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Entwurf

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DIN EN 14514:2004-11,
DIN EN 14514
Berichtigung 1:2005-03 und
DIN EN 14607-7:2006-12

**Raumfahrttechnik –
Grundsätze und Verfahrensweise;
Englische Fassung prEN 16603-10:2016**

Space engineering –
System engineering general requirements;
English version prEN 16603-10:2016

Assurance produit spatiale –
Nettoyage profond des matériels de vol;
Version allemande prEN 16603-10:2016

Anwendungswarnvermerk

Dieser Norm-Entwurf mit Erscheinungsdatum 2016-08-12 wird der Öffentlichkeit zur Prüfung und Stellungnahme vorgelegt.

Weil die beabsichtigte Norm von der vorliegenden Fassung abweichen kann, ist die Anwendung dieses Entwurfs besonders zu vereinbaren.

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DIN-Normenausschuss Luft- und Raumfahrt (NL)

Nationales Vorwort

Dieses Dokument (prEN 16603-10:2016) wurde vom Technischen Komitee CEN/CLC/TC 5 „Raumfahrt“ erarbeitet, dessen Sekretariat vom DIN (Deutschland) gehalten wird.

Das zuständige deutsche Normungsgremium ist der Arbeitsausschuss NA 131-06-02 AA „Interoperabilität von Informations-, Kommunikations- und Navigationssystemen“ im DIN-Normenausschuss Luft- und Raumfahrt (NL).

Dieses Dokument (prEN 16603-10:2016) basiert auf ECSS-E-ST-10C Rev.1 DIR1.

Dieses Dokument wird DIN EN 13292:1999-06, DIN EN 14514:2004-11 und DIN EN 14607-7:2006-12 ersetzen.

Dieses Dokument enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die englische Originalfassung von prEN 16603-10:2016.

Dieses Dokument wurde speziell zur Behandlung von Raumfahrtsystemen erarbeitet und hat daher Vorrang vor jeglicher Europäischer Norm, die denselben Anwendungsbereich hat, jedoch über einen größeren Geltungsbereich (z. B. Luft- und Raumfahrt) verfügt.

Änderungen

Gegenüber DIN EN 13292:1999-06, DIN EN 14514:2004-11, DIN EN 14514 Berichtigung 1:2005-03 und DIN EN 14607-7:2006-12 wurden folgende Änderungen vorgenommen:

- a) Anforderungen zusammengeführt;
- b) Titel geändert;
- c) Normnummer geändert;
- d) Inhalt redaktionell überarbeitet.

Nationaler Anhang NA (informativ)

Begriffe und Abkürzungen

Die Benummerung der folgenden Begriffe und Abkürzungen ist identisch mit der Benummerung in der englischen Fassung.

3 Begriffe und Abkürzungen

3.1 Begriffe aus anderen Normen

Für die Anwendung dieses Dokuments gelten die Begriffe nach ECSS-S-ST-00-01 und insbesondere die folgenden Begriffe:

- 1) Abnahme
- 2) Zulassung
- 3) Bezugskonfiguration
- 4) kritisch
- 5) Entwicklung
- 6) Einrichtung
- 7) Inspektion
- 8) Integration
- 9) Produktbaum
- 10) Anforderung
- 11) Spezifikation
- 12) Subsystem
- 13) System
- 14) Test
- 15) Verifizierung

Für die Anwendung dieses Dokuments gelten die Begriffe nach ECSS-E-AS-11C und insbesondere die folgenden Begriffe:

- 16) Technologie-Reifegrad

3.2 Spezifische Begriffe dieser Norm

3.2.1

Rückverfolgbarkeit von Anforderungen

Attribut der Anforderung, welches jede einzelne Anforderung mit den übergeordneten Anforderungen innerhalb einer Anforderungsgruppe verknüpft

ANMERKUNG Dies ermöglicht die Ableitung eines Anforderungsbaumes, welcher den einheitlichen „Fluss“ der Anforderungen zeigt.

3.2.2

wiederkehrendes Produkt

Produkt, welches einer qualifizierten Konstruktion entspricht und in Übereinstimmung mit der entsprechenden Bestandsdatei für die Herstellung produziert wird

3.2.3

Systemengineering

interdisziplinärer Ansatz, welcher die Gesamtheit der technischen Bemühungen regelt, um eine Anforderung in eine Systemlösung umzuwandeln

ANMERKUNG Aus IEEE P1220.

3.2.4

Verifizierungsmatrix

erste Ausgabe des Verifizierungskontrolldokuments (en: verification control document), welches für jede zu verifizierende Anforderung die Verfahren, Ebenen und Phasen der Produktverifizierung enthält

ANMERKUNG Siehe ECSS-E-ST-10-02 für eine detailliertere Definition von VCD.

3.3 Abkürzungen

Für die Anwendung dieses Dokuments gelten die Abkürzungen nach ECSS-S-ST-00-01 und die folgenden:

Abkürzung	Bedeutung	
AIT	Montage, Integration und Prüfung	(en: assembly, integration and test)
AIV-Plan	Plan zur Montage, Integration und Verifizierung	(en: assembly, integration and verification plan)
AOCS	Subsystem zur Lage- und Bahnregelung	(en: attitude and orbit control sub-system)
AR	Abnahmebewertung	(en: acceptance review)
CDR	kritische Entwurfsprüfung	(en: critical design review)
COTS	handelsübliches Produkt	(en: commercial off-the-shelf)
CRR	Bewertung der Inbetriebnahmeergebnisse	(en: commissioning results review)
ANMERKUNG	Bei Raumfahrzeugen (z. B. Trägern, Raumtransportern, Besatzungstransportern) kann die CRR durch eine Flugqualifikationsbewertung oder FQR (en: flight qualification review) ersetzt oder ergänzt werden.	
DDF	Datei zur Festlegung der Konstruktion	(en: design definition file)

