OCORA

Open CCS On-board Reference Architecture

Requirements Management Guideline

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References

Reader's note: please be aware that the numbers in square brackets, e.g. [1], as per the list of referenced documents below, is used throughout this document to indicate the references.

[1] OCORA-BWS01-010 – Release Notes

[2] OCORA-BWS01-020 – Glossary

[3] OCORA-BWS01-030 – Question and Answers

[4] OCORA-BWS01-040 – Feedback Form

[5] OCORA-BWS03-010 – Introduction to OCORA

[6] OCORA-BWS04-010 – Problem Statements

[7] OCORA-BWS08-010 – Methodology

[8] OCORA-BWS08-020 – Tooling

[9] OCORA-TWS04-011 – Functional Vehicle Adapter – Requirements

[10] OCORA-TWS05-020 – Stakeholder Requirements

[11] OCORA-TWS05-021 – Program- & Design Requirements (B)

[12] OCORA-TWS09-010 – Testing – Strategy

[13] EuroSpec Requirements Management, 2nd edition, August 2016

[14] The Easy Approach to Requirements Syntax: The Definitive Guide

[15] ISO/IEC/IEEE 29148:2018 - Systems and software engineering

Wherever a reference to a TSI-CCS SUBSET is used, the SUBSET is referenced directly (e.g. SUBSET-026). We always reference to the latest available official version of the SUBSET, unless indicated differently.

1 Introduction

1.1 Purpose of the document

The purpose of this document is to define OCORAs requirements management.

This document is addressed to experts in the CCS domain and to any other person, interested in the OCORA concepts for on-board CCS. The reader will gain insights regarding the topics listed in the table of content and is invited to provide feedback to the OCORA collaboration and can, therefore, engage in shaping OCORA. Feedback to this document and to any other OCORA documentation can be given by using the feedback form [4].

If you are a railway undertaking, you may find useful information to compile tenders for OCORA compliant CCS building blocks, for tendering complete CCS system, or also for CCS replacements for functional upgrades or for life-cycle reasons.

If you are an organization interested in developing CCS building blocks according to the OCORA standard, information provided in this document can be used as input for your development.

1.2 Applicability of the document

This Requirements Management Guideline holds all generic description explaining the OCORA Requirements provided as several level based extracts out of the requirements management tool Polarion (e.g. Stakeholder Requirements [10], Program- & Design Requirements [11], Functional Vehicle Adapter – Requirements [9], etc.). It is in close relation with the documents High Level Methodology [7] and Tooling [8].

1.3 Context of the document

This document is published as part of the OCORA Delta release, together with the documents listed in the release notes [1]. It is the first release of this document which will be further developed in consecutive releases.

Before reading this document, it is recommended to read the Release Notes [1]. If you are interested in the context and the motivation that drives OCORA we recommend to read the Introduction to OCORA [5], and the Problem Statements [6]. The reader should also be aware of the Glossary [2] and the Question and Answers [3].

2 OCORAs Requirements Management

2.1 Introduction

Requirements are an important deliverable of OCORA. As it is a 'brown-field' approach in a regulated environment, many requirements are already given and experience with different solutions exists. To avoid a 'piling' of requirements, which may stop the innovation power for better solutions and do not contribute to the problem solving, a more structured requirements management approach is proposed. As it may add complexity at the beginning, it will be more robust and transparent during the subsequent phases.

It has the following characteristics:

- Full traceability of external (i.e. from outside OCORA) and internal requirements to anticipate their changes but also to trace back inherited problems during implementation
- Strict focus on business objectives for requirements and design decisions
- Separation in Requirement Blocks, representing the different perspectives on requirements during lifecycle
- Clustering to building blocks to support modularity and the discussion with potential suppliers

OCORAs requirements management guideline is based on EuroSpec's Requirement Management, ref. [13].

2.2 Expected Results

OCORA aims to provide tender templates for the next generation CCS On-board solutions. Over time these requirements will be enriched with return on experience from past procurements.

OCORA requirements will be provided in a structured format. This allows procurement projects to pick the suitable set of requirements and OCORA to manage the generic requirements catalogue over time, including traced activities, such as:

- adding (e.g. new applications and functionality),
- changing (e.g. update of norms and standards) and
- releasing (e.g. superseded functionality)

According to the OCORA Tooling definition, ref. [8] all OCORA Requirements will be managed in Polarion.

Modelling artefacts exported from Capella will be reviewed and traced in Polarion even though they origin from Capella and any changes need to be performed in Capella (Master).

3 Definitions

3.1 Requirements Structure

For a program like OCORA, the transparent management of requirements is essential. The structure of the requirements can be found in **Figure 1**.

