DOCUMENT

ESA standardization guide for SMEs

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Introduction and organization of the guide

This document is released for general guidance purpose only, and therefore is not meant to take any precedence on applicable project requirements, documents and definitions.

This aim of this document is to get the unfamiliarised user aware of the ESA Space Standardization System by providing information at different levels, as shown in Figure 1-1
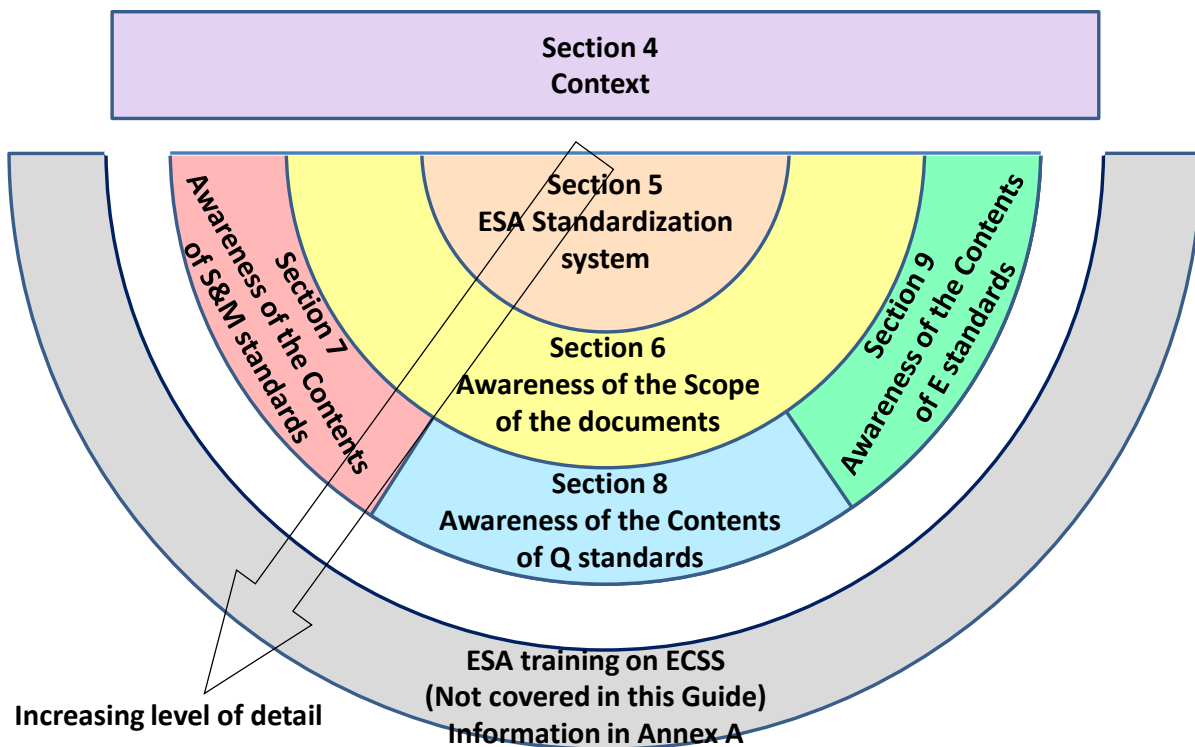
Figure 1-1: Organization of the present document

The following levels of information are provided:

- Section 4 Clarifies **the context** of the use of the standards and requirements made applicable in ESA space projects by virtue of a contract.

- Describing the ESA Space Standardization documentation itself, at three levels of detail:

  — At the first level, Section 5 gives a general explanation of the **ESA Space Standardization system**, to understand the basic concepts, and in particular the use of the LEAS (List of ESA

Approved Standards), types of documents in the LEAS (standards, handbooks and TMs) and their intended use by projects, the characteristics of the complete system and individual standards, and the impact of these characteristics in the way of using them.

It is important to note that ECSS constitutes the main source of documents for the LEAS, and therefore special attention is given to the ECSS system.

— At the second level, Section 6 provides a **general awareness of the particular ECSS documents**, without entering in their content, by explaining the general scope of the individual (normative and non-normative) documents, and giving guidelines on the applicability of the normative ones (standards).

— At a third level, Sections 7, 8 and 9 provide a **general view of the content of the different standards** in the S&M, Q and E branches, respectively, giving a detailed view of the type of requirements in them, and justifying the documentation (e.g. DRDs) required by them.

It is important to understand that these sections are for familiarization purposes only, and a detailed tailoring of the requirement will require an expert in the subject. These sections, however, will provide the necessary information to understand, in general terms, what is required by each document and have a general idea of the level of resource commitment involved.

For a more detailed knowledge of the documents, participation in the ESA training courses on ECSS would be necessary. Annex A provides additional information on these courses.

Additionally, an Annex B is provided, proposing a simplified scheme for documentation. ECSS requires a high number of documents, defining their contents but not their structure nor their organization. This flexibility permits to merge documents with similar information, so that the total documentation to be presented can be thoroughly simplified. This simplification is probably not of the interest of large companies (but they can also use it if so desired), because the various documents are prepared by different people, and sometimes by different departments. However, it is probably of high interest for small organizations, where all the documents to be delivered are prepared by a small group.

The documentation scheme presented in this Annex B is only a proposal and therefore not mandatory. That means that, if so desired, the complete deployed system of documents can be delivered, or any intermediate solution.

1
Scope

This document describes the ESA Space Standardization system and documents, with special emphasis on the ECSS system.

Its purpose is to provide the user a thorough understanding of it, with the objective to make meaningful assessment of the effort needed in the application of the standards. It is not its aim to train on the exact contents and requirements, for which an ESA training programme on ECSS exists.

This document is released for general guidance purpose only, and therefore is not meant to take any precedence on applicable project requirements, documents and definitions.

2
References

ESA/REG/001 Rev 4 (1 January 2016)	ESA procurement regulations and related implementation instruction
ESA/REV/001 Annex IV Rev 3	General conditions of tender for ESA contracts
ESA/REG/002 Rev 2 (29 June 2015)	General Clauses and Conditions for ESA contracts
ECSS-S-ST-00-01	ECSS – Glossary of terms

3
Terms, definitions, abbreviated terms and conventions

3.1 Terms from other documents

For the purpose of this guide the terms and definitions from ECSS-S-ST-00-01 "ECSS – Glossary of terms" apply, except for the terms defined in 3.2.

3.2 Terms specific to the present document

3.2.1 economic conditions

set of financial element applicable during a reference period of time

NOTE 1   Example of these financial elements are the hourly rates and the overheads.

NOTE 2   Reference economic conditions are those prevailing when the decision to commit to the project is taken. Current economic conditions are the conditions prevailing when the service is provided.

3.2.2 tailoring

process by which standards applicable to a specific project are selected, and each of them adapted to the project specificities by selection of the existing requirements, with or without modification, or addition of new ones

NOTE   For details on the tailoring process, see 5.2.8.1.

3.3 Abbreviated terms and symbols

For the purpose of this document, the following abbreviated terms apply:

Abbreviation	Meaning
ABCL	as-built configuration list
AH	adopted document as a handbook
An.	Annex
ANSI	American National Standard Institute
AOCS	attitude and orbit control subsystem
AR	acceptance review
AS	adopted document as a standard
ASIC	application specific integrated circuit
BAS	business agreement structure
BCP	baseline cost plans
BSC	bare solar cell
CAD	computer aid design
C3 (or CCC)	cleanliness and contamination control
CB	configuration baseline
CBCP	current baseline cost plan
CBS	cost breakdown structures
CC	common cause
CCC (or C3)	cleanliness and contamination control
CCN	contract change notice
CCS	company/country structure
CCSDS	Consultative Committee for Space Data Systems
CDR	critical design review
CEP	cost estimation plan
CER	cost estimate report
CIDL	configuration item data list
CIL	configuration item list
CMF	common mode failure

Abbreviation	Meaning
CMP	configuration management plan
CoC	certificate of conformity
COG	centre of gravity
comm	communications
COTS	commercial off-the shelf
CPBF	company price breakdown form
CR	change request
CSAR	configuration status accounting report
CSMP	cost and schedule management plan
CVG	coverglass (for PVAs)
CWA	caution and warning analysis
DCP	develop cost plan
DDF	design definition file
DDL	deliverable document list
DDR	detailed design review
Dep	dependability (=RAM)
DG	Director General
DIL	deliverable item list
DJF	design justification file
DoC	declaration of conformity
doc	document
DRB	delivery review board
DRD	document requirement definition
DVP	design validation plan
EAC	estimation at completion
EC	economic conditions
ECLS	environmental control and life support
ECSS	European Cooperation for Space Standardization
EEE	electric, electronic and electromagnetic

EGSE	electrical ground support equipment		**ILS**	integrated logistic support
EIDP	end item data package		**ISO**	International Standardization Organization
ELR	end-of-life review		**ITT**	invitation to tender
EM	electromagnetic		**ITU**	International Telecommunication Union
EMC	electromagnetic compatibility		**LEAS**	List of ESA Approved Standards
EN	European Norm		**LET**	linear energy transfer
EPD	external protection diode		**LRR**	launch readiness review
EPPL	European preferred part list		**MAI**	manufacturing, assembly and integration
ESA	European Space Agency		**MAIT**	manufacturing, assembly and integration and test
ESCC	European Space Components Coordination		**MaRD**	management requirement document
ESD	electrostatic discharge		**MCR**	mission close-out review
ESSB	ESA Standardization Steering Board		**MDR**	mission definition review
ETC	estimation to completion		**MGSE**	mechanical ground support equipment
EVA	extra-vehicular activity		**MIL**	(US) Military Standards
FDIR	failure detection isolation and recovery		**MIP**	manufacturing inspection point
FMEA	failure mode and effect analysis		**MMIC**	monolithic microwave integrated circuit
FMECA	failure mode and effect criticality analysis		**MMP&P**	materials, mechanical parts and processes
FOS	factors of safety		**MoM**	minutes of meeting
FPGA	field programmable gate array		**MOS**	margin of safety
FRR	flight readiness review		**MPP**	milestone payment plan
FT	function tree		**NC**	nonconformance
FTA	fault tree analysis		**NCR**	nonconformance report
GMM	geometrical mathematical model		**NDI**	non-destructive inspection
GS	ground segment		**NDT**	non-destructive test
GSE	ground support equipment		**OBDM**	on-board data management
GSO	ground systems and ops		**OBS**	organizational breakdown structures
HB	handbook		**ODSI**	organize-document-submit-implement (see 5.2.7)
HFE	human factors engineering			
HSIA	HW/SW interaction analysis		**Ops**	operations
HW	hardware		**ORR**	operational readiness review
ICP	inventory control plan			
ID	implementation document			
I/F	interface			

OTS	off-the-self	**SD**	space debris
PA	product assurance	**SDM**	SD mitigation
PAD	part approval document	**SEE**	single event effect
PAP	PA plan	**SE**	system engineering
PARD	PA requirement document	**SEP**	system engineering plan
PCB	printed-circuit board	**SET**	single event transient
PDR	preliminary design review	**spec**	specification
PMP	project management plan	**SME**	small and medium enterprise
PMP	project management plan	**SR**	system review
PP	planetary protection	**SRD**	system requirement document
PRD	project requirement document	**SRR**	system requirements review
PRR	preliminary requirements review	**ST**	standard
PSS	ESA Procedures, Specifications and Standards	**SW**	software
		TBT	thermal balance test
PT	product tree	**TCS**	thermal control subsystem
PVA	photovoltaic assembly	**TEB**	tender evaluation board
QA	quality assurance	**TEC-QR**	ESA office responsible for Space standardization
QAP	QA plan		
QR	qualification review	**TID**	total ionizing dose
RAM	reliability, availability and maintainability	**TM**	technical memorandum
		TMM	thermal mathematical model
RAMS	reliability, availability and maintainability and safety	**TNID**	total non-ionizing dose
		TRL	technology readiness level
req	requirement	**UV**	ultraviolet
RF	radiofrequency	**V&V**	verification and validation
RFD	request for deviation	**VCD**	verification control document
RFQ	request for quotation	**VP**	verification plan
RFU	ready for use	**W&D**	waivers and deviations
RFW	request for waiver	**WBS**	work breakdown structures
RID	review item discrepancy	**WCA**	worst case analysis
RMP	risk management plan	**WP**	work package
RMPP	risk management policy and plan	**w.r.t**	with respect to
RoD	review of design	**WTA**	warning time analysis
S/C	spacecraft		
SCA	solar cell assembly		
SCD	source control drawing		
SCF	SW configuration file		

4
Standards and requirements in context

4.1 Overview

Standards are documents created by experts. These experts have not any legal civil authority, which means that standards are not mandatory, unless they are made mandatory by other binding legal document, for example, a contract.

