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Space systems — Programme management — Requirements management

Systèmes spatiaux — Management de programme — Management des Exigences

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

This second edition cancels and replaces the first edition (ISO 16404:2013), which has been technically revised.

The main changes compared to the previous edition are as follows:

— The terms and definitions have been updated to be consistent with ISO 10795.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

There is a consensus that successful aerospace programmes/projects depend on meeting the needs and requirements of the stakeholders/customers. When the requirements are for a complex system or for a system that may take many years to be developed, a formal requirements management (RM) process is mandatory and justified.

Requirements management concerns the collection, analysis, and validation of requirements with all the communications and negotiations inherent in working with people.

This document will help to clarify and enhance current practices to improve programme management. It is intended to be used by space programmes when establishing, performing, or evaluating requirements management processes in the space sector.

This document describes requirements management functions and principles and defines a common requirements management terminology for use with any product line.

Requirements management is an integral element of any programme, but, in space, it is particularly important due to

— specific environmental conditions in space,

— a need for a high level of performance,

— a limited number of models,

— limited access to the product during operations,

— quasi-impossibility of repairing in the case of failure during flight,

— often high complexity of the organization, and

— associated high costs.

The deployment of this standardized common set of requirements management is intended to encourage and facilitate international space cooperation.

Annex A gives the general template for a requirements management plan.

Space systems — Programme management — Requirements management

1 Scope

This document presents the requirements for requirements management (RM) for space projects.

This document addresses the space programme/project management requirements, applicable through a top-down approach in a contractual relationship between customers and suppliers.

The objective of this document is to state and establish a common reference framework for all the customers and suppliers in the space sector to deploy requirements management for all space products and projects.

This document on requirements management includes

— a definition of the requirements management scope for the space sector,

— the standard processes for requirements management within the product lifecycle management, and

— a set of rules for requirements management activities to be implemented by the actors (customers and suppliers), including rules derived from best practices.

The primary target audience for this document includes

— the requirements management/systems engineering process owners of the customers and suppliers,

— the programme/project managers managing the space programmes, and

— the chief engineers and the quality managers.

The term "programme" is understood as a group of several projects. Both "programme" and "project" can be used in the same context throughout this document.

In addition, this document allows customer/supplier flexibility in its implementation and tailoring.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9000, *Quality management systems — Fundamentals and vocabulary*

ISO 10795, *Space systems — Programme management and quality — Vocabulary*

ISO 14300-1, *Space systems — Programme management — Part 1: Structuring of a project*

ISO 21351, *Space systems — Functional and technical specifications*

3 Terms and definitions

For the purposes of this document, the terms and definitions in ISO 9000, ISO 10795 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
design verification
evaluation of the implementation of the design (architecture, components) against the *requirements* (3.5) to determine that they can be met

Note 1 to entry: This is compliant with ISO 9001 verification.

3.2
product lifecycle
description of all stages of the product throughout its life starting from the expression of its need until the disposal, whatever the form is

3.3
product verification
evaluation of the implementation of the product against the *requirements* (3.5) to determine that they have been met

Note 1 to entry: This is compliant with ISO 9001 verification.

3.4
qualification
act or conduct by the supplier to provide evidences to prove that design, manufacturing (including manufacturing process) of hardware/software is adequate to fulfil all *requirements* (3.5) under required environment conditions

Note 1 to entry: This may be implemented by analysis, test, inspection, or demonstration.

[SOURCE: ISO 10795:2019, 3.183]

3.5
requirement
need or expectation that is stated, generally implied or obligatory

Note 1 to entry: "Generally implied" means that it is custom or common practice for the organization and interested parties, that the need or expectation under consideration is implied.

Note 2 to entry: A specified requirement is one that is stated, for example in documented information.

Note 3 to entry: A qualifier can be used to denote a specific type of requirement, e.g. product requirement, quality management requirement, customer requirement, quality requirement.

Note 4 to entry: Requirements can be generated by different interested parties or by the organization itself.

