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A Study on Constructing Common Database for Supporting Urban Rail Transit Project

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Abstract

A variety of Urban Rail Transit (URT) systems have been operating and they have different technology bases, causing a lot of difficulties in taking measures against trouble, training, upgrading, interoperability and so on. As such, a standardization project has been carried out to solve the problems by setting up the national standards for URT systems. A common database was built to provide the integrated engineering environment to the community of URT project. This paper discusses the design of the database and how it can be utilized in the successful promotion of the project. The products of the projects are stored into the database with traceability management to be referred to by other new URT projects for reusing and sharing the acquired knowledge through cross organizations.

Key Words : Integrated Environment, Traceability, Standardization, Systems Engineering, Urban Rail Transit

1. Introduction

Urban Rail Transit (URT) in Korea is defined as transport facilities and measures operating through a track in urban area. It is a large- scale and complex system composed of several subsystems such as vehicle, power, track signal control, station, etc. When the system encounters some failures, accidents or malfunctioning in operation, it is not easy to find out the exact causes of them, and thus great damage spreads out badly in general. Because of various kinds of systems and technologies, there have been suffering embarrassment while operating the system such as in taking measures against trouble, test and evaluation, operation, maintenance, training, upgrading, interoperability and so on [1]. Lots of systems have been imported from foreign countries and developed with different technology bases. There has been also difficulties to establish a standard or basis for systems, and thus resulting in downgrading the quality of service and safety from a falling off in efficiency of construction and operation [1-2].

To solve the problems above, URT Standardization Project (URTSP) has been carried out to set up the national standards for the efficient execution of all sorts of activities needed during the whole phases of a project. It has been supporting the central and regional governments,

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the operation companies and the industries according to the URT law, and also the law itself [1]. A common database was built using a systems engineering (SE) tool to provide the integrated engineering environment to the community of URT project (URTP). It will be utilized during the whole phases of a project such as in placement of order, acceptance, operation and disposal. And the products of current and previous projects will be stored into the database to be referred to by other new projects. The attempt to drive the project on the basis of SE tool is to reuse and share the material and information on URT among the people involved in projects [2]. The relevancy among equipment, documents and regulations, and the revisions of them will be managed too. And the functional analysis of the key equipment will be performed with the database for the development to verify the standards [2-3].

In this paper, we discuss the design of the database and how it can be utilized in the successful promotion of the project. A key usage of the database is obtained by managing the traceability among products and regulations through cross organizations. In most traceability applications, a number of independent organizations work together [4]. The traceability was constructed among standards, regulations and products of the projects with cross reference. The constructed traceability could provide the strong basis for any new development of systems that needs to consider the products of previous projects, standards and regulations perspectives. Also, the incorporation of the newly coming and ever changing standards or regulations is possible for the development using the traceability among the changes of them.

2. URT and the URTSP

2.1 Definition of URT

URT is usually a kind of local rail systems serving urban or older suburban areas. It is defined as urban transportation, urban rail or urban rail transit by UIC, urban guided transport or urban railway by IEC. It is defined by the law in Korea as transport facilities and measures operating for the smooth traffic in urban area through a track like a rail line or monorail, etc. The urban area means a city which has more than 100,000 inhabitants, or more than two adjacent regions which are the same traffic zone. URT facilities include the track lines, vehicles, substations, communication and train control systems, depots and stores. And also are included facilities for R&D, training, management and any other construction and operation [1].

The first URT in Korea was opened in 1899. It was withdrawn in 1966, and the first subway line was built in 1974. After that, the URT systems have been expanded widely with imports and development of various systems. It is very important transportation now, about 773 km of subway lines in several big cities like Seoul, Busan, Inchon, etc., and more than 8 million people are using it everyday on an average [2].

URT is a large-scale and complex system composed of several subsystems such as vehicle, power, signal control, communication, track, station, operation control system and so on. When the system encounters some failures, accidents or malfunctioning in operation, it is not easy to find out the exact causes of them, and thus great damage spreads out badly in general [3]. Because of various kinds of systems and technologies, there have been suffering embarrassment while operating the system such as in taking measures

against trouble, test and evaluation, operation, maintenance, training, upgrading, interoperability, and so on [1]. Lots of systems have been imported from foreign countries and developed with different technology bases. There had been also difficulties to establish a standard or basis for systems with those situations, and thus resulting in downgrading the quality of service and safety from a falling off in efficiency of construction and operation. URTSP has been carried out since 1995 to solve the problems mentioned above [1-2].

