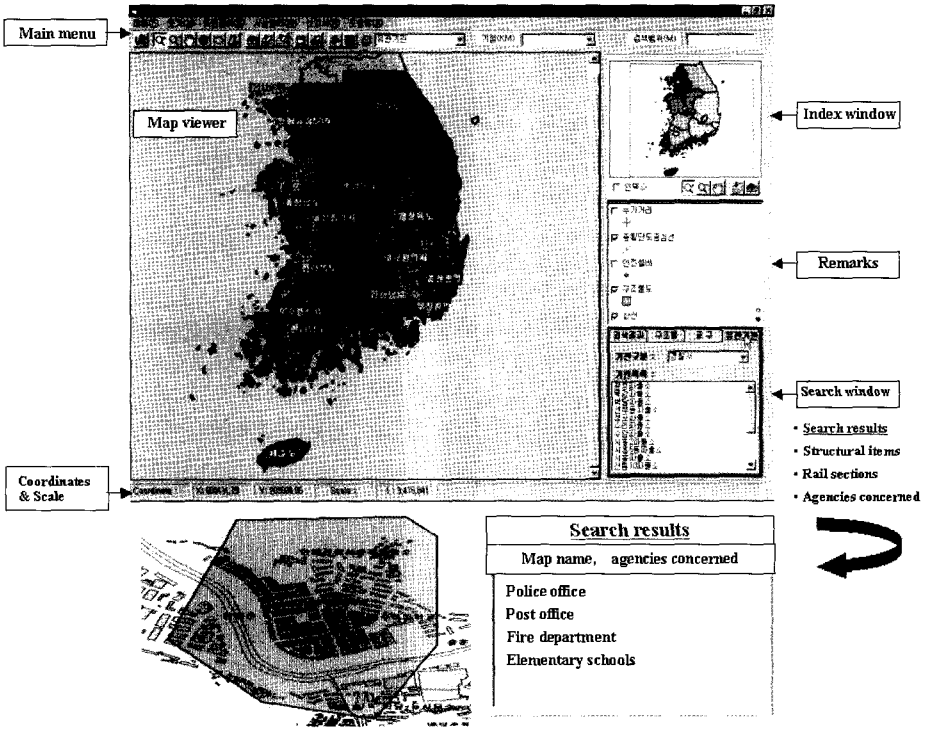

Figure 3. Main window of the GIS based system

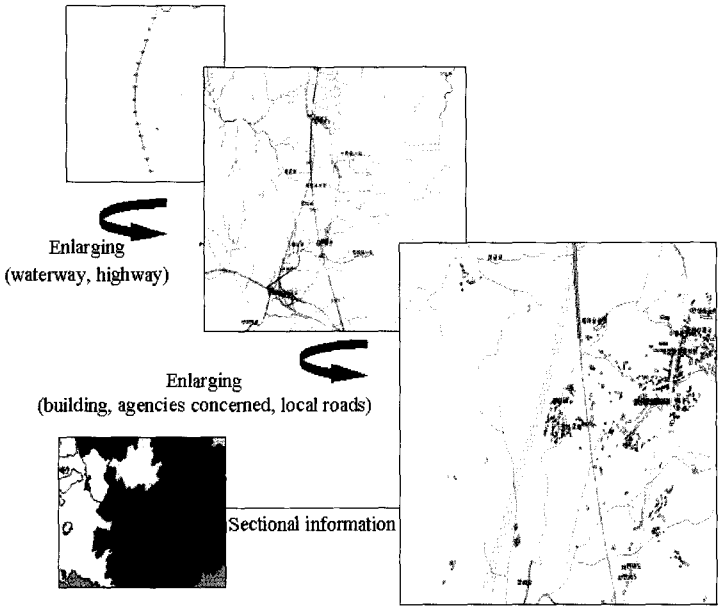

Figure 4. Function of searching locations

4. APPLICATIONS AND IMPROVEMENTS OF DEVELOPED SYSTEM

The target of the present system is supporting information that is available at this point of time under first stage construction. It is necessary to get additional data for commercial operation and guarantee security as main system. Further considerations and improvements are as follows.

- ☐ Update of a map of fully constructed railway after completion of the first stage construction and confirmation of access routes and improvement of numerical maps through a spot investigations
- ☐ Optimization of selected areas and ranges of space information being managed for safety
- ☐ Application of information from satellite for confirmation of geographical data during update cycles of numerical map and changes
- ☐ Interconnection
- ☐ Obtaining a map of fully constructed railway on the section interconnected to conventional lines to get the coordinates of the sections crossing with new lines and additional input work

And in the spheres of national catastrophe management, it is essential to prepare a standard classifications, an index system, of access points to each HSR line by kilometer post. For the above mentioned purpose it is most urgent for government to improve the signposts around the correspondent roads and crossings.

5. CONCLUSIONS

In this paper database system on HSL-related facilities like track, electrical facilities, communications and safety equipment for supporting HSR emergency conditions was presented. The presented system extracts the useful road data adjacent and crossing with HSR lines, which gives the information about concerned external agencies like local administrative organizations, police offices and fire department to request quick support and cooperation. This system is developed based on GIS and integrated into the railway information management system.

6. REFERENCES

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Kim, Sang-Ahm He received his BSc in electrical engineering from Korea University in 1993, and the MSc degree and PhD, also in electrical engineering, from Korea University in 1997 & 2002. Currently he is senior researcher of Safety System Research Group in the Korea Railroad Research Institute. His research interest is in the area of railway safety & performance assessment.

Hong, Seon-Ho He received his BSc in civil engineering from Myongji University in 1995, and the MSc degree, also in civil engineering, from Myongji University in 1997. Since 1997 he is a senior researcher of Safety System Research Group in the Korea Railroad Research Institute. His research interest is in the area of information system based on GIS technology, railway safety & performance assessment.

Wang, Jong-Bae joined the Korea Railroad Research Institute in 1997 after earning PhD degree from Kwangwoon University. As a senior researcher at KRRI, his works include performance evaluation & standardization of metropolitan transit rolling-stock, establishment of safety rules & regulations, HSL operational safety management. Dr. Wang is currently leader of the Safety System Research Group.