

# System Requirements Verification Based on Requirement Traceability Management System

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**ABSTRACT:** The Urban Maglev Train system is on the stage of test and evaluation to verify its Reliability, availability and safety. The complexity of train system is gradually getting increased and the diversity of verification requirements is also getting increased.

We are planning to confirm System Requirement satisfaction by verifying VRs that are coming from SR. We have already finished Critical Design Review (CDR) on the final design results and established Verification Requirements including verification method, event name, detail test name, expecting result type, operator, responsible person. There are four kinds of test methods in verification depending on the character of Verification Requirements like test, analysis, measurement, demonstration.

The Urban Maglev Train System has largely divided into seven parts vehicle, signal, communication, electricity, station, railroad and base of vehicle. In case of vehicle, the total Verification Requirements (VRs) are more than 400 and total number of VRs of the Urban Maglev Train system is almost reaching 2000 and all of Verification Requirements are must be checked at least one way.

Since there so many tests items, an effective and systematic VRs management tool is needed. For successful progress of Test & Evaluation, we need a methodology to communicate all relative institutions for easy understanding on the test schedule, results, status and more.

It is almost impossible that all Verification Requirements are under the control by human considering its amount. Therefore the demand of system engineering computer system has been increasing. So in the verification process for Urban Maglev Train, we are using a data base that allows us tracking traceability between System Requirement and Verification Requirements as well as verification status.

In the process of System Requirement Verification, especially when we are facing with newly introduced complex system that never commercialized, appropriate management tools are essential no matter what is computer system or document. In this sturdy, a methodology on the systematic VRs management with a tool that allows us more easy controlling is going to be presented.

## 1 INTRODUCTION

Korea urban maglev train project has scheduled from 2006 to 2012 for the purpose of achieving the demand of transportation in addition to developing a system that lead to prior occupation by providing competitive performance, quality and cost.

We are now just entered into test and evaluation stage to verify its reliability, availability and safety.

The urban maglev system has divided in to largely seven sub-system vehicle, signal,

communication, electricity, station, railroad and base of vehicle and all of them have their

To verify SRs, we have made a matrix describing Test & Evaluation scheme. The total Verification Requirements (VRs) in the matrix are almost 2000 that we must be checked. Since just one missing of VR could cause serious effect to entire system. In other words, an omission of VR is adaption of risk. But considering its outsized scale and complex system, it is impossible to control all massive facts effectively by human. That's why the demand of System Engineering Software has been increasing

## 2 VERIFICATION REQUIREMENTS MATRIX

### 2.1 Discrimination of Verification Requirements

The specification consists with specific and precise figures or sentences coming from a set of system requirement described by qualitative and proclamatory sentences and it must be satisfying all system requirements. That means that the specification satisfaction through verification is the satisfaction of system requirements.

For more easy control and preventing any missing in Test & Evaluation process, we simplified and extract important keywords or sentences from the Specification and finally a Verification Requirements Matrix has settled

METHOD	DESCRIPTION	QUANTITY
TEST	A methodology to see whether System , components or software program can meet required goals with granted environment	56
MEASUREMENT	Measure something's amount or size based on same kind stuff.	151
ANALYSIS	Inquire some facts or matter	67
CONFIRMATION	Checking and recognition it's desired goal	77
TOTAL		435

Figure 1. Traceability of Verification Requirement

### 2.2 Making Traceability

The main purpose of Test & Evaluation is to check that how well the design results and product can meet the Requirements. To make it success, systematic process and system are necessity.

Urban Maglev Project Verification Requirements (VRs) are defined already as numeral or sentences with verify method and each of VR could be verified at least one way. And, for batter control of traceability, we grant a code to all of VRs considering the relations between sub-system, product breakdown structure (PBS) and VRs.

### 2.3 Granting a method of evaluation

VRs are could be verified by some ways by the type of its character and then we must choice pertinent evaluation method to all VRs. For example, on the requirement of "Vehicle must endure from the impact compression stress" it is impossible to confirm by

destructive inspection but we can see it through a simulation of collision analysis. In other words, granting an evaluation method could be defined by VRs own character. Some of them would be evaluated by test and some of them would be verified by analysis.

There are 4 kind of method according to the purpose test, measurement, analysis and confirmation. In case of vehicle, we have granted evaluation method to VRs as follows.