This is the case in ESA. It is the ESA policy to include, as part of any ESA Space contract, all or part of the standards listed in an ESA official document called the LEAS "List of ESA Approved Standards" (plus some additional ones specific to the mission). Section 4.2 gives further details on how ESA contracts are managed and where to find the information and guidance that ESA contractors may need.

That standards are made normative by the ESA contracts means that they are of mandatory application during the execution of the project. The ESA contractors shall perform their work in accordance with the standards listed in their contracts, and they have to demonstrate to the ESA project team that they have met the requirements in such standards. Section 4.3 provides further information on how ESA projects are organized to ensure compliance with the standards.

4.2 Standards in ESA contracts

4.2.1 ESA contract cycle

The ESA procurement process, from the initiation of a tender to the award of a contract, is regulated by ESA/REG/001 "ESA procurement regulations and related implementation instructions", which is a public document available on the ESA website under the heading "Law at ESA – ESA Rules and Regulations". The following is a summary of such a process addressing only the relevant aspects to put the application of standards in context.

a.   **Invitation to tender (ITT) issuance and evaluation**

An ITT as explained in 4.2.2 is issued by the Agency following a scrutiny of the procurement package by a Tender Evaluation Board (TEB) established for such purpose for each (competitive or non-competitive) tender. "Invitation to Tender" (ITT) is the term used in the case of competitive tenders and "Request for Quotation" (RFQ) in the case of non-competitive tenders. The presentation here below summarizes the process for competitive procurements.

The TEB will include, among others, representative(s) of the initiator of the tender and a contract officer, and may also include additional members and/or experts and/or observers. If the complexity of the tender so

requires, the TEB may, prior to receiving any tender, appoint evaluation panels, which will have an advisory function.

ITTs are put on line and is made accessible to all the EMITS registered users. The ITT includes, among others, the time limits for the tendering period, the methods and conditions of submission of the tenders, the statement of work /technical requirements and the draft contract as well as the criteria and the weighting factors that will be used for their evaluation.

If justified by the complexity of the ITT, the all potential bidders may be invited to briefing meetings for clarification (such invitations are then published on EMITS). As a consequence of these meetings, and before the end of the closing period, the ITT may be clarified or even modified. After the closing date, all tenders received will be open by a Tender Opening Board. All the tenders received are confidential to avoid disclosure of their content. Tenders not admitted for evaluation shall be returned unopened to the tenderers, who may request a debriefing of the reasons of the rejection.

All admitted tenders are sent by the Tender Opening Board to the TEB, who will:

1. Verify that all admitted tenders are complete and constitute full response to the ITT requirements. Tenders not meeting these conditions will be eliminated from competition.

2. Evaluate the remaining tenders against the evaluation criteria, weighted-up by the corresponding weighting factors.

3. During the evaluation the Agency may identify issues in the proposals that require clarification The bidder may then be requested to clarify such issue. The ESA procurement rules forbid any other kind of contact, discussion or negotiation with tenderers during this phase of evaluation.

4. Conclude on a result of the evaluation, and issue a recommendation to the appropriate authority (either internal or, above certain financial thresholds, to the Industrial Policy Committee) for approval.

   The authority will take into account the TEB recommendation, but may also consider other elements such as the overall price and geographical return.

5. With the approval by the relevant authority, the contract will be negotiated with the recommended Bidder and if successful , the contract is signed by both parties.

b. **Award of the contract and review procedures**

. Activities covered by the contract cannot be started before negotiation of all points and signature of the contract, unless the Agency authorizes the starting of some activities by a formal Preliminary Authorization to Proceed.

Upon signature of the contract with the winning tenderer , the non-selected tenderers will be notified with a "regret letter". Upon receipt of such letter, the non-selected tenderers may request, in writing to the Contracts Officer, an oral debriefing. Award notices are published by the Agency on a procurement dashboard which is published regularly on EMITS News.

Any economic operator demonstrating a direct interest in an Agency procurement and claiming a potential loss due to a procedural breach of the rules stated in ESA/REG/001, may seek review. The review procedure, bodies and compensations are also laid down in ESA/REG/001.

4.2.2 General conditions of tender for ESA contracts

4.2.2.1 Overview

Details on ESA ITTs and corresponding tenders are laid down in ESA/REG/001 Annex IV "General conditions of tenders for ESA contracts". The following is a summary of such a conditions addressing only the aspects of relevance to standardization.

4.2.2.2 The Invitation to Tenders (ITT)

An ITT issued by ESA contains the following documents:

a. **A cover letter**, including aspects such as date and time of delivery of the tender, minimum period of validity, type of contract (see 4.2.3.2), and geo distribution requirements. It may include also the price (as a hard limit, or as a guide), and additional acceptance factors.

b. **The general conditions of the Tender (GCT)**, which are just a pointer to ESA/REG/001 Annex IV itself.

c. **The special conditions of the Tender (SCT)**, specify and complete the various points of the GCT including e.g. administrative, planning subcontracting, geographical and financial aspects, specific for the particular ITT.

d. **The evaluation criteria and weighting factors**, which will be used to assess and score the accepted tenders, as explained in 4.2.1a.

e. **The draft contract** containing the specific contract conditions such as liabilities, delivery, price and payments (referring to the General Clauses and Conditions for ESA contracts with amendments a or modifications as necessary)

f. **The Statement of Work**, including if applicable:

   1. A Project management requirement Document (Project MaRD), and

   2. Technical specifications and requirements.

   The possible ways of specifying these requirements is further explained in 4.3.4.

g. **Other** documents specific to the particular ITT.

4.2.2.3 The tenders issued by a bidder as a response to an ESA ITT

The General Tender Conditions (ESA/REG/001, Annex IV) covers the contents of a standard tender. Unless otherwise specified by the ITT itself, a tender presented by a tenderer as a response to an ESA ITT, shall consist of the following documents:

a. **A cover letter**, explaining the major issues in a general way, and signed by the tenderer legal representative.

b. **An executive summary**, including a summary of the contents of the tender and a summary of the main issues with certain level of detail.

c. **The technical proposal**, including:

   1. Requirements, specifications and plans, including a specification tree.
   2. Design references, including:
      (a) Mission assessment
      (b) System analysis and system budget
      (c) Concept of design
      (d) Design definition, including mechanical, thermal, electrical, software and interfaces

      (e)   Integration and test logic

      (f)   Operations logic

3.   Ground Support Equipment (GSE)

4.   Compliance matrix with Technical system requirements

5.   Cost drivers

6.   Schedule critical developments and contingencies

7.   New technology items and other risk factors, including TRL assessment

8.   PA/QA/Safety factors

d.   **Management and administrative proposal**, including if applicable:

1.   Management and subcontractor(s) plan, including:

      (a)   A project management plan (PMP) showing compliance with the project management requirements specified i.a.w. 4.2.2.2f.1. .

      (b)   Project Requirements Documents (PRDs) to be placed on their lower tier suppliers.

      (c)   Evidence of proposed subcontractor(s) concurrence to the PMP and PRDs in 1. And 2. above.

2.   Proposed project organization, including:

      (a)   The Project Organization breakdown structures

      (b)   Key personnel

      (c)   Geo and company breakdown

      (d)   The contract breakdown structure

e.   **Implementation proposal**, including if applicable:

1.   Risk identification

2.   Product tree

3.   Model matrix, describing the applicability of models to each element of the product tree.

4.   The WBS, including the Work Package Descriptions, the control work packages, and the DIL (deliverable item list).

5.   The Cost Breakdown Structures (CBS)

6.   The project schedule, including and schedule tree, the Agency (mandatory) and additional proposed milestones, master schedule, planning constrains and specific plans.

7.   Configuration management requirements, including the set of configuration baselines and the Configuration item List, with reference to the product tree.

8.   The list of deliverables, including the DDL (Deliverable document list) and the DIL (Deliverable item list).

9.   Logistics

      (a)   Transportation plan

      (b)   Logistic plan

10.   Project review requirements.

f.   **Financial proposal**, including:

1.   the cost estimations (see M-60), and the estimation system(s) used and the justification of their suitability,

2.   the correlation between cost and manpower data with the WBS and CBS,

NOTE   Attention of the reader is drawn to the ESA requirements in the use of ESA specific software and forms, and authorized signatures.

3.   a cost calendar consistent with the proposed schedule, and a proposed price variation formulae if necessary,

4.   the cost forms as required by the individual ITT

5.   the profit fee acceptance,

6.   the payment scheme acceptance,

7.   the statement of geo distribution,

8.   the currency conversion rates if necessary,

9.   and statements on taxes and custom duties and royalties and licenses.

g.   **The contractual proposal**

1.   Declaration of compliance with the ITT requirements, explicitly with:
      (a)   Intellectual property rights
      (b)   Technical and management requirements specified in the ITT i.a.w. 4.2.2.2f.

               NOTE   ECSS provides for this a compliance matrix.
      (c)   Contract conditions specified in the ITT.

2.   If the declaration of compliance in 1. above is made, alternative options may be included for consideration by the Agency (but this should be used with caution since it may impact the marking of the tender),.

4.2.3   General clauses and conditions for ESA contracts

4.2.3.1   Overview

Details on clauses for ESA contracts are laid down in ESA/REG/002 "General Clauses and Conditions for ESA contracts" (GCC). The following is a summary of such a clauses and conditions addressing only the aspects of relevance to standardization.

4.2.3.2   Type of contracts and their management

4.2.3.2.1   Type of prices

Type of prices is covered by ESA/REG/002 Annex II and ECSS-M-ST-60 (in ECSS, they are called "**business agreement** types"). Table 4-1 is a summary of the type of prices considered in both document.

Table 4-1: Type of prices in ESA business agreements

Fixed price		Cost reimbursement
Firm (a.1)	Possibility of ceiling price (a.3)	Cost + fixed price
With variation (a.2)		Cost + incentive price
Fixed unit price (a.4)		Time & material

a. Fixed price contracts

1. Firm fixed price - price not subject to any adjustment or revision.

2. Fixed price with variation, which is a price not subject to any adjustment or revision, except for the update of the **economic conditions** by applying an <u>agreed price variation formula</u>, agreed between the parties.

3. Ceiling price to be converted into firm price or fixed price with variation,

4. Fixed unit price, where the price is defined per unit of the various supplies and services covered by the contract.

b. Cost reimbursement

1. Cost plus fixed price

2. Cost plus incentive price

3. Time and material

4.2.3.2.2 <u>Cost grouping</u>

Cost grouping is covered by ESA/REG/002 Annex I (Part II) and ECSS-M-60, which requires that the suppliers deliver their internal CBS.

Figure 4-1 shows the example given in ECSS-ST-M-60.

ESA/REG/002 identifies the costs in the CBS shown in Table 4-2, but does not impose necessarily this structure. However, it requires that the supplier specifies the <u>method of allocation</u> of a cost to any of the cost groups. Changes to this method during the contract are subject to a light change procedure.

ESA/REG/002 also specifies the type of direct and indirect cost which are allowable or unallowable in cost reimbursement contracts.

