




ERJU SYSTEM PILLAR

Requirements Management Plan



Requirements Management Plan

| | |
|------------------|---|
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| Abstract | This requirements management plan describes the general requirements management approach for the System Pillar. |
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1 Preamble

1.1 Purpose


Purpose of the System Pillar Requirements Management Plan

This Requirements Management Plan defines how requirements shall be collected, analysed, documented, tracked, and managed in the System Pillar through all task and domains. It shall define how requirements are written, how changes to requirements are managed, and how conflicts between requirements are addressed forward to the corresponding responsibility. [SPPR-8313]

1.2 Intended Audience

The content of this plan is valid for all the System Pillar tasks and domains according to *SPPROCESS/10 SEMP V 01_01/SEMP Systems Engineering Management Plan : 723395* and *SPPROCESS/10 SEMP V 01_01/List of System Pillar deliverables : 723395*.

1.3 Document Context

This document is a key part of the  Systems Engineering Management Plan - 01 Main.

1.4 Glossary

No references

2 Requirements management

2.1 Scope and goals



Scope and goals of the System Pillar requirements management


In the context of System Pillar, and the requirements management activities apply to the management of all stakeholder requirements, system requirements and application conditions. This includes in detail non-functional, functional requirements, including those that result from interfaces between the systems in question and other external entities and environments.


Requirements management is used to identify, control, decompose, allocate and maintain requirements across all system levels 1-5 and to provide bidirectional traceability between the requirements. It also manages the changes to established requirement baselines over the life cycle of the system or product. [SPPR-11214]

2.2 Roles and work coordination


Roles of the System Pillar requirements management

The requirements management functional team (REQ-F) serves as a communication group of  SPPR-10727 - Requirements Manager from different domains to interact with each other. The REQ-F team is managed and held by  SPPR-10728 - Lead Requirements Manager (EET) and the corresponding EET work package leads for requirements management. The following tasks are performed:

- **Coordinate and support the completion of the full set of requirements:** support to establish complete sets of requirements and full traceability based on the work of the tasks and domains (e.g. for high-level requirements, operational concept and vision, for the whole system of interest)
- **Requirements allocation support:** provide support to allocate requirements and functions to the System Pillar tasks
-  **SPLI-75 - Application Lifecycle Management support:** concept editing and content management
- **Requirements management moderation:** requirements management platform and methods and moderation of the creation, negotiation and change management processes for requirements, facilitation of the functional team for requirements
- **Requirements quality assurance:** assure the coherence, quality, and completeness of the full requirement implementation in specifications (requirements from all sides, like from sector, task 1 or between other tasks or domains), as well as for the processes and interfaces between tasks

On their counterpart the  SPPR-10727 - Requirements Manager shall:

- Collect relevant assigned requirements
- Assign relevant requirements

Please refer to  SPPR-2560 - Functional Team for general explanations.

Requirements management team organisation (REQ-F group)


The following table contains all domain members which are actively participating or contributing in the REQ-F group.

| Domain | Name | E-mail |
|--|--|------------------------------------|
| EET | Dennis Kunz (REQ-F team railway lead) | Dennis.Kunz@deutschebahn.com |
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| Task 4 DAC/FDFTO | | |
| Task 5 Harmonised Diagnostics | | |

[SPPR-6470]

2.3 Relevant processes

Requirements management processes relevant for the System Pillar

The relevant processes related to this requirements management plan are listed below. All mentioned processes do not prescribe a process model (e.g., waterfall, agile, hybrid), but they are compatible with any process model. For each of the  SPPR-9573 - Requirements work item types a process is defined for the creation and management of those requirements. [SPPR-11714]



2.3.1 Define stakeholder requirements

This process will be defined at a later stage.



2.3.2 Consolidate stakeholder requirements

This process will be defined at a later stage.

2.3.3 Define system requirements

The process to define system requirements is described in  SPPR-5206 - Define system requirements as part of the  Systems Engineering Management Plan - Annex 03 Requirements Definition Process. For the details on the derivation of non-functional requirements (RAMS) please consider the *SPPRAMS/Phase 2/ERJU PRAMS Plan : 723395*.