2.2 Status of URTSP

URTSP has been carried out to set up the national standards for the efficient execution of all sorts of activities needed during the whole phases from design, manufacture and test to acquisition, operation and maintenance of the systems. It is to study on the standard specifications and test criteria to improve the performance, safety and operation efficiency of the systems based on the URT Act. And the development of key technologies and equipment is also being carried out in parallel with verifying the standards and the test criteria in this project [1].

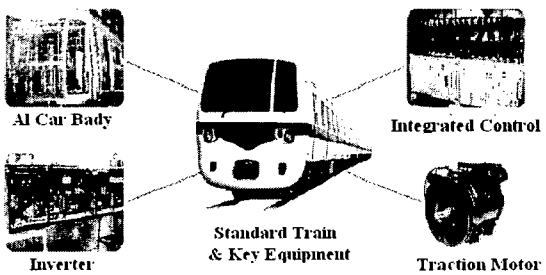

Fig. 1. Standard URT train

The 1st phase of URTSP focused on the development of the standard specifications, requirements for safety, performance and quality of the vehicle including the guideline for precision diagnosis. The standard train shown in Fig. 1 was developed and operated more than 100,000 km on the test track with high-speed DC circuit breaker, precast-slab track, train maintenance information system, etc. that had been developed together with.

The 2nd phase of URTSP from 2007, is mainly aiming for the development of the standards for DC-AC vehicle, station facilities, communication, AC power supply, etc. with which had not been dealt during phase I of URTSP. And the key equipment like vehicle reliability & availability management system, selective earth current protection system, DC insulator, security system, etc. are on development now. The URT standards and guidelines are being revised and will be decreed again by the government [1].

- Phase I (1995~2006) : Development of standard specifications, safety, performance and quality requirements for vehicles and facilities of signal control, power and track, and guideline for precision diagnosis of vehicles, in parallel with development of standard train, high-speed DC circuit breaker, maintenance system, etc.
- Phase II (2007~2012) : Development of standard specifications for information and telecommunication, station and AC power for URT, in parallel with development of power protection system, DC insulator, intelligent security system, etc.

3. Common Database for URT

The common database was built by using an SE tool to provide the integrated engineering environment for the community composed of users and participants of URTP. It will be utilized by the central and regional governments, construction and operation companies and industries during the

whole phases of the project. The attempt to drive the project on the basis of SE tool, is to reuse and share the material and information on URT among the people involved in projects [2]. And the functional analysis of the key equipment will be performed with the database on the integrated engineering environment for the development to verify the standards. The relevancy among equipment, documents and regulations, and the revisions of them will be managed through the tool too. And it will support to print documents out automatically [2-3].

Common database is to provide with project work environment for the people involved in the project. This can make anyone of them deal with, review and store the work of project through connection to just one database. It is more than simple perusal of information by connection to a server like Internet, is to handle and store into the database directly outcomes, references, decisions, etc. of the project.

3.1 Common Database

An integrated common database was designed on a server computer in the project office, with classification codes for the project data using an SE tool, Cradle®. The database will be used for joint ownership, practical application, revision management, etc. of the products. Fig. 2 shows the environment for construction and use of database among the users and participants of the projects. This could be also used for executing other similar projects, or maintaining the material and information wholly at the change of persons in charge or constitution for a project which is normally large in scale and long period in time.

