

EuroSpec



Requirements Management



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Requirements Management

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1 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 align train operator's needs in order to reduce the whole life cycle cost of the train, shorten the delivery time and speed up the innovation cycle and the deployment of innovations.

The benefits of EuroSpec:

- 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;
- Reduction of diversity in request to the industry for more competitive and mature products;
- To provide to the industry free "Customer needs" for their future R&D program, through requirements that are not yet fulfilled by existing product nor solution.
- To promote through our common requirements to the industry the availability of information required for improving operation performance and ensuring long term sustainability of our assets, supporting open interfaces.

The EuroSpec specifications comprise merged functional and product basic requirements. All EuroSpec specifications focus on technical aspects based on lessons learned and on foreseen developments

A EuroSpec specification is a voluntary specification 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 Leaflets / International Railway Solutions (IRS)
- EuroSpec Specifications
- Company Specifications

2 INTRODUCTION

This document is a voluntary specification, produced by SNCF-VOYAGEURS, Rail Delivery Group (RDG), Deutsche Bahn (DB), Nederlandse Spoorwegen (NS), Österreichische Bundesbahnen (ÖBB) and Schweizerische Bundesbahnen (SBB).

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

Purpose of this document

This document provides a voluntary specification for Requirements Management for use by companies in the rail sector if they so choose.

The purpose of this document is to provide a common specification for Requirements Management in rolling stock between train operators. This document is to replace individual company specific functional requirements and constitutes a common reference being used for tendering and verification.

Application of this document

- This specification 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.
- Specific compliance requirements and dates of application have therefore not been identified since these will be the subject of the internal procedures or contract conditions of those companies that choose to adopt this standard.

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3 SCOPE

This document provides a common focus on "requirements management" for use by EuroSpec working groups to give guidance on drafting requirements to give a standardised approach. It can also be used by companies in the rail sector if they so choose as a guideline for their respective specifications. 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.

4 NORMATIVE REFERENCES

The following referenced documents are indispensable for the application of this document. ENs are developed by CEN¹ or CENELEC², UIC Leaflets and IRS are developed by UIC³, ISOs are developed by ISO⁴, IEC are developed by IEC⁵ and are made available from their members.

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 29148:2018	Systems and software engineering - Life cycle processes – Requirements engineering
EN 15380-2	Railway applications - Designation system for railway vehicles - Part 2: Product groups
EN 15380-4	Railway applications - Classification system for railway vehicles - Part 4: Function groups
EN 15380-5	Railway applications - Classification system for railway vehicles - Part 5: System Breakdown Structure (SBS)
ISO/IEC 15288	Systems and software engineering - System life cycle processes

5 TERMS, DEFINITIONS AND ABBREVIATIONS

TSI	Technical specification for interoperability
EN	Euro Standard

¹ Comité Européen de Normalisation / European Committee for Standardization - www.cen.eu

² Comité Européen de Normalisation Électrotechnique / European Committee for Electrotechnical Standardization - www.cenelec.eu

³ Union internationale des chemins de fer / International Union of Railways - www.uic.org

⁴ International Organization for Standardization - www.iso.org/home.html

⁵ International Electrotechnical Commission - www.iec.ch/homepage

6 REQUIREMENTS CHARACTERISTICS

6.1 Quality criteria for individual requirements

Following ISO 29148:2018 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 is stated in such a way so that it can be interpreted in only one way; The requirement is stated simply and is easy to understand.
consistent	<ul style="list-style-type: none"> The set of requirements contains individual requirements that are unique, do not conflict with or overlap with other requirements in the set, and the units and measurement systems are homogeneous.
complete	<ul style="list-style-type: none"> The requirement sufficiently describes the necessary capability, characteristic, constraint or quality factor to meet the entity need without needing other information to understand the requirement.
singular	<ul style="list-style-type: none"> The requirement statement includes only one requirement: the requirement states a single capability, characteristic, constraint or quality factor.
verifiable	<ul style="list-style-type: none"> The requirement is structured and worded such that its realization can be proven (verified) to the customer's satisfaction at the level the requirements exists. Verifiability is enhanced when the requirement is measurable.
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 the entire procurement process.