2.3.4 Consolidate system requirements

The process to consolidate system requirements is described in  SPPR-11477 - Consolidate system requirements as part of the  Systems Engineering Management Plan - Annex 03 Requirements Definition Process.

2.3.5 Request requirements changes

For changes to a requirement please follow the *SPPROCESS/SEMP Annex D Processes/SEMP process 91-Change Control Management Process : 723395* and the 2.8 - Requirements workflow concept.

2.3.6 Manage requirements

This process will be defined at a later stage.

2.3.7 Define application conditions



This process will be defined at a later stage.

2.3.8 Consolidate application conditions

This process will be defined at a later stage.

2.4 Requirements quality characteristics


Quality of requirements







In the context of the System Pillar, requirements must be created and maintained with high quality. For this purpose, the standard  SPPR-10493 - ISO/IEC/IEEE 29148:2018 is followed as well as the requirements quality criteria based on  SPPR-4100 - INCOSE Guide to Writing Requirements. [SPPR-11301]

Style of requirements

In System Pillar, requirements are written in structured natural language using defined textual patterns. Although it is possible to use other ways to represent requirements (e.g. elements of modelling languages), textual requirements are chosen as the main representation style. However, in comparison to plain text these requirements are enhanced by:

- active inline links to other work items (as a main Polarion feature)

-  Systems Engineering Management Plan - 02 MBSE Methodology Handbook (Capella analysis and architecture model)

The patterns and corresponding rules of how requirements are written are defined in the *SPPROCESS/SEMP Annexes/SEMP Annex R2 - Rules for writing textual requirements* : 723395 to achieve the the quality characteristics  SPPR-3805 - Necessary (C1) to  SPPR-10223 - Correct (C15). The rules take in account common standards and guidelinse such as  SPPR-10493 - ISO/IEC/IEEE 29148:2018, ,  SPPR-4100 - INCOSE Guide to Writing Requirements ,  SPPR-10499 - ASD-STE100 and  SPPR-3560 - Easy approach to requirements syntax (EARS). [SPPR-11302]

Individual requirements have to achieve the characteristics C1 to C9:

Necessary (C1)

The requirement defines a capability, characteristic, constraint, or quality factor to satisfy a life-cycle concept, need, source or parent requirement. [SPPR-3805]

Appropriate (C2)

The requirement's intent and amount of detail is appropriate to the level (the level of abstraction or system architecture) of the entity to which it refers. [SPPR-3812]

Unambiguous (C3)

The requirement is stated such that it can be interpreted in only one way by all the intended stakeholders. [SPPR-3813]

Complete (C4)

The requirement sufficiently describes the necessary capability, characteristic, constraint, condition, or quality factor to meet the need or parent requirement without needing other information to understand the requirement. [SPPR-3814]

Singular (C5)

The requirement states one single (i.e. atomic) capability, characteristic, constraint, or quality factor. [SPPR-3815]

Feasible (C6)

The requirement can be realized within entity constraints (e.g.: cost, schedule, technical, legal, ethical, safety) with acceptable risk. [SPPR-3816]

Verifiable (C7)

The requirement is structured and worded such that its realisation can be verified to the approving authority's satisfaction. [SPPR-3817]

Correct (C8)

The requirement is an accurate representation of the need or source or parent requirement from which it was transformed. [SPPR-3818]

Conforming (C9)

The requirement conforms to an approved standard pattern and style guide or standard for writing and managing requirements. [SPPR-3819]

Requirement sets (e.g. system requirements specification) have to achieve the characteristics C10 to C15:

Complete (C10)

The requirement set sufficiently describes the necessary capabilities, characteristics, constraints, interactions, functionality, standards, regulations, safety, security, resilience, and/or quality factors without requiring other requirements at the appropriate level of abstraction. [SPPR-3820]

Consistent (C11)

The requirement set contains individual requirements that are unique, do not conflict with or overlap with other requirements in the set, makes use of homogeneous units and measurement systems and uses a consistent language and terms that are consistent with the architectural model, project glossary and data dictionary. [SPPR-3822]

Feasible (C12)

The requirement set can be realised within entity constraints (e.g.: technical, legal, cost, schedule) with acceptable risk. [SPPR-3844]

Comprehensible (C13)