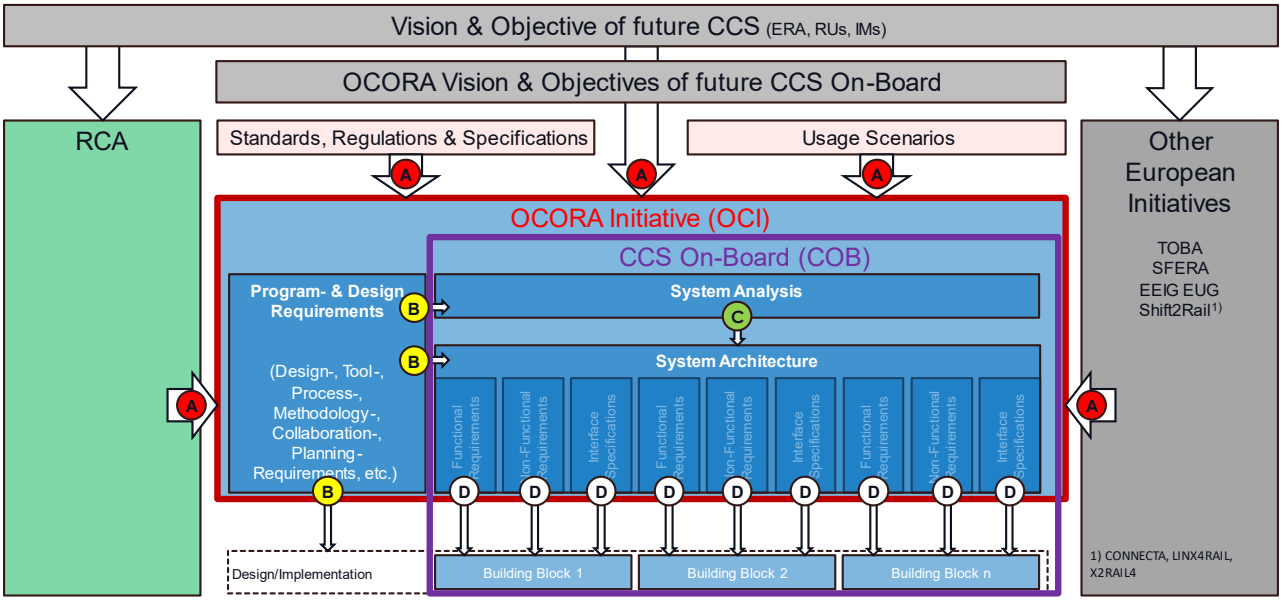

Figure 1 Requirements Structure

In a nutshell, the **Stakeholder Requirements (A)** are the foundation of OCORA requirements. They contain all requirements towards the **OCORA Program** and the envisages **CCS On-board System**. In essence they include:

- OCORA Vision and Objective of future CCS On-board as described in [5]
- Regulations / Norms and Standards
- Operational Scenarios
- Requirements from external Stakeholders (e.g. RCA, ER JU / Shift2Rail, EULYNX, EUG, TOBA, SFERA, etc.)

Program- & Design Requirements (B) are focusing on how the OCORA program defines tools, processes, methodology, collaboration, planning and applicable design rules. They are to be used within the program and to be considered during the system analysis and the system design/architecture work.

System Requirements (C) are defining the CCS On-board system, hence they describe how the system is developed in the MBSE System Analysis (RCA & OCORA), considering the A- and B-Level Requirements.

The **Building Block Requirements (D)** regarding the OCORA building blocks, are developed in the MBSE System Architecture (logical / physical), considering the MBSE System Analysis. The resulting documentation form the OCORA inputs for tender templates, together with the applicable program requirements.

3.2 Requirements Characteristics

3.2.1 Quality criteria for individual requirements

Following ISO 29148, ref. [15] the characteristics of individual requirements are defined as:

Characteristics:	Definition:
Necessary	• The requirement defines an essential capability, characteristic, constraint and or quality factor • If it is left out, a deficiency in the product will exist
Unambiguous	• The requirement shall not be open for interpretation
Consistent	• The requirement is free of conflicts with other requirements in the specification • The requirement is free of conflicts in itself
Complete	• All necessary information is provided in the requirement
Singular	• The requirement statement includes only one requirement
Verifiable	• The requirement has the means to prove that the system satisfies the specified requirement
Traceable	• The requirement has a relation to its origin (e.g. a requirement or need from a higher level), realisation, documents through entire procurement process

Table 1 Requirements Characteristics

3.2.2 Quality criteria

Following ISO 29148, ref. [15] the characteristics for an overall specification are defined as:

Characteristics:	Definition:
complete	• The set of requirements shall contain all necessary information
consistent	• The set of requirements is free of conflicts to other requirements, OCORA specifications or standards, like ENs, and TSIs
affordable	• The requirements can be satisfied by a solution that is obtainable / feasible within life cycle constraints
bounded	• The set of requirements represent the scope needed only to satisfy the user needs
unique	• The specification contains each requirement only once
traceable	• The set of requirements has a relation to its goals and origin; the existence of the set of requirements can be comprehended
High-quality	• The set of requirements shall use correct lay-out, use correct English, be checked and be approved and all required meta data shall be available • All requirements in the specification fulfil the quality criteria for individual requirements

Table 2 Quality Criteria

3.2.3 Language Usage

To serve as a generic requirements catalogue, OCORA will publish all requirements in present tense.