Note 5 to entry: It can be necessary for achieving high customer satisfaction to fulfil an expectation of a customer even if it is neither stated nor generally implied or obligatory.

Note 6 to entry: This constitutes one of the common terms and core definitions for ISO management system standards given in Annex SL of the Consolidated ISO Supplement to the ISO/IEC Directives, Part 1. The original definition has been modified by adding Notes 3 to 5 to entry.

[SOURCE: ISO 9000:2015, 3.6.4]

3.6
requirements baseline
set of *requirements* (3.5) that has been formally reviewed and agreed upon, that thereafter serves as the basis for further development, and that can be changed only through formal change control procedures

3.7
requirements management
RM
discipline that covers all the tasks that are performed to manage *requirements* (3.5), such as gathering, developing, organizing, tracing, analysing, reviewing, allocating, changing, and validating requirement objects, as well as managing documents and databases that contain them with the purpose of defining and delivering the right product or service

3.8
requirements management plan
RM plan
management plan which describes all the activities related to *requirements management* (3.7) for a specific project or programme that includes the *requirement* (3.5) cascading activity and the requirements management interaction with configuration management and functional analysis

Note 1 to entry: This plan describes the activities that need to be performed to support the verification and validation activities in order that the design and product can be verified against requirements.

3.9
requirement validation
set of activities to ensure that *requirements* (3.5) are correct and complete so that the product meets upper-level requirements and user needs

3.10
stakeholder
customer, user, person who will receive the goods or services and is the direct beneficiaries of the systems, or other interested party who affects or is affected by the project, providing overarching constraints within which the customers' needs should be achieved

[SOURCE: ISO 18676:2017, 3.9, modified — The definition has been editorial updated to define "stakeholder" in its singular form.]

3.11
systems engineering
interdisciplinary approach governing the total technical and managerial effort required to transform a set of *stakeholder* (3.10) needs, expectations, and constraints into a solution and to support that solution throughout its life

[SOURCE: ISO/IEC/IEEE 24748-1:2018, 3.57]

3.12
traceability
ability to trace the history, application or location of an object

Note 1 to entry: When considering a product or a service, traceability can relate to:

— the origin of materials and parts;

— the processing history;

— the distribution and location of the product or service after delivery.

Note 2 to entry: In the field of metrology, the definition in ISO/IEC Guide 99 is the accepted definition.

[SOURCE: ISO 9000:2015, 3.6.13]

4 Abbreviated terms

The following abbreviated terms are used in this document.

CM	configuration management
KPI	key performance indicators
PLM	product lifecycle management
RM	requirements management
ROI	return on investment
SE	systems engineering
SMART	specific, measurable, achievable, relevant, and traceable
TBC	to be confirmed
TBD	to be defined
V&V	validation and verification

5 Objective and scope of requirements management

5.1 Objective of requirements management

The objective of requirements management is to ensure that stakeholders' needs (customers, users, system's operating environment, trade and marketing, regulations, etc.) are understood, agreed upon, and realized (i.e. that the final design and the delivered products fulfil stakeholders' needs). The best opportunity for requirements management to influence a good outcome of the project is an early implementation. Greatest return on investment (ROI) of requirements management is if it is implemented early.

5.2 Scope and interfaces

5.2.1 Requirements management scope

a) Requirements management is a transversal activity that lasts for the whole product lifecycle. Requirements management shall be started as early as possible and shall be sustained through all the phases of the project, including

1) concept and definition,

2) design and development,

3) production,

4) support, and

5) disposal.

b) Requirements management is a discipline that shall be applied to all engineering domains. Requirements management shall, as a minimum, apply to technical requirements, although non-technical requirements may also be managed.

c) Requirements management covers the following high-level functional processes described in Clause 6:

1) capture the needs and develop the requirements;

2) allocate and flow down the requirements;

3) validate the requirements;

4) verify the design against the requirements;

5) verify the product against the requirements;

6) manage the requirement changes.

d) Requirements management is an essential part of systems engineering. It is strongly linked to all elements of systems engineering.