6.2 Quality criteria for a set of requirements

Following ISO 29148:2018 the characteristics for an overall specification are defined as:

complete	<ul style="list-style-type: none"> The set of requirements stands alone such that it sufficiently describes the necessary capabilities, characteristics, constraints or quality factors to meet entity needs without needing further information.
consistent	<ul style="list-style-type: none"> The set of requirements is free of conflicts to other requirements, EuroSpec specifications or standards, like ENs, and Technical Specifications for Interoperability (TSIs); The set of requirements contains individual requirements that are unique, do not conflict with or overlap with other requirements in the set, and the units and measurement systems are homogeneous.
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.
traceable	<ul style="list-style-type: none">• The set of requirements has a relation to its goals and origin; the existence of the set of requirements can be understood.
High-quality	<ul style="list-style-type: none">• 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 (Chapter 6.1).
Feasible	<ul style="list-style-type: none">• The complete set of requirements can be realized within entity constraints (e.g., cost, schedule, technical) with acceptable risk.

6.3 Weak words, words to use with care

In order to ensure all requirements have the characteristics defined in section 6.2, the terms in each requirement have to be chosen with care. 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)

7 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 29148:2018 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 29148:2018 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-driven	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>

8 QUALITY CHECK AND APPROVAL PROCESS OF REQUIREMENTS

In order to illustrate how the theoretical approaches of chapters 6 and 7 can be checked in practice, the ReqMan checklist for writing EuroSpec requirements and a EuroSpec quality metric to evaluate the quality of requirements is defined.

8.1 ReqMan checklist for writing EuroSpec requirements

The following checklist is for the use of persons who write EuroSpec requirements and shall help them to check their requirements themselves:

1. Is the requirement formulated as a complete, clear and understandable sentence?
2. Is the requirement formulated in the active voice?
3. Is the requirement formulated according to EARS Syntax?
4. Is the requirement free of "weak words"?
5. Does the requirement describe a function or a property of a system or sub-system?
6. Does the requirement include only one requirement?
7. Is the requirement free of implicit assumptions?
8. Can the fulfilment of the requirement be verified with an explicit performance level?
9. Are all attributes of the EuroSpec-Template filled in?
10. Does the requirement have a version number and a date?
11. Are the abbreviations, technical words defined in a glossary?

8.2 EuroSpec quality metric to evaluate the quality of requirements

The EuroSpec quality metric is a tool used to indicate to the experts in the working group the main potential improvements of the specifications as well as provide transparent tracking of issues identified by the Requirements Management working group. This tool allows a quantified statement of defined quality criteria of the requirements to be performed. Figure 8.2-1 shows an output of this quality evaluation.