Table 4-2: ESA example of CBS

Direct costs	Indirect costs (Overheads)
Direct material cost	Industrial overheads[1]
	Facility unit rates
	Percentage overhead on other cost elements
Direct labour cost	General administration
	General R&D
	Indirect costs related to subcon's handling
Supplies	Supplies of similar low value and high usage
[1] Example: Amortization, Maintenance, Energy, Cleaning, Advertisement, .Legal fees, etc.	
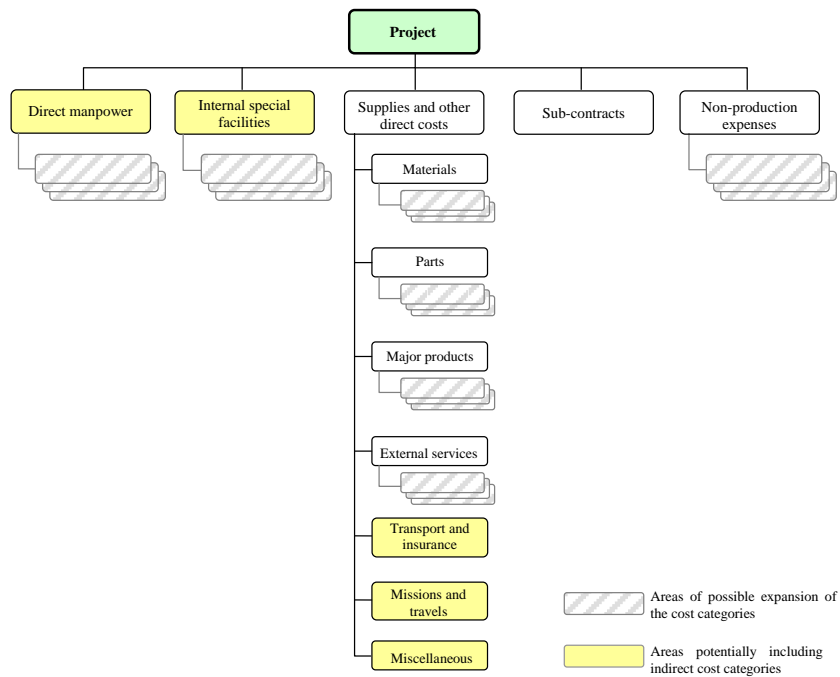
Figure 4-1: Example of CBS in ECSS-M-60

4.2.3.3 General conditions

4.2.3.3.1 Audits and inspections

The following requirements are covered by ESA/REG/002 (and by ECSS-Q-ST-10).

The Agency has the right to audit and inspect the suppliers and their lower level tier suppliers. This means that the suppliers shall:

• Give the Agency appropriate access to their own premises.

• Ensure contractually this access to the premises of the lower level tier suppliers.

The Agency's right to audit includes the right to:

a. Audit the performance of the work

b. Audit the cost and rates, and specifically the claimed overhead rates and any supplier claim in the case of cost reimbursement or ceiling price

c. Audits related to quality assurance

d. Audits regarding the nationality of the economic operator

4.2.3.3.2 Key personnel and subcontractors

The contract shall be executed by the key personnel and the subcontractors specified in the contract.

Personnel changes are subject to a procedure laid down in ESA/REG/002.

Changes of subcontractors shall be subject of a Contract Change Notice (CCN).

The contractor remains responsible for the proper execution of any sub-contract placed by him.

4.2.3.4 Changes to the contract

Changes to contracts can be of type A or B. Columns [1] to [4] of Table 4-3 summarize the definition of each type, who born the cost and the initiation conditions. Columns [5] and [6] summarize the change process depending of the initiator.

Table 4-3: Changes to ESA contracts

Type [1]	Cost born by [2]	Definition [3]	Initiation [4]	Process	
				Initiated by Agency [5]	Initiated by the Supplier [6]
A	Agency	Change to contract requirements	The Agency may require The supplier may request	1) [Agency] CR 2) [Supplier] CR quotation and objections (1 month) 3) [Agency] Rider or CCN 4) [Both] Signature	1) [Supplier] Proposed CCN, including impact on contract 2) [Agency} Acknowledge & evaluation scheme 3) [Agency] Either: - Rejection (and comm), or - Sign and send
		Agency failure to contract' undertakings			
B	Supplier	Any change not classified as "A"	The Agency and supplier may initiate		

4.2.4 Correspondence between ESA contract and ECSS documentation

A very interesting point to highlight is that the vast majority of the documents required by ESA/REG/001 Annex IV to accompany any tender are also required by ECSS Standards. In other words, there is a large overlapping between the contract requirements, and the requirements in ECSS. The larger overlapping is with standards in the S and M branches, but in a lower extent, also with some few requirements in E10 (System engineering) and some Q (product assurance) standards. Table 4-4 is a comparison between the documentation requirements in a generic response to an ITT, and the corresponding ones in the S and M standards. As it can be seen, most of the requirements in the S and M branches are also required by the contract itself.

Table 4-4: Correlation between the requirements in the ESA General Condition of Tender and the requirements in ECSS

	#	Requirement	General conditions of tender (ESA/REG/001 Annex IV)	Standards
ITT	1.	Preparation by the customer of a SRD/PRD, as a result of tailoring, and including a tailoring or applicability matrix	#A.5 (The draft contract of the ITT)	ECSS-S-ST-00C, # 9.2 & Annex A ECSS-M-ST-10C(R1), #5.1.2
TECHNICAL PROPOSAL	2.	Specification tree	Annex B (Technical proposal)	ECSS-E-ST-10C, #5.2.3.1c & Annex J
	3.	Mission assessment	Annex B (Technical proposal)	ECSS-E-ST-10, #5.3.1a
	4.	System analysis & system budget	Annex B (Technical proposal)	ECSS-E-ST-10C, # 5.3.1a
	5.	System budget	Annex B (Technical proposal)	ECSS-E-ST-10C, # 5.4.1.2a & Annex I
	6.	Concept of design	Annex B (Technical proposal)	ECSS-E-ST-10C, #5.3.3c & Annex C
	7.	Design definition (mech., electr., …)	Annex B (Technical proposal)	ECSS-E-ST-10C, # 531c, 5.3.1f, 5.4.1.1b, 5.4.1.4a & Annex G
	8.	Integration & test logic	Annex B (Technical proposal)	----
	9.	Operations logic	Annex B (Technical proposal)	----
	10.	GSE	Annex B (Technical proposal)	----
	11.	Technical requirement compliance matrix	Annex B (Technical proposal)	ECSS-S-ST-00C # 9.3 & Inf. Clause 7
	12.	Cost drivers	Annex B (Technical proposal)	----
	13.	Critical path	Annex B (Technical proposal)	ECSS-M-ST-60C, #8.1b
	14.	Identification of other critical developments & contingencies	Annex B (Technical proposal)	----
	15.	TRL	Annex B (Technical proposal)	ECSS-E-ST-10C
	16.	Identification of risk factors <<25>>	Annex B (Technical proposal)	ECSS-M-ST-80C, #7.2.4a
	17.	PA/QA/safety aspects	Annex B (Technical proposal)	Single point failure
MANAGEMENT & ADMINISTRATIVE PROPOSAL	18.	Project management Plan (PMP)	Annex C.A (Management & admin proposal)]	ECSS-M-ST-10C(R1), #5.1.3a & Annex A
	19.	Configuration management plan (CMP)	Part of the PMP	ECSS-M-ST-40C(R1) Annex A
	20.	Cost & Schedule Management Plan (CSMP)	Part of the PMP	Part of the PMP
	21.	ILS approach	Part of the PMP	Part of the PMP
	22.	Risk management policy and plan (RMPP)	Part of PMP	ECSS-M-ST-80C, Annexes A & B
	23.	SRD/PRD to the lower tier suppliers NOTE: This req makes <<1>> recursive	Annex C.B (Management & admin proposal)]	ECSS-S-ST-00C, # 9.2 & Annex A ECSS-M-ST-10C(R1), #5.1.2
	24.	Evidence of subcon compliance with reqs above	Part 3.D.1.ii	----
	25.	Project organization breakdown structures, referred to the WBS	Annex C.C (Management & admin proposal)	ECSS-M-ST-10C(R1) #5.2 & Annex A (part of the PMP)
	26.	Key personnel	Par 3 D.2 (2nd bullet)	----
	27.	Geo and company breakdown (Country/Company grouping CCG)	Annex C.D	ECSS-M-ST-60C, #9.2.6a, 9.3.5a & Annex E
	28.	Business agreement structure (BAS) or Contract structure	Annex C.E	ECSS-M-ST-60C, 7.1.2a & b

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	#	Requirement	General conditions of tender (ESA/REG/001 Annex IV)	Standards
IMPLEMENTATION PROPOSAL	29.	Risk identification <<16>>	Annex D.A	ECSS-M-80C, #7.2.4a
	30.	Product tree	Annex D.B	ECSS-M-10C(R1) #5.3A & Annex B
	31.	Model matrix	Annex D	----
	32.	WBS	Annex D	ECSS-M-10C(R1) #5.3h & Annex C
	33.	WPs	NOTE: ESA/REG/001 Annex IV includes the WPs, control WP and DIL together with the WBS.	ECSS-M-10C(R1) #5.3n & Annex D
	34.	Control WP		----
	35.	DIL		----
	36.	CBS	Annex D.	ECSS-M-60C #7.1.1a & Annex A
	37.	Project schedule, including: - Master schedule - Agency milestones - Additional milestones - master schedule - Planning constrains - Specific plans	Annex D.F	ECSS-M-60C #8.2a, 8.2c & Annex B
	38.	Configuration baselines	NOTE: ESA/REG/001 Annex IV put together the CBs and the CIL in a Configuration Management Document	ECSS-M-ST-40C(R1) #5.3.1.3a & b
	39.	Configuration Item List (refer to PT)		ECSS-M-ST-40C(R1) #5.3.1.2b & Annex B
	40.	Configuration Item Data List (CIDL)	---	ECSS-M-ST-40C(R1) #5.3.3.2a & Annex C
	41.	SW Configuration File (SCF)	---	ECSS-M-ST-40C(R1) #5.3.3.2b & Annex E
	42.	As-built Data List	NOTE: Meaningless at the time of the contract	ECSS-M-ST-40C(R1) #5.3.3.3a & Annex D
	43.	Conf Status Accounting Report (CSAR)	NOTE: Meaningless at the time of the contract	ECSS-M-ST-40C(R1) #5.3.3.1b & Annex F
	44.	DDL (and DIL <<28>>)		----
	45.	Transportation plan		----
	46.	Logistic plan		Part of the PMP
	47.	Project review programme	Annex D.G	ECSS-M-ST-10 Rev1 #5.4
FINANCIAL PROPOSAL	48.	Cost estimation system	Part 3, #F.1.ii	M-ST-60 Annex F (Cost estimating plan)
	49.	Cost estimations		M-ST-60 Annex G (Cost estimate report)
	50.	Cost & manpower data correlated to WBS & CBS		M-ST-60 Annex J Cost & manpower report (?) Annex D Company price breakdown forms
	51.	Cost calendar= Schedule + Price variation formulae	Part 3, #F.3.iii	M-ST-60 #9.2.5
	52.	Profit fee acceptance		
	53.	Payment scheme acceptance		
	54.	Geo-distribution statement		M-ST-60 Annex E (Geo distribution rep.)
	55.	Currency conversion rates		
	56.	Taxes/custom/royalties/licenses		
	57.			
	58.	Declaration of compliance with: - Intellectual property rights - Technical and management reqs. - Contract conditions		
	59.	Alternative solutions (only if in compliance with <<44>>)		
NOTE: This table does not include all the requirements in the ESA General Conditions of Tender, only those ones related to standardization				

4.3 Standards in ESA projects

4.3.1 Project phasing

4.3.1.1 Phases of a typical ESA project

A project is divided in phases to ensure that a space project is executed in a coordinated, efficient and structured manner, from initiation to completion, and by all the involved actors. Project phases are closely linked to activities on system and product levels. A typical (space segment) ESA project is divided in the following phases:

- Phase 0: Mission analysis and needs identification, where the mission statement is defined, identifying different possible mission concepts

- Phase A: Feasibility, where the different possible mission concepts identified before are materialized in possible system concepts and architectures, comparing them against the identified needs, assessing the technical and programmatic feasibility of the possible concepts.

- Phase B: Preliminary definition, where the different possible technical solutions of the system and operation concepts are confirmed, trade-off studies are conducted to select the preferred system concept and technical solution for this concept, and the preliminary design definition for the selected system concept is established.