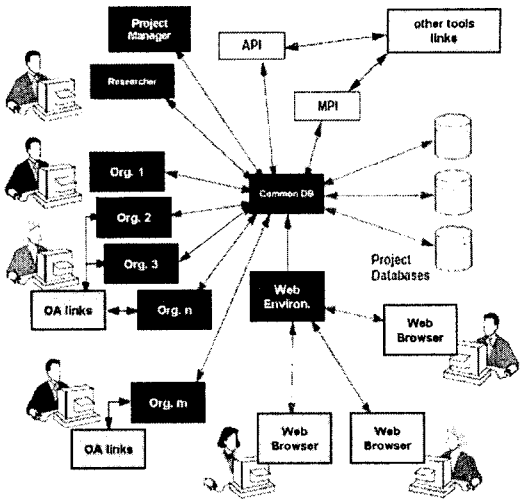

Fig. 2. Environment for use of common database

Database consists of the schema and actual data. Any document resulting from URTP can be stored into project database. And the products of previous projects will be stored into the database to be referred to by other new projects. This can be also read and referred by permitted ones. The schema was designed considering following [3]:

- Establishment of classification code considering the types of products of a project
- Design of the database structure in accordance with the classification code, and the space for input data
- Creation of frames linked to executive programs for each type of documents at input
- Definition of the easy and clear way of data input
- Design of queries and schema for inputing
- Application of searching schema to find out data at the user's point of view

3.2 Concept of Traceability

Traceability is to identify the relationships between various artifacts of the development process, i.e., the lineage of requirements, the

relationships between a design decision and the affected requirements, the assignment of requirements to design features, the relationships of test results to the original source of requirements. It is the means by which the design group understands the process of translating a user's requirements, goals, and objectives into an operational system. The design process can be viewed from many different perspective, each perspective serving to constrain the design domain. An effective traceability management can enhance the capture, assess, and utility of traceability information significantly. The value of traceability data will become increasingly evident [4].

EPCglobal has proposed an architecture for a network of RFID databases where each database provides a standardized query interface. It facilitates simple retrieval of traceability data from individual repositories, but it does not support cross-organizational query processing. Theseos provides traceability with the ability to execute complex traceability queries that may span multiple RFID databases [5]. WholeHealth uses traceability application to request a pedigree for pill bottle, contained the pills administered to the patient, to treat a patient with a drug [5].

The Council for the Central Laboratory of the Research Council (CCLRC) scientific metadata model (CSMD) is a common model for the representation of scientific study metadata, proposed to aid interoperability of scientific information systems on the Grid. The model is to form a specification of the type and categories of metadata that studies should capture about their investigations and the data they produce [6-7]. The proposed model is restricted to the boundary of scientific study.

4. Implementation and Operation

4.1 Common Database

1) Management process: The process to manage the database for URT was determined with considering the national process of the enactment and revision of a law. It is shown in Fig. 3 minutely.

2) Classification code: It was decided by dividing into classes and analyzing all kinds of documents like reports, drawings, references or information resulting from a project considering

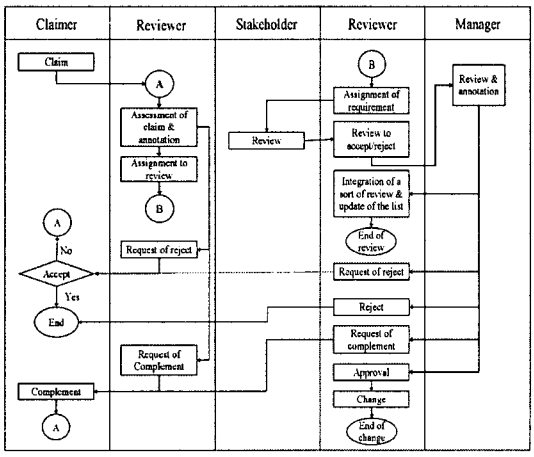

Fig. 3. Management process for the database

Document Structure

<< 2nd Phase of URTSP >>

Doc. Code : A(00)- S(00)- T(00)- S.N (000)