The requirement classification will be exclusively managed using the dedicated requirements attribute “Requirement classification”. This means the requirement text remains always neutral regarding its classification.

Possible requirement classifications are:

- Requirement
- Design Recommendation
- Optional Requirement
- Information
- Operator Choice

In order to ensure that all requirements have the characteristics defined in **Table 1**, the terms in each requirement have to be chosen carefully. The following terms are to be avoided or to be used carefully:

- Comparatives and superlatives: (better, best, higher, most, smallest, largest)
- Subjective statements: (easy, good, user friendly, nice, good looking, inviting)
- Ambiguous terms: (always, optimal, minimal, maximum)
- Open ended statements: (at least, not limited to)
- Loopholes: (possible, as applicable)
- Negative statements: (has not, is not, no)
- Connective statements: (and, or)
- Passive voice (it is possible to)

3.3 Requirements Attributes

The OCORA requirements are managed in Polarion. The following figure visualizes a work item SRQ (System Requirement).

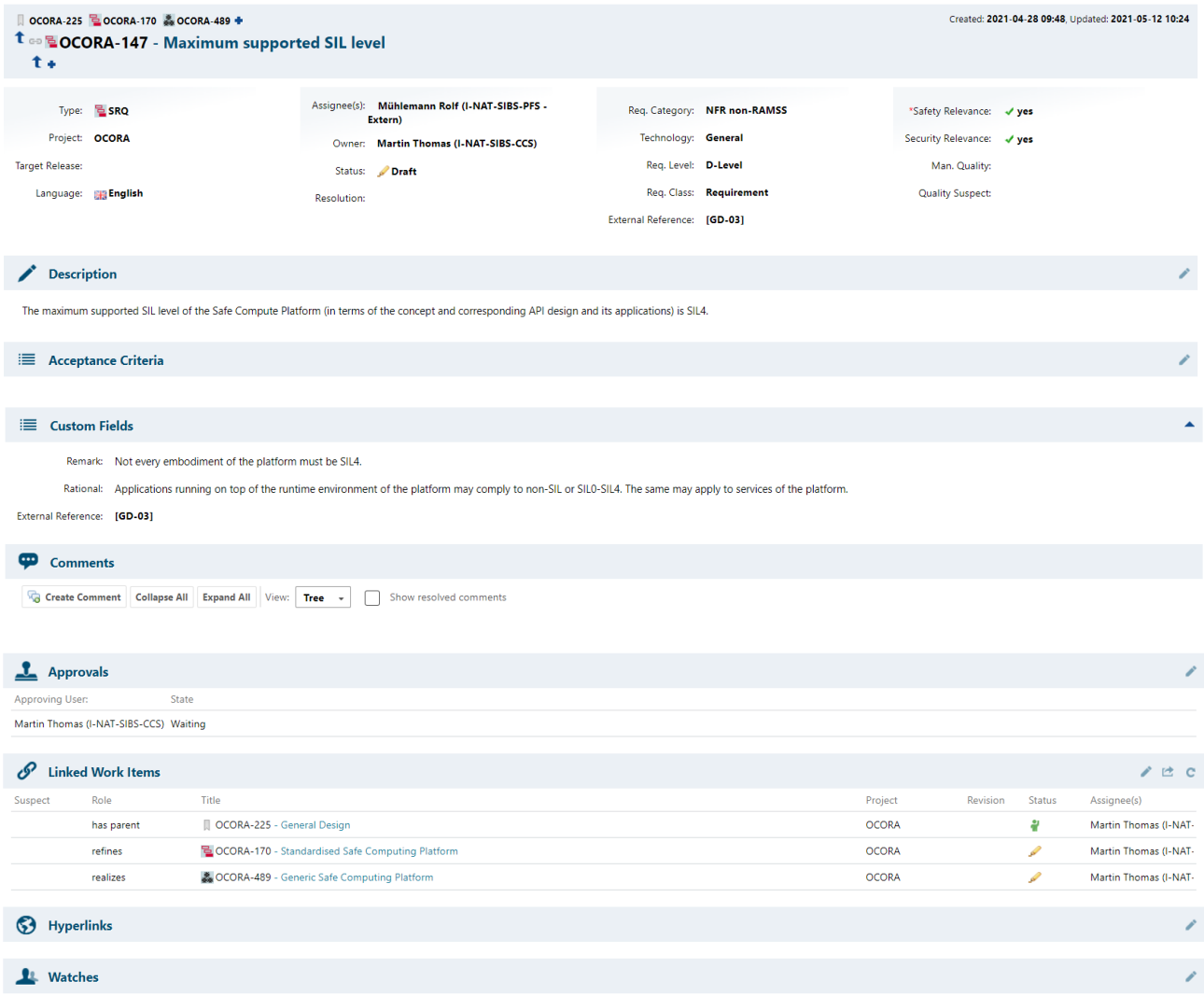

Figure 2 Example of a Work Item type SRQ (System Requirement) OCORA-147

3.3.1 Generic Attributes

The following attributes are generic:

- **Type:** SRQ (System Requirement)[1]
- **Project:** OCORA
- **Language:** English

3.3.2 System managed Attributes

The following attributes are managed automatically by Polarion:

- **Unique Identification:** (e.g. OCORA-147)
- **Created Date and Time:** (e.g. 2021-02-02 13:47)
- **Updated Date and Time:** (e.g. 2021-02-05 11:22)

[1] The notion “SRQ” might be renamed to “Requirement” at a later stage.