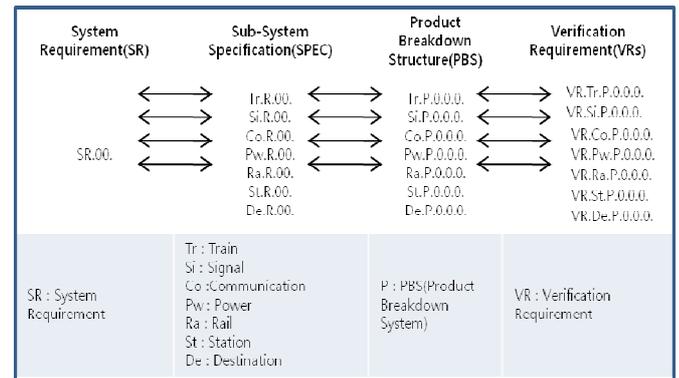


Figure 2. Test Method Decision

### 2.4 Assignment of evaluation methods

One of the important things when we decide and grant evaluation method is that the persons interested in Test & Evaluation should be considered because it is closely involved in cost, schedule available equipment/space and so on. The figure3 is showing the Verification Matrix reflecting the result of evaluation method arrangement mutually agreed.

Verification Matrix for Urban Maglev Train\_Vehicle

The matrix shows columns for: Verification Requirement, Input Description, Storage Details, Verification Description, Verification Method, Test Status, Cost, Report, Approval, Validation, and others. A central box highlights the mapping of VRs (VR.Tr.P.1-14 to VR.Tr.P.1-19) to Evaluation Methods (TEST, MEASUREMENT, ANALYSIS, CONFIRMATION).

