

EuroSpec



EuroSpec Requirements Management



Mobility
Networks
Logistics



EuroSpec

Requirements Management

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Table of Contents

1	Requirements characteristics	6
1.1	<i>Quality criteria for individual requirements.....</i>	6
1.2	<i>Quality criteria for overall specifications.....</i>	6
1.3	<i>Weak words, words to use with care</i>	7
2	Requirements Syntax.....	8
3	Quality Check of requirements.....	9
4	Requirements attributes	10
4.1	<i>Common understanding of attributes.....</i>	10
4.2	<i>Attributes used by EuroSpec working groups</i>	12
4.3	<i>Attributes of EuroSpec specifications.....</i>	12
4.4	<i>Template of EuroSpec specifications.....</i>	12
4.5	<i>Common understanding of values of attributes</i>	13
5	Requirements Traceability.....	14
6	Requirements Validation and Verification	15
6.1	<i>Common understanding of validation and verification.....</i>	15
6.2	<i>The role of requirements management at EuroSpec partners.....</i>	15
7	Requirements Interchange.....	20
8	Appendix	21
8.1	<i>Appendix I: Traceability and V-Model.....</i>	21
8.2	<i>Appendix II: Allocation of methods for validation and verification to means of compliance</i>	23

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Foreword

EuroSpec is a group of European train operating companies providing harmonised product specifications for use in train procurement and refurbishment.

The main target is to improve the reliability and quality of trains by using common and standardised functional and non-functional specification and verification methods.

The benefits of using EuroSpecs:

- Increase of reliability by sharing good practice and experience;
- Simplification of the tender process in time and cost as a result of fewer variations in requirements between tenders;
- Standardised products and cost reduction due to harmonisation of train operators' requirements.

The EuroSpec specifications comprise merged functional and product basic requirements. All EuroSpec specifications focus on technical aspects exclusively based on the existing national requirements.

A EuroSpec specification is a voluntary standard designed to be used within the European region. The primary field of application is the European rolling stock domain and all associated interfaces.

Regarding the hierarchy this common specification can be positioned as follows, in order of prevalence:

- EN standards
- UIC/ UNIFE Technical Recommendations (TecRecs)
- UIC Codes (leaflets)
- EuroSpec Specifications
- Company Specifications

Introduction

This document is a voluntary standard, produced by Société Nationale des Chemins de fer Français (SNCF), the Association of Train Operating Companies (ATOC), Deutsche Bahn (DB), Nederlandse Spoorwegen (NS), Danske Statsbaner (DSB), Österreichische Bundesbahnen (ÖBB) and Schweizerische Bundesbahnen (SBB).

Individual companies may choose to mandate it through internal instructions/procedures or contract conditions.

This document provides a common focus on "requirements management" for use by companies in the rail sector if they so choose. The document refers to existing standards and best practices and has the following chapters as content:

- Requirements Characteristics
- Requirements Syntax
- Requirements Attributes
- Requirements Traceability
- Requirements Validation and Verification
- Requirements Interchange

The document is set out as a quick reference chart for requirements management to facilitate easy implementation of requirement management principles.

This standard is voluntary. Individual companies may however elect to mandate all or part of its use through company procedures or contract conditions. Where this is the case, the company concerned must specify the nature and extent of application.

Disclaimer

Although every effort is made to ensure the accuracy of the information in this document, Société Nationale des Chemins de fer Français (SNCF), Association of Train Operating Companies (ATOC), Deutsche Bahn (DB), Nederlandse Spoorwegen (NS), Danske Statsbaner (DSB), Österreichische Bundesbahnen (ÖBB) and Schweizerische Bundesbahnen (SBB) cannot be held responsible for any information from external sources, technical inaccuracies, typographical errors or other errors herein. Information and links may have changed without notice