DDP	Konstruktionsentwicklungsplan	(en: design development plan)
DJF	Datei zur Begründung der Konstruktion	(en: design justification file)
DRD	Definition der Dokumentanforderungen	(en: document requirements definition)
ECSS	European Cooperation for Space Standardization	
ELR	Bericht am Ende der Gebrauchsdauer	(en: end-of-life review)
FDIR	Ausfall, Erkennung, Isolierung, Wiederherstellung	(en: failure, detection, isolation, recovery)
FM	Flugmodell	(en: flight model)
FMECA	Fehlermöglichkeits-, Einfluss- und Kritikalitäts-Analyse	(en: failure modes, effects, and criticality analysis)
FRR	Bewertung der Flugbereitschaft	(en: flight readiness review)
FTA	Analyse des Fehlerbaums	(en: fault tree analysis)
GSE	Bodendienstgerät	(en: ground support equipment)
ICD	Schnittstellenkontrolldokument	(en: interface control document)
ILS	integrierte Logistikunterstützung	(en: integrated logistic support)
IRD	Schnittstellenanforderungsdokument	(en: interface requirement document)
LRR	Bewertung der Startbereitschaft	(en: launch readiness review)
MCR	Missionsabschlussbewertung	(en: mission closed-out review)
MDD	Missionsbeschreibungsdokument	(en: mission description document)
MDR	Missionsdefinitionsbewertung	(en: mission definition review)
MOP	Missionsoperationsplan	(en: mission operations plan)
MS	Missionsziel	(en: mission statement)
ORR	Bewertung der Einsatzbereitschaft	(en: operational readiness review)
PDR	vorläufige Entwurfsprüfung	(en: preliminary design review)
PMP	Projektmanagementplan	(en: project management plan)
PRR	vorläufige Anforderungsbewertung	(en: preliminary requirement review)
PUM	Benutzerhandbuch des Produkts	(en: product user manual)
QR	Qualifikationsbewertung	(en: qualification review)

RAMS	Zuverlässigkeit, Verfügbarkeit, Instandhaltbarkeit, Sicherheit	(en: reliability, availability, maintainability, safety)
RF	Funkfrequenz	(en: radio frequency)
RJF	Datei zur Begründung der Anforderung	(en: requirement justification file)
ROD	Konstruktionsbewertung	(en: review of design)
ROM/RAM	Festwertspeicher/Arbeitsspeicher	(en: read only memory/random access memory)
RTM	Matrix zur Rückverfolgbarkeit der Anforderungen	(en: requirement traceability matrix)
R&D	Forschung und Entwicklung	(en: research and development)
SE	Systemengineering	(en: system engineering)
SEP	Systemengineeringplan	(en: system engineering plan)
SFT	Funktionsprüfung des Systems	(en: system functional test)
SRR	Bewertung der Systemanforderung	(en: system requirement review)
SVT	Systemvalidierungsprüfung	(en: system validation test)
TP	Technologieplan	(en: technology plan)
TRL	Technologie-Reifegrad	(en: technology readiness level)
TS	Spezifizierung technischer Anforderungen	(en: technical requirements specification)
UM	Benutzerhandbuch	(en: user manual)
VCD	Verifizierungskontrolldokument	(en: verification control document)
VP	Verifizierungsplan	(en: verification plan)
w.r.t.	bezüglich	(en: with respect to)

CEN/CLC/TC 5

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Foreword

This document (prEN 16603-10:2016) has been prepared by Technical Committee CEN/CLC/TC 5 “Space”, the secretariat of which is held by DIN (Germany).

This document (prEN 16603-10:2016) originates from ECSS-E-ST-10C Rev.1 DIR1.

This document is currently submitted to the CEN ENQUIRY.

This document will supersede EN 13292:1999, EN 14514:2004 and EN 14607-7:2004.

This document has been developed to cover specifically space systems and will therefore have precedence over any EN covering the same scope but with a wider domain of applicability (e.g.: aerospace).

1

Scope

This standard specifies the system engineering implementation requirements for space systems and space products development.

Specific objectives of this standard are:

- to implement the system engineering requirements to establish a firm technical basis and to minimize technical risk and cost for space systems and space products development;
- to specify the essential system engineering tasks, their objectives and outputs;
- to implement integration and control of engineering disciplines and lower level system engineering work;
- to implement the “customer-system-supplier model” through the development of systems and products for space applications.

Generally, System Engineering is a discipline that can find beneficial application to the development and production of a wide variety of systems and throughout the product decomposition hierarchy. However the requirements in this Standard were developed to be appropriate for application as they are to complex space systems and products only; for lower level elements tailoring is necessary. The pre-tailoring table in Section 7 contains the applicability of the requirements of this document and its annexes according to product type. Specific requirements related to system engineering, like technical specification, verification, and testing are specified in dedicated documents and standards within the set of ECSS system engineering standards ECSS-E-ST-10-XX.

Discipline or element specific engineering implementation requirements are covered in dedicated ECSS standards. These standards are based on the same principles, process and documentation model. The applicability of each these standards can therefore not be considered in isolation from the others.

NOTE 1 The term “Discipline” is defined in ECSS-M-ST-10, as “a specific area of expertise within a general subject”. The name of the discipline normally indicates the type of expertise, e.g. in the ECSS system mechanical engineering, software and communications are disciplines within the engineering domain.

NOTE 2 The requirements on the system engineering process are gathered in this standard; specific aspects of the SE process are further elaborated in dedicated standards.

This standard may be tailored for the specific characteristic and constraints of a space project in conformance with ECSS-S-ST-00.

2

Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revision of any of these publications do not apply, However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the more recent editions of the normative documents indicated below. For undated references, the latest edition of the publication referred to applies.