The requirement set is written such that it is clear as to what is expected of the entity and its relation to the system of which it is a part. [SPPR-3821]

Able to be validated (C14)

It can be validated that the requirement set will lead to the achievement of the needs and higher level requirements within the constraints (such as cost, schedule, technical, and regulatory compliance) with acceptable risk. [SPPR-3823]


Correct (C15)

The requirement set is an accurate representation of the needs, sources, or higher level requirements from which it was transformed. [SPPR-10223]

2.5 Requirements management tools

Tools for the requirements management

For all requirements-related activities, an Application Lifecycle Management (ALM) tool should be applied. In this requirements management plan, Polarion is prescribed as the ALM tool for the System Pillar.


The  Systems Engineering Management Plan - 03 Engineering Tools describes further specific tool and toolchain aspects of the System Pillar (e.g., Capella for the architecture description).

This requirements management plan does not provide concrete requirements-related and tool-specific work instructions (e.g., concrete click-by-click instructions). [SPPR-11365]

2.6 Requirements document types


Requirements document types used in the System Pillar

The details on all System Pillar deliverables are described in the *SPPROCESS/10 SEMP V 01_01/List of System Pillar deliverables : 723395*. The requirement-related deliverables are listed below as well as the system definition document which serves a main input to the requirements documents.

Note: The common business objectives are provided by the document  Common Business Objectives. [SPPR-11713]

Stakeholder Requirements Specification

This document collects all requirements that are elicited and collected from all stakeholders that are relevant for the project and the system of interest.

Excerpt from  SPPR-10493 - ISO/IEC/IEEE 29148:2018: "The Stakeholder Requirements Specification (StRS) describes the organisation's motivation for why the system is being developed or changed, defines processes and policies/rules under which the system is used and documents the top-level requirements from the stakeholders' perspective including expressing needs of users/operators/maintainers as derived from the context of use in a specific, precise and unambiguous manner. In the context described in the BRS, the StRS describes how the organisation will utilise the system as a means to contribute to the business."

Template:  Template - Stakeholder Requirements Specification [SPPR-9731]

System Definition

This document contains the following content of the system (according to EN 50126-1):

- system objective (intended purpose);
- system functions and elements, where relevant (including human, technical and operational elements);
- system boundary including other interacting systems;
- physical (interacting systems) interfaces and functional (functional input and output) interfaces;
- system environment (e.g. energy and thermal flow, shocks, vibrations, electromagnetic interference, operational use);
- existing safety and security measures and, after the necessary relevant iterations, definition of the safety requirements identified by the risk assessment process;
- assumptions that determine the limits for the risk assessment

Template: *SPPROCESS/80 Templates/System Definition Template : 723395 [SPPR-7906]*

System Requirements Specification

This document defines functional and non-functional requirements from a black-box specification point of view. It is structured by system capabilities, system functions and system actors.

Extract from EN 50126-1 (see the document for more information):

"The objectives of this life cycle phase [phase 4] are to:

1. specify the **overall RAMS requirements** for the system under consideration;
2. provide a comprehensive and identified set of requirements for the subsequent life cycle phases;
3. specify necessary monitoring requirements according to the process for analysing operation and maintenance performance arranged in the Safety Plan (that enable the system to perform the required tasks in life cycle phase 11).

[...] The **overall RAMS requirements** for the system shall be specified **on the basis of the system definition of sub-clause 7.3 and the risk analysis and evaluation of sub-clause 7.4**. The RAMS requirements for the system under consideration shall include:

1. functional requirements and supporting performance requirements, including safety functional requirements and associated safety target for each safety-related function
2. logistic support requirements;
3. interfaces;
4. application environment and mission profile;
5. tolerable risk levels for the consequences arising from the identified hazards, when applicable
6. external measures necessary to achieve the requirements;
7. system support requirements;
8. details of the limits of the analysis;
9. details of any assumptions made;
10. identification of technology related standards;
11. scope of diagnosis and monitoring, specifically requirements for the monitoring of the effectiveness of
12. the proposed safety measures.

[...] The results of this life cycle phase shall be documented, including

a) the **RAMS system requirements specification**; [...]"

Note: Security requirements will be managed as well by this document.

