Development of Web-based Railway Risk Assessment Information Management System (RAIMS)

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Abstract

This paper introduces Railway Risk Assessment Information Management System (RAIMS) developed by Korea Railroad Research Institute (KRRI). This project is one subject of Railway Safety Technology Development project which has been supported by Government since 2004. The purpose of RAIMS is to make the risk management process more systematically effective by recording the accident in a form of valuable information. RAIMS is composed of four sub-systems for; accident analysis, railway risk analysis, system management, and requirement verification management. Since the contents of those modules constitute a major part of railway safety management, RAIMS generates valuable information that can be used for decision making for enhancing the railway safety in Korea.

1. Overview

RAIMS is an output of the project sponsored by Government from 2004 to 2009, which has been conducted by Korea Railroad Research Institute (KRRI). The present RAIMS is an interim output of the project that will be completed at the end of 2009. This paper presents background and key functions, emphasizing its structure and characteristics.

The purpose of RAIMS is to generate key risk assessment results that can be used for railway safety management. In other words, RAIMS is a subset of overall Railway Safety Management System (SMS), where Railway Safety Management System is operated by higher authority managing over railway safety policies. RAIMS provides key information such as identified accident hazards, quantitative risk assessment results, and other required elements constituting the overall railway safety management suggested in [1]. Thus, the information generated by RAIMS is based on risk models and assessment techniques, tailored for railway application in Korea from general risk assessment methodology. Figure 1 shows the framework adopted for railway SMS, where the information flow and interfaces are linked between relevant safety management elements (activities).

Since RAIMS is assumed to support for railway safety management, RAIMS contains the risk assessment technique and procedure for railway system in Korea, the study of which has been conducted for several years in KRRI, sponsored by Government. The study has mainly focused on;

1. the classification of railway accident type and hazards
2. preliminary hazard analysis (PHA)
3. the evaluation of hazard frequency
4. the evaluation of hazard severity
5. the evaluation of risk
6. the cause of critical hazards
7. the safety requirement management
8. the cost-benefit analysis for safety policy
RAIMS is basically web-based system. Several users are registered to the system and only admitted users can access to the system. Users are divided into three groups; general users, analysts, and system manager. General users are those who are to look up all information related to accidents of interest and analysis results. General users group includes those who have authorities in railway safety management. They can refer the information from this system whenever they need railway risk data for safety management purposes. They can see the current railway safety level from the result and use it for their decision making. Analysts are to assess railway accidents and to evaluate their risk on regular basis. The results are saved in database system in the forms of report, charts, and table.

Accident report is analyzed based on procedures and methods pre-defined in the system. This minimizes subjectivism that may be entered in the process of describing accident cause, type, or accident sequence. For example, an accident is recorded in standard form. Each field in the form is selectively chosen from categories that are pre-defined.

2. Functions of RAIMS

RAIMS is composed of four sub-systems for; accident analysis, risk analysis, system management, and requirement verification management, the structure of which is shown in Figure 2.

2.1 Accident Analysis
Accident data are input from Excel sheet, the data fields of which are pre-defined. All relevant information is input to accident information database of the system. The accident search module provides the classified accidents and shows all accident information when requested (Figure 3)

Accident analysis is composed of four steps:

Step1) Environment analysis: This analysis is to review the weather condition, geological position, trains related to accident, train speed, accident date, railway infra-system related to the accident of interest, and so on, which can be usually taken into account as the environmental conditions to the accident. (Figure 4)
Step 2) Hazard analysis: Hazard analysis includes the identification of hazards, causes, and workers/passengers information relevant to the accident. As the accident information is stored, an assessor opens the accident information and identifies hazards. Hazard log, a result from Preliminary Hazard Analysis (PHA), is pre-stored and used as a basis for identifying hazards from the accidents happened in the train operation. The identified hazard is connected to the predefined accident cause(s), which is later utilized for the cause analysis. (Figure 5)

Step 3) Damage analysis: Damage analysis identifies the loss of life and casualties, the loss of properties, and the loss from train delay. (Figure 6)

Step 4) Option analysis: This analysis is to define the actions that could prevent the accident of interest and propose additional barrier(s) to supposedly prevent similar accident in the future. The actions are classified from the viewpoint of hazard elimination, hazard reduction, hazard control, and damage reduction. (Figure 7)

Accident analysis module basically provides various charts as selected by users. As well as the hierarchical structure prepared on the left hand side, selectable items are on the menu which users can choose from. Then they can see the charts for accident data specified on user’s own selection. Tables show the accident frequencies (or rates) for specified period, accident type, accident cause, railway lines, etc. Fatalities and injuries are also calculated for all kinds of accident categories. Various graphs are provided for intuitive understanding of tabulated accident data. All functions of the module help to conveniently observe the trend of railway accident. Figure 8 is one example of the hazard frequency and hazard severity for accident occurred during specified period and for specific accident type.