- Phase C: Detailed definition, where the detailed design definition is completed at all levels in the customer-supplier chain, including production and testing of models, detailed I/F definition, and production plans.

- Phase D: Qualification and Production, where the product is qualified and the completely manufactured and verified, including HW, SW and associated GSE.

- Phase E: Utilization, where the product is launched, on-orbit verification performed (commissioning), all the on-orbit and operations and on-ground activities are performed in order to achieve the mission objectives.

- Phase F: Disposal, where the disposal plan is implemented. Disposal of the S/C may consist of de-orbiting (into a graveyard orbit), re-entry into the atmosphere, or otherwise, and may include passivation of all sources of energy.

Normally, ESA does not contract all phases with the same supplier. In a typical case, Phase 0 is run by the project initiator, top level customer (ESA) and representatives of the end user (the community who will benefit from the mission), i.e. no supplier involvement. Phase A and the first part of phase B are conducted by the top level customer (ESA) and one or several first level suppliers. At the second part of Phase B the system concept has been selected, and it is the moment to select a supplier to performed the detailed design of such a concept and the manufacturing of such a design, so normally this second part, and Phases C and D are contracted to the same supplier, normally called **the prime**. Phase E and F (launch, operation and disposal), the launch is contracted to a different supplier, and the operation and disposal, depending on the nature of project, are conducted by ESA itself, by an operator contracted by or supporting ESA, or by an independent operator. Although the main activity of the prime finalizes with Phase D, still a strong support from it will be necessary for both the launching campaign and the commissioning of the Spacecraft. Figure 4-2 gives a graphical interpretation, however it is important to understand that this figure is provided for illustrative purpose only, and a particular project may deviate from this typical case.
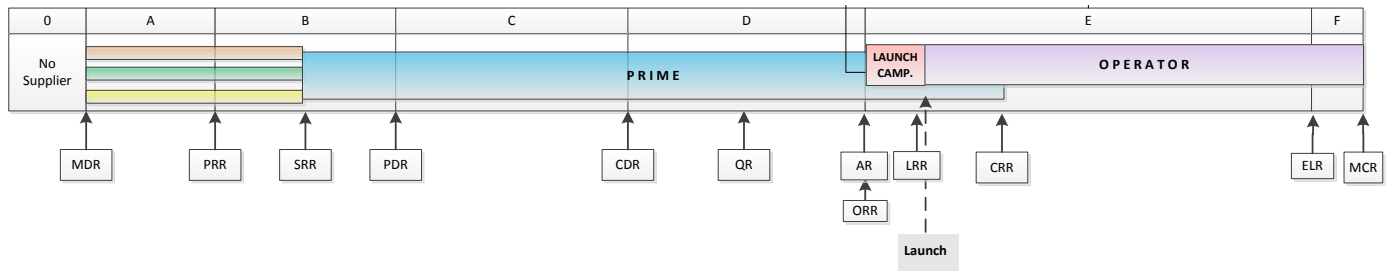
Figure 4-2: Typical suppliers per project phases

4.3.1.2 Project reviews

Project reviews are formal examinations of the status of a project at particular points in time, against established targets and requirements. There are a number of reviews that are common to any typical project. On top of them, a project can decide on the necessary additional reviews.

The reviews common to any typical project are summarized also in Figure 4-2. It is important to note that at the endo of each phase there is always a review, one of its objectives being to decide if the project is in a position to move to the next phase or otherwise.

Table 4-5: Typical project reviews

Review	Name	Main objectives
MDR	Mission definition review	Release mission statement
PRR	Preliminary requirements rev.	Confirmation and selection of technical and programmatic feasibility of system concepts
SRR	System requirements review	Preliminary design definition assessment / Release of technical requirements specification
PDR	Preliminary design review	Prelim. Design verification/ Release of M, Q & E plans, product & spec trees, WBS & verif. Plan Readiness for Phase C
CDR	Critical design review	Release the final design, MAIT plans & user manual / Confirm external I/F, define critical processes / Readiness for Phase D
QR	Qualification review	Confirm that design (including margins) meet the requirements / For recurrent products: 1st article / Production master files / Series production acceptance
AR	Acceptance review	Confirm the product is free of errors / Authorize delivery / W&D acceptance Additional AR are carried out at all lower levels, before the final AR represented here
ORR	Operational readiness review	Verify readiness of operational procedures and teams / Release of ground segment
LRR	Launch readiness review	Confirm that everything is ready for launch (including launcher, launch pad, whether, …) Normally performed 1 or 2 days before launch
CRR	Commissioning result review	At the end of commissioning, as part of on-orbit verification. Readiness for routine ops.
ELR	End-of-life review	Verify mission has completed its useful operation / Ensure configuration for safe disposal
MCR	Mission close-out review	Ensure all mission disposal activities have been completed.
NOTE: On top of the above, a project can decide on the additional reviews as necessary		

Reviews are formal events, which means that they are conducted in accordance with an approved procedure, driven by a formally appointed review authority, and performed by a formally appointed review team. In typical

project reviews, the authority belongs to the top level customer (ESA), the review team is composed of experts from the customer and the supplier not having participated in the project, and the supporting team is composed of project people from both customer and supplier. All the details for conducting formal reviews are specified in ECSS-M-ST-00-01 "Organization and conduct of reviews".

4.3.2 Type of references in an ESA project

4.3.2.1 Type of standardization documents

Standardization documents used by ESA include the following three categories:

- Standards, which are documents issued for direct use in invitations to tender (ITTs) and business agreements (e.g. contracts).

  The suitability for business agreements does not mean that a specific legal language is used. It means simply that **the obligations of each actor are unambiguously identified as such and clearly defined**.

- Handbooks (HBs), which are documents built as non-normative, and providing guidelines, good practices, suitable ways of implementing standards or collection of data.

  The fact that HBs are built as non-normative means that they are written in a descriptive style, where no obligations are identified. This does not prevent, however, that exceptionally a specific project wants to force a given way of implementing the requirements, and then it can make a HB normative.

- Technical memoranda (TMs), which are documents build as non-normative, and providing useful information or data not yet mature for a standard or a handbook.

  The fact that TMs document practices non-mature for standardization means that generally they are not identified as normative. This does not prevent, however, that exceptionally a specific project want to force to use a given non-standardized practice for a particular application, and then it can make a TM normative.

4.3.2.2 Normative and informative references

As said in 4.1, any standardization document (including standards), is not mandatory unless it is made normative by virtue of a legally binding document, e.g. a contract (in which case it binds the signing parties).

The above implies that the list of the normative documents applicable in a project are those ones so declared in the contract, and until the extension specified therein. This set of normative documents is called the list of "Normative References" of the contract.

The contract can include also a list of "Informative references". This list includes documents that can help in the application of the documents in the "Normative References" or in the implementation of the contract, by describing suitable ways (but not the only possible ones) of complying with the requirements. Therefore, this list is provided only for information and is not binding.

Normally, the list of Normative References includes only standards. However, as explained in 4.3.2.1, in some exceptional cases a particular way of implementing the requirements (i.e. a HB) or a non-standardized practice for a specific work (i.e. a TM) needs to be made mandatory, in which case the HB or TM will be part of the Normative References and become a binding part of the contract.

The list of Informative References will include typically HBs and TMs, but may also contain some STs. If a document (including a standard) is in the list of Informative References, and not in the list of Normative References, then it is <u>not normative</u> (only for reference) in the context of the project. The reason to include a standard as informative references is that it may include useful information, but the project does not want to make it mandatory.

4.3.2.3   The principle of non-retroactivity

The list of Normative References of a contract makes applicable a given version of a document (normally the last version published when the contract is issued). Unless otherwise agreed between customer and supplier, this is the version applicable during the entire life of the contract, irrespective of the evolution of the standard. For example, if version C of a standard is made applicable by the contract, and after signature of the contract the standard evolves to version D, version C is still the applicable version to that contract. Of course, customer and supplier may convene to move to version D (with or without economic compensations), in which case a change to the contract needs to be signed by both, making version D applicable. If moving to version D implies a change in the requirements, it is considered a change type "A", otherwise could be considered a change type "B". Type of change contracts are covered in ESA/REG/002.

The above principle can be summarized saying that standards are not applicable retroactively in a contract, unless the contract is modified.

4.3.3   ESA documents for the application of the standards in ESA projects

4.3.3.1   Application of standards in ESA projects – The LEAS

Application of standards in ESA projects is defined in ESA/ADMIN/IPOL(2007)11, which is of mandatory application in ESA.

This ADMIN defines a document called the LEAS (List of ESA Approved Standards). The LEAS has two main sections, Section 1 "Normative documents" and Section 2 "Reference documents". The LEAS is issued twice a year.

The contents of ESA/ADMIN/IPOL(2007)11 can be summarized as follows:

a.   Every ESA project shall apply all the standards is **Section 1** of the LEAS. If a document is not applied, individual justification for the non-application of the document shall be provided.

>   NOTE 1   This tailoring activity in the context of ESA corresponds to the Step 3 of the tailoring activity in the context of ECSS explained in 5.2.8.1.

>   NOTE 2   Section 2 is not of mandatory use by projects, which means that the use of this Section 2 is decided by each project. A project may therefore decide to use every documents in this section as normative, informative, or not use it at all, at their own judgement.

b.   The list of standards derived from the LEAS in accordance with Point a. above shall be established and verified by the Project Manager and ESA Quality department head (or delegated PA manager), depending on the type of standard (M, E or Q), with the support of the technical department (TEC or HSO), at three stages:

1.   Prior the ITT, with the intention that this list is part of the ITT

2.   After tender evaluation, to ensure that tenders considered valid do not deviate from this list in a way unacceptable to ESA.

3.   During the execution of the project, to maintain departure from standards and document due to nonconformances (RFW and RFD) at an acceptable level.

4.3.3.2 The ESA MaRD and PARD templates

Level 2 Management and Product Assurance standards in ECSS are so generic that a pre-tailoring approach for all ESA projects makes sense to account for the ESA specificities.

> NOTE 1   For a discussion on the level of ECSS standards, see 5.2.1. The only ECSS Level 1 standard is ECSS-E-ST-S-00. All the other ECSS standards are Level 2 or Level 3.

> NOTE 2   Engineering standards are so project specific that a similar approach for all ESA projects is meaningless.

The ESA MaRD (ESA Management Requirements Document) and PARD (ESA Product Assurance requirements document) templates are two ESA documents built by including, respectively, the management and the PA requirements in the ECSS M and Q standards, pre-tailored for applicability to a generic ESA project.

ESA MARD and PARD templates still may need a final tailoring performed by each project, to account for the project specificities. Hopefully, this final tailoring will be minimum. The resulting documents after this final tailoring are called "Project MaRD" and "project PARD".

> NOTE   This tailoring activity in the context of ESA corresponds to the Step 4 of the tailoring activity (for M and Q Level 2 standards) in the context of ECSS explained in 5.2.8.1.

4.3.4 Mechanisms for the application of standards in ESA projects

4.3.4.1 Generic and specific requirements

Requirements in an ESA contract can be specified in different ways:

a.   By listing documents containing the requirements in a "Normative references" list (see 4.3.2.2). Documents in this list may fall in two categories:

    1.   Documents containing generic requirements, called standards, applicable to a wide range of projects.

    The use of this type of documents has many advantages for both ESA and the ESA supplier, without losing flexibility (through tailoring). Among others:

    o   It makes for both the amount of information and paperwork much less heavy by substituting a pile of paper attached to the contract by a list of generic documents easily retrievable and generally known and understood (and in many cases managed by automatized systems e.g. databases).

    o   Once the supplier is familiarized with the ESA system of standards, analysis of an ITT becomes much more easier because it will be necessary to assess and evaluate only the requirements diverging from this system.

    o   For ESA, it makes much easier to compare in a fair basis two different proposals.

    2.   Specific documents containing particular requirements, applicable only to the specific project, or to a limited number of projects.

    The use of this type of documents has not the advantages explained in a.1 above, but sometimes it is needed to cover some specificities of the project.

b.   By stating them in the contract itself, or in a document attached to the contract.