3.3.3 Individual Attributes

The Polarion work item type for a requirement contains the following individual attributes (with **(m)** marked attributes are mandatory):

Attribute	Definition	Example / Explanation
Description (m)	Description of the requirement	Free text field describing the requirement.
Acceptance Criteria (m)	Indication of methods and / or documentation to verify a requirement.	Please note, the usual way is a to use “linked work items” to link the related test case as Polarion work item with the requirement.
Comments	All review comments ever given, indicating date and person and a status	All review comments ever given, indicating date, person, and a status
Approvals	Documents the performed approval process	Approvals given by person. This is for example a “must have” in order to have the status of the work item changed to approved. Always at least one person must have given his/her approval.
Linked Work Items	Any linked work item. The possible link roles and work items that can be linked are part of the setup	To achieve traceability, the linking between work items and work item types is mandatory (e.g. Parent/Child, Hazards, Tests, etc.). For example, a risk assessment gives hazards. Hazards are documented in work items of type “Hazard”. Hazards trigger system requirements to mitigate the hazards.
Hyperlinks	Possibility to link any document or webpage to a work item by hyperlink.	
Watches	Watchers will be notified by e-mail about any change to the work item.	

Table 3 Individual attributes of requirements

3.3.4 Status Attributes

The Polarion work item type for a requirement contains the following status attributes (with **(m)** marked attributes are mandatory):

Attribute	Definition	Example
Target Release	Correlation with specific releases	e.g. Delta, Rel. 1.0, etc. OCORA plans to not use this field
Assignee(s) (m)	Who to perform a next step. Used for OCORA internal management purposes.	Martin Thomas (I-NAT-SIBS-CCS)
Owner (m)	Source of requirement. Used for OCORA internal management purposes.	Mühlemann Rolf (I-NAT-SIBS-CCS)
Status (m)	Indication of the approval state of the requirement	The standard workflow for work items is Draft, In Review, In Approval, Approved, Deleted. Please note: Process description later in this document
Req. Category (m)	Assignment of requirements into defined categories	Functional, Reliability Availability, Maintainability Safety, Security, NFR non-RAMSS, Performance...
Technology (m)	Assignment of requirements into defined groups	Business, General, Mechanical, Hardware, Software
Resolution	Resolution is needed to be given is case of status change to “deleted”	A work item is never completely deleted, since for example it could be part of a document of an old release. Only the status is changed to deleted, which would be visible in all documents or links to other work items. In order to delete a work item, a resolution must be stated, why this specific work item is deleted.
Safety Relevance	Assignment if requirement is relevant for	yes, no – default is yes

(m)	safety	
Security Relevance (m)	Assignment if requirement is relevant for security	yes, no – default is yes
RAM Relevance (m)	Assignment if requirement is relevant for RAM	yes, no – default is yes (this is not yet implemented)
Man. Quality	Result of automatic quality check	
Requirement classification (m)	Requirement classification status of the requirement to the project	Requirement Design Recommendation Optional Requirement Operator Choice Info
Rationale	Reason to state the requirement	e.g. TSI compliance Free text field
Remark	Remark	e.g. “Is in line with EN 50126” Free text field

Table 4 Requirement Status Attributes

3.3.5 Mapping of OCORA and EuroSpec attributes

The following tables provides the mapping between OCORA attributes and EuroSpec attributes:

OCORA Attribute	EuroSpec Attribute	EuroSpec Definition
Unique Identification	ID	Unique Identification of the requirement
Status	Status	Indication of the approval state of the requirement
Requirement Category	Requirement type	Assignment of requirements into defined groups
Requirement classification	Requirement classification	Importance and legal status of the requirement to the project
Description	Requirement-text	Description of the requirement
Rationale	Rationale	Reason to state the requirement
Foreseen by OCORA as linked work item, (e.g. TSI Subset)	Source	Indication from where the requirement originates
Owner	Owner	Owner of the requirement
Not foreseen by OCORA, can be added by tendering party later	Degree of fulfilment	Expected measure of compliance by the tender
Linked Work Items and Hyperlinks	Annex to requirement	Any appendices to the requirement given to the supplier industry
Comments	Comment of Requirement Review Board (RRB)	Remarks of the RRB to the requirement
Acceptance Criteria[2]	Verification (points in time)	Indication of methods and/ or documentation to verify a requirement

Table 5 Requirements Attributes

The following EuroSpec attributes according to [13] do not have a 1:1 mapping to OCORA attributes: Version, Requirement type, Decisions, Comment of Owner, Product element EN 15380-2, Function element EN 15380-4, Change since last release.