Purpose as described by  SPPR-10493 - ISO/IEC/IEEE 29148:2018 (condensed excerpt from page 54):

- description of what the system should do, in terms of the system's interactions or interfaces with its external environment
- completely describe all inputs, outputs and required relationships between inputs and outputs
- communicates the requirements of the acquirer to the technical community who will specify and build the system

- collection of requirements that constitutes the specification and its representation acts as the bridge between the two groups and needs to be understandable by both the acquirer and the technical community

Template: *SPPROCESS/80 Templates/System Requirements Specification Template* : 723395
[SPPR-7923]

2.7 Requirements work item types

Requirements work item types used in the System Pillar

The following main requirements types are defined for the System Pillar. Each work item type has dedicated attributes. These attributes, their purposes, and particularly their technical representation are defined in an attribute schema. Please note that further and an update of these attributes need to be defined at the later stage to ensure proper requirements flow down, compliance, verification and validation. [SPPR-11277]

Requirement


A requirement is the result of a formal transformation of one or more needs or parent requirements into an agreed-to obligation for an entity to perform some function or possess some characteristic within specified constraints with acceptable risk. They are written as formal textual "shall" statements in a structured, natural language what an entity must achieve. [SPPR-4192]

Stakeholder Requirement


Stakeholder requirements are precise requirements of stakeholders for the system of interest. They are derived from stakeholder needs (e.g. railway requirements and the operational analysis) and provide the stakeholder-oriented view of what the system of interest shall achieve. [SPPR-9768]

System Requirement


System requirements are precise functional or non-functional requirements for the system of interest. They are derived from the system analysis and architecture or stakeholder requirements and provide the technology-oriented view of how the system of interest shall achieve the stakeholder requirements.

Except from  SPPR-10493 - ISO/IEC/IEEE 29148:2018: "[...] specify, from the supplier's perspective, what characteristics, attributes, and functional and performance requirements the system is to possess in order to satisfy stakeholder requirements. As far as constraints permit, the requirements should not imply any specific implementation." [SPPR-3791]

Functional requirement

A  SPPR-3791 - System Requirement which specifies what the system of interest does, i.e. actions or functions that the system of interest must perform. In general, functional requirements capture the required behaviour of the system of interest. [SPPR-4173]

Non-functional requirement

A  SPPR-3791 - System Requirement which specifies the key system characteristics that determine how well the system performs duties and to define measurable criteria for evaluating a system function's effectiveness. They are often referred to as the performance targets and "quality attributes" of a system, which includes "-ilities," encompassing characteristics like safety, reliability, usability, serviceability, upgradeability, manufacturability, stability, portability, and more. They are essential to any specification as they emphasize measurable, quantitative criteria over vague qualitative descriptions, thereby ensuring the overall system's verifiability.

They are specified without imposing unnecessary design constraints or prescribing specific solutions., like the system-wide non-functional characteristic such as weight, reliability, or durability However, they can specify imposed specific limitations or restriction on how the system (or component, entity) is realised to define a clear solution or implementation (rather than simply guiding design choices). [SPPR-4174]

Application Condition

Application conditions are specific conditions imposed on external entities that interact with the system under consideration. They are also precise requirements about the environment and use of the system under consideration in its application. The following list contains examples for application conditions:

- skills of maintenance people that need to be trained
- operators of the system
- requirements about the physical environment

- maintenance processes ("exported constraint, relevant for users").
- physical needs
- temperatures of server rooms
- engineering rules
- precautions in installation and testing
- rules and methods for maintenance and fault-finding
- safety-related ones (SRAC) and RAM-related ones (RAM RAC)

Note: Application Conditions shall not be used to export requirements to another system or subsystem. If something is expected from another level 3 system or subsystem, it shall first go through ARC domain who will derive it. This ensures clear entry points for subsystems, improve completeness of analysis by considering the big picture when more than one sub-system is involved.

Additional note: External should be more specific in the frame of System Pillar. This could be external to system level 2 (so external to CCS and TMS etc.). This to avoid having subsystems (system level 3 and higher) exporting requirements to each other instead of having them clearly defined at global system with appropriate system analysis. In the context of System Pillar, "external" has to be understood as "external to CCS system" for tasks/domains, system level or analysis phase (OA, SA, LA or PA).
[SPPR-3728]

The following requirement-related content types are defined and used which support the derivation of requirements.