    This approach has the advantage of highest flexibility, but also lacks of all the potential explained in a.1 above, and therefore its use is restricted to the requirements specific to the project.

4.3.4.2   The project requirement document (PRD) or system requirement document (SRD)

Since any project has requirements specific to it, ESA contracts use a combination of the approaches explained in 4.3.3.1. Ideally, generic requirements are specified by listing the corresponding standards in the list of Normative References. Requirements specific to the project are specified by making mandatories specific (non-standard) documents, or by listing the requirements in the contract itself.

All the requirements (generic or specific) applicable to a project are capitalized in a document called by ECSS the "Project requirement Document" (PRD). Traditionally, in ESA this document has been called the "System Requirement Document" (SRD). Normally, the term SRD/PRD will be used in this guide.

The SRD/PRD could be a physical document listing all the requirements , but more frequently is a document pointing other documents containing the requirements.

To obtain the advantages described in 4.3.4.1a.1, the generic documents pointed by the SRD/PRD needs to be consistent through all the ESA projects. To ensure this consistency, ESA projects select the applicable generic documents from a common list, the LEAS (see 4.3.3.1).

It is important to understand that **an ESA supplier does not need access to the LEAS**, because standards in this list are made applicable to a specific project by including them as "Normative references" in the contract itself. However, since many of the books in this list could be made applicable in a given contract by including them in the SRD/PRD, it is interesting to know which type of documents this list includes. Therefore, the following documents may be (but not necessarily all) pointed by the SRD/PRD:

a.   Generic documents, tailored to the project needs:

1.   Project MaRD and PARD

As explained in 4.3.3.2, the project MaRD and PARD are the ESA MaRD and PARD templates, tailored (hopefully minimally) to account for the specificities of the project.

2.   Standards
   o   ECSS standards, which cover the M (Project management), Q (Product Assurance), E (Engineering) and U (Space sustainability) domains. All these branches are put together by a document called ECSS-S-ST-00, explaining how the ECSS system works, and ECSS-S-ST-00-01 "ECSS Glossary of terms".

   Since the M and PA Level 2 documents are already covered by the PARD and MARD, the SRD/PRD will include only the E and U documents.
   o   A number of CCSDS standards. CCSDS standards are limited to communication and data handling (i.e. in the E branch)
   o   Some few standards applicable exclusively to ESA projects (not applicable outside ESA). They are called ESSB.
   o   Some very few other standards:
      –   ESCC specifications, which are specifications applicable to EEE manufacturers. Very few are also applicable to ESA projects and therefore included in the LEAS.
      –   PSS (old ESA documents, to be eventually substituted by not yet developed ECSS documents),
      –   One MIL standard, two ISO standards, and the Internet protocol (IPv4).

b.   Specific documents, to cover the specificities of the project.

4.3.4.3 Project documentation

The documentation to be produced in a project is listed in the DIL (Deliverable Item List). The DIL will include all relevant DRDs, plus additional documents to be produced not covered by DRDs.

4.3.4.4 Flowing down requirements (the customer-supplier model)

Figure 4-3 presents the customer-supplier model adopted by ECSS and described below.
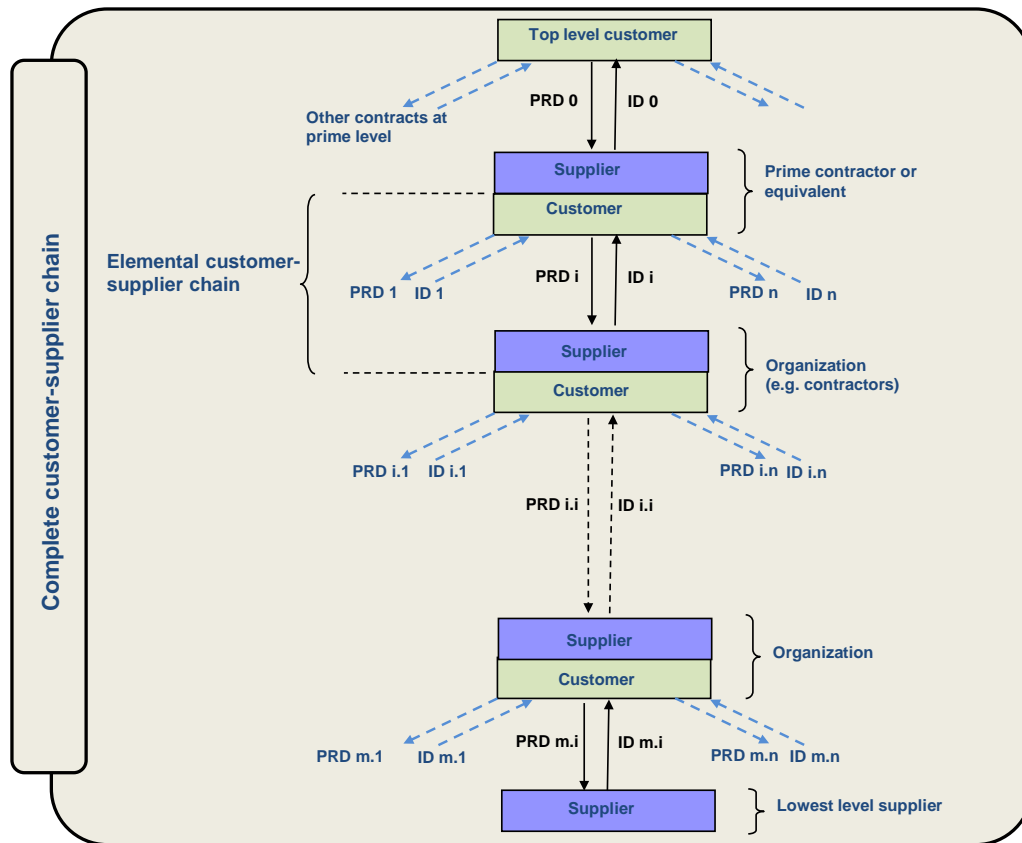
Figure 4-3: The customer supplier model

The top level customer, in the present case ESA, produces a Project Requirement Document, or SRD/PRD, with the ECSS tailored requirements and the project specific requirements (see 4.3.4.1a.2). This SRD/PRD is flowed down to the ESA suppliers. In fact, ESA produces a SRD/PRD per supplier.

The supplier, let's say the prime, shall analyze this SRD/PRD and respond to ESA with an Implementation Document, or ID. The implementation document explains how every requirement will be actually implemented.

Now the prime has to do the same with each of his suppliers, normally called contractors. The main difference is that the prime normally has a number of contractors per project, what means that he shall produce several SRD/PRD's, and will receive several IDs. What it is important is that he flows down to each supplier only the requirements applicable to him, derived from the requirements that he received from ESA.

The same scheme shall repeat until the lowest level supplier.

The complete tree is called the complete customer-supplier chain. When the focus is put to the individual relation between two organizations, one acting as customer and the other as supplier, this relation is called elemental customer-supplier chain. Standards are designed to regulate this relationship (see 4.3.2.1).

4.3.5 Verifying requirements in ESA projects

The ECSS Glossary recognizes the following classes of products (see ECSS-S-ST-00-01C #2.3.157): Services, software, hardware and processed materials.

Any ESA contract will require to deliver, among others, one of the above stated products, in compliance with the requirements in the SRD/PRD. It is the responsibility of the supplier not only to produce the product, but also to demonstrate that his product is in compliance with the requirements in the SRD/PRD, that is, to verify the product.

Verification is covered by ECSS-E-ST-10-02 "Verification". In accordance with this standard, not all need to be subject to a formal verification process. The set of requirements that shall be subject to such formal process are normally established by ESA, in consultation with the prime, and then introduced in a document called VCD (Verification control document). All the requirements in the TS shall be part of this subset.

The VCD includes the Verification matrix, which is a matrix listing one by one all the requirements to be verified, together (among others) with the product decomposition level and verification stage (qualification, acceptance, pre-launch, in-orbit, …) in which the requirement has to be verified, and the method of verification for such requirement. Four methods of formal verification are accepted:

a.   Verification analysis (including demonstration by similarity)

b.   Test (including demonstration)

c.   Review of design (RoD)

d.   Inspection

One important remark is necessary here: **All the requirements need to be met (unless exempted by the customer via RFD or RFW), irrespective if they will be formally verified (via VCD) or not**. If at any moment it is considered important to ensure that a requirement (listed in the VCD or not) is actually met, the customer (i.e. ESA) has the right to require demonstration of compliance against that requirement. Demonstration of compliance of the requirements that are not in the VCD, when required, can be made as appropriate via the above stated methods, or via other less demanding methods, for example, by quality audits.

For additional information on verification, see ECSS-E-HB-10-02 "Verification handbook", which provides guidance and acceptable methods of complying with the requirements in ECSS-E-ST-10-02 "Verification".

5
Awareness of the ESA approved standards

5.1   Overview

As explained in 4.3.4.1a.2, the list of ESA approved standards (LEAS) includes a number of standards from different sources. After tailoring this list, a large part of these standards will be made applicable by listing them in the "Normative references" of the Project list of applicable documents. It is therefore important to understand how these documents shall be read and understood.

The standards of the LEAS covering the wider standardization scope, and the larger in number, are ECSS. Awareness of the ECSS standards is necessary to have a sound understanding of the overall ESA requirements. Section 5.2 covers this subject.

Other standards in the LEAS are less numerous and cover very specific areas (which may be or not of interest for a particular project). Among others, the LEAS includes some few ESSB (internal ESA standards), a number of CCSDS (international standards dealing only with data handling and communications), and some few ESCC (European specifications dealing only with EEE components) and PSS (old ESA documents, still applicable). After describing ECSS, these other documents are introduced in this guide comparatively, by describing the main differences with ECSS. Section 5.3 covers this subject.

5.2   Awareness of the ECSS system of documents

5.2.1   Hierarchical structure: branches, disciplines and levels

As shown in Figure 5-1, ECSS standardization documents are organized in a tree structure in five branches and several disciplines. The branches are M (Project management, 5 disciplines), Q (Space PA, 7 disciplines), E (Space engineering, 7 disciplines), and U (Space sustainability, 2 disciplines). A fifth discipline, S (ECSS system), integrates all this together.

> NOTE   As described in 5.2.2.5 and Figure 5-5, the scope of the E30 (Mechanical) discipline is so wide that is further subdivided in five sub-disciplines: E31 (Thermal), E32 (Structural), E33 (Mechanisms), E34 (ECLS) and E35 (Propulsion).

Each of these disciplines and sub-disciplines may include one or several standards. They may include also any number of handbooks and technical memoranda. Standards in a discipline are classified as Level 2 or 3 (the only Level 1 document is ECSS-S-ST-00, in the S branch, integrating all of them). In general, **each discipline includes one (and only one) Level 2 standard,** but may include any number (i.e. one, several or no-one) Level 3 standards.

There are two exceptions to this rule, since E33 (Mechanisms) and E60 (Control engineering) do not have Level 2 standard (i.e. they have only Level 3 standards). This point is further explained later.

As further explained in 5.2.3, Level 2 standards can be identified because they contain only one group of two digits in their name (e.g. ECSS-E-ST-50C), while Level 3 standards contain two groups of two digits each (e.g. ECSS-E-ST-50-01C).

It is important to understand that level of a standard does not refer to their importance or precedence order, only to how generic their requirements are. Requirements in Level 2 standards are more generic, requirements in Level 3 are more specific.