EN reference	Reference in text	Title
EN 16601-00-01	ECSS-S-ST-00-01	ECSS system - Glossary of terms
EN 16603-11	ECSS-E-AS-11	Adoption Notice of ISO 16290, Space systems - Definition of the Technology Readiness Levels (TRLs) and their criteria of assessment
EN 16603-10-02	ECSS-E-ST-10-02	Space engineering – Verification
EN 16603-10-06	ECSS-E-ST-10-06	Space engineering – Technical requirements specification
EN 16603-10-09	ECSS-E-ST-10-09	Space engineering – Reference coordinate system
EN 16603-10-24	ECSS-E-ST-10-24	Space engineering – Interface control
EN 16601-10	ECSS-M-ST-10	Space project management – Project planning and implementation
EN 16601-40	ECSS-M-ST-40	Space project management – Configuration and information management
EN 16602-20-10	ECSS-Q-ST-20-10	Off-the-shelf items utilization in space systems

Terms, definitions and abbreviated terms

3.1 Terms from other standards

- a. For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 apply, in particular for the following terms:
 - 1. acceptance
 - 2. approval
 - 3. configuration baseline
 - 4. critical
 - 5. development
 - 6. equipment
 - 7. inspection
 - 8. integration
 - 9. product tree
 - 10. requirement
 - 11. specification
 - 12. subsystem
 - 13. system
 - 14. test
 - 15. verification
- b. For the purpose of this Standard, the terms and definitions from ECSS-E-AS-11C apply, in particular for the following terms:
 - 1. technology readiness level

3.2 Terms specific to the present standard

3.2.1 requirement traceability

requirement attribute that links each single requirement to its higher level requirements inside the requirement set

NOTE This enables the derivation of a requirement tree, which demonstrates the coherent flow-down of the requirements.

3.2.2 recurring product

product which conforms to a qualified design and is produced according to the corresponding production master file

3.2.3 system engineering

interdisciplinary approach governing the total technical effort required to transform a requirement into a system solution

NOTE From IEEE P1220.

3.2.4 verification matrix

initial issue of the VCD which contains for each requirement to be verified the methods, levels and stages of product verification

NOTE See ECSS-E-ST-10-02 for a more detailed definition of the VCD.

3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-S-ST-00-01 and the following apply:

Abbreviation	Meaning
---------------------	----------------

AIT	assembly, integration and test
------------	--------------------------------

AIV plan	assembly, integration and verification plan
-----------------	---

AOCS	attitude and orbit control sub-system
-------------	---------------------------------------

AR	acceptance review
-----------	-------------------

CDR	critical design review
------------	------------------------

COTS	commercial off-the-shelf
-------------	--------------------------

CRR	commissioning results review
------------	------------------------------

NOTE For space vehicles (e.g. launcher, transfer vehicle, crew transport vehicle) the CRR can be replaced or complemented by a flight qualification review (FQR).

DDF	design definition file
------------	------------------------

DDP	design development plan
------------	-------------------------

DJF	design justification file
------------	---------------------------

DRD	document requirements definition
------------	----------------------------------

ECSS	European Cooperation for Space Standardization
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ELR	end-of-life review
------------	--------------------

FDIR	failure, detection, isolation, recovery
FM	flight model
FMECA	failure modes, effects, and criticality analysis
FRR	flight readiness review
FTA	fault tree analysis
GSE	ground support equipment
ICD	interface control document
ILS	integrated logistic support
IRD	interface requirement document
LRR	launch readiness review
MCR	mission closed-out review
MDD	mission description document
MDR	mission definition review
MOP	mission operations plan
MS	mission statement
ORR	operational readiness review
PDR	preliminary design review
PMP	project management plan
PRR	preliminary requirement review
PUM	product user manual
QR	qualification review
RAMS	reliability, availability, maintainability, safety
RF	radio frequency
RJF	requirement justification file
ROD	review of design
ROM/RAM	read only memory / random access memory
RTM	requirement traceability matrix
R&D	research and development
SE	system engineering
SEP	system engineering plan
SFT	system functional test
SRR	system requirement review
SVT	system validation test
TP	technology plan
TRL	technology readiness level
TS	technical requirements specification
UM	user manual

VCD	verification control document
VP	verification plan
w.r.t.	with respect to

Overview of system engineering

4.1 The system engineering discipline

System engineering is defined as an interdisciplinary approach governing the total technical effort to transform requirements into a system solution.

A system is defined as an integrated set of elements to accomplish a defined objective. These elements include hardware, software, firmware, human resources, information, techniques, facilities services, and other support elements.

In this standard the concept of “system” is used in a wide sense. The highest level, often called “mission level” or “space system”, consists usually of one (or more) space segment(s), of a ground segment, and of a user segment. Elements of system decomposition are also considered a system. For the purpose of this standard the system can be any element at any level of decomposition as defined by the function tree (see Annex H) or the product tree (see ECSS-M-ST-10 Annex B). The scope of an element can include hardware, software, procedures, man-in-the-loop, facilities and services.

From the perspective of the considered system, requirements originate from the next upper level (the customer) and elements are procured from the next lower level (the suppliers).

NOTE 1 The customer-supplier model is described in ECSS-S-ST-00.

NOTE 2 Through this standard the notion of customer refers to several actors, in relation to the project phase. In fact a customer can be e.g. a scientific community in phase 0, a commercial user in phase A or an Agency in phase B. A supplier can on the other hand be an Agency in both phase 0 and phase A.

Figure 4-1 shows the boundaries of system engineering, its relationship with production, operations, product assurance and management disciplines and its internal partition into the following system engineering sub-functions:

- requirement engineering, which consist on requirement analysis and validation, requirement allocation, and requirement maintenance;
- analysis, which is performed for the purpose of resolving requirements conflicts, decomposing and allocating requirements during functional analysis, assessing system effectiveness (including analysing risk factors);

and complementing testing evaluation and providing trade studies for assessing effectiveness, risk, cost and planning;

- design and configuration which results in a physical architecture, and its complete system functional, physical and software characteristics;
- verification, which objective is to demonstrate that the deliverables conform to the specified requirements, including qualification and acceptance;
- system engineering integration and control, coordinating the various engineering disciplines and participants throughout all the project phases.

Figure 4-2 shows system engineering sub-functions, their inter-relationships and their main activities during the system engineering process.

System engineering sub-functions are applied in an iterative mode during implementation of the system engineering process described in clause 4.2.