1 REQUIREMENTS CHARACTERISTICS

1.1 Quality criteria for individual requirements

Following ISO 29148:2011 the characteristics of individual requirements are defined as:

necessary	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> The requirement shall not be open for interpretation¹
consistent	<ul style="list-style-type: none"> The requirement is free of conflicts with other requirements in the specification The requirement is free of conflicts in it self
complete	<ul style="list-style-type: none"> All necessary information is provided in the requirement
singular	<ul style="list-style-type: none"> The requirement statement includes only one requirement
verifiable	<ul style="list-style-type: none"> The requirement has the means to prove that the system satisfies the specified requirement
traceable	<ul style="list-style-type: none"> The requirement has a relation to its origin (e.g. a higher level requirement or need), realisation, documents through entire procurement process

1.2 Quality criteria for overall specifications

Following ISO 29148:2011 the characteristics for an overall specification are defined as:

complete	<ul style="list-style-type: none"> The set of requirements shall contain all necessary information for the product
consistent	<ul style="list-style-type: none"> The set of requirements is free of conflicts to other requirements
affordable	<ul style="list-style-type: none"> The requirements can be satisfied by a solution that is obtainable / feasible within life cycle constraints
bounded	<ul style="list-style-type: none"> The set of requirements represent the scope needed only to satisfy the user needs
unique	<ul style="list-style-type: none"> The specification contains each requirement only once

¹ If you have to explain why it is not open to interpretation, it apparently is open to interpretation and therefore ambiguous.

1.3 Weak words, words to use with care

In order to ensure all requirements have the characteristics defined in section 1.2, 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: (shall not have, shall not be, no)
- Connective statements: (and, or)
- Passive voice (it shall be possible to)

2 REQUIREMENTS SYNTAX

In order to improve the overview in the requirements, a standard approach to requirements syntax shall be adopted. This document refers to proposed systems of the ISO 29148:2011 and the Easy Approach to Requirements Syntax (EARS) developed by Rolls Royce.

A principal point in the requirement syntax is a clear focus of the considered system.

ISO 29148:2011 focuses on a system being built up as follows:

[Condition] [Subject] [Action] [Object] [Constraint]

The EARS defines the following patterns:

Pattern	Use
ubiquitous	The <system name> shall <system response>
event-driven	When <trigger>, the <system name> shall <system response>
state-drive	While <in a state>, the <system> shall <system response>
unwanted behaviour	If <trigger>, then the <system> shall <system response>
optional	Where <feature>, the <system> shall <system response>

3 QUALITY CHECK OF REQUIREMENTS

In order to illustrate how the theoretical approaches of chapters 1 and 2 can be checked in practice, this document shows examples for quality checks of requirement characteristics and formulations.

The EuroSpec Specifications for Railway Vehicles are checked by the EuroSpec working group “Requirements Management” in order to ensure the required quality level of the EuroSpec Specifications. Any requirement (requirement text and descriptive attributes) can be checked separately. By following chapters 1 and 2 the criteria listed below can be checked²:

- Unambiguous
- Consistent
- Complete
- Singular
- Formulation with EARS

As a result of the quality check by the EuroSpec working group “Requirements Management” comments (detail information about fulfillment of quality criteria in textual description) and recommendations for re-wording are given to the author(s) of the EuroSpec requirements.

Example 1:

Requirement: *“It shall be impossible to contaminate fresh water with waste water.”*

Comments:

- Requirement is incomplete
- Requirement is not verifiable
- No fulfillment of EARS; no subject (system) stated

Recommendation for re-writing:

- *“The toilet system shall prevent the contamination of fresh water by waste water.”*

Example 2:

Requirement: *“The toilet paper dispenser shall fit rolls of toilet paper according to UIC Code 563.”*

Comment: no comment – The requirement fulfills the quality criteria according to this document.

² The quality criteria necessary, verifiable and traceable are left out, as the evaluation can only be made by or with experts or no attributes for verification or traceability exists up to now in the EuroSpec specifications.