e) The major objects managed by requirements management are

1) "requirement" (object to be detailed with attributes such as stakeholder, source, rationale, identification, author, status, allocation to design, and statement of the verification method),

2) "links" (object to be detailed as the link between requirements, but also links from/to other objects enabling requirements management to reach its primary objective and ensuring that stakeholders' needs are understood and realized),

3) "input documents" (source documents or data that contain the requirements),

4) "output documents" (reports, compliance matrix, product verification matrix, traceability matrix, impact analysis, design documentation, and specification), and

5) "requirements baseline".

f) Requirements management needs to use other types of objects, but is usually not a master of the following objects in order to ensure efficiency:

1) "product breakdown structure", "configured items", and "functions", used to organize requirements and allocate them;

2) "analysis and trade items", used to make decisions on the requirement validation, for example objects "risk", "issue", "decisions", and "discussions", used to support requirements management processes;

3) "change management items", such as "change request" and "change order".

5.2.2 Interfaces and support for other disciplines

5.2.2.1 General

Requirements management interface with the following disciplines is based on an iterative data exchange throughout the project lifecycle. As a transversal activity, requirements management supports these disciplines as described in 5.2.2.2 to 5.2.2.7.

5.2.2.2 Monitoring quality of requirements

Metrics or key performance indicators (KPIs) shall be collected and analysed on a regular basis to measure quality of requirements and support the evaluation of the effectiveness of the requirements management process (see 8.4).

5.2.2.3 Support to design

Requirements management provides an input to the design team in terms of input requirements. Lower-level requirements will be derived as an output of the design effort. This is an iterative process where both sides shall be aware of the current development status.

5.2.2.4 Support to engineering

a) Requirements management enables the specification authors/engineers to create their documents with visibility of all the stakeholders' needs and design inputs and outputs. The specification authors/engineers will know what impact any requirement changes may have on other requirements, design elements, and verification requirements which are linked to each of the requirements in their specification.

b) Requirements management enables the product implementation to be traceable to customer needs.

5.2.2.5 Support to configuration management

a) Requirements management enables the implementation of a change in the requirements database in line with the change process and generates changes for consideration within the formal configuration management process. Requirements management may provide impact assessments of changes for input into the formal configuration management process.

b) Requirements management enables the relationship between the requirements, design, and product baselines to be maintained.

5.2.2.6 Support to verification team

a) Requirements management and verification shall be strongly integrated to enable close out and delivery of the product to the project.

b) Requirements management provides an input to the verification team to be integrated into the verification activities. The product verification activities include testing. Through the testing, it will be proved if the product complies with the customer requirements/user needs. Requirements management ensures that the requirements management database is maintained with the latest verification input.

5.2.2.7 Support to specialist domains

Requirements management provides the facilities to enable the specialists to identify, derive, and track their requirements. The main specialist domains are

— customer support,

— environmental engineering,

— manufacturing,

— marketing and sales,

— operations,

— procurement,

— qualification and certification,

— product assurance and quality assurance,

— software engineering,

— reliability,

— safety,

— supportability, and

— through-life support.

6 Requirements management overall process

6.1 General

The following describes the overall process of requirements management (RM).

a) The space systems to be developed include many levels of systems/subsystems/components which are described through the breakdown structure of the final product. Each system level is developed in accordance with its requirements which are defined by the upper level. The requirements are cascaded to the lowest level (part or module). These requirements have to be developed in order to address the needs of all identified customers (internal and external). The development of requirements is an iterative process that reproduces itself at each level of the product breakdown structure. As each customer need is developed into specific requirements, these are further developed by design activities into lower-level requirements.

b) 6.2 to 6.7 describe the individual activities of the overall requirements management (RM) process. A short description of the implementation of this process is given in Figure 1.