Area	Section		Type		Area	Section		Type	
총칭	공정관리	01	공문	OD	전력	표준규격	01	공문	OD
TM	위원회	02	계획서	PL	IE	안전기준	02	보고서	RE
	워크숍/세미나	03	협약서	AG		품질인증	03	검토서	ED
	보고회	04	보고서	RE		성능시험	04	발표자료	PT
	도시철도법령	05	검토서	ED		지락보호시스템	05	회의자료	MD
	기술자문	06	발표자료	PT		전차선로해설무	06	기술자료	TD
	홍보	07	회의자료	MD		전력설비운라인	07	설계도면	DW
	견산	08						시험공가	TE
	협약	09							
차량	표준규격	01	공문	OD	역사	표준규격	01	공문	OD
RS	안전기준	02	보고서	RE	IS	안전기준	02	보고서	RE
	품질인증	03	검토서	ED		품질인증	03	검토서	ED
	성능시험	04	발표자료	PT		성능시험	04	발표자료	PT
	경험진단	05	회의자료	MD		내진설계	05	회의자료	MD
	신뢰도/가동도관	06	기술자료	TD		소음저감장치	06	기술자료	TD
			설계도면	DW		내진보강장치	07	설계도면	DW
			시험평가	TE		미세입자제거장	08	시험공가	TE
						열유체해석도로	09		
정보	표준규격	01	공문	OD	도시	법	01	공문	OD
통신	품질인증	02	보고서	RE	설도	시행령	02	계획서	PL
IC	성능시험	03	검토서	ED	법령	규칙	03	협약서	AG
	차자상간통합데이	04	발표자료	PT	LW	지침	04	보고서	RE
	지능형종합감시시	05	회의자료	MD				검토서	ED
			기술자료	TD				발표자료	PT
			설계도면	DW				회의자료	MD
			시험평가	TE				안내문	IF

Fig. 4. Document structure with classification code

the way to classify with the scale and the volume of data. Fig. 4 shows the structure of the document, consisting of three groups of categories which are area, section and type, and a serial number for each document. The basic policy for the classification was delivered from the project office of URTSP.

3) Schema: It is represented by ERA (Element, Relationships and Attributes) based on entity-relationship data model. Element contains actual data with relationships of directive links between other elements. Attribute consists of the basic character of its element such as name, identifier, created date, updated date, revision number, etc., and purposive character for the management such as the security level, significance, status (approved, deferred, canceled, reviewed). The schema designed was shown in Fig. 5.

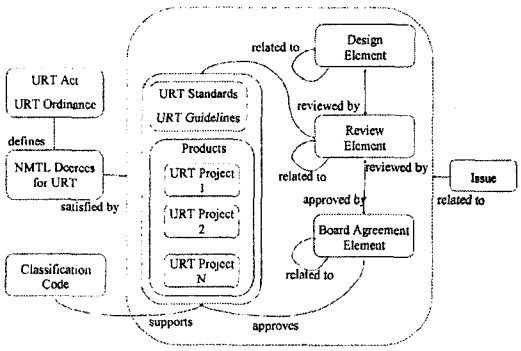

Fig. 5. Schema for the database

4) Queries: There are 311 queries showed in Fig. 6 because the data are stored in the database by the classification code (number of section codes times number of type codes). They were designed considering the minimum input items and the proper searching functions at the user's point of view. The serial number is added automatically to the document code to diminish errors at input. The queries are managed by the classification code shown in Fig. 6, and users are able to search by queries or by federation of them for data.

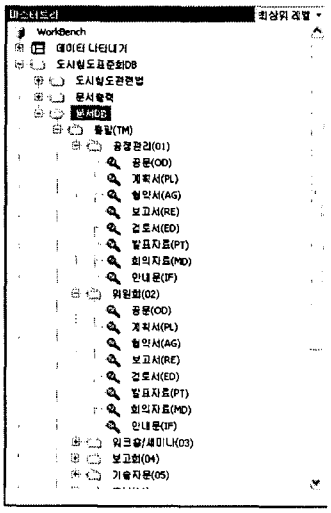

Fig. 6. Master tree of queries for database

5) Frames: They provide the environment to handle the data of the database, shown in Fig. 8. The products of a project can be stored into the database and opened again through the frames. The frames are linked to their executive programs for data. The type of data could be MS-Word, Excel, Powerpoint, Text, other wordprocess file, or any kind of images. Those are also provided through web access for users.