[2] Please note: Test Cases will be defined as Polarion work items “Test Case” and will be linked to the respective requirements in the attribute Acceptance Criteria.

4 Process

4.1 Quality Check

To illustrate how the theoretical approaches of chapter 3 can be checked in practice, a checklist for writing OCORA requirements and a OCORA quality metric to evaluate the quality of requirements is defined. This checklist is based on EuroSpec, ref. [13].

This checklist is addressed to people who write OCORA requirements and shall help them to check their requirements by themselves.

1. Is the requirement formulated as a complete, clear and understandable sentence?
2. Is the requirement formulated in active voice and present time?
3. Is the requirement free of "weak words"?
4. Does the requirement describe a function or a property of a system or sub-system?
5. Does the requirement include only one requirement?
6. Is the requirement free of implicit assumptions?
7. Can the fulfilment of the requirement be verified?
8. Are all attributes filled in?

In addition, automatically generated reports in Polarion are supporting as additional quality checks.

4.2 Requirement Status

The requirement status is managed using the **Status attribute.** It may adopt the following values.

Value of attribute	Definition
Draft	A new work item automatically receives the status "Draft". The author works with the work item in this status until it is complete and ready for review.
In Review	The work item is ready for informal review. In this status, the work item can no longer be changed (except for status comments and approval status). Reviewers entered as Approvers in the Approvals attribute are invited to comment, approve or disapprove.
In Approval	The work item is ready for formal approval. In this status, the work item can no longer be changed (except for status and comments).
Approved	The work item is released. In this status, the work item can no longer be changed (except status).
Deleted	The work item is deleted. It remains in Polarion for documentation purposes, but is no longer considered by reports, for example.

Table 6 Requirement Status

The transition between the different status are described in the OCORA Methodology document, ref. [7].

4.3 Requirements Approval Process

To monitor progress of approvals while drafting the status of the requirements is defined.

The status of requirements defines the development state of the requirements. Changing the status also changes the required activity of the requirement.

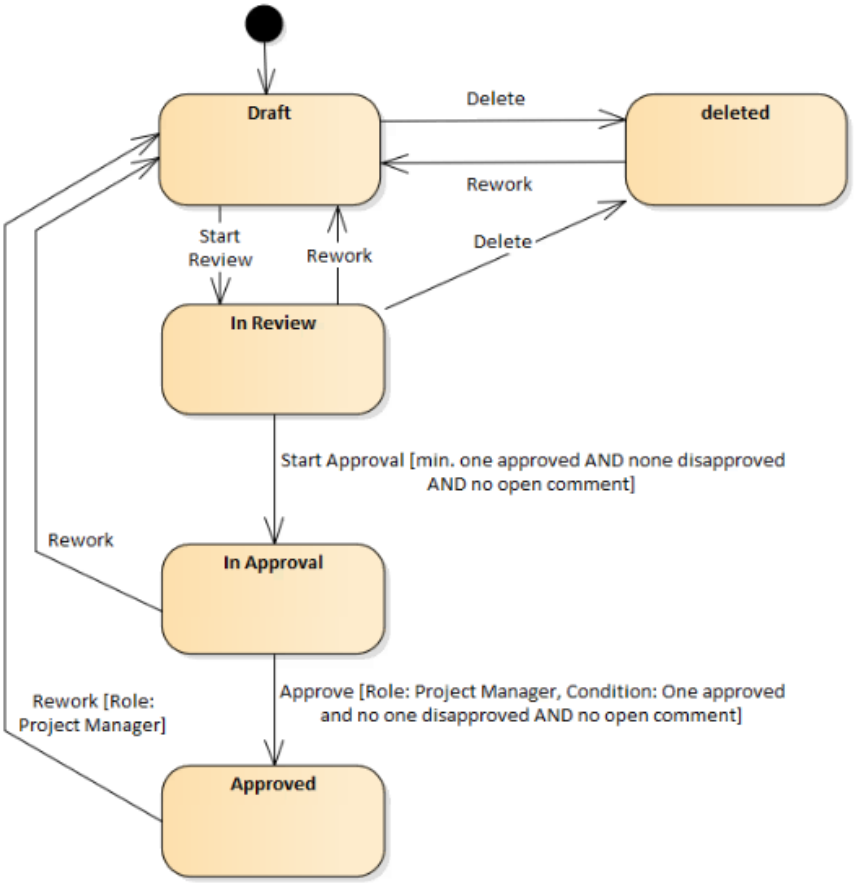

Figure 3 Status of Requirements

A requirement starts as a draft. Requirements which have to be reviewed will be set to the status “under review” and after the requirement has been approved, the status will be set accordingly. The status of requirements that are not approved will be set to draft or deleted. After all requirements have been approved, the OCORA Release as a whole can be approved, released and published.

4.4 Requirements Publishing Process

OCORA publishes content in subsequent releases.