RM process flow			RM process description
Iterative requirements engineering phases	Assess	**1. Capture needs and develop requirements**	Identify, agree, and capture stakeholder needs. Translate needs into agreed requirements. Prioritize requirements. Examine new and changed requirements to assess impact.
	Allocate and link	**2. Allocate and flow down requirements**	Assign functional breakdown to requirements. Allocate the applicable customer requirements to next requirements level and design elements. Flow down each level requirements to next lower-level requirements when applicable for traceability purposes.
	Validate	**3. Validate requirements**	Check that each requirement is validated to be correct, complete, and consistent with all the related upper-level requirement. Enter method of verification and raise Request for Deviation and Change Request for disputed requirements.
	Incorporate design	**4. Verify design against requirements**	Reference or link to the part of the design that is/will be related to the requirement. Check that the design element satisfies the requirement. **Design Verification Matrix (DVM)** Assign verification method, level, and milestones for each requirement.
	Verify product	**5. Verify product against requirements**	Reference or link to the product that is/will be related to the requirement. Check that the product element satisfies the requirement. **Product Verification Matrix (PVM)** Assign verification method, level, and milestones for each requirement.
Maintenance phase	Maintain quality	**6. Manage requirements change**	Assess the impact of changes and maintain current version of requirements and linkage. **Change Impact Assessment**

Figure 1 — Good practice example of "Single iteration of requirements management process"

c) Figure 2 shows these activities within the context of the development hierarchy. The hierarchical level at which the manufacturing and development of products takes place is individual to each project and/or product. The requirements management process activities identified throughout Figure 1 can be conducted concurrently; this is only constrained, however, in the completion or 'closing out' of those activities. The completion of one activity shall not occur until the previous upper-level activity is completed. For example, at any development level, design verification should

not be 'closed out' until the requirements that were used as input to design against them have been validated.
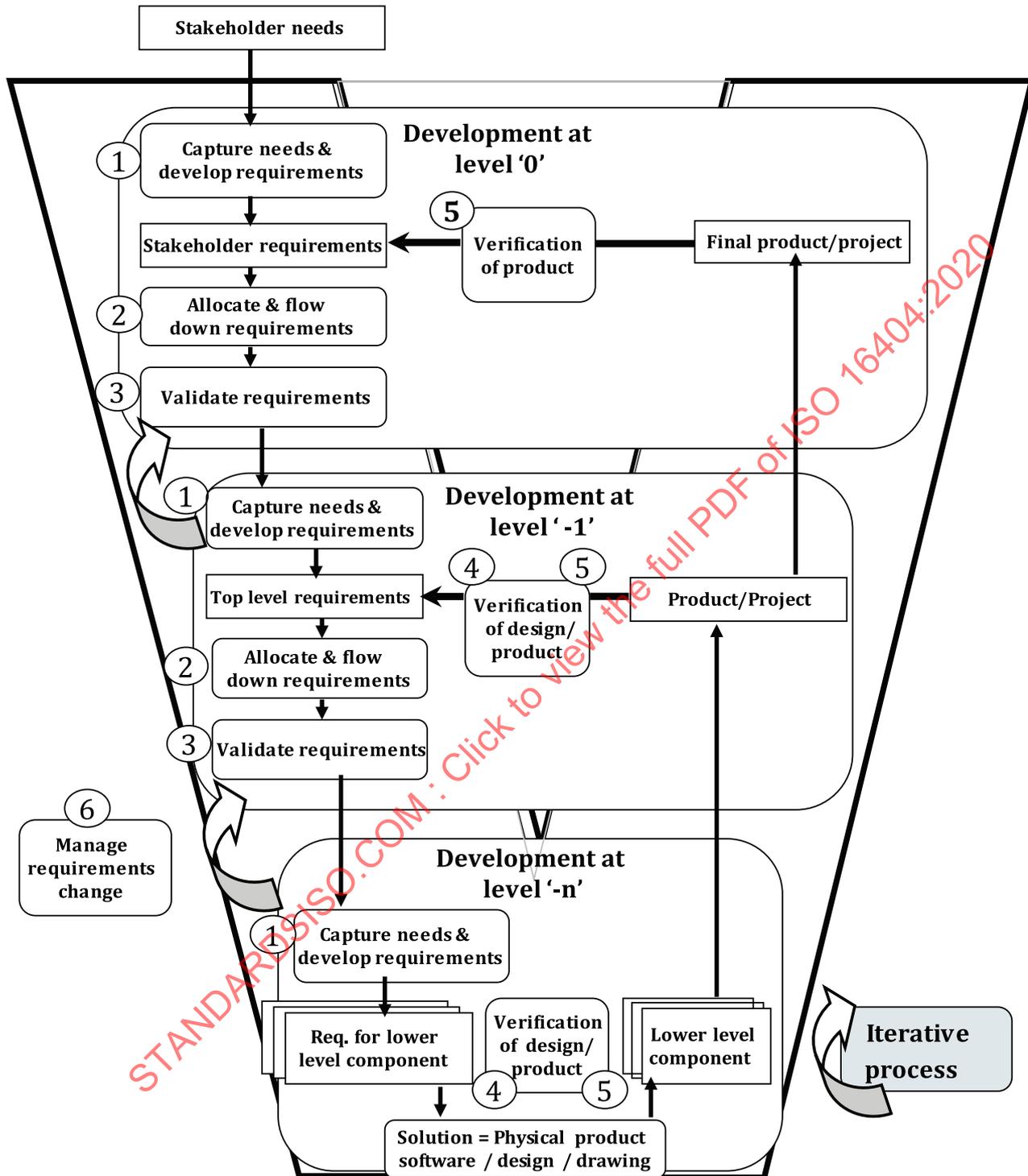
Figure 2 — Requirements management process activities in the "V-cycle" development model hierarchy