Within the frame of a project, the system engineering function is generally implemented by a system engineering organisation of the supplier which is in charge of transforming the requirements of the customer into a system solution delivered by the supplier. For the purpose of this standard, the '*system engineering function*' only is referred to in the normative statements, independent of whether the supplier has a formal 'system engineering organisation' or not.

NOTE With respect to the next lower level, the supplier plays the role of the customer.

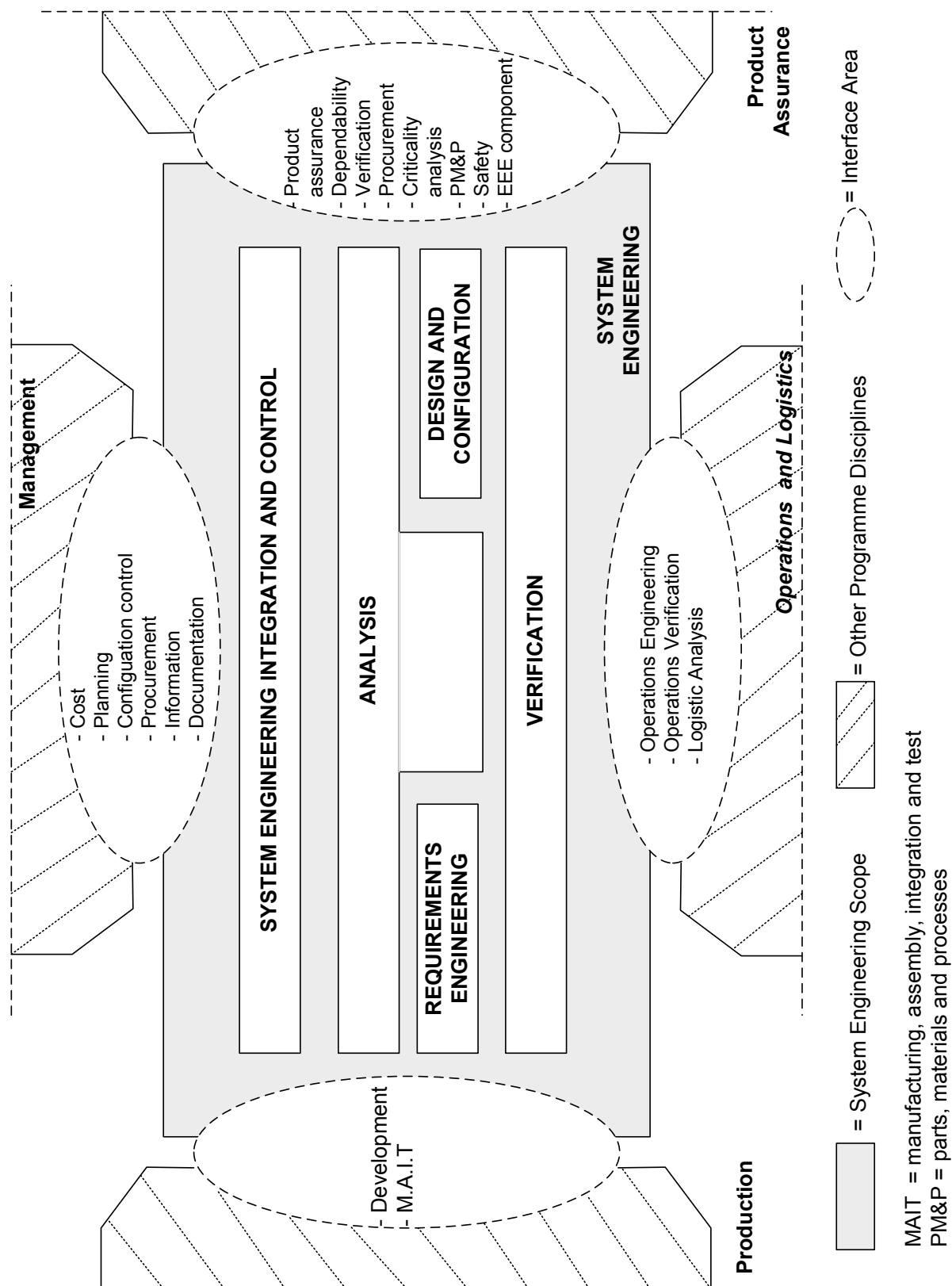


Figure 4-1: System engineering, sub-functions and boundaries

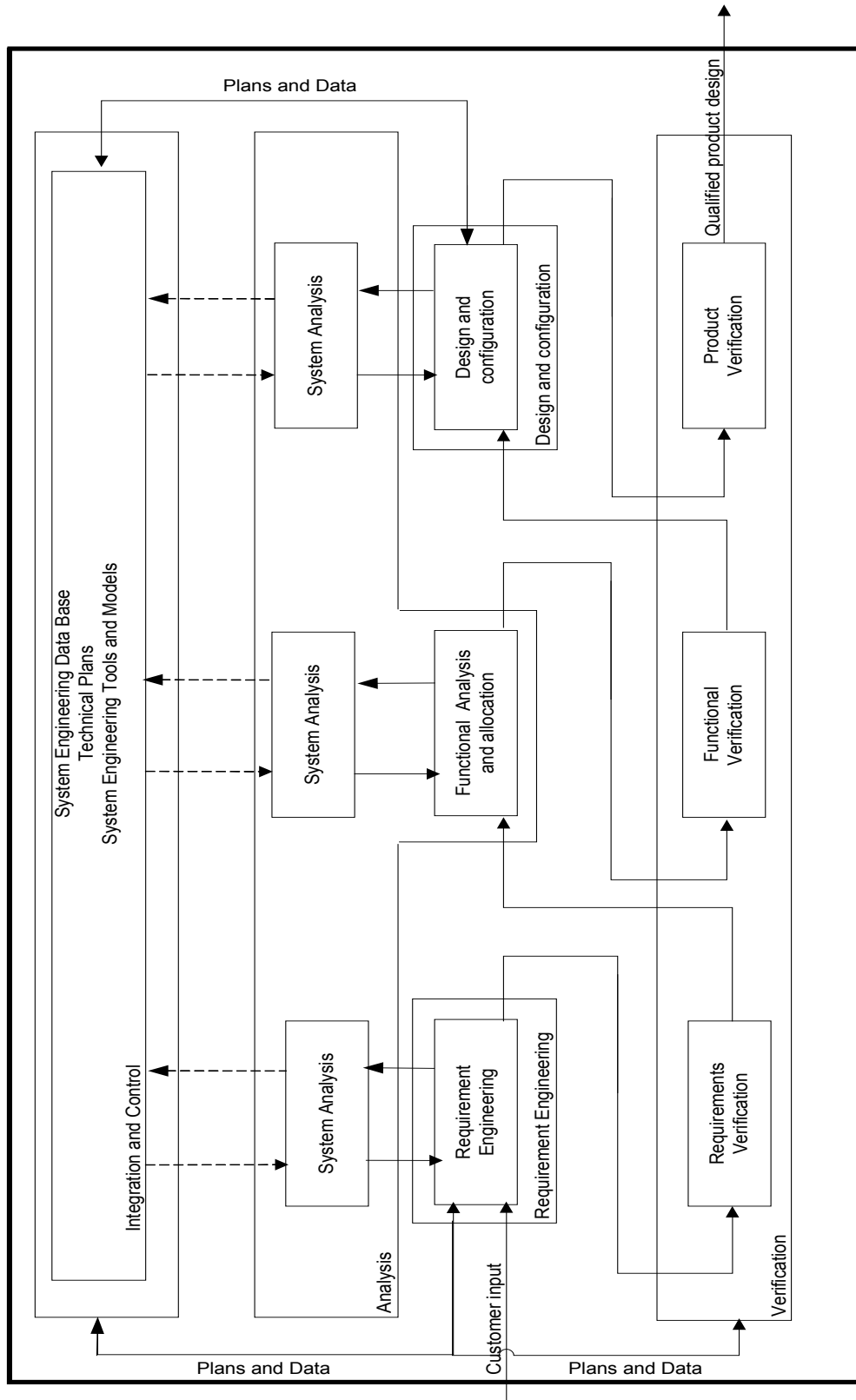


Figure 4-2: System engineering sub-functions inter-relationships

4.2 The system engineering process

The system engineering activities of a project are conducted by an entity or resources within the project team of a supplier. This entity or the resources that perform this function is called in this document “system engineering function”. The system engineering process is in turn applied by each system engineering function of each supplier of the elements of the product decomposition.

The system engineering process consists of activities to be performed by the system engineering function within each project phase. The objective is to obtain a product which satisfies the customer technical requirements within pre-established objectives of cost and time. The requirements for these activities are described in clause 5.

The system engineering process is intrinsically iterative across the whole life of a project, in particular in the initial phases (i.e. 0, A, and B) of the development of a complex system (e.g. a spacecraft), procured through a multi-layered set of suppliers.

During these phases, the system engineering function derives design oriented technical solutions using as an input to the design-independent customer requirements contained in a technical requirements specification (TS). This is achieved through an iterative top-down process by trading off several design solutions at an increasing level of detail.

NOTE For definition and requirements for a technical requirements specification see ECSS-E-ST-10-06.

Through this process the system engineering function performs a multidisciplinary functional decomposition to obtain logical lower level products (both hardware and software). At the same time the system engineering function decides on balanced allocations, throughout the system, of resources allocated by the customer and respects agreed margin philosophies as a function of the relevant technology readiness levels.

The functional decomposition defines, for each level of the system, the technical requirements for the procurement of subassemblies or lower level products as well as the requirements for the verification of the final characteristics of each product.

The system engineering process uses the results of these lower level verification activities to build a bottom-up multi-layered evidence that the customer requirements have been met.

The system engineering process is applied with various degrees of depth depending on the level of maturity of the product (e.g. new development or off-the-shelf).