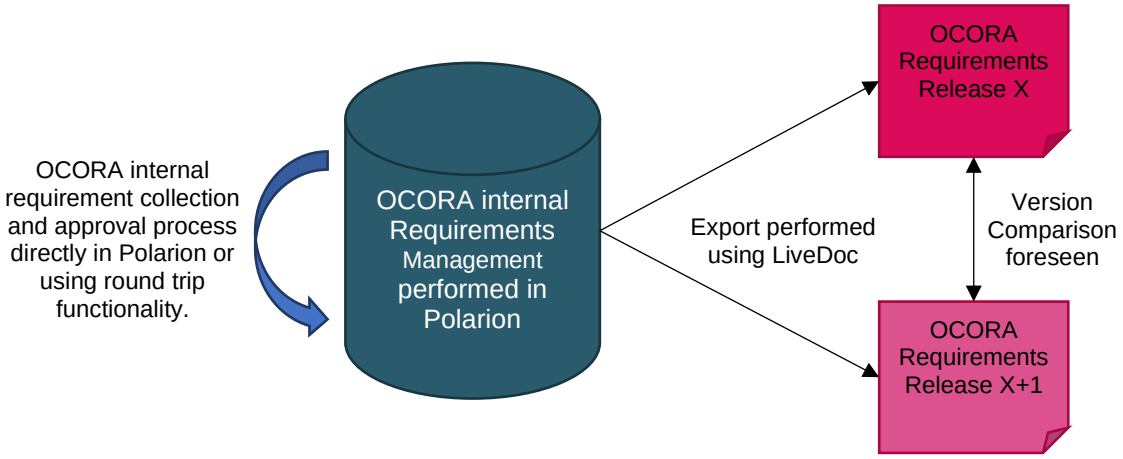

Figure 4 Requirements Publishing Process

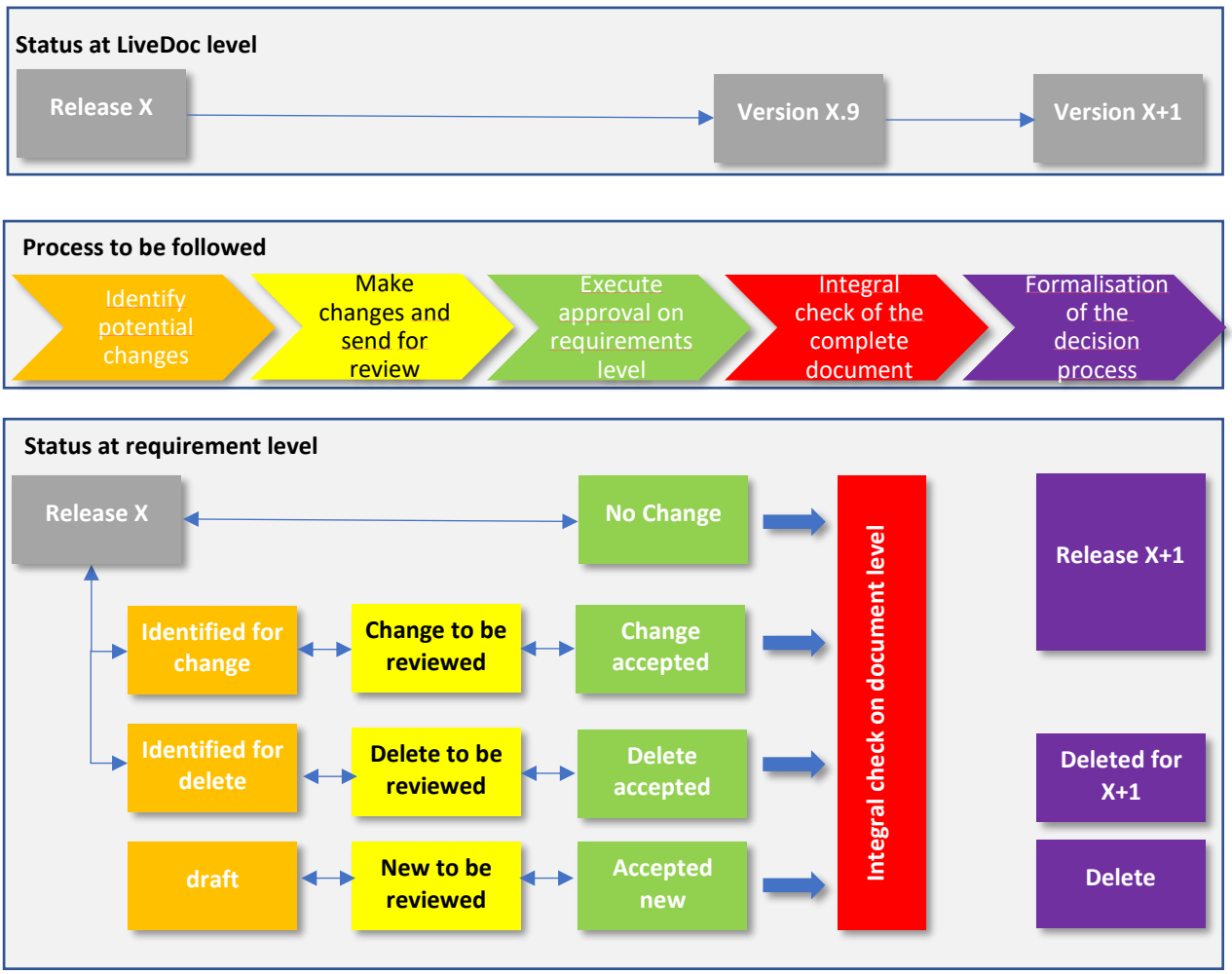

Figure 5 Baselining / Version Upgrade Process

5 Requirements Traceability

For the OCORA partners it is important to have a clear and common understanding of the term traceability and what it can be used for.