4 REQUIREMENTS ATTRIBUTES

Requirements contain a number of attributes of which the description is one.

4.1 Common understanding of attributes

The following attributes are commonly agreed (attribute name, definition, function) by all EuroSpec partners.

Attribute	Definition	Function
ID	Unique Identification of the requirement	Ensure that the requirement remains uniquely traceable, and to enable traceability to needs, solutions and documents
Version	Version of the requirement	To describe an evolution or a creation during a project or in a standard database
Status	Indication of the approval state of the requirement	To describe a defined status of a requirement in a standard database or requirement maturity level during a project
Requirement type	Assignment of requirements into defined groups	This aids analysis and allocation
Requirement classification	Importance and legal status of the requirement to the project	To differentiate between the requirements with regard to relevance and legal status like Requirement (RE - mandatory), Design Recommendation (DR) or Optional Requirement (OR)
Requirement-text	Description of the requirement	Draft the requirement
Rationale	Reason to state the requirement	To describe the reason why a requirement is stated (traceability to the need) To describe the chosen text of the requirement The rationale provides the reason that the requirement is needed and points to any supporting analysis, trade study, modelling, simulation, or other substantive objective evidence

Attribute	Definition	Function
Source	Indication from where the requirement originates	To determine the traceability of the requirement to previous experiences like projects, working groups, lessons learned
Decisions	List of decisions taken with respect to the requirement	To provide traceability between the requirement and decisions of the project or organisation If possible with a signed document that reflects the decision The documentation of decisions is helpful for discussion in projects
Owner	Owner of the requirement	To ensure a clear allocation to the person being responsible for drafting requirement. The owner: <ul style="list-style-type: none"> • Ensures that requirement is written • Responds to questions • Validates and verifies the requirement
Comment of owner	Remarks of the owner to the requirement	To allow the owner to provide comments
Comment of tenderer	The comments to the requirement by the tenderer	To allow the tenderer to provide comments
Degree of fulfillment by <tenderer name>	Expected measure of compliance by the tender	To allow partial fulfillment to a requirement to optimise demands and potential solutions
Product element EN 15380-2	Link between requirement and the product element of the EN 15380-2	To relate the item of the product breakdown of EN 15380-2
Function element EN 15380-4	Link between requirement and the functional element of the EN 15380-4	To relate the item to the system breakdown of EN15380-4
Annex to requirement	Any appendices to the requirement given to the supplier industry	To relate the requirement to stored documents

4.2 Attributes used by EuroSpec working groups

The technical specifications drafted by the EuroSpec working groups include the following attributes:

- ID
- Requirement classification
- Requirement-text
- Rationale
- Product element EN 15380-2
- Status
- Source
- Comment of owner
- Annex to requirement

4.3 Attributes of EuroSpec specifications

All published EuroSpec Specifications for Railway Vehicles include the following attributes:

- ID
- Requirement classification
- Requirement-text
- Rationale
- Product element EN 15380-2

EuroSpec specifications will be made available in the following formats:

- Portable Document Format (pdf)
- MS Excel® Spreadsheet

4.4 Template of EuroSpec specifications

The EuroSpec specification template includes all used attributes.

EuroSpec									
ID	Requirement classification	Requirement-text	Rationale	Product element EN 15380-2	Status	Source	Comment of owner	Annex to requirement	
EuSp.xy.01	--				--				
EuSp.xy.02	--				--				
EuSp.xy.03	--				--				
EuSp.xy.04	--				--				
EuSp.xy.05	--				--				
EuSp.xy.06	--				--				
EuSp.xy.07	--				--				
EuSp.xy.08	--				--				
EuSp.xy.09	--				--				
EuSp.xy.10	--				--				
EuSp.xy.11	--				--				

4.5 Common understanding of values of attributes

For the attribute **Requirement Classification** the following values are defined and used in EuroSpec specifications:

Value of attribute	Definition	Function
Requirement (RE)	Requirement (RE) is a functional or non-functional requirement, which must be fulfilled by the supplier.	If a requirement in a EuroSpec specification is marked as a Requirement (RE), a supplier <u>shall not</u> offer an alternative.
Design Recommendation (DR)	A Design Recommendation is a non-functional requirement and provides a solution for a linked RE.	<p>A Design Recommendation is linked to one or more (functional) requirements. It gives guidance to the design by the supplier. If the supplier follows the design recommendation, it can be used as a compliance demonstration to the requirements to which it refers.</p> <p>If a requirement in a EuroSpec specification is marked as a Design Recommendation, a supplier may offer an alternative solution to fulfill the linked (functional) requirement.</p>
Optional Requirement (OR)	<p>An Optional Requirement is a requirement from the EuroSpec specification for which the train operating company (TOC) has to decide if it will be applied to a project.</p> <p>If an Optional Requirement is chosen by a TOC in a project, it must be fulfilled by the supplier (like RE).</p>	<p>The function of an Optional Requirement is to provide a choice between different (functional) requirements. The reasons for this choice could be different train concepts or different opinion between the TOC's.</p> <p>An Optional Requirement can either be a functional or a non-functional requirement.</p>
Information (INFO)	Information (INFO) is a textual statement without a legal status.	An Information (INFO) can be used in EuroSpec specifications for additional information, e.g. definitions of terms, etc.

5 REQUIREMENTS TRACEABILITY

For the EuroSpec partners it is important to have a clear and common understanding of the term traceability and what it can be used for.³

Traceability is the capability to comprehend and follow requirements, relations 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 15288⁴.

“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 project.”⁵

Traceability creates the base for efficient and high quality requirements management and enables the following of the connections between different information. Traceability pursues the following objectives:⁶

- Detectability: Requirements traceability supports the proof, that requirements or objectives are implemented and fulfilled in a system.
- Impact analysis: Requirements traceability supports impact analysis, for example by analyzing the consequences for other requirements when changing a requirement (change management) or by analyzing 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 on different levels of detail (Parent-Child-Relation)
- Relationship between requirements on the same level
- Relationship between requirements and other types of information, e.g. objectives, use-cases, test-cases, etc.

Connections for traceability can be classified in:

- Pre-Requirement-Specification-Traceability: e.g. for connections between system requirements and customer requirements or objective documents
- Post-Requirements-Specification-Traceability: e.g. for connections between system requirements and test-cases.
- Traceability between requirements

³ It is not the Intention of this EuroSpec document to create further explanations and definitions of well-known terms. If in international standards or in literature exists useful references for this document, these will be linked and quoted.

⁴ The V-model based on ISO 15288 is enclosed in Appendix 1

⁵ Hood, Wiedemann, Fichtinger, Pautz (2010, p. 36)

⁶ Rupp (2009, p. 398)

6 REQUIREMENTS VALIDATION AND VERIFICATION

For the EuroSpec partners 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 TOC 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 by the tender respectively by the supplier. 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 systems conformity to its specification. Verification tests a system against system requirements and/or design requirements⁷.

The difference between validation and verification can be pointed in the questions⁸:

- Are we building the **right** train? (Validation)
- Are we building the train in a **right 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 shall be defined during the process of writing requirements.

6.2 The role of requirements management at EuroSpec partners

The requirements management of the EuroSpec partners and the EuroSpec specifications have to answer the following questions from the train operating companies' point of view:

- What (or which requirements) must be validated and verified?
- How do requirements have to be validated and verified?
- When do requirements have to be validated and verified?

⁷ Hood, Wiedemann, Fichtinger, Pautz (2010)

⁸ Boehm (1981)

The “What (or which requirement)” deals with the question whether each requirement of a requirement specification must be validated and verified. According to the V-Model based on ISO/IEC 15288 there are two aspects for validation by the TOC:

- the TOC internal validation of stakeholder requirements
- the validation of these stakeholder requirements with the supplier

Requirements validation can avoid future misunderstanding and expensive changes. In accordance with ISO 9001 the supplier has “to ensure that customers’ [including TOC] requirements are determined and are met with the aim of enhancing customer satisfaction.”