The system engineering process can be applied with different level of tailoring as agreed between customer and supplier in their business agreement.

The system engineering function has interfaces with those other functions in charge of management, product assurance, engineering disciplines, production, and operations and logistics.

NOTE The project phases are defined in ECSS-M-ST-10.

4.3 Overview of system engineering tasks per project phase

4.3.1 Overview

The allocation of specific system engineering requirements per phase depends strongly on the type of business agreement established between customer and supplier and the nature and level of complexity of the system subject of the agreement. The breakdown and the details of the tasks are defined in the business agreement specific documents.

NOTE Some projects define them in a Statement of work (SoW).

The actors in the customer-supplier relationship change between phases and across levels. In the following clauses each system engineering organisation is meant to be the supplier's system engineering organisation during that phase.

4.3.2 General

- a. The system engineering function plans its activities in conformance with the project phases as defined in the Project Management Plan in accordance with ECSS-M-ST-10.

NOTE The phases or combination thereof to be implemented for a project are specified in the business agreement.

- b. The system engineering function monitors the execution of all system engineering activities including lower levels.
- c. The system engineering function identifies the critical items.
- d. The system engineering function ensures that for critical items the technical requirements specification, the design definition file and the design justification file are available at latest by end of Phase B .

NOTE Information regarding the expected delivery of system engineering documents for each project review is provided in 7.

The documents to be approved by the customer as well as the time of their approval are listed in the business agreement.

4.3.3 Phase 0 Overview: Mission analysis-need identification

- a. For Phase 0, the system engineering function
 - 1. supports the identification of customer needs.
 - 2. proposes possible system concepts.

3. supports the MDR and ensures implementation of the MDR actions.
4. performs an analysis of the Mission Statement document, and integrates this analysis and any relevant contribution from lower level suppliers in to a Mission Description document(s) in conformance with Annex B, and maintains this latter document for the final selected concept.
5. proposes the requirements against the expressed user needs for agreement with the customer.

NOTE Mission Statement captures the declared “user needs”.

4.3.4 Phase A Overview: Feasibility

- a. For Phase A, the system engineering function
 1. finalises the expression of the needs identified in Phase 0.
 2. proposes system solutions (including identification of critical items and risks) to meet the customer needs.
 3. supports the PRR and ensure implementation of PRR actions.
 4. finalises the validation of the requirements against the expressed needs together with the customer.