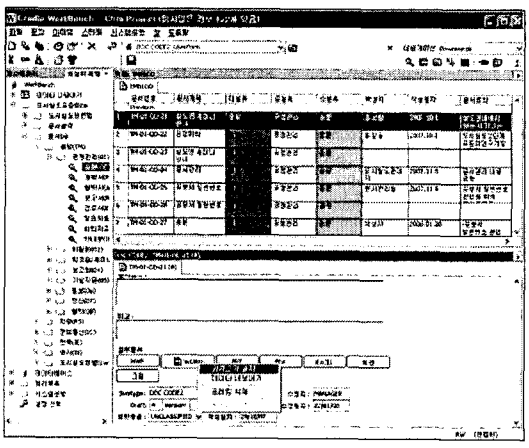

Fig. 7. Designed frame view

4.2 Traceability

The traceability was constructed among the standards, regulations and the products of URTPs with cross-reference. The standards or regulations affect to the whole lifecycle of URT system and project. It could provide the strong basis for the development of systems in considering the standards not to omit the regulations perspectives as requirements. Every article of standards or regulations, or every product of projects was dealt as an item in the database, and an item is to be linked to other related items through traceability. Fig. 8 shows the steps to establish the traceability on Workbench module of Cradle® tool between items interrelated. Traceability of the technical baseline and any changes will be maintained while documenting the configuration, technical data, trade studies and effectiveness analyses by SE tool [4-8,9].

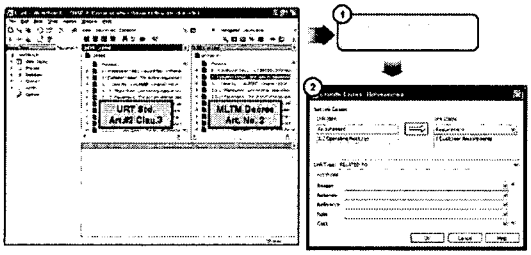

Fig. 8. Example of establishing traceability

4.3 Operation and Management

Any user related to an URTP can use the database with the permission of the project office. They can search for, input, change, confirm the revisions of, and print out any data about URT. The procedure for data input is as following:

- Identify the classification code in the code table for the datum to be input
- Select the query same with the code in the master tree
- Open the query selected to call the input dialog box
- Input the title of the datum with automatically added number on it
- Input the management items for the datum such as keywords, authors, etc.

When searching for information with a designated word, it will extract the data only in accordance with the attribute value. And a view screen, shown in Fig. 9, can be configured suitable for user's purposes. It can be stored at project level to be seen with other people, or at user's level just for the user only.

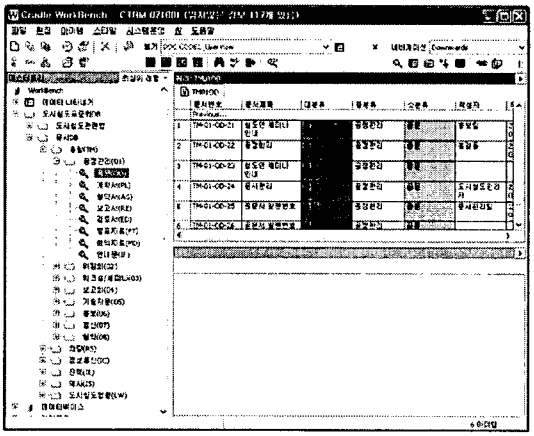

Fig. 9. Example of view screen at user's level

5. Conclusion

The objective of the URTSP is to research for standardization and develop key technologies of URT in Korea. This project is supporting all the activities to manage URT systems on the basis of URT Act, and playing the role for guidance to advance the technology furthermore. It has kept improving the safety and reliability of systems. The regulations and standards have been also maintained by the project, and they will be considered to be correspondent with the

international standards. The computer-aided systems engineering tools were considered to help manage the technologies, standards, regulations, the products of projects, etc. And the various stakeholders relating to URT can get access to the required information and use with cross-organizations through the tools. It could prevent system development and operation from trial and errors, and improve the capacity of technology and management.

It can be used as a short cut for developing a new system to apply new specification to the existing systems or improve some problems of the existing systems. Most URT systems take lots of budget and time to develop, and it is very important to make good use of information in the course as well as the end products of the previous projects. This work is to support to provide information about URT easily and clearly such as regulations, standards, products of project, etc. through common database with traceability among data. And it could also help have higher productivity and quality for developing system-level design, and support effective and efficient management. This could be extended on the basis of systems engineering environment to functional analysis, interface and configuration management, test, validation, and so on.

Acknowledgement

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Biography

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