Concept Aspect

A content for sketching concepts regarding analysis purposes which is linked to requirements.
[SPPR-3735]

Common Business Objective

A generic target or high level objective defining the mandate of the System Pillar. They are derived by tasks and domains and are not created by them. They can be formulated freely. [SPPR-3734]

Note regarding rules for common business objectives

This document does not define any content-related rules or processes for the common business objectives. They are taken as a given input without applying specific rules to them. [SPPR-10641]

Railway Requirement

Railway requirements are epics, visions, needs or user stories coming from stakeholders as their concrete vision (who, what, why). It can be formulated in a few sentences and has not a strict form criteria. These can be translated to more precise operational requirements during analysis processes in case they describe operational epics for the business target picture of an operational area (like CCS or energy). The can be freely formulated but should follow the writing patterns of epics and user stories. They should be specific enough to be assigned to exactly one System Pillar task. [SPPR-3768]

Note regarding rules for railway requirements


This document does not define any content-related rules or processes for the railway requirements. They are taken as a given input without applying specific rules to them. Only the mentioned basic link rules below are provided for the corresponding work item type to establish traceability to the lower-level requirements. [SPPR-10640]

Operational Requirement

Operational requirements are operational needs which an operational procedure and its design has to fulfil. It is a need issued in the context of the operational analysis and may qualify some operational actor, actor property, activity or scenario. [SPPR-3762]

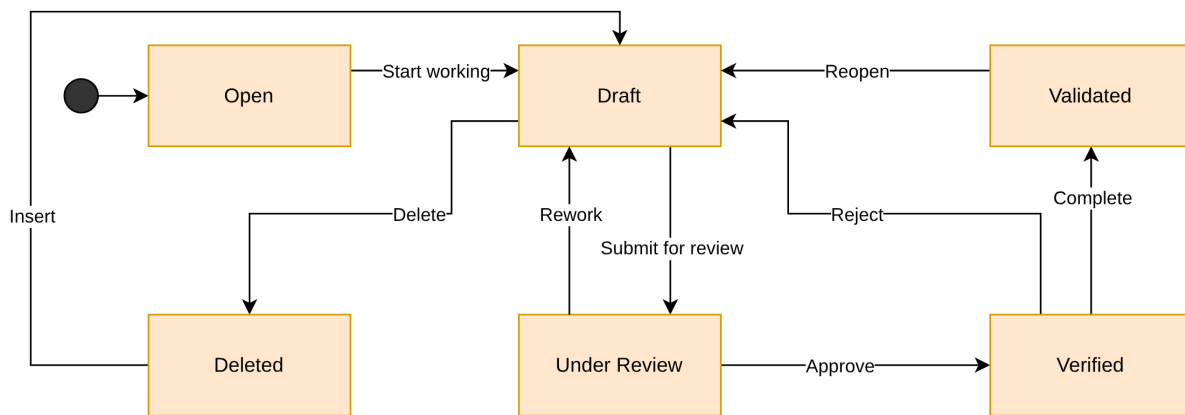
2.8 Requirements workflow concept

Requirements workflow concept

Each system requirement and stakeholder requirement work item is formalised regarding the workflow by proper and specific workflow states in accordance with [2.4 - Requirements quality characteristics](#) and  Requirements Management Plan - Annex R1 Requirements Rules. [SPPR-11692]

Requirements work item workflow

The following diagram described the requirements workflow including the workitem states and the transitions between them.