6.2   Capture needs and develop requirements

a)   Stakeholders' requirements (customers, users, system's operating environment, trade and marketing, regulations, etc.) shall be identified, captured, and analysed for their completeness, consistency, traceability, testability, and singularity. It shall be ensured that everyone understands

the requirements, has access to them, and commits to perform the work. Stakeholders' needs (including customers), expectations, constraints, and interface shall be translated into documented requirements (missing information obtained, conflicts identified, analysed, and resolved) and prioritized (rejected, altered, etc.).

b) The ownership for each requirement shall be defined. Each requirement shall have a clear owner who defines the flow down and ensures that it satisfies the higher and lower levels. The owner shall ensure that all mandatory attributes as defined in the requirements management plan shall be completed. This is an iterative process.

c) Requirements shall be assessed to verify that each specified requirements are:

1) unambiguous,

2) complete,

3) verifiable and concrete,

4) consistent with each other,

5) achievable,

6) expressing needs and not solutions,

7) appropriate for the level of requirement hierarchy, and

8) really needed.

6.3 Allocation and flow down requirements

Each requirement shall be allocated to at least one element of the product breakdown structure. A requirement may be allocated to one or many elements. Every lower-level requirement shall link or relate to the source of that requirement. This can be a higher-level requirement or a design element.

6.4 Validate requirements

Each requirement shall be validated to ensure that it is correct, complete, and consistent with all the upper-level requirements that it is related to.

6.5 Verify design against requirements

The design shall be verified to ensure that it satisfies the requirements. The design verification shall ensure that all requirements have been taken into account by the design.

6.6 Verify product against requirements

Configuration items (physical products, software, designs, drawings, etc.) being passed 'up' from one level to another shall be verified to ensure that they satisfy the respective requirements. There is a need to check that all requirements have been met and that the item satisfies the purpose it was designed for. This verification has to be performed at each level. At the highest level in the hierarchy, the final product shall be verified against the highest-level requirements/user needs. At any development level where multiple items are being integrated, there is a need for the verification activities to follow any integration sequence defined in the product/project integration plan.

6.7 Requirements change management

Any change in a requirement shall be documented and justified and an assessment shall be made of the impact of change and redesign utilizing requirements traceability throughout the lifecycle of the requirement. Requirements change management shall be considered in the context of the configuration

management of the product/project. Requirements change management is an embedded process within document change management.