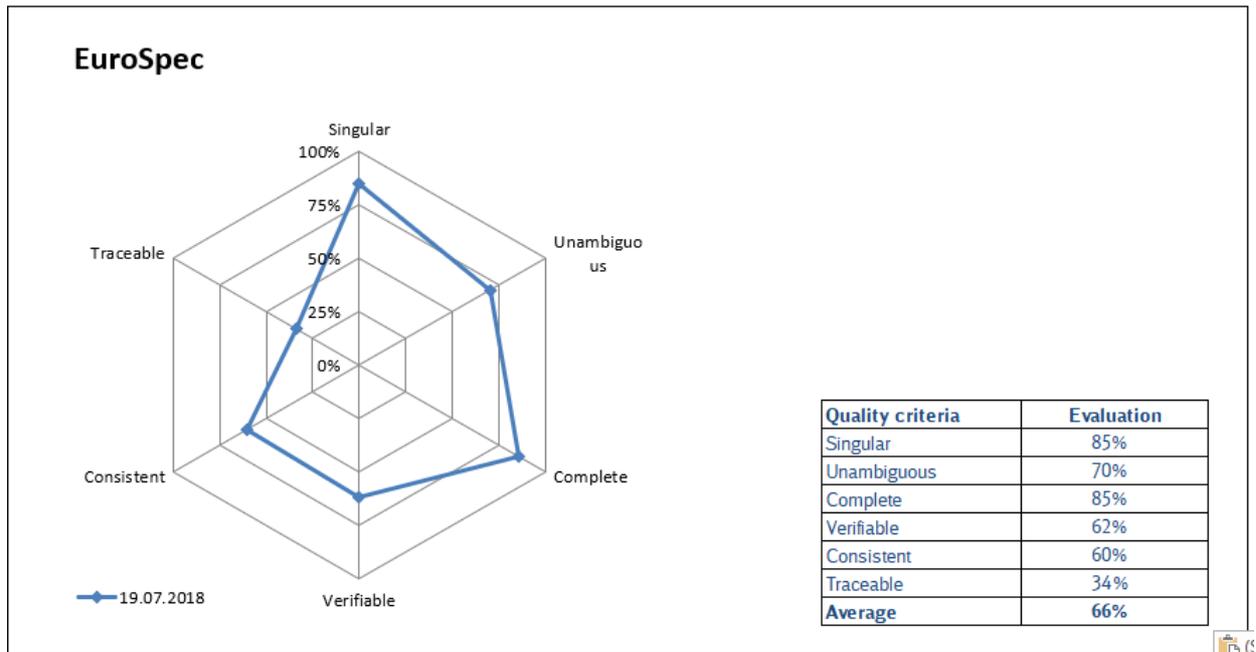


Figure 8.2-1: output of quality evaluation by using the EuroSpec quality metric

9 REQUIREMENTS ATTRIBUTES

Requirements contain a number of attributes which must be defined to have a complete description and understanding.

9.1 Common understanding of attributes

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

Attribute	Definition	Function	To be completed by whom	To be completed at what stage
ID	Unique Identification of the requirement, information or heading.	Ensure that the item remains uniquely traceable, and to enable traceability to needs, solutions and documents	Customer	Call for tenders
Version	Version of the requirement	To describe the creation or an evolution during a project or in a standard database	Customer	Call for tenders
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	Customer	Call for tenders
Requirement type	Assignment of requirements into defined groups	This aids analysis and allocation	Customer	Call for tenders
Requirement classification	Importance and legal status of the requirement to the project	To differentiate between the requirements with regard to relevance and legal status as follows: Requirement (RE - mandatory), Design Recommendation (DR), Optional Requirement (OR) or Alternative Choice (CH))	Customer	Call for tenders
Requirement-text	Description of the requirement	To describe the requirement	Customer	Call for tenders
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	Customer	Call for tenders

Attribute	Definition	Function	To be completed by whom	To be completed at what stage
Source	Indication from where the requirement originates	To determine the traceability of the requirement to previous experiences, e.g. projects, working groups, lessons learnt	Customer	Call for tenders
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 discussions in projects	Customer	Call for tenders
Owner	Owner of the requirement	To ensure a clear allocation to the person responsible for drafting a requirement, the owner: <ul style="list-style-type: none"> • Ensures that the requirement is created • Responds to questions • Validates and verifies the requirement 	Customer	Call for tenders
Comment of owner	Remarks of the owner to the requirement	To allow the owner to provide comments	Customer	Call for tenders
Comment of tenderer	The comments to the requirement by the tenderer	To allow the tenderer to provide comments	Tenderer	Offer
Degree of fulfilment of tenderer	Expected measure of compliance by the tender	To allow partial fulfilment to a requirement, to optimise demands and potential solutions	Tenderer	Offer
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. If no reference to the standard exists, the item is allocated to "N/A".	Customer	Call for tenders
System element EN 15380-5	Link between requirement and the system element of the EN 15380-5*	To relate the item to the system breakdown of EN 15380-5. If no reference to the standard exists, the item is allocated to "N/A" or a customised allocation can be generated.	Customer	Call for tenders

Attribute	Definition	Function	To be completed by whom	To be completed at what stage
Function element EN 15380-4	Link between requirement and the functional element of the EN 15380-4*	To relate the item to the functional breakdown of EN 15380-4. If no reference to the norm exists, the item is allocated to "N/A".	Customer	Call for tenders
Non-functional element EN 15380-5	Link between requirement and the non-functional element of the EN 15380-5 Annex A*	To relate the item to one topic out of a list of non-functional elements according to EN 15380-5 Annex A - performance parameters and boundary conditions. If no reference to the norm exists, the item is allocated to "N/A".	Customer	Call for tenders
Annex to requirement	Any appendices to the requirement given to the tenderer	To relate the requirement to stored documents	Customer	Call for tenders
Change since last release	Description of the modifications that have been made to one or more attributes of this requirement since the last release	To provide traceability between the releases of published attributes of this requirement.	Customer	Call for tenders
Verification (points in time)	Indication of methods and/ or documentation to verify a requirement	To allocate verification methods and/ or documentation to a requirement over different points in time (Offer of Tenderer(s); Design Review; First Article Inspection (FAI) of components; First Integration Inspection (FII); Authorization for Service)	Customer	Call for tenders

9.2 Attributes used by EuroSpec working groups

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

- ID
- Requirement classification
- Requirement-text
- Rationale
- Product element EN 15380-2
- System element EN 15380-5
- Function element EN 15380-4
- Non-functional element EN 15380-5
- Status
- Change since last release
- Source
- Comment of owner
- Annex to requirement
- Verification (points in time)

9.3 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
- System element EN 15380-5
- Function element EN 15380-4
- Non-functional element EN 15380-5
- Change since last release
- Verification (points in time)

EuroSpec specifications will be made available in the following formats:

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

9.4 Template of EuroSpec specifications

The template of EuroSpec specifications (appendix III) includes all used attributes and can be obtained from the Requirements Management working group.