[SPPR-11534]

Requirements work item states

The work item states are explained in the following table to describe the workflow:


| State | Description |
|--------------|---|
| Open | Work item is created but the work hasn't started yet. |
| Draft | (Re)Work has started and the work item is assigned to a person. |
| Under Review | Work has reached a final draft. In this status, a verification of the work item content can be started. |
| Verified | The work item content is approved by reviewers. This status corresponds to a verified requirement from the perspective of SP project. In this status, a validation of the work item can be started. See also 2.3.4 - Consolidate system requirements for further information. |
| Validated | The requirement is considered complete and can be released. This status corresponds to a validated requirement from the perspective of SP project. |
| Deleted | The work item cannot be deleted completely from the database by the author. Instead, the work item status is moved to "Deleted" and a resolution is needed. |


[SPPR-11539]

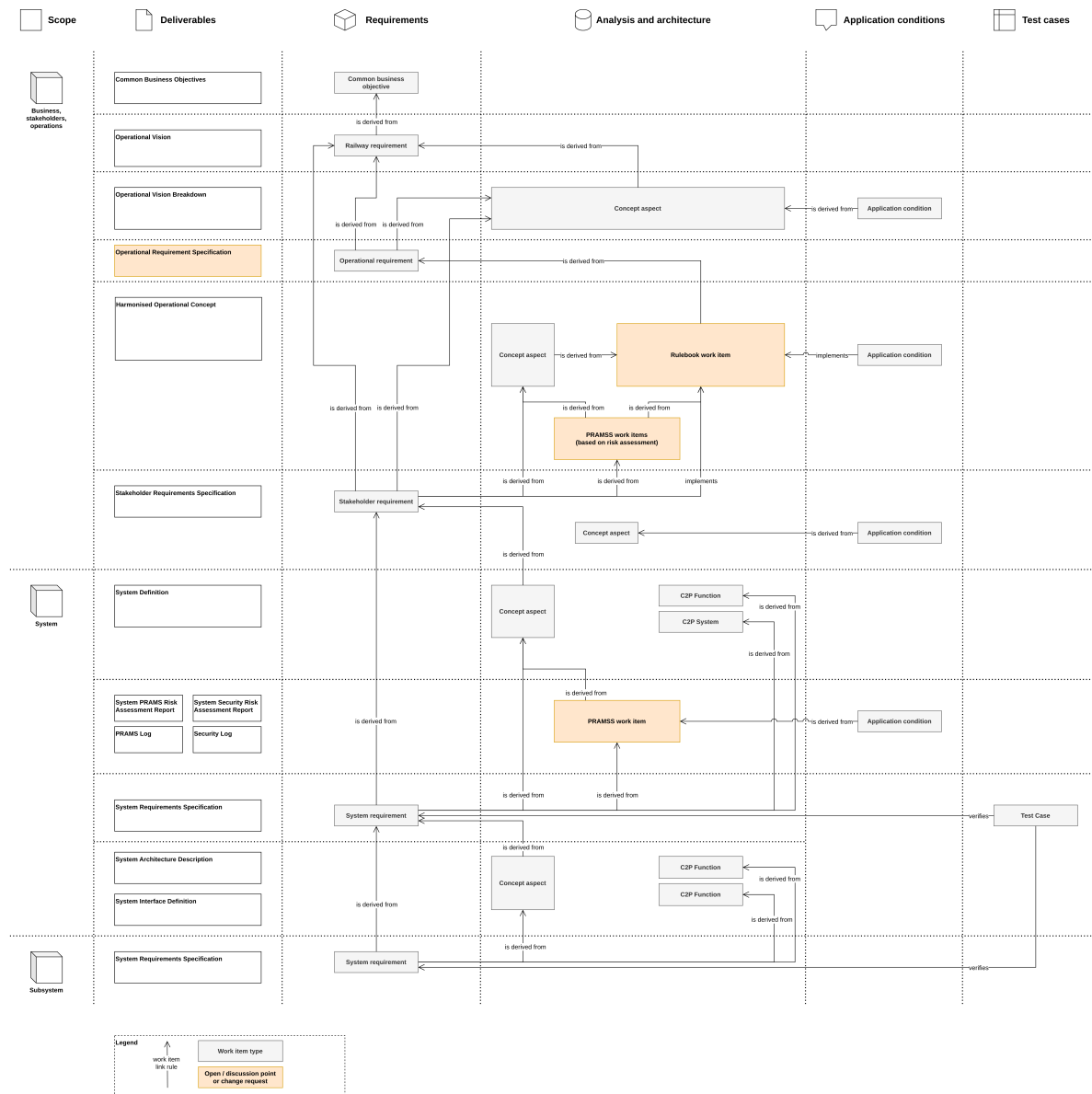
2.9 Requirements traceability concept

System Pillar traceability map for requirements

The following visualisation describes existing or proposed work items and their link rules used in Polarion to relate deliverables, requirements, analysis and architecture content.