Traceability is the capability to comprehend and follow requirements, relationships, and dependencies between requirements during the whole life cycle of a system.

More specific traceability shall be done during the technical processes referring to the following V-model, based on ISO/IEC 152883.

"*Traceability covers at least two important aspects: the first aspect is traceability between various pieces of information at one point in time, for example traceability between customer requirements and system requirements. The second aspect is traceability of one single piece of information throughout time, for example how one requirement changed during the course of a project.*"

The first aspect of the ISO 152883 traceability is covered by this "Requirement Management Guideline" and that the second aspect of the ISO 152883 traceability is covered by the "Baselining" process, see **Figure 5**.

Traceability is the foundation for efficient, high-quality requirements management, illustrating the relation of different artefacts. Traceability pursues the following objectives:

- Detectability: Requirement's traceability supports the proof, that requirements or objectives are implemented and fulfilled in a system.
- Impact analysis: Requirement's traceability supports impact analysis, for example by analysing the consequences for other requirements when changing a requirement (change management) or by analysing the influence between requirements.
- Identification of sophisticated requirements in specifications and system functions

Different types of connections between requirements and information for traceability can be for example:

- Relationship between requirements
- Relationship between requirements and other artefacts, e.g. objectives, use-cases, test-cases, etc.

Traceability relations can be classified, see **Figure 6** below:

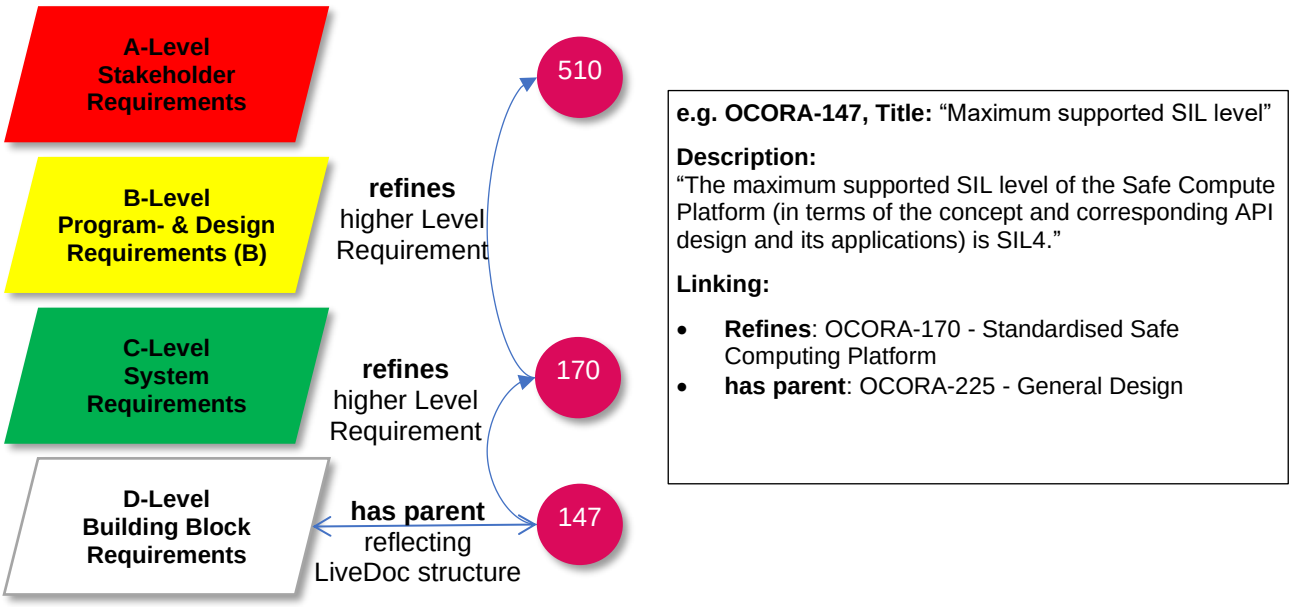

Figure 6 OCORA Requirement Linking example

6 Requirements Validation and Verification

For the OCORA it is important to have a clear and common understanding of validation and verification. The focus is to emphasise - from the train operating companies' point of view - what are the tasks related to validation and verification for the Railway Undertakings and how both can be implemented in the requirements specification during the process of purchasing rolling stock.