7   Requirements management plan

7.1   General

Any company involved in a space project is advised to take into account the requirements stated in a quality management system standard.

At a given level, the supplier shall adapt the management requirements contracted with his own customer to his own suppliers. The customer shall consequently fulfil his own obligations towards the next higher level in accordance with ISO 14300-1. Requirements management (RM) is a subset of the quality management system of the stakeholder and the management requirements contracted between the customer and his own suppliers.

7.2   Functional and technical specifications

In ISO 21351, process guidelines for functional and technical specifications related to a product or a system are described. The format and the content of the functional and technical specifications shall be in accordance with ISO 21351.

7.3   Requirements management plan

a) In response to the project management specification as defined in ISO 14300-1, each concerned supplier prepares a project requirements management plan which contains descriptions of main activities, implementation methods, and general related organization to set up these activities.

b) The requirements manager shall develop and maintain the project requirements management plan. It is the responsibility of the project manager to ensure that the plan is introduced to the project team and applied by the team.

c) The template to use to define the requirements management plan is in Annex A. In Annex A, each single section shall contain a description of the purpose of what should be included in the plan and an example of 'good practice' from the divisions/business units.

d) The following are the rules to apply for programme/project RM plan implementation.

   1) Programme/project RM plan can be extended per project-specific needs.

   2) Programme/project RM plan can refer to other programme/project documentations, if the information already exists there.

   3) Sections of the RM plan may include all the details necessary for the implementation of the RM standard, but shall refer to other applicable documents, if they exist.

e) The requirements management plan defines the requirements management process, tool, roles and responsibilities, and methods to be applied to the related programme/project. The roles and responsibilities of teams and individuals within the programme to support requirements management will also be defined.

f) The requirements management plan

   1) provides an overview of the structure and the content of the plan,

   2) addresses the main topics, such as adaptation of standard requirements management data, model, process, and interfaces to other processes (i.e. configuration management and validation and verification), and

3) describes the project-specific environment, infrastructure, and tools supporting the process. The requirements management plan shall be applicable to all the requirements of the programme/project, including sub-contractors, etc.

g) The requirements management plan shall be developed at the earliest phase possible and shall be kept updated for the entire lifetime of the product defined by the project.

8 Rules for requirements management

8.1 General

The objective of this document is to deploy a high-value requirements management (RM) of all products based upon a common reference framework, enabling and facilitating collaboration between different stakeholders as well as cross programmes/projects.

Two categories of rules have been defined, the rules to be satisfied by each stakeholder for the implementation of requirements management activities and the rules for requirements management itself.

8.2 Rules for deployment of requirements management activities

The supplier shall ensure that the requirements management activities are deployed and implemented as defined in Table 1.

Table 1 — Mandatory rules for deployment of requirements management

Rules for deployment of requirements management activities	
Company/business level	
01	Each stakeholder shall ensure that requirements are managed for each pro-gramme/project in a correct and effective way.
02	A standard requirements management deployment method shall be defined and proposed for all new developments within each stakeholder.
03	A specific requirements management education and skill development plan shall be developed and applied at stakeholder level.
04	Each stakeholder shall establish and maintain a dedicated requirements management competence team to support all programmes/projects on all requirements management-related topics. In case no dedicated requirements management team is established, the requirements management function shall be assigned to a dedicated and competent member in every project.
05	Each stakeholder shall ensure that one RM toolset is available to all projects/products throughout the business.
06	Each stakeholder shall use the stakeholder recommended tool.
Programme/project level	
07	Each programme manager shall be informed of the benefits of requirements management and apply her/his stakeholder requirements management rules. Any intentional deviation from it shall be justified and documented within the requirements management plan.
08	Each programme shall identify a requirements management function and maintain it for the whole programme lifecycle.
09	A requirements management plan shall be documented and implemented for each programme/project.
10	Interfaces with other PLM tools and processes shall be defined for each pro-gramme/project.
11	Exchange of RM objects and related data between suppliers, industrial part-ners, and stakeholders shall be defined and implemented.