9.5 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 offer an alternative</u> .
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 to the supplier. If the supplier follows the design recommendation, it can be used as a compliance demonstration of 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 fulfil the linked (functional) requirement.</p>
Alternative Choice (CH)	Alternative Choice (CH) is a requirement (RE) which requires a choice between alternatives.	<p>Requirement includes an alternative and therefore the train operating company has to choose one when applying EuroSpec specification.</p> <p>Where no selection of an alternative has been made by the train operating company, the choice for an alternative is up to the supplier.</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 due to different train concepts or different opinions between the TOCs.</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.	Information (INFO) can be used in EuroSpec specifications for additional information, e.g. definitions of terms, etc.

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

Value of attribute	Definition	Function
draft	Proposition for a new requirement or a re-written requirement (Status is set by the working group)	The requirement is in progress by the working group
under review	The requirement is under review	The review process for the requirement is running
approved	The requirement has been approved	The requirement can be published
rejected	The requirement has been rejected	The requirement is no longer in use

For the attribute **Change since last release** the following values are defined and used in EuroSpec specifications:

Value of attribute	Definition	Function
No change (-)	No modifications have been made to any of the attributes of this requirement.	The requirement remains unchanged. No further actions are needed.
New	The requirement has been added since the last release.	The requirement has been added and therefore it has to undergo the review process.
Changed	At least one published attribute of the requirement has been changed since the last release.	The requirement has been changed and therefore it has to undergo the review process.
Minor Change	A very small change, e.g. fixing grammar or spelling, has been done. It does not change the meaning of the requirement.	The content of the requirement has not been changed and therefore the requirement does not have to be reviewed.
Removed	This requirement has been removed since the last release.	The requirement has been removed and therefore it has to be added to a possible list of removed requirements.

For the attribute **Non-functional element EN 15380-5** the following values are used in EuroSpec specifications according to EN 15380-5 (2014) Annex A Table A.1:

Value of attribute	Comments
N/A	Not applicable
+01 Reliability, Availability, Maintainability (RAM)	performance parameter
+02 Safety	performance parameter (includes crash and fire safety)
+03 Security	performance parameter (IT security)
+04 Health protection	performance parameter (protection of workers)
+05 Life Cycle Cost (LCC)	performance parameter (also including Integrated Logistic Support – ILS)
+06 Visibility and Audibility	performance parameter, awareness of vehicle presence,

	e.g. warning horn, exterior lighting
+07 Physical limits	boundary condition (vehicle key dimensions)
+08 Electromagnetic compatibility (EMC)	boundary condition
+09 Weight	performance parameter / boundary condition
+10 Acoustics and Vibration	performance parameter / boundary condition
+11 Environmental condition	boundary condition (e.g. temperature, weather)
+12 Environmental protection	performance parameter (e.g. recyclability, sustainability, banned substances)
+13 Thermodynamics	performance parameter
+14 Aerodynamics	performance parameter
+15 Vehicle dynamics and gauging	performance parameter / boundary condition
+16 Industrial design (interior and exterior aesthetics) and ergonomics	performance parameter (e.g. customer comfort)
+17 Operating performance	performance parameter / boundary conditions (route and operating profile)
+18 Structural mechanics	performance parameter
+19 Rescue and recovery	performance parameter
+20 Power distribution and management	performance parameter
+21 Energy consumption	performance parameter
+22 External Command and Control and signalling	boundary condition
+23 Operational conditions	performance parameter / boundary condition (like operator's specific requirements, regulations and normative requirements)
+24 Maintenance provisions	boundary condition (including cleaning provisions)

10 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.⁶

Traceability is the capability to understand 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 15288⁷.

"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."⁸

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:⁹

- 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 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 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

⁶ 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 useful references for this document exist, these will be linked and quoted.

⁷ The V-model based on ISO 15288 is enclosed in Appendix 1

⁸ Hood, Wiedemann, Fichtinger, Pautz (2010, p. 36)

⁹ Rupp (2009, p. 398)

11 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.