Figure 3. Verification Matrix

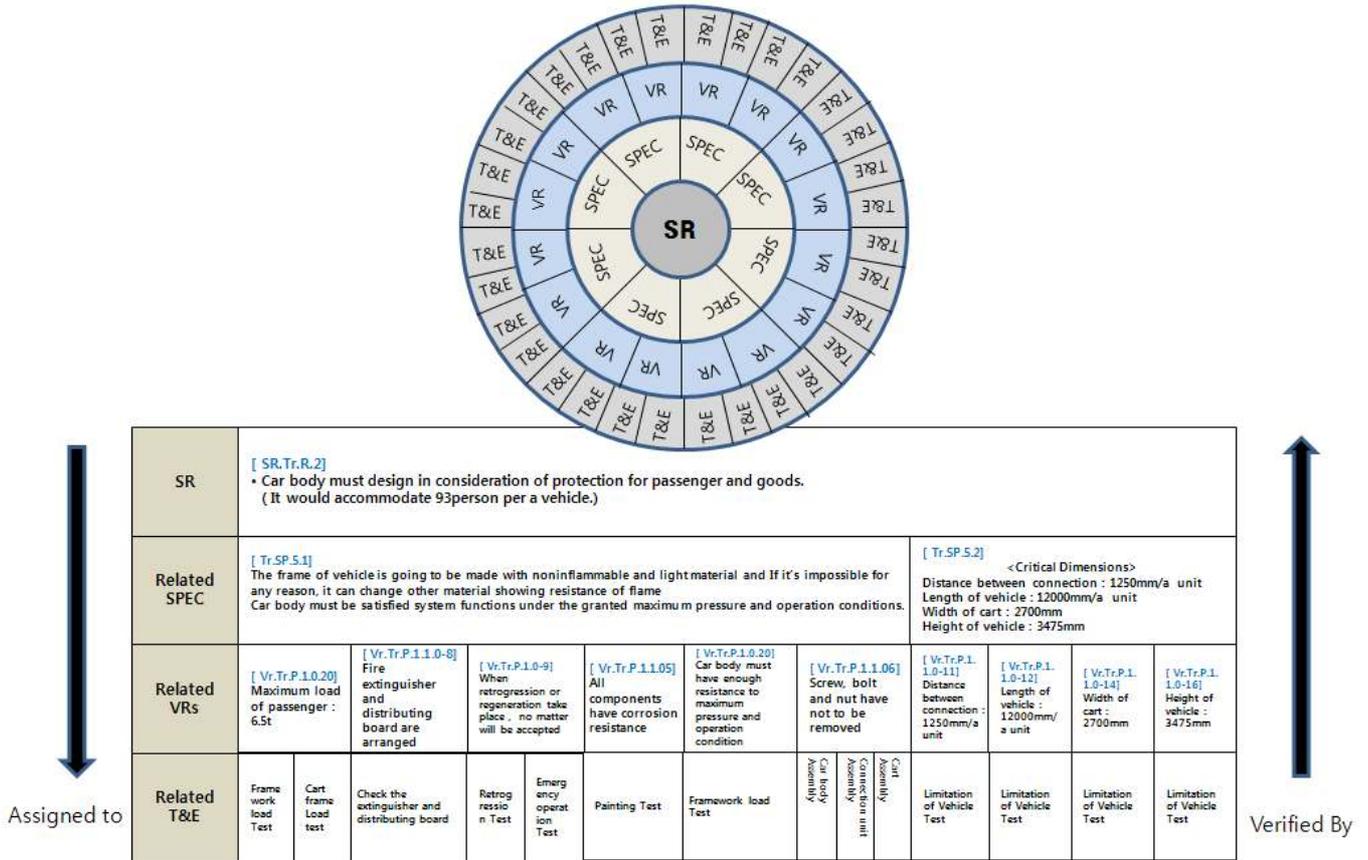


Figure 4. Traceability of Verification Requirements

### 3 VERIFICATION REQUIREMENT MANAGEMENT

#### 3.1 Verification Methodology

Basically, our SR management refers general methodology of SE management. System Requirements are describing so comprehensive that it is not easy to see what we need to check and verify. For administrative purpose, top-down breaking method that could more specify SR has been applied. For example, showing Figure5, on the requirement SR.Tr.R.2 “Car body must design in consideration of protection for passenger and goods.” two specifications “The frame of vehicle is going to be made with noninflammable and light material and If it’s impossible for any reason, it can change other material showing resistance of flame. Car body must be satisfied system functions under the granted maximum pressure and operation conditions” [Tr.SP.5.1] and <Critical Dimensions> Distance between connection : 1250mm/a unit Length of vehicle : 12000mm/a unit Width of cart : 2700mm

Height of vehicle : 3475mm [Tr.SP.5.2] are concerned and [Tr.SP.5.1] has six verification requirements and [Tr.SP.5.2] has four verification requirements and appropriate evaluation methods have assigned to VRs. A system requirement will be verified by reverse tracking from T&E plan to specification. Each of SR has some related Specifications, Verification Requirements and Test & Evaluation plan. In other words, all of system requirements may have their own verification methods at least one way. In the middle of assigning process, it is very important to review closely that any keywords have not been missing otherwise we can’t assure the SR satisfaction when it comes through the Evaluation process. By gathering T&E plans, we could find whether a VR is satisfied or not. By gathering VRs evaluation results, we could also find the status of Specification and SR. The figure 4 is showing a set of chain from the system requirement to test & evaluation that are linked accordance with their source. In some cases, a verification requirement possessed several ways to be confirmed

### 3.2 Documentation

When Test & Evaluation start, verification status observing the progress is going to be managed. That is very important thing in aspect not just management but also communication among the interested parties.

Because sharing information organically about the test results, schedule and status is necessary for successful T&E. To get easy communication among the interested parties, we have made a document as below. The report has composed with test result/criteria, weekly/monthly verification status, Product Breakdown Structure verification status, System/Sub-System verification status, Total Maglev System and Issues status.



Figure 5. Verification Matrix

## 4 VERIFICATION REQUIREMENT CONTROL BASED ON SR DATABASE

### 4.1 Cradle Database

Cradle Database is one of the well-known System

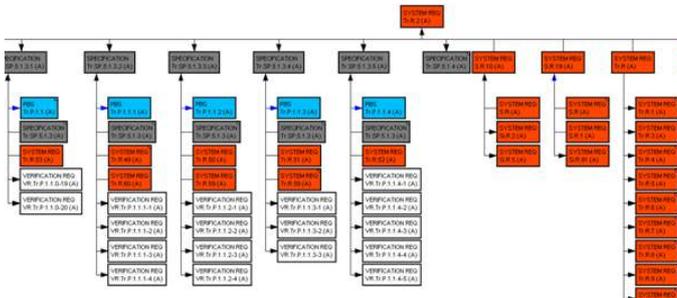


Figure6. Diagram of Hierarchical Structure

Engineering support software that allows us more systematic VRs tracking and control preventing any missing. It has several abilities in requirement

analysis, system function analysis, building architecture and more. By using this software we build up our system requirement management structure. There are many items in the database such as Operation concept (OC), system requirements (SR), Product Breakdown Structure (PBS), Specification, Verification Requirements (VR), Test & Evaluation Plan (T&E) and Issue management item and all of them have connected with what already discriminated its traceability.



Figure 7. Details in each Items

### 4.2 Contents in each items

Each item has composed by the type of its character. In case of the specification, design results and history summery data have been entered. For more detail information about the date, reviewer and progress, a historical report has attached.

### 4.3 Building master tree

Low data accumulation and making traceability is very important operation that requires long time and effort but the most important fact in using database is what how well you can show the information which relative person might be interesting. We set a list up of the master tree considering developer, designer and operator. There are 10 items in the master tree from Operation to report that you can print or save. Basically, most of items have split as many as its sub-systems.

In the item of Requirement, you can search User requirements and System requirements that were collected by diverse studies like passenger survey, stakeholder requirements and operating organization requirements as well.

Figure8. Requirement Item

position. So far, there are number of Interface Issues but most of them are coming from Vehicle to

Figure10. I/F(Interface Issues) Item

4.4 Product Breakdown Structure (PBS)

If you want to see how the Maglev system has formatted, you can find it at the PBS item where you also can confirm their appearance by pictures.