The rolling stock supplier undertakes the main work of planning and executing verification. To make sure that requirements and functions are implemented correctly the TOC can demand verification for components, sub-systems and the system. This verification must be defined by the TOC while writing requirements and agreed with the supplier as early as possible. The TOC and the supplier have to agree for each requirement:

- The methods for validation and verification,
- The criteria for validation and verification and
- The means of compliance (documentation) for validation and verification.

With methods, criteria and the means of compliance the question “how do requirements have to be validated and verified?” can be answered. These three must be documented and agreed between TOC and supplier.

The methods for validation and verification for EuroSpec specifications are, with regards to the ISO 29148 standard, defined as followed:

Methods for validation and verification	Definition	Function
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.

Methods for validation and verification	Definition	Function
First Article Inspection (FAI)	<p>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.</p> <p>A FAI is carried out before approval of series production and is typically called for in a contract.</p>	<p>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.</p>
Analysis	<p>Use of analytical data or simulations under defined conditions to show theoretical compliance</p>	<p>Used where testing to realistic conditions cannot be achieved or is not cost-effective. Analysis may be used when such means establish that the appropriate requirement, specification or derived requirement is met by the proposed solution.</p>
Design Review	<p>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.</p>	<p>Validation of agreed functional and non-functional requirements of the system and identification and elimination of potential problems and errors as early as possible.</p>
Simulation	<p>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.</p> <p>Simulations can be used to show under defined conditions theoretical compliance.</p>	<p>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.</p> <p>Simulation can be used e.g. in the process of development to show movement and functional processes, dynamic loads and stresses.</p>

Methods for validation and verification	Definition	Function
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.
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.
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 must not be manufactured under series conditions. Type testing includes the validation of required parameter. Several type tests can be necessary for one test object.

Methods for validation and verification	Definition	Function
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.

In Appendix II a non-exhaustive allocation of methods and means of compliance is presented.

The “when” deals with the question; at what point in time should a validation or verification method be executed and the means of compliance that must be presented by the supplier to the TOC. These steps are the point in time or quality gates.

Point in time	Definition
Offer of Tenderer(s)	Point in time to compare the offers of tenderers
Design Review	Point in time to confirm general design of system or system element will fulfil the requirement
First Article Inspection (FAI) of components	Point in time to confirm developed system or system element will fulfil the requirement
First Integration Inspection (FII)	Point in time to verify integrated system or system element, will comply with the requirement
Contractual acceptance	Point in time to validate and verify that the system complies with the contracted requirements

7 REQUIREMENTS INTERCHANGE

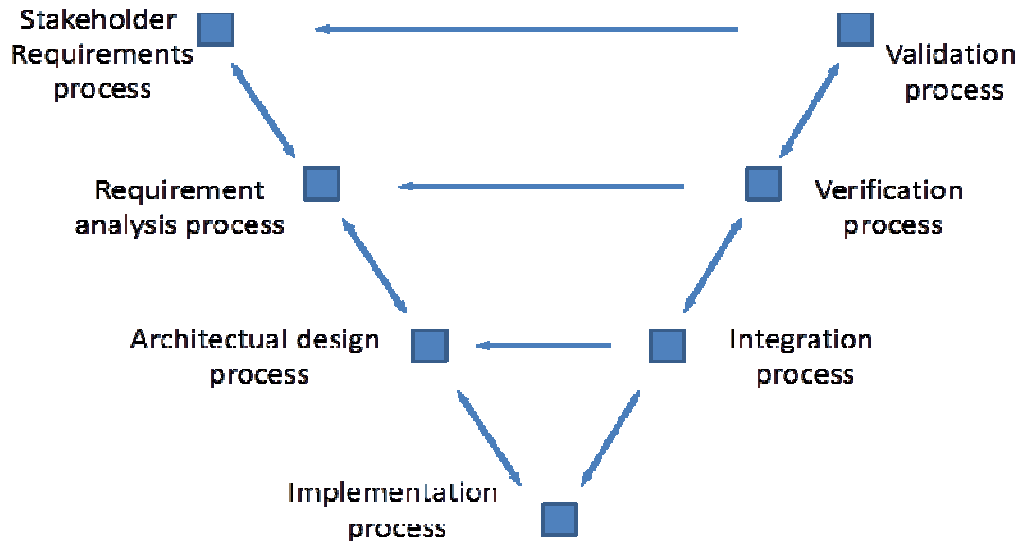
As there are different requirement interchange processes and formats available to the EuroSpec partners and the system suppliers, the EuroSpec partners came to the conclusion, that for the moment it is not useful or possible to determine one specific data exchange format for requirement specifications.