Will be developed in 2008
Figure 3: Accident Search View

Figure 4: Environment Analysis View
Figure 5: Hazard Analysis View

Figure 6: Damage Analysis View
Figure 7: Option Analysis View

Figure 7: Accident Analysis Result View
2.2 Risk Analysis
Risk analysis module can be accessed only by risk analysts. The main issue regarding railway risk model is how to model the accident scenarios and to map them into the event tree. For this assessment, standard event tree was devised for each accident type. Mapping all accidents into the proposed standard event tree is not always possible, since some accidents do not follow the same sequence defined by the standard event tree. In this case, some assumptions were made on such accidents. Standard event trees models are developed for all railway accident types, respectively which are categorized as in section 2.3. Figure 9 is one example of event tree model for collision accident.

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One characteristic of risk analysis module of RAiMS is that the risk of railway systems can be assessed by the ET-FT linking approach usually used for the complex systems [2, 3]. Accident scenarios that can lead to undesired consequence are defined on the standard event tree. Variation from the standard event tree can be drawn using an event tree editor. Each branch of accident sequences requires one or more supplementary fault trees, which can be developed by fault tree editor (Figure 10).

![Event tree editor view.](image)

However, since there are quite a number of event trees and fault trees in the railway risk assessment model, RAiMS adapted a systematic technique for integrating event trees and fault trees. Integrated one-top modeling technique [2, 3] facilitates the complex representation of risk assessment model, providing automatic ET-FT linking for ET-FT models of interest. Each module has a powerful graphical user interface. The graphical interface supports for the development of large model by automatically linking pages of interest. A cut set browser provides analysts with the accessibility on all kind of information about minimal cut sets generated by fault tree analyzer as well as the opportunity of convenient sensitivity analysis, for example. Figure 11 explains one top model technique and Figure 12 shows a real view of one top model of RAiMS, where;

- Description: for the management of properties
- Model: for the management of ET, FT, and data
- One Top: for Integration of FT’s into one big one FT
- Analysis: for the calculation of minimal cut sets and other quantitative outcome.
Figure 11: Explanation of One Top model Technique of RAIMS-Risk Analysis

Figure 12: Explanation of One Top model Technique of RAIMS-Risk Analysis
2.3 System Management
The main function of system management module is to pre-define the codes for; accident types, accident causes, environmental factors, train types, railway lines, etc. This module enables the information relevant to accidents to be input conveniently, by providing classified menu being used in other modules. Thus, system manager or system analyst defines the classified codes before other modules are activated. Other function of system management module is to authorize users to access to the system. Depending on the type of users, different degree of accessibility is assigned.

Railway accidents are categorized as;

- Train accident  
  Collision  
  Derailment  
  Fire accidents  
- Railroad-crossing accident  
- Death or injury accident except by train or railroad-crossing accident  
  Passengers  
  Public  
  Railroad employees on duty  

Death or injury accident except by train or railroad-crossing accident should satisfy the conditions; 1) train operation delay longer than one hour, 2) loss more than 50 million won, 3) accident stirring-up social criticism.

Railway incidents other than railway accidents is defined as less severe accident than railway accident such as train operation delay less than one hour, separation of trains causing no further loss, etc.

Besides the codes for accident types, the codes for accident causes, etc. are pre-defined in the system management module, which are utilized in other modules. One reason for pre-defining accident cause, etc. is to prevent assessor from subjectively inputting, for example, the accident cause on his own word(s), which may result in inconsistent description of cause for the same accident.

3. Conclusions and Future Work
This paper shortly presents railway Risk Assessment and Information System (RAIMS) developed and being developed in Korea Railroad Research Institute in Korea. Whereas this system is based on the study for railway risk assessment methodology for several years, it does not completely reflect all the results of the study. Requirement Verification Management (RVM) module is one example, which is to develop the technique to manage the railway safety requirements in order to verify the correctness, traceability, consistency, etc. The technique will be implemented into RAIMS in 2008 and effectively interlinked with other modules to generate valuable information associated with railway system requirements.

RAIMS is a key part of overall railway safety management since it provides risk assessment results for Government, duty holders, or other authorities to make decision regarding railway safety management policy, for example, how to reduce risk due to train collision. RAIMS is developed in a way that the information generated will be sufficient and valuable for the higher purpose. Conclusively, the use of the RAIMS can facilitate the process of railway risk management and provide valuable information in the process of railway safety management.
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References