6.1 Common understanding of validation and verification

Validation and verification are important activities during all the technical processes of the V-Model and are important interfaces to requirements management and networked management disciplines like test management.

Validation and verification are used to demonstrate the requirements' compliance respectively by the tenderer, prior to contract signing and by the supplier, afterwards. Validation and verification is not only used for requirement (contractual) acceptance but also for risk management during the project.

Validation and verification are closely related but have the following main difference:

Validation is about checking whether a system meets the needs and expectations of the customer. Validation tests a system against the customer (or user) requirements.

Verification is about checking a system's conformity to its specification. Verification tests a system against system requirements and/or design requirements.

The difference between validation and verification can be pointed in the questions:

- Are we building **the right CCS On-board system**? (Validation)
- Are we building **the CCS On-board system in a correct way**? (Verification)

Validation and verification shall be planned as early as possible, as it influences test management. A proper preparation for the costly test-management is needed.

Validation and verification criteria's will be attached as linked work items to each requirement defined during the process of writing requirements once the OCORA Testing Strategy [12] is in place.

6.2 Methods for Validation and Verification

The following methods for validation and verification are applied based on EuroSpec, ref. [13].

	Definition	Function	Applicability
Inspection	An inspection is an examination of the item against applicable documentation to confirm compliance with requirements.	Inspection is used to validate and verify properties best determined by examination and observation. Inspection is generally non-destructive and typically includes the use of sight, hearing, smell, touch, and taste; simple physical manipulation; mechanical and electrical gauging; and measurement.	Validation and Verification
1st Article Inspection (FAI)	A FAI is a special form of inspection of components, subsystems or systems manufactured under series conditions to see if it meets specifications and to ensure that the process can and does reliably produce what is intended. A FAI is carried out before approval of series production and is typically called for in a contract.	A FAI includes all relevant functional, non-functional, quality and produce process requirements to components, subsystems or systems. A FAI can be carried out when all corresponding validation and verification methods - for example design reviews, type tests, calculations etc.- are successfully finished.	Quality Management (results in a Project Management Gate)
Analysis	Use of analytical data or simulations under defined conditions to show theoretical compliance	Used where testing to realistic conditions cannot be achieved or is not cost effective. Analysis may be used when	Testing Validation

		such means establish that the appropriate requirement, specification or derived requirement is met by the proposed solution.	
Design Review	A formal and systematic validation within a product development process of components, subsystems or systems whereby a design is detailed and evaluated against its requirements.	Validation of agreed functional and non-functional requirements of the system and identification and elimination of potential problems and errors as early as possible.	Testing Verification Validation
Simulation	Simulation is the imitation of the operation of a real-world process or system over time. A model represents the key characteristics, behaviors or functions of the selected physical or abstract system or process. The model represents the system itself, whereas the simulation represents the operation of the system over time. Simulations can be used to show, under defined conditions, theoretical compliance.	Used where testing to realistic conditions cannot be achieved or is not cost effective. Simulation may be used when such means establish that the appropriate requirement, specification, or derived requirement is met by the proposed solution. Simulation can be used e.g. in the process of development to show movement and functional processes, dynamic loads and stresses.	Testing
Calculation	Calculation to validate or verify agreed or specified parameter, under defined parameters and rules of calculation, by a mathematical proof to show theoretical compliance.	For the input-parameters of the calculation, methods of calculation and the result parameter are presented and evaluated.	Testing Validation
Demonstration	A qualitative exhibition of functional performance usually accomplished with no or minimal instrumentation or test equipment. Demonstration uses a set of test activities with system stimuli selected by the supplier to show that system or system element response to stimuli is suitable or to show that operators can perform their allocated functions when using the system. Observations are made and compared with predetermined responses.	Demonstration may be appropriate when requirements or specifications are given in statistical terms (e.g., mean time to repair, average power consumption, etc.).	
Routine Test	Examination of every component, subsystem or system during or after the manufacturing process to prove its compliance with the requirements.		
Test	An action by which the operability, maintainability or performance capability of an item is quantitatively verified when subjected to controlled conditions that are real or simulated.	These verifications often use special test equipment or instrumentation to obtain very accurate quantitative data for analysis.	Testing
Type test	Test of one or more components, subsystems or the system to prove that the construction is in compliance with the required specification and the relevant standards.	The test object does not need to be manufactured under series conditions. Type testing includes the validation of required parameter. Several type tests can be necessary for one test object.	
Certification	Certification is a written assurance that the system or system element has been developed in accordance with the required standard and meets the requirements. This assures that the system or system element can perform its assigned functions to a negotiated standard.	The development reviews and system verification and validation results form the basis for certification. Certification is generally performed by a third party against an accepted standard.	

The validation and verification of requirements with these different methods are always based on documents, data and information to show and prove the compliance of a component, subsystem or system. One or more means of compliance can be allocated to each method for validation and verification of requirements. The result of these methods is to be reported as verification report.

7 Requirements Integration and Testing

The requirements for the integration and testing activities will be developed in accordance with the document OCORA-TWS09-010 – Testing – Strategy [12].