FUNCTIONAL REQUIREMENTS
DEVELOPMENT AND VALIDATION
PROCESS

Documentation of the process and tasks to develop and validate interlocking functional requirements based on the EIFFRA approach

Annex A to the GENERIS Project Declaration

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Abbreviations

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<tr>
<td>EIFFRA</td>
<td>Euro-Interlocking Formal Functional Requirements Approach</td>
</tr>
<tr>
<td>SELRED</td>
<td>Structured English Language for Requirements Development</td>
</tr>
<tr>
<td>UML</td>
<td>Unified Modelling Language</td>
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References to Cited Texts

[1] Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS), EN 50126

1. **Introduction**

This document describes the requirements development and validation process that is used for the CENELEC conform development of national functional requirements of signalling systems for European railways. The process is based on the re-use of the generic European functional requirements, developed by railways through the Euro-Interlocking project, using the Euro-Interlocking Formal Functional Requirements Approach (EIFFRA).

Through the definition of the process, the specific tasks in the requirements development process are defined, as well as skills and resources needed to define, develop and validate national functional requirements for interlocking systems.

It is important to note that the process and estimate of resources in this document assumes that 3 or more railways have already implemented the requirements in the Euro-Interlocking requirements catalogue based on the EIFFRA approach.

2. **Requirements development and validation process**

The requirements process is described using the following four elements:

- **who** is doing it: the **roles**
  A role in the process is being taken on or played by one or several persons or organisations. The same person can also take on several roles.

- **how** it is done: the **tasks**
  A task describes how the deliverables are produced. Tasks are carried out by people playing a role.

- **what** is done: the **deliverables**
  A deliverable is the result produced by people carrying out tasks.

- **when** it is done: the **workflow**
  A workflow shows the relationship between roles, tasks and deliverables.

2.1 **Roles**

The main **roles** in the requirements process are described in terms of the functions they provide and the qualifications needed for assuming the role.

**client**

- Function: To take responsibility of railway side commitments, to define the general parameters of the project and possibly to provide funding of requirements development work
- Qualifications: To have the will and competence to decide on goals and to commit resources


**domain expert(s)**

- Function: To serve as a source for the requirements of the railway company and to help verify the requirements
- Qualifications: Several types of domain experts are needed.
  - Signalling domain expert: To have a very good understanding of the interlocking domain of the railway company
  - Operations domain expert: To have a very good understanding of the operating procedures of the railway company

**requirements engineer(s)**

- Function: To specify and manage the requirements applying the EIFFRA approach
- Qualifications: To have a good understanding of the EIFFRA approach, the requirements development process and the techniques used.

**approval authority(s)**

- Function: To perform the final validation of the requirements
- Qualifications: Knowledge of the functional requirements of the applicable railway, knowledge of the validation techniques to be used

The people performing these roles in a project can be provided by different organisations:

<table>
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<tr>
<th>Role</th>
<th>railway company</th>
<th>Euro-Interlocking core team</th>
<th>third parties</th>
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<tr>
<td>domain expert(s)</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>client</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
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<tr>
<td>requirements engineer(s)</td>
<td>yes</td>
<td>yes</td>
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<tr>
<td>approval authority(s)</td>
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The Euro-Interlocking core team will do most of the actual specification and modelling work. Domain experts from the railway company are the source of the requirements and are therefore very much needed for specifying the requirements.
2.2 Definition of tasks

2.2.1 Task 1: Set-up

- **provide justification** for high level management (decision makers) at the railway for going ahead with functional requirement development

- **establish a memorandum of understanding** with the stakeholders involved (railway company, Euro-Interlocking project, third parties) covering things like **process** to be followed, and a **work breakdown plan** including tasks, time planning, resources, milestones and deliverables

- **make sure** that all **roles** in the project **are filled with people** and establish a commitment (especially in terms of availability) from all the persons who play any of the different roles in the project (e.g. different kinds of domain experts like operator, signal engineer and v&v experts)

- **provide training** for people who have not sufficient skills for their role, e.g. requirements engineering, DOORS and/or UML training for requirements engineers

2.2.2 Task 2: Establish a common vocabulary

The common vocabulary is established by producing **cross-references** that connect the railways vocabulary to the Euro-Interlocking vocabulary. If no connection is possible the Euro-Interlocking vocabulary can be expanded. Two cross-references are produced:

- a **terms cross-reference** that maps the national vocabulary of the railway company to the Euro-Interlocking terms glossary

- a **commands and statuses cross-reference** that maps the national commands and statuses to the Euro-Interlocking commands and statuses

2.2.3 Task 3: Specify textual requirements

The following tasks are executed **iteratively** in **several cycles**.

2.2.3.1 Elicit the functional requirements

Based on the Euro-Interlocking requirements the specific functional requirements for the railway company have to be elicited. Several categories of requirements have to be covered:

- Develop and capture the high-level functional requirements (often based on high-level operational requirements, for example, headways)

- Develop and capture the functional safety requirements
• Functional requirements (glass box (uses cases) and black box requirements (possibly structured according to the element they refer to, e.g. points, signals, routes, etc.))

• Failure mode and degraded mode functional requirements

• Functional requirements related to commands and statuses going to and coming from external systems such as neighbouring interlocking systems, TCCS systems and track elements

**Option Operating Rules and Regulations**

Capture and document the operating rules and regulations of a given railway. Link those operating rules to the national functional requirements and to the hazard list.