It is also important to note that **the establishment of an order of precedence in ECSS standards is unnecessary** (and the same for ESSB, i.e. ESA-only standards), since they have been set up consciously to be a system of standards, so avoiding duplication and contradiction. Therefore they will not conflict each other. This point is further elaborated in 5.2.4.1.1.
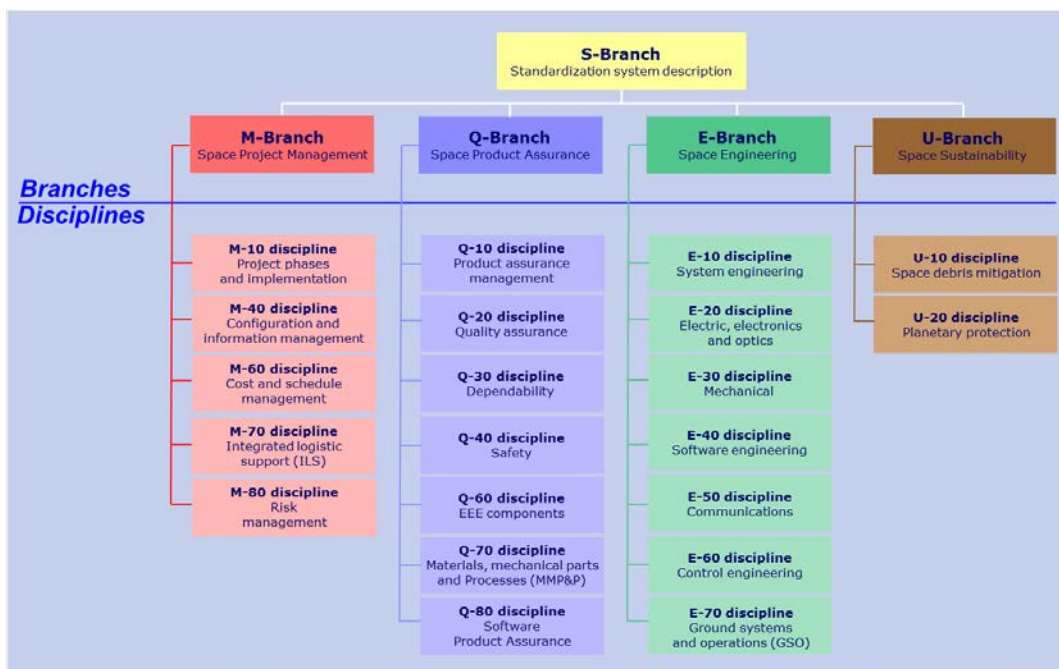
Figure 5-1: ECSS and ESSB structure of branches and disciplines

5.2.2 The ECSS documents in each discipline

5.2.2.1 Overview

Clauses 5.2.2.2 to 5.2.2.6 present the standards and non-normative documents (handbooks and technical memoranda) in the various ECSS disciplines, showing the corresponding tree structures in Figure 5-2 to Figure 5-7.

The information in these Figures is shown here for illustrative purposes only. Since this information may become obsolete very quickly, the reader is invited to visit the ECSS website (www.ecss.nl), where the information is kept up-to-date. Please note that the figures represent not only the already published documents, but also the ones under updating (identifies with a capital "U"), and the new ones currently under production, to be published shortly (identified with a capital "N").

5.2.2.2 Documents in the S branch

The S branch is not subdivided in disciplines. There are only 2 standards (and no handbook nor technical memorandum) in the S branch:

— ECSS-S-ST-00 "ECSS system: description, implementation and general requirements", which explain how the ECSS system of documents works putting together the other four branches, and specifies the highest level requirement on the application of the system. It is considered the Level 1 standard in ECSS.

— ECSS-S-ST-00-01 "ECSS Glossary of terms", that capitalizes the terms and definitions of general use in ECSS, to ensure consistency among documents. ECSS-S-ST-00-01 is a necessary document for the application of the general rule for terms and definitions explained in 5.2.4.2.2

5.2.2.3 Documents in the M branch

The M branch contains only standards, i.e. it does not contain non-normative documents (handbooks and technical memoranda). The standards in the M branch are represented in Figure 5-2.

As it can be seen in this Figure, there are five disciplines, with only one Level 2 standard in each discipline, except M10, which has one Level 2 and one Level 3 standards.
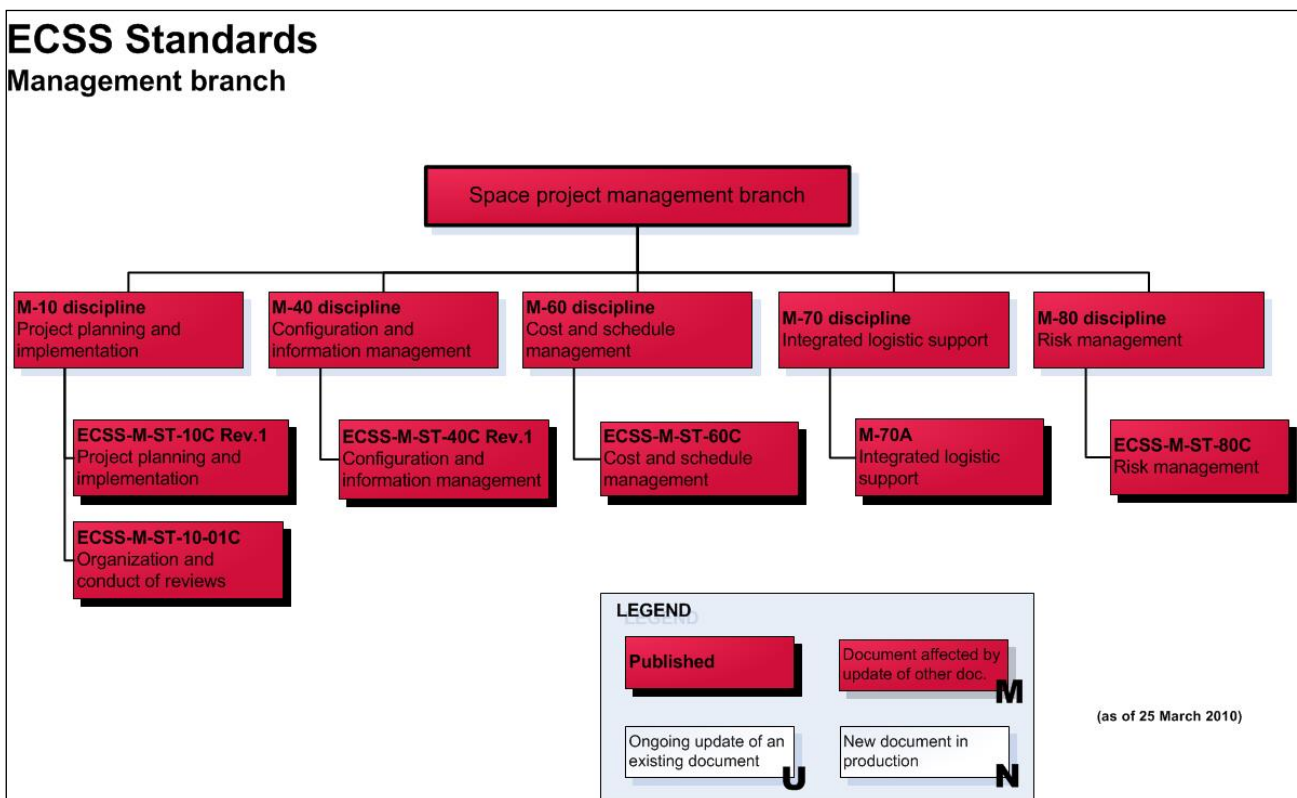
Figure 5-2: Standards in the M (Space project management) disciplines

5.2.2.4 Documents in the Q branch

The Q branch contains the following documents:

• Standards in the disciplines of the Q branch are represented in Figure 5-3. View A shows the standards in all disciplines, except in Q-70. View B shows the standards in the Q-70 discipline.
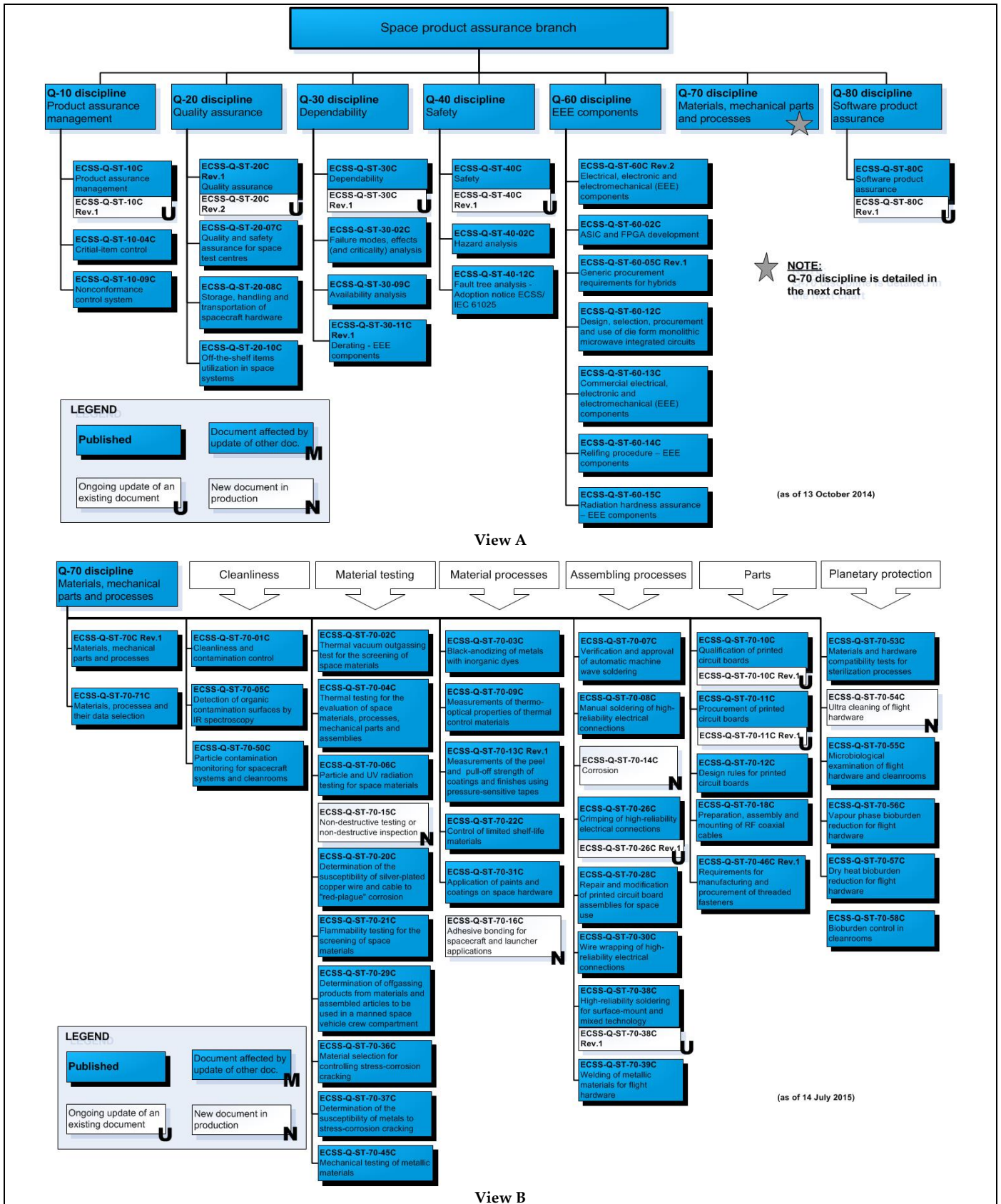
Figure 5-3: Standards in the ECSS-Q (Space product assurance) disciplines