NOTE Mission Statement captures the declared “user needs”.

4.3.5 Phase B Overview: Preliminary definition

- a. For Phase B, the system engineering function
 1. establishes the system preliminary definition for the system solution selected at end of Phase A.
 2. demonstrates that the solution meets the technical requirements according to the schedule, the budget, the target cost and the customer requirements.
 3. supports the SRR and PDR, and ensuring implementation of the SRR and PDR actions.

4.3.6 Phase C Overview: Detailed definition

- a. For Phase C, the system engineering function
 1. establishes the system detailed definition.
 2. demonstrates the capability to meet the technical requirements of the system technical requirements specification.
 3. supports the CDR and ensures implementation of the CDR actions.

4.3.7 Phase D Overview : Qualification and production

- a. For Phase D, the system engineering function
 - 1. finalizes the development of the system by qualification and acceptance.
 - 2. finalizes the preparation for operations and utilization.
 - 3. supports QR and AR and ensures implementation of the QR and AR actions.

4.3.8 Phase E Overview: Operations / utilization

- a. For Phase E, the system engineering function
 - 1. supports the launch campaign.
 - 2. supports the entity in charge of the operations and utilization following the terms of a business agreement.
 - 3. supports the FRR, ORR, LRR, CRR, ELR, and recurring products AR, and ensure implementation of the actions of those reviews.
 - 4. supports the execution of all system engineering activities and provision of documents in support to anomaly investigations and resolutions.

NOTE Phase E and its reviews as presented in Table A-1 refer only to mission level. In case of lower level product, activities to be considered by the system engineering function are only related to maintenance and anomaly investigations.

4.3.9 Phase F Overview: Disposal

- a. For Phase F, the system engineering function
 - 1. supports the entity in charge of the disposal following the terms of a business agreement.
 - 2. supports the MCR and ensure implementation of the actions of the MCR.

NOTE Phase F and its review as presented in Table A-1 refer only to mission level. In case of lower level product, activities to be considered by the system engineering function are only related to disposal.

General requirements

5.1 System engineering plan

- a. The system engineering function shall produce and maintain a system engineering plan (SEP) in conformance with Annex D.

NOTE The system engineering function establishes the SEP with the contributions and constraints of management, product assurance, engineering disciplines, production, and operations and logistics.

- b. <<deleted and moved modified as Note to 5.1a>>

- c. The SEP shall take consideration of the lower level plans, ensure consistency between these plans, and, be consistent with these plans.

NOTE 1 The early version of the Project Management Plan (PMP), which includes the early version of the SEP, contains all the information which was traditionally contained in the Design and Development Plan (DDP). See Annex R which illustrates the mapping between a typical DDP and ECSS DRDs.

NOTE 2 The SEP content evolves with the phase of the project, with more information on risk analysis and new technologies in early phases 0, A and B, and more information on verification and validation aspects in phases C, D.

NOTE 3 The SEP can be considered a collection of documents delivered over the life-cycle as illustrated in Table A-1.

NOTE 4 No SEP lower than equipment/unit.

- d. The system engineering function shall support the project manager in the project reviews as defined in the Project Management Plan in accordance with ECSS-M-ST-10.

5.2 Requirement engineering

5.2.1 General

- a. The system engineering function shall analyse the requirements for the system issued by the customer.

NOTE 1 This analysis enables the transformation of customer requirements into the supplier's system solution.

NOTE 2 The level of the required analysis and form of any deliverable is expressed in the business agreement.

- b. The system engineering function shall derive, generate, control and maintain the set of requirements for the lower level elements, defining their design and operational constraints and the parameters of functionality, performance, and verification necessary to meet the system requirements issued by the customer.

- c. The system engineering function shall ensure consistency of the requirements at system level, at lower levels, as well as amongst levels.

NOTE Consistency of requirements of different system engineering sub-functions at the same level is the responsibility of the higher level system engineering function.

- d. The system engineering function shall ensure requirements generated in 5.2.1b. are in conformance with characteristics specified in ECSS-E-ST-10-06 clause 8.

NOTE <<deleted>>

- e. The system engineering function shall ensure that each requirement for the lower level elements has a justification reflected in the requirement justification file in conformance with Annex O.

NOTE Tailoring of a standard in a list of applicable standards, or of a requirement in an applicable standard, is possible where each tailoring measure is duly justified.

5.2.2 Requirement traceability

- a. The system engineering function shall ensure forward and backward traceability of all requirements:

1. to their sources;
2. to the lower level requirements, if existing;
3. to changes in the design inducing modifications of the requirements;
4. to their verification close-out.

NOTE to item 1: Examples for sources: a higher level requirement, an imposed management constraint, an applicable standard or an accepted lower level constraint.

- b. The system engineering function shall establish and maintain the requirements traceability matrix in conformance with Annex N.
- c. The system engineering function shall ensure that the requirement close-out traceability is documented in the VCD in conformance with ECSS-E-ST-10-02 Annex B.

5.2.3 Requirement engineering process

5.2.3.1 Technical requirements specifications

- a. The system engineering function shall establish technical requirements specifications of the next lower level products consistent among them and with the technical specification received from the customer.
- b. The system engineering function shall ensure that the technical requirements specifications it establishes conform to ECSS-E-ST-10-06 and its DRD in Annex A.
- c. The system engineering function shall establish a specification tree in conformance with Annex J.

NOTE 1 Requirements common to more than one lower level product can be gathered in “common” technical specifications called “support specifications” (e.g. GDIR “General Design and Interface Requirements”, environmental, test, EMC requirements specifications).

NOTE 2 Requirements for equipment level products (or lower level products) can be issued in self-contained specifications.

- d. <<deleted>>

5.2.3.2 Requirement consolidation

- a. The system engineering function shall consolidate requirements by identifying and resolving incomplete, duplicate, ambiguous, and contradictory requirements, including with the customer for customer-issued requirements.
- b. The system engineering function shall reflect the consolidated requirements in the release of the technical specifications.