For simplicity reasons, only one step of system to subsystem relationships is shown. The further details on the deliverables across the system levels are described via the  SPPR-8944 - Tailoring principle for the System Pillar deliverables in the *SPPROCESS/10 SEMP V 01_01/List of System Pillar deliverables* : 723395. Work items of the analysis and architecture are defined by the *SPPROCESS/10 SEMP V 01_01/System Pillar MBSE Methodology Handbook* : 723395 and the *SPPRAMS/Phase 2/ERJU PRAMS Plan* : 723395.

Please also consider  SPPR-11164 - System Pillar traceability map - MBSE work items for the details on the traceability between single Capella model elements for the system analysis as well as the logical and physical architecture.





[SPPR-7265]

The following detailed work item link rules must be used to establish the overall traceability:

System Requirement is derived from one or more analysis aspect or architectural element

| | |
|-----------------|--|
| Source Workitem | System Requirement |
| Link Role | is derived from |
| Target Workitem | Application Condition, Change Request, Concept Aspect, Hazard, Risk, System Requirement, C2P-Function, C2P-Exchange Item, C2P-System |
| Mandatory type | mandatory link for source |
| ID | SPPR-2398 |



Concept Aspect is derived from System Requirement

| | |
|-----------------|--|
| Source Workitem |  Concept Aspect |
| Link Role | is derived from |
| Target Workitem |  System Requirement |
| Mandatory type | optional link |
| ID | SPPR-2230 |




Risk is mitigated by Constraint

| | |
|-----------------|--|
| Source Workitem | {c} Constraint |
| Link Role | mitigates |
| Target Workitem |  Risk |
| Mandatory type | mandatory link for target |
| ID | SPPR-2296 |




Railway Requirement is derived from Common Business Objective

| | |
|-----------------|---|
| Source Workitem |  Railway Requirement |
| Link Role | is derived from |
| Target Workitem |  Common Business Objective |
| Mandatory type | mandatory link for both |
| ID | SPPR-2218 |



Operational Requirement is derived from Railway Requirement or Concept Aspect

| | |
|-----------------|---|
| Source Workitem |  Operational Requirement |
| Link Role | is derived from |
| Target Workitem |  Railway Requirement,  Concept Aspect |
| Mandatory type | mandatory link for both |
| ID | SPPR-2229 |

Common Business Objective is needed from a stakeholder

| | |
|-----------------|--|
| Source Workitem |  Common Business Objective,  Stakeholder Requirement |
| Link Role | is needed from |
| Target Workitem |  Stakeholder |
| Mandatory type | mandatory link for source |
| ID | SPPR-2216 |

Assessment assesses an Operational Requirement

| | |
|-----------------|---|
| Source Workitem |  Assessment |
| Link Role | assesses |
| Target Workitem |  Operational Requirement |
| Mandatory type | optional link |
| ID | SPPR-2232 |

3 Appendix

3.1 Standards and references

ISO/IEC/IEEE 29148:2018

Systems and software engineering - Life cycle processes - Requirements engineering

| | |
|------------|--|
| Hyperlinks | external reference - https://www.iso.org/standard/72089.html |
|------------|--|

INCOSE Systems Engineering Handbook

INCOSE Systems Engineering Handbook - A Guide For System Life Cycle Processes And Activities (Fifth Edition 2023)

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| Hyperlinks | external reference - https://www.incose.org/publications/se-handbook-v5 |
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INCOSE Guide to Writing Requirements

This page is a summary of a detailed rules that can be found in the INCOSE Guide for Writing Requirements (v4.0 July 2023).

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| Hyperlinks | external reference - https://www.incose.org/communities/working-groups-initiatives/requirements |
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ASD-STE100

Simplified Technical English (STE)

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| Hyperlinks | external reference - https://asd-ste100.org/index.html |
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Easy approach to requirements syntax (EARS)

Easy approach to requirements syntax (EARS) by Alistair Mavin, Adrian R. G. Harwood and Philip Wilkinson

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| Hyperlinks | external reference - https://alistairmavin.com/ears/ |
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