- Non-normative (handbooks and technical memoranda) documents in the disciplines of the Q branch are represented in Figure 5-4.
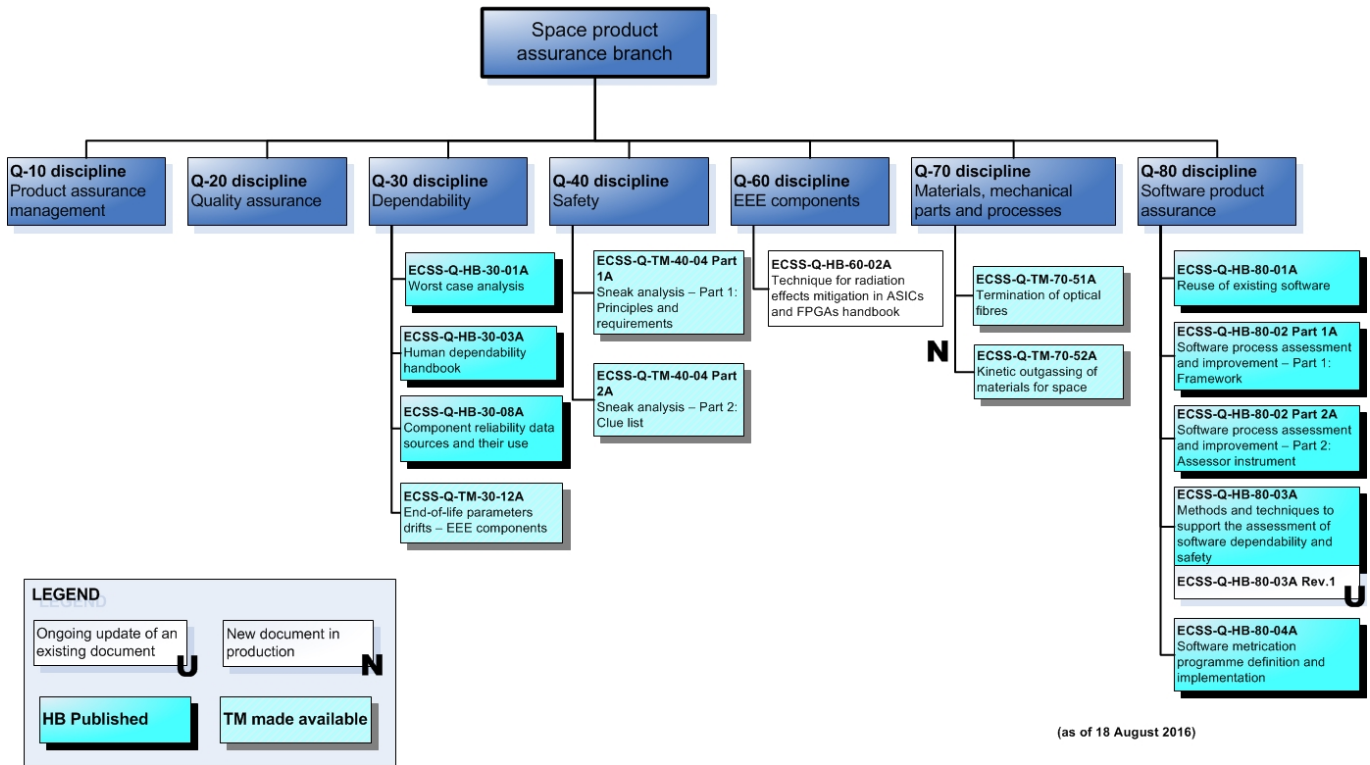
Figure 5-4: HBs and TMs in the Q (Space product assurance) disciplines

5.2.2.5 Documents in the E branch

The E branch contains the following documents:

- Standards in the disciplines of the E branch are represented in Figure 5-5. View A shows the standards in all disciplines, except E-30. View B shows this E-30 (Mechanical) discipline, further subdivided in five sub-disciplines: E-31 (Thermal), E-32 (Structural), E-33 (Mechanisms), E-34 (ECLS) and E-35 (Propulsion).

Space engineering branch

E-10 discipline
System engineering

E-20 discipline
Electrical and optical engineering

E-30 discipline
Mechanical engineering

E-40 discipline
Software engineering

E-50 discipline
Communications

E-60 discipline
Control engineering

E-70 discipline
Ground systems and operations

ECSS-E-AS-11C
Adoption Notice of ISO 16290 – Definition of TRLs and their criteria of assessment

ECSS-E-ST-10C
System engineering general requirements
ECSS-E-ST-10C Rev.1 U

ECSS-E-ST-10-02C
Verification
ECSS-E-ST-10-02C Rev.1 U

ECSS-E-ST-10-03C
Testing

ECSS-E-ST-10-04C
Space environment

ECSS-E-ST-10-06C
Technical requirements specification

ECSS-E-ST-10-09C
Reference coordinate system

ECSS-E-ST-10-11C
Human factors engineering

ECSS-E-ST-10-12C
Method for the calculation of radiation received and its effects, and a policy for design margins

ECSS-E-ST-10-24C
Interface management

ECSS-E-ST-20C
Electrical and electronic
ECSS-E-ST-20C Rev.1 U

ECSS-E-ST-20-01A Rev.1
Multipaction design and test

ECSS-E-ST-20-06C
Spacecraft charging

ECSS-E-ST-20-07C Rev.1
Electromagnetic compatibility

ECSS-E-ST-20-08C Rev.1
Photovoltaic assemblies and components

ECSS-E-ST-20-20C
Interface requirements for electrical power N

Note:
E-30 discipline is detailed in the next chart

ECSS-E-ST-40C
Software general requirements

ECSS-E-ST-50-12C (see NOTE 1)
SpaceWire - Links, nodes, routers and networks
ECSS-E-ST-50-12C Rev.1 U

ECSS-E-ST-50-51C
SpaceWire protocol identification

ECSS-E-ST-50-52C
SpaceWire - Remote memory access protocol

ECSS-E-ST-50-53C
SpaceWire - CCSDS packet transfer protocol

ECSS-E-ST-50C
Communications

ECSS-E-ST-50-01C
Space data links - Telemetry synchronization and channel coding

ECSS-E-ST-50-02C
Ranging and Doppler tracking

ECSS-E-ST-50-03C
Space data links - Telemetry transfer frame protocol

ECSS-E-ST-50-04C
Space data links - Telecommand protocols, synchronization and channel coding

ECSS-E-ST-50-05C Rev.2
Radio frequency and modulation

ECSS-E-ST-50-21C
SpaceFibre N

ECSS-E-ST-50-13C
Interface and communication protocol for Mil std 1553B

ECSS-E-ST-50-14C
Spacecraft discrete interfaces

ECSS-E-ST-50-15C
CAN bus extension protocol

ECSS-E-ST-60-10C
Control performances

ECSS-E-ST-60-20C Rev.1
Star sensor terminology and performance specification

ECSS-E-ST-60-21C
Gyros terminology and performance N

ECSS-E-ST-60-30C
Attitude and orbit control systems (AOCS) requirements

ECSS-E-ST-70C
Ground systems and operations

ECSS-E-ST-70-01C
On-board control procedures

ECSS-E-ST-70-11C
Space segment operability M

ECSS-E-ST-70-31C
Ground systems and operations - Monitoring and control data definition M

ECSS-E-ST-70-32C
Test and operations procedure language

ECSS-E-70-41A
Telemetry and telecommand packet utilization
ECSS-E-ST-70-41C U

NOTE 1: At next issue, the document might be renumbered to: ECSS-ECSS-E-ST-50-50

(as of 14 July 2015)

LEGEND

Published

Document affected by update of other doc. M

Ongoing update of an existing document U

New document in production N

View A

E-30 discipline
Mechanical engineering

ECSS-E-ST-31C
Thermal control general requirements

ECSS-E-ST-31-02C
Two-phase heat transport equipment
ECSS-E-ST-31-02C Rev.1 U

ECSS-E-ST-31-04C
Exchange of thermal model data for space applications N

ECSS-E-ST-32C Rev.1
Structural general requirements

ECSS-E-ST-32-01C Rev.1
Fracture control

ECSS-E-ST-32-02C Rev.1
Structural design and verification of pressurized hardware

ECSS-E-ST-32-03C
Structural finite element models

ECSS-E-ST-32-08C Rev.1
Materials

ECSS-E-ST-32-10C Rev.1
Structural factors of safety for spaceflight hardware

ECSS-E-ST-32-11C
Modal survey assessment

ECSS-E-ST-33-01C
Mechanisms
ECSS-E-ST-33-01C Rev.1 U

ECSS-E-ST-33-11C
Explosive systems and devices
ECSS-E-ST-33-11C Rev.1 U

ECSS-E-ST-34C
Environmental control and life support

ECSS-E-ST-35C Rev.1
Propulsion general requirements

ECSS-E-ST-35-01C
Liquid and electric propulsion for spacecraft

ECSS-E-ST-35-02C
Solid propulsion for spacecraft and launchers

ECSS-E-ST-35-03C
Liquid propulsion for launchers

ECSS-E-ST-35-06C Rev.1
Cleanliness requirements for spacecraft propulsion hardware

ECSS-E-ST-35-10C
Compatibility testing for liquid propulsion systems

LEGEND

Published

Document affected by update of other doc. M

Ongoing update of an existing document U

New document in production N

(as of 15 October 2014)

View B

Figure 5-5: Standards in the E (Space engineering) disciplines

- Non-normative (handbooks and technical memoranda) documents in the disciplines of the E branch are represented in Figure 5-6.

Figure 5-6: HBs and TMs in the E (Space engineering) disciplines

5.2.2.6 Documents in the U branch

The U branch contains only standards, i.e. it does not contain non-normative (handbooks and technical memoranda) documents. The standards in the U branch are represented in Figure 5-7.

As it can be seen in this Figure, there U branch contains three disciplines, with only one (Level 2) standard in each discipline, except U30, which has no document assigned yet.
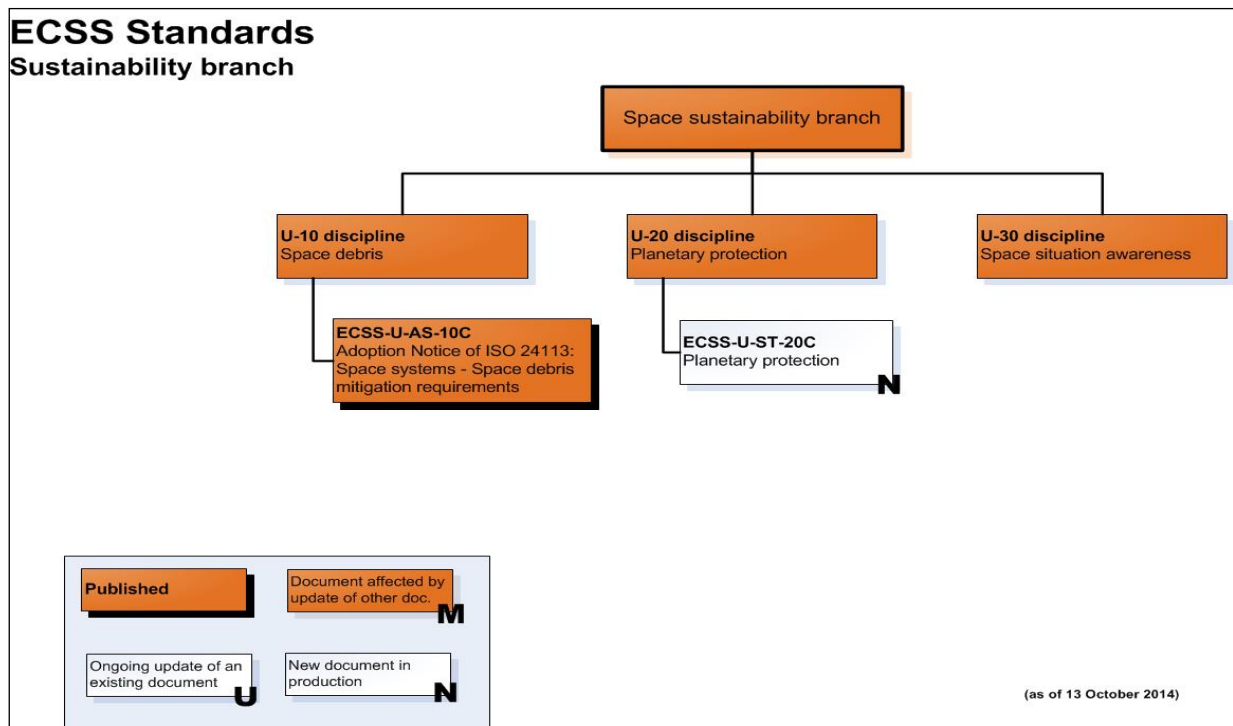
Figure 5-7: Standards in the U (Space sustainability) disciplines

5.2.3   Denomination of documents

The name of an ECSS document gives information on the type of document, the discipline that it belongs to and its level (Level 2 or 3). Figure 5-8 shows a generic name of an ECSS document.
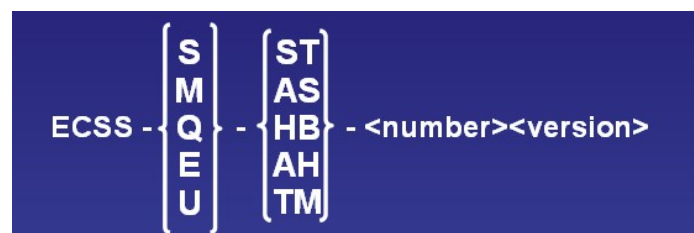
Figure 5-8: ECSS document denomination scheme

In this figure:

a.   **<S, M, Q, E, U> represents the branch:** S is used for the ECSS system documents; M, Q, E and U for Management, Product assurance, Engineering and Sustainability documents, respectively.

b.   **<ST, AS, HB, AH, TM> is the type of document**: ST for standard, AS for external document adopted as standard, HB for handbook, AH for external document adopted as handbook, and TM for technical memorandum.