5.2.3.3 Requirement risk analysis

- a. <<deleted>>
- b. The system engineering function shall perform the requirements analysis to identify impacts on system risks.

- c. As part of the risk management process implemented on the project, the system engineering function shall report the requirement impacts on the system risk.

NOTE ECSS-M-ST-80 Annex E describes the risk reporting process.

5.2.3.4 Requirements verification methods

- a. The system engineering function shall ensure that for each requirement contained in the technical requirements specification, one or a combination of verification methods are identified.

NOTE Technical requirements specification is defined in ECSS-E-ST-10-06 Annex A.

- b. The system engineering function shall ensure that for each requirement contained in the technical requirements specification, the verification methods are reflected in the verification matrix.

NOTE Technical requirements specification is defined in ECSS-E-ST-10-06 Annex A.

5.2.3.5 Requirement allocation

- a. The system engineering function shall ensure that the system requirements and their verification methods are allocated to lower levels and included in the specifications of the related products.

5.2.3.6 Requirements consistency

- a. <<deleted>>.
- b. <<deleted>>

5.2.3.7 Requirements agreement

- a. In phase 0 the system engineering function shall propose requirements in response to the expressed user needs, for agreement with the customer.

NOTE User needs are expressed in the Mission Statement document.

5.2.3.8 Requirements maintenance

- a. The system engineering function shall ensure that agreed changes to requirements are applied to and maintained in system and lower level specifications.
- b. <<deleted>>.

5.2.3.9 Requirements baseline

- a. The system engineering function shall establish the list of documents constituting the system requirements baselines in contribution to the configuration baselines.

NOTE Details on configuration baselines are provided in ECSS-M-ST-40.

5.3 Analysis

5.3.1 System analysis

- a. In phase 0 the system engineering function shall perform an analysis of the Mission Statement document, produce Mission Description document(s) in conformance with Annex B, and maintain this latter document for the final selected concept.
- b. The system engineering function shall perform a functional analysis, produce the functional architecture, and produce the function tree which satisfy the customer technical requirements specification, in conformance with Annex H.
- c. The system engineering function shall document the functional architecture in the design definition file (DDF) in conformance with Annex G.
- d. The system engineering function shall justify the functional architecture in the DJF in conformance with Annex K.
- e. The system engineering function shall perform a physical analysis, produce the physical architecture and produce the product tree in conformance with ECSS-M-ST-10 Annex B.
- f. The system engineering function shall document the physical architecture in the DDF in conformance with Annex G.
- g. The system engineering function shall justify the physical architecture in the DJF in conformance with Annex K.
- h. The system engineering function shall analyse the performance of the system, including end-to-end evaluation, documenting the results of the analysis in the Design Justification File in conformance with Annex K.
- i. The system engineering function shall analyse the influence of mission, design, development, operations and constraints on cost and schedule as an input to the project cost and schedule consolidation and to the utilisation recurring cost
- j. The system engineering function shall document analysis that it performs in an analysis report.

NOTE An example of analysis report is given in Annex Q.

5.3.2 System environments and design and test factors

- a. The system engineering function shall establish the influence of all types of environments applied during each life profile event on system and its elements in terms of nominal and extreme environmental conditions including all applicable operational phases.
- b. The system engineering function shall establish the criteria for qualification and acceptance in conformance with Annex K of system and system elements for all types of environment.
- c. The system engineering function shall ensure that analyses include design induced effects between system components or the system and its external environment and account for analysis uncertainties, in conformance with Annex K.
- d. The system engineering function shall establish the design and test factors and margins applicable for design in conformance with Annex K.

NOTE 1 Design factors are factors applied to specified loads to ensure robustness of the design.

NOTE 2 Test factors are factors applied to specified loads to demonstrate margins w.r.t. these loads (e.g. qualification / acceptance factors).

- e. The system engineering function shall establish test environment conditions for product verification in test specifications.

5.3.3 Trade-off analyses

- a. The system engineering function shall conduct or consolidate trade-off analyses to:
 - 1. assist in selecting system concepts, designs and solutions (including people, parts and materials availability);
 - 2. support material selection and process decisions;
 - 3. support make-or-buy and supplier selection;
 - 4. examine alternative technologies to satisfy functional and design requirements;
 - 5. evaluate environmental and cost impacts of materials and processes;
 - 6. evaluate alternative physical architectures to select preferred products and processes;
 - 7. establish the system and its configuration items;
 - 8. analyze planning critical paths and propose alternatives;
 - 9. select standard components, techniques, services and facilities that reduce system life-cycle cost;

10. establish model and product verification philosophy for achieving qualification and acceptance objectives while considering testability;
 11. assess design capacity to evolve.
- b. The system engineering function shall evaluate alternative concepts, designs and solutions against each other in a Trade-off report in conformance with Annex L.
 - c. The system engineering function shall document alternative system concepts considered during system trade-off studies in a System Concept Report in conformance with Annex C.

5.3.4 Analysis methods, tools and models

- a. The system engineering function shall define the analysis methods and tools to be used during the product life cycle, as well as the related models and data exchanges between the tools, and document these in the SEP in conformance with Annex D.
- b. The system engineering function shall ensure that analysis tools are validated.
- c. The system engineering function shall ensure that analysis tools are maintained.
- d. The system engineering function shall ensure that analysis tools are capable of exchanging and using models and data where agreed by customer and supplier.

NOTE 1 For exchange of models and data, see ECSS-E-TM-10-20 and ECSS-E-TM-10-21.

NOTE 2 Exchange can be either direct or via interfaces.

- e. The system engineering function shall ensure that analysis tools are capable of transferring models and data for multi-disciplinary analysis where agreed by customer and supplier.

NOTE 1 Details on product data exchange and system modelling and simulation are provided in ECSS-E-TM-10-20 and ECSS-E-TM-10-21.

NOTE 2 Exchange can be either direct or via interfaces.

- f. The system engineering function shall ensure that models produced by analysis tools are validated based on documented procedures and results.
- g. The system engineering function shall ensure that modelling and test accuracy as well as limitations are considered (as part of Annex K) when establishing the performances and specifying environmental conditions for product verification.
- h. The system engineering function shall ensure that models are kept operational in accordance with the terms of the business agreement.