**2.2.3.2 Document the functional requirements in textual form**

The Euro-Interlocking textual requirements catalogue is used as a starting point to formulate & categorise new requirements and make changes to existing ones. All textual requirements are managed in DOORS and are formulated in compliance with SELRED.
The diagram above is an example of the capturing of Euro-Interlocking textual requirements catalogue in the DOORS requirements management tool.

2.2.4 Task 4: Cross-referencing of functional requirements and the hazard list

The textual functional requirements in DOORS and the Euro-Interlocking Generic Signalling Hazard List (also in DOORS) are to be cross-referenced in DOORS, based on the cross-referencing approach approved by the Steering Group in 2003 as part of the EIFFRA Approach. This task includes:

- **Setting up** the Euro-Interlocking **textual functional requirements** for cross-referencing in DOORS
- **Setting up** the Euro-Interlocking **hazard list** for cross-referencing in DOORS
- **Cross-referencing** the Euro-Interlocking **textual functional requirements** with the **generic signalling hazard list** in DOORS
- **Review and adapt** the Euro-Interlocking hazard list
- **Review and adapt the cross-references** between the functional requirements and the hazard list

The following is an example of how cross-referencing is generally done in the Euro-Interlocking textual requirements catalogue in the DOORS requirements management tool.

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2.2.5 Task 5: Model requirements

The following tasks are executed iteratively in several cycles.

2.2.5.1 Model the functional requirements based on UML

The generic Euro-Interlocking UML model is adapted to the requirements of the railway company. The following elements of the UML model have to be covered:

- Model use cases & control cases
- Model domain objects
- Model important interactions
- Model dynamic behaviour

The following is an example of the object class diagram in UML describing an interlocking system.
2.2.5.2 Verify the UML model of the requirements

The railway’s requirements as they are modelled in UML are to be verified both by the Euro-Interlocking Core Team and by the given railway. The basis for verifying the model will be the test cases described in section 2.2.6.3.

This can be done either directly on the model or by using the simulation tool described in section 2.3.

If there were changes or additions made in the generic area of the model, these changes must also be verified by the railways whose requirements have already been captured in the model.

2.2.5.3 Formal verification of the requirements

If, in the future, a tool for the formal verification of the modelling of the requirements in UML is developed and made available to the project for a reasonable cost, this tool can be applied to the UML model for verification purposes.

2.2.6 Task 6: Simulation and Validation of requirements

2.2.6.1 Set up graphic user interface for simulation

The graphic user interface for the simulation of the national interlocking requirements is to be developed for each railway and supplier, in accordance with their needs.

2.2.6.2 Simulation of requirements

The graphic user interface for the simulation of the national interlocking requirements is to be developed for each railway and supplier, in accordance with their needs.

The following is an example of the Graphical Use Interface of the simulation tool used for the simulation of the Euro-Interlocking GENERIS functional requirements.
2.2.6.3 Specification of test cases, cross-referencing to functional requirements

Test cases are to be specified based on use cases and sequence diagrams in UML.

Each test case must have its own unique identity number.

At least the identity number of each test case must be captured in DOORS in order to support the change management process and the validation of the requirements in DOORS.

All functional requirements are then to be cross-referenced to their corresponding test case(s).

2.2.6.4 Validation of requirements

The validation of the textual functional requirements in DOORS involves the following sub-tasks:

- Validation of the requirements based on the knowledge of railway domain experts, using the both the
  - simulation of the requirements based on the UML model and
  - the corresponding test cases

It is important to note that the textual functional requirements in DOORS are to be the basis for the implementation and validation of a railway’s functional requirements in a given supplier’s interlocking product.

The model of the functional requirements in UML and the corresponding simulation of the model are intended as domain knowledge in order to support the understanding of the functional requirements in DOORS.

2.2.7 Task 7: Manage requirements

The is an ongoing task that is to be done in accordance with the Euro-Interlocking Change management processes approved by the Steering Group. This includes:

- manage changes to the textual requirements in DOORS
- configuration management of the UML model of the requirements
- manage changes to the test cases in DOORS

2.3 Deliverables

The following main deliverables are produced in the requirements process:

- National Vocabulary Cross-Reference
2.4 Intention of the Deliverables

It is important to note that the intention of the deliverables above, in particular the textual functional requirements in DOORS, the simulation of those requirements based on the UML model and of the corresponding test cases of any given railway is to also use these for the following purposes:

- That a railway use the deliverables for the procurement of new interlocking technologies for their network (CENELEC: Generic Application)

- As the basis for suppliers when implementing the given functional requirements in the process of developing a Generic Application interlocking product for a railway that has not used that product in its network before

- To develop a test specification for that Generic Application interlocking product

- To perform final product (system) validation (Generic Application) against the national functional requirements delivered within the context of the GENERIS project and the process described in this document.
2.5 Workflow

The workflow is shown as an activity diagram and shows the main tasks. It does not strictly define a sequence of tasks but rather some dependencies among tasks which are often performed in an iterative way.
3. Example of Work Break-down Structure and effort estimation

Remarks:

- It is foreseen that a detailed work break-down structure be done with each railway whose functional requirements are to be developed within the context of the GENERIS project.

- The estimation of the resources needed by railway is largely dependent on the work on functional requirements already done by that railway. A more exact resources planning must be done with each railway carrying out the development of its functional requirements.

- It is foreseen that the resources needed and planned for the railway also be included in this detailed planning.

- **Important:** This is a first, rough draft of the task planning done for the work together with RHK. The task planning may differ for future railways based on the experience of the development work done on functional requirements.
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