11.1 Common understanding of validation and verification

Validation and verification are important activities during all the technical processes of the V-Model.

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 requirements¹⁰.

The difference between validation and verification can be pointed in the questions¹¹:

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

11.2 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?

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.

¹⁰ Hood, Wiedemann, Fichtinger, Pautz (2010)

¹¹ Boehm (1981)

Requirements validation can avoid future misunderstanding and expensive changes. In accordance with ISO 9001 the supplier has “to ensure that customer’s 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 on each requirement:

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

Thus, together, methods, criteria and means of compliance enable the question “how requirements have to be validated and verified” to be answered. This shall 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 follows:

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.
First 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.

Methods for validation and verification	Definition	Function
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 such means establish that the appropriate requirement, specification or derived requirement is met by the proposed solution.
Design Review	A formal and systematic validation or verification within a product development process of components, subsystems or systems whereby a design is detailed and evaluated against its requirements.	Validation or verification of agreed functional and non-functional requirements of the system and identification and elimination of potential problems and errors as early as possible.
Simulation	Simulation is the imitation of the operation of a real-world process or system over time. A model represents the key characteristics, behaviours 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.
Calculation	Calculation to validate or verify agreed or specified parameters, 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.

Methods for validation and verification	Definition	Function
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 validations or 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 does not need to be manufactured under series conditions. Type testing includes the validation of required parameters. 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.

In Appendix II a non-exhaustive allocation of methods and means of compliance is presented which can be considered as examples.

The “when” deals with the question; until 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. It is important to prioritise on the amount of verifications. It is not required to demand verification methods and means of compliances for every requirement for every point in time.

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 in the vehicle, will comply with the requirement
Authorization for Service	Point in time to validate and verify that the system complies with the contracted requirements

12 REQUIREMENTS INTERCHANGE

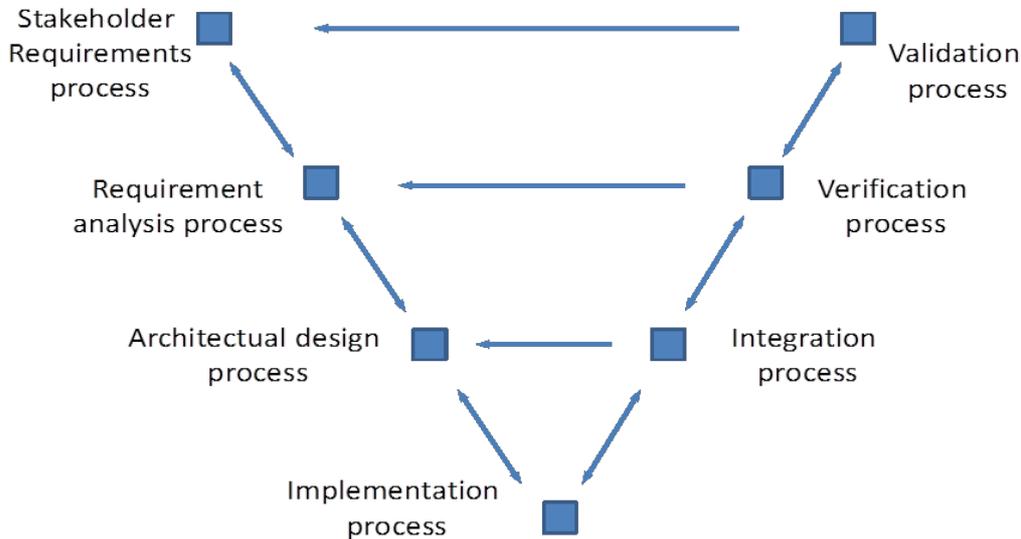
As there are different requirement interchange processes and formats available to the EuroSpec partners and the system suppliers, the EuroSpec partners came to the conclusion, that for the moment it is not useful or possible to determine one specific data exchange format for requirement specifications.

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 requirements management.

13 APPENDIX

13.1 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	<ul style="list-style-type: none"> - Identify the interaction between users and the system (e.g. use-cases or operational scenarios) - 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	<ul style="list-style-type: none"> - 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 organisational 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 to chapter 11 for the standard verification methods)- Analyse, record and report verification, discrepancy and corrective action information
Validation	Provide objective evidence that services provided by a system satisfy stakeholder requirements 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

13.2 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 data files 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

13.3 Appendix III: EuroSpec Templates



EuroSpec
Specification Templ:

Available at: info@eurospec.eu

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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