5.4 Design and configuration

5.4.1 Design

5.4.1.1 General

- a. The system engineering function shall establish a design of the system from its functional architecture, requirement allocation, and technology selection.

NOTE This includes definition of the interfaces and corresponding ICDs.

- b. The system engineering function shall ensure that the design addresses system aspects, covering its whole lifecycle, producing the physical architecture documented in conformance with Annex G and the product tree in conformance with ECSS-M-ST-10 Annex B.
- c. The system engineering function shall take into account the outcome of the design and verification activities of the lower level products.
- d. The system engineering function shall ensure that the design covers hardware, software, and human-in-the-loop (HITL).
- e. The system engineering function shall ensure that the design is supported by analyses consistent with the level of maturity of the design.
- f. The system engineering function shall coordinate with all entities for design data exchange..

NOTE This relates to coordination between the various entities given in Figure 4-1.

5.4.1.2 Technical budgets and margin policy

- a. The system engineering function shall define, control and maintain all technical budgets of the system in conformance with Annex I in terms of target, current status and their trends.
- b. The system engineering function shall apportion and control budget requirements to all levels of system decomposition.
- c. The system engineering function shall define and apply the margin policy agreed between customer and supplier in compliance with Annex D.2.1<4.2>b.5.

NOTE The system margin policy is defined in the SEP.

5.4.1.3 Design methods, tools and models

- a. The system engineering function shall define the design methods, tools and related models to be used during the product life cycle and document them in the SEP.
- b. The system engineering function shall ensure that design tools are validated and maintained.

- c. The system engineering function shall ensure that design tools are capable of exchanging and using design models and data where agreed by the customer and supplier.
- d. The system engineering function shall ensure that models are kept operational in accordance with the business agreements.
- e. The system engineering function shall ensure that design models produced by design tools are validated.
- f. The system engineering function shall ensure that all design models are defined in accordance with the Coordinate System Document with transformation methods as defined in ECSS-E-ST-10-09.

NOTE Coordinate system document is delivered as part of the SEP.

5.4.1.4 Design files

- a. The system engineering function shall establish and maintain a design definition file in conformance with Annex G.
- b. The system engineering function shall establish and maintain a design justification file in conformance with Annex K.
- c. The system engineering function shall establish and maintain a product user's manual (PUM) or user's manual (UM) in conformance with Annex P.

NOTE In case the product considered is a space segment, the Space Segment User Manual defined in ECSS-E-ST-70 Annex E is generated with support of the system engineering function.

5.4.2 Configuration

5.4.2.1 Configuration content

- a. The system engineering function shall ensure that the configuration includes the system functional, physical and software characteristics, budgets, and, internal and external interfaces.
- b. The system engineering function shall ensure that the configuration includes lower decomposition levels.
- c. The system engineering function shall ensure that the configuration is documented in the DDF and in configuration definition documents.

NOTE Details on configuration definition documents are provided in ECSS-M-ST-40.

5.4.2.2 Configuration baselines

- a. The system engineering function shall establish the system configuration baselines to be placed under control at defined project milestones.

NOTE Details on system configuration baselines are provided in ECSS-M-ST-40.

5.4.2.3 Configuration assembly constraints

- a. The system engineering function shall define and document the hierarchy and assembly sequence of the system elements in line with the physical architecture.
- b. <<deleted and incorporated in 5.4.2.3a.>>.

5.5 Verification

5.5.1 General

- a. The system engineering function shall define the Verification Plan in accordance with ECSS-E-ST-10-02 Annex A and coordinate the product verification accordingly..

5.5.2 Product verification

- a. <<deleted, covered by 5.5.2c.>>.
- b. The system engineering function shall assign the product to a verification product category, as defined in ECSS-E-ST-10-02 Table 5-1.
- c. The system engineering function shall specify the configuration and environment conditions for product verification and the criteria for its qualification and acceptance.
- d. The system engineering function shall confirm that all product verification objectives are achieved by analysing the results of the verification activities.

NOTE This includes analysis of Verification Control Document and its closeout documents, as defined in ECSS-E-ST-10-02 Annex B.

- e. <<deleted>>
- f. The system engineering function shall ensure that the verification covers the complete product including hardware, software, human-in-the-loop (HITL), operations and representative mission scenarios (including pre-launch, launch and early orbit, in-orbit, post-landing, or other mission scenario).

NOTE 1 The testing performed during and at the end of the integration of a system is defined as System Functional Test (SFT).

NOTE 2 For system composed of different segments (e.g. space segment, ground segment), the testing performed to ensure operability and functionality of the complete system is defined as System Validation Test (SVT).

NOTE 3 System validation is performed against user needs and is typically performed under customer authority, with supplier involvement as detailed in the business agreement.

5.6 System engineering integration and control

5.6.1 Management of system engineering activities

- a. The system engineering function shall implement the SEP including quantification of this effort as input to management.
- b. <<deleted>>
- c. <<deleted>>
- d. <<deleted>>
- e. <<deleted, covered by 5.6.1a>>.
- f. The system engineering function shall ensure that all engineering changes, dispositions and decisions are provided to project configuration control in accordance with the Configuration Management Plan.
- g. The system engineering function shall ensure that the experience gained in past and in parallel activities is systematically considered and support project management in the collection of experience gained for future use.

5.6.2 Planning

- a. The system engineering function shall ensure that the SEP is consistent with the project schedule logic.

NOTE Details on the project schedule content are provided in ECSS-M-ST-60, in particular the DRD Annex B.

5.6.3 Engineering data

- a. The system engineering function shall define the engineering data to be stored in a data repository.
- b. The system engineering function shall ensure that engineering data can be exchanged in electronic form between the different organizations in charge of the elements of the product decomposition levels via agreed and validated interfaces.
- c. The system engineering function shall ensure the timely availability of engineering data which enable the system to be designed, produced, tested, delivered, operated, maintained, and disposed of.