The EuroSpec partners explicitly support the introduction and use of a common standard data exchange format for the railway industry. For that the EuroSpec partners support the gradual introduction of the Requirement Interchange Format (ReqIF) standard.

Nevertheless the railway manufacturers and suppliers shall implement processes and have an organization to support the requirement management.

8 APPENDIX

8.1 Appendix I: Traceability and V-Model



Process	Purpose	Traceability task
Stakeholder definition	Define the requirements for a system that can provide the services needed by users and other stakeholders in a defined environment	-Identify the interaction between users and the system -Maintain stakeholder requirements traceability to the sources of stakeholder needs
Requirement analysis	Transform the stakeholder, requirement-driven view of desired services into a technical view of a required product that could deliver those services	Demonstrate and maintain mutual traceability between the system requirements and the stakeholder requirements
Architectural design	Synthesise a solution that satisfies system requirements	-Divide the system functions identified in requirements analysis -Maintain mutual traceability between specified design and system requirements
Implementation	Produce a specified system element	Record evidence that the system element meets supplier agreements, legislation and organizational policy
Integration	Assemble a system that is consistent with the architectural design	Analyse, record and report integration information, including results of integration actions, non-conformances, and corrective actions taken

Process	Purpose	Traceability task
Verification	Confirm that the specified design requirements are fulfilled by the system	<ul style="list-style-type: none">-Conduct verification to demonstrate compliance to the specified design requirements (refer §6 for the standard verification methods)-Analyse, record and report verification, discrepancy and corrective action information
Validation	Provide objective evidence that the services provided by a system when in use in its intended operational environment	<ul style="list-style-type: none">-Conduct validation to demonstrate conformance of services to stakeholder requirements-Analyse, record and report validation data according to criteria defined in the validation plan

8.2 Appendix II: Allocation of methods for validation and verification to means of compliance

Methods for validation and verification	Means of compliance
Inspection	Inspection report Mock-up 3D Model
First Article Inspection (FAI)	Type test reports Drawings Part list Calculations Certificate Measurement reports Test plan for series production Test specifications Test protocol FAI report
Inspection of document	Drawings Part lists Maintenance documentation Technical specifications Calculations Inspection report
Analysis	Analysis input information Analysis report
Design Review	Connection diagram Concept Functional Specification RAMS report Design Review report
Simulation	Graphics Movies EDV-data Report Simulation report
Analysis of Calculation	Calculation
Demonstration	Demonstration specifications Demonstration report
Routine Test	Test specifications Measurement reports
Test	Test specification Test program Test protocol Test report Security test report
Type test	Test specification Test program Test protocol Test report
Certification	Certificate

EuroSpec

“EuroSpec” stands for European Specifications for railway rolling stock. The activity is an initiative of several European train operating companies (TOC). The main focus is on trains consisting of self-propelled carriages, using electricity as the motive power (EMU).

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