Figure9. PBS(Product Breakdown Structure) Item

Infrastructures such as Vehicle to Signal, Vehicle to Communication, Vehicle to Electricity and more. Approximately, 30 Interface issues were deducted. In the I/F item, you can see the detail history of the issues.

4.8 Issue Item

During the project period, many issues have been generated, reviewed and settled. They are can be distinguished from I/F Issues. I/F Issues are mainly focused on the adjustment of conflicting interests among the parties but Issues concerns overall technical problem that could affect to time and cost. They could be momentous information to those who are going to operate or manage this system in the future. Issue item consist of its subject, main discourse, relative specification, comments by all parties, record of meeting and more.

4.5 Specification Item

Specification item has two sub-items Design Review and Specification. The design result comparing with specification drew out from PDR (Preliminary Design Review) and CDR (Critical Design Review).

4.6 T&E Item

The T&E item includes a performance test mainly for Vehicle and the other tests related to infrastructure. In this item, you can see the kind, method, test manual including criteria for making judgment and test result. If you want to see only passed or failed items, it is possible by filtering function.

4.7 Interface Issues Item

One of the most essential roles of SE is to find out and lead an agreement on the Interface Issues as good and fast as possible even through all parties in a bundle of Interface issue can't take advantageous

Figure11. Issue Item

4.9 History Item

Since this Urban Maglev Train is the first commercialization in Korea, no System Requirements and Specifications were available. So in the process of researching and developing suitable standardization of it, SRs and SPEC are subject to change while total project period. Some of them have changed many times and some of them have never

changed. This information could help decide when some Requirements or Specification need to be changed. All of change history and reviewed results are on the item of History and for more and detail information, over 300 history reports have attached.



Figure12. History Item

4.10 Document Item

In some instances, documents need to be printed out for the purpose of reviewing so some documents that are frequently used, are available at the Document Item.

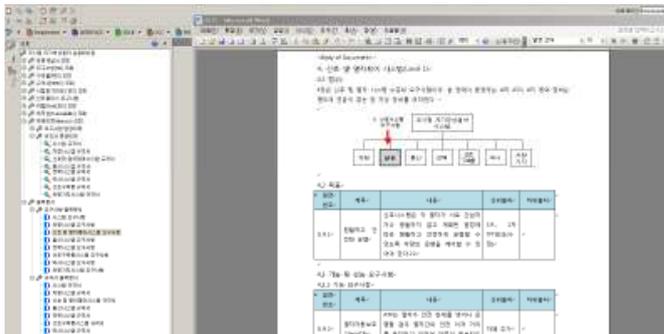


Figure13. Document Item

4.11 Traceability Item

Of all items, the most valuable and useful item is the Item of Traceability. It affords a view of co-relationship from System Requirements (SRs) to

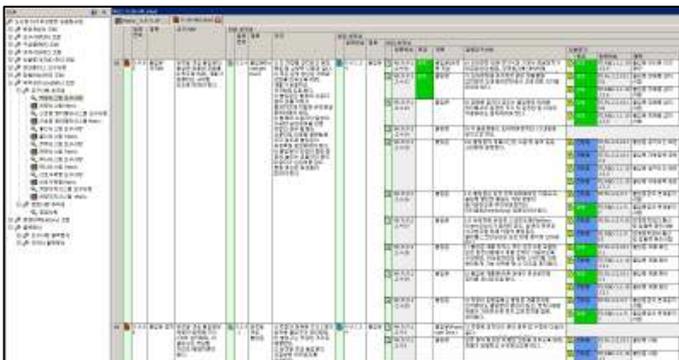


Figure14. Traceability Item

T&E item. All contents are linked with upper and lower items following their origin source and once the tests are implemented, we could manage System Requirements Verification.

5 CONCLUSION

The Urban Maglev Train system is at the very beginning of its test and evaluation phase. Taking into consideration its complexity, It is almost impossible that all Verification Requirements are under the control by human. Verification Matrix defined test methods to each verification requirements was made through PDR (Preliminary Design Review) and CDR (Critical Design Review). In the process, all of VRs are granted traceability cods and test & evaluation methods. And also they are linking to related specification and system requirements.

There are 10 items in the database and all of them linked one another. For easy data management and sharing, we have established a mater tree listing from Operation concept to Document. In this tree, you can find what about requirements management history. so systematic verification tool for more effective and efficient System Requirements Verification is essential. In the verification process for Urban Maglev Train, we are established a data base that allows us tracking traceability more effectively.

Finally we got the system that System Requirements could be evaluated by entering the results of Test & Evaluation linked to the verification requirements.

From 2011 to 2013, Test & Evaluation process will implement according to the Master plan that was already made by SE Leader. When the results of T&E are available, we could confirm our System Requirements Verification.

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