It is important to understand that AS have, from a legal point of view, the same treatment than ST, i.e. they are considered normative documents in ECSS. AH have the same treatment than HB, and therefore they are considered non-normative documents in ECSS.

NOTE 1   At the present time, there is no AH document in ECSS, but some may be adopted in the future.

NOTE 2   There is no intention in ECSS of adopting any document as TM.

c.   **<number> is one or two groups of two digits each**.

1.   One group of two digits, for Level 2 standards (more generic requirements)

2.   Two groups of two digits each, for Level 3 standards (more specific requirements)

3.   **The branch + 1st group (of two digits) represents the discipline** in accordance with Figure 5-1.

d.   <version> is a letter from A onwards, representing the issue.

It may include also a Revision index (Rev. x), from 1 onwards.

5.2.4   Characteristics of the ECSS system

5.2.4.1   Characteristics of ECSS as a system of standards

5.2.4.1.1   ECSS is a consistent system of standards

ECSS has been built with the intention to be a **consistent set of documents**, not a simple collection of them. In practical terms, that means that:

a.   ECSS covers as far as possible all its intended scope. It is recognized that the existing ECSS documents cover now a days the fundamental aspects of space standardization, until the point necessary for space projects. Every year some few documents are added, but this is due to technology evolution rather than lacks in the system.

b.   There is no overlapping (and therefore no contradiction) among documents. A big effort is put by ECSS to avoid overlapping among documents. Overlapping (even without contradiction) is considered negative for several reasons, among others:

1.   In regulation, repeating requirements does not make them more binding, so not advantage in overlapping.

2.   Tailoring is a complex task. If one requirement is repeated in two or more documents, tailoring may become impractical, since once a requirement is modified, it may be in contradiction with the non-modified one, so tailoring of every requirement may need to recheck the whole system for consistency.

3.   Verification is a complex and costly activity. If one requirement is repeated, it may happen that it is verify several times, by several different actors, in several different moments. An even worse situation is if the result of this verifications are not all fully consistent, or not comparable.

To avoid overlapping, cross-references between documents are used. So, if one document needs to cover aspects under the scope of a second document, the former simply refer to the appropriate clause or paragraph of the latter. This creates two kind of cross-references among ECSS standards:

—   Normative references, when a clause or paragraph of this second document is made mandatory by a normative provision (i.e. a requirement) of the first document. Note that in ECSS "Normative references" are not "important documents", but documents referenced form normative text. If they are not made mandatory by a requirement, they are not in "Normative references".

— Informative references, or "Bibliography", when a clause or paragraph of the referred document is mentioned by the first document for providing additional information, i.e. referenced from informative text.

In ECSS this distinction is so important for standards, that "Normative references" is always Clause 2 of every ECSS standard, while "Bibliography" is a section at the end of the document.

Note that, to apply an ECSS standard, all the Normative references shall be available, since at least one paragraph of them is mandatory. However, documents in "Bibliography" are not necessary at all to apply the standard, they are listed only for information.

The application of the above principles immediately implies three consequences:

- **There is no need of precedence rules in ECSS standards** (see 5.2.4.1.2)

- To ensure consistency, **ECSS standards are released in batches** (see 5.2.4.1.3)

- **ECSS standards cannot be applied in isolation** (see 5.2.4.1.4).

5.2.4.1.2   No need of precedence rules in ECSS standards

Since standards do not contradict (even not overlap) each other, all standards, irrespective of their structural level (Level 2 or 3), have the same precedence level. The ones applicable to a particular project are the ones made normative by the contract, all equally binding.

5.2.4.1.3   ECSS standards are released in batches

To ensure consistency, **ECSS standards are released in batches**. Please note that, with the exception of a couple of documents, all ECSS standards are in issue C (i.e. version C, or version C Rev x). The reason is that consistency of all ECSS standards is ensured at a given moment, and then the complete set is released approximately at the same time with the same issue number (C in this case).

Further evolution of individual standards is performed via Rev's, which respect the consistency assumptions initially done for the issue of the complete set. Rev's of individual standards are triggered by CRs (Change Requests) by the users. Every CR received by the ECSS Secretariat from an user of an ECSS country is assessed by the ECSS governing bodies, and then accepted or rejected. If accepted, is classified as urgent or not urgent. When an ECSS standard is affected by an urgent CR, a Rev of the standard is started, and then all the urgent and not-urgent CRs affecting the document are implemented. The message is that, if you identify lacks, pitfalls or mistakes in ECSS documents, **please write a CR to the ECSS Secretariat** using the CR format in the ECSS Website (www.ecss.nl).

When the ECSS governing bodies would decide to produce a next issue of the ECSS standards, the consistency assumptions done for issue C may be changed, but they will be for all standards at the same time, and then the complete set would be released as issue D.

The couple of documents still in version A or B have not been aligned yet with the consistency assumptions for issue C, which means that they may not be fully consistent with the rest of the documents. This couple of documents will be eventually aligned also with issue C assumptions.

5.2.4.1.4   ECSS standards cannot be applied in isolation

A consequence of 5.2.4.1.1 is that, unlike other standardization systems (e.g. ISO), no ECSS standard can be applied in isolation, because part of the requirements necessary for an application may also relevant for other applications. The result is that they may be covered by other standard, and simply referred form the present one. In other standardization systems, a given standard may contain all aspects relevant for a given application, many aspects repeated in other standard for a different application. ECSS is, as explained above, a consistent system of documents, and therefore no duplication among standards exists. The immediate implication is that, to cover the

many aspects of a given application, several documents will be necessary. In other words, **tailoring of the ECSS system for a given application needs a knowledgeable expert**, well aware of both the exact needs of such application, and where they are covered in the ECSS documents.

For example, to procure a start sensor, ECSS-E-ST-60-20 "Star sensors" will be applicable, but it will not be the only document necessary. The other applicable documents will depend very much of the exact needs (for example, it is not the same if the equipment is procured off-the-shelve that it is developed ad-hoc for the particular application), but examples of documents that will be likely necessary, in its totality or in part, are:

- M-ST-40 "Information and documentation management", to ensure that the documentation delivered by the supplier meets the project expectations and can be integrated within.

- E-ST-10-02 "Verification", since a part of the requirement would need a formal verification.

- E-ST-10-03 "Testing", at least Clause 4 "General requirements", and 5 "Space segment equipment"

- E-ST-10-04 "Space environment", tailored for the operational environment of the mission

- E-ST-10-06 "TS", which specifies how to write a TS and how to draft the requirements within.

- E-ST-10-09 "Reference coordinate system", specifying the correspondence among different coordinate system to be used by different elements of the Space system.

- E-ST-10-12 "Radiation dose", specifying the maximum radiation dose allowed by different elements, and how to calculate it depending of the environment and their position within the S/C.

- E-ST-10-24 "I/F control", specifying how to control the physical and functional I/Fs between different elements of the Space system (including so the star tracker)

- E-ST-20 "Electric and electronics", specifying generic requirements that any electric or electronic product shall meet.

- E-ST-20-07 "EMC", specifying requirements to ensure electromagnetic compatibility

- E-ST-40 "SW engineering", only needed if the SW is procured separately, or it is necessary to change it (and therefore to re-qualify it)

- E-ST-50-1x (corresponding 1x to the standard covering the protocol used for the bus at which the equipment will be connected),

- E-ST-60-10 "Control performances",

- E-ST-70-31 "Monitoring and control data definition", specifying the data to be provided by the supplier of a product, such that these data can be integrated so that it can be tested and operated.

- Q-ST-10-04 "Critical item control" (if it is considered a critical item for the mission),

- Q-ST-10-09 "Nonconformances", specifying how to deal with nonconformances with the requirements

- Q-ST-20-10 "Off-the-shelve item utilization" (only if procured off-the-shelve)

- Q-ST-30 "Dependability"

- Q-ST-30-02 "FMECA"

- Q-ST-30-11 "Derating of EEE components"

- Q-ST-60 "EEE components"

- Q-ST-60-15 "Radiation hardness assurance"

- Q-ST-80 "SW Product assurance", with the same comments that for E-ST-40.

5.2.4.2   Characteristics of individual ECSS standards

5.2.4.2.1   Normative and descriptive material

All the information within a standard is either descriptive or normative.

a. Normative statements of a standard called in a contract **constitute an integral part of the contract** and therefore it binds the signing parties. Normative statements includes:

1. Requirements, which are statements that shall be complied with by an identified actor (customer or supplier). They are identified by the verb "**shall**", and all the "shall's" constitute requirements.

2. Recommendations are identified with the verb "**should**", and all the "should's" constitute recommendations. They are statements expressing the preferred way or solution of doing something, but not preventing other possibilities. In practical terms that means that recommendations need to be negotiated between customer and supplier, which sometimes can be very time consuming. To avoid this, it is a good practice that every project, before issuing the ITT, tailors all the recommendations by going through all of them (in ECSS, very few) and deciding for this particular project, one by one, if it is relevant (and therefore tailor it by converting it into a requirement by changing the "should" into "shall"), or not (and therefore tailoring it out by deleting it). It is not surprising, therefore, that there is no recommendations in your project, or its number is very low.

3. Permissions, which are alleviation to stated requirements or recommendations, if certain (specified) conditions are met. They are identified with "if… then **may**" or "if… then **need not**".

4. Definitions, which explain the meaning of terms used in requirements, recommendations or permissions. In all ECSS standards, all definitions are in Clause 3. More information on this in 5.2.4.2.2.

> NOTE   Strictly speaking, "Normative references" (Clause 2) is also normative. However, this clause only summarized the documents made normative by the requirements, recommendations, permissions and definitions, and therefore it does not includes additional binding conditions.

In ECSS, normative statements have the following characteristics:

— Normative statements are individually identified. Therefore, if there is a reference to e.g. requirement 11.8.2c of a given standard, there is one and only one requirement with such a reference within that standard and therefore it can be referred to without ambiguity. This makes cross-references, tailoring and verification control much easier.

— Normative statements are unambiguous and verifiable. Unambiguous means that they are written so that the text can be understood in one way and only in one way. Verifiable means that (irrespective if they will be verified via a formal verification process or not, see 4.3.5), it can be objectively assessed if the requirements has been met or not, i.e. the result of this assessment does not depend of the person or entity doing the assessment. For example:
   o "The part shall be shorter than 10 cm" or "the supplier shall submit the System Engineering Plan to the customer for approval" are both verifiable.
   o "The part shall be as short as possible" or "The process shall be performed following the best engineering practices" are both non-verifiable.

b. Descriptive material is provided exclusively for the better understanding and clarification of the requirements, but it does not modify the obligation of the contract itself, and therefore **it does not constitute part of the contract**. Descriptive material includes:

1. Descriptive clauses, which are clauses without normative statements. In ECSS, each clause is either normative (containing normative statements, see a. above), or descriptive. Mix of normative and descriptive material in the same clause is not possible in ECSS (except the obvious case explained in b.3 below). Descriptive clauses are identified with the title "Principles", "Introduction", "Overview" or "Rational".

2. Descriptive annexes, which title always includes the word "Informative". They do not contain normative statements (see a. above)

3. NOTES to the normative statements, which are small pieces of information explaining a particular normative statement, and placed just after such statement. They are always identified with the word NOTE.

4. Bibliography (also called sometimes "Informative references"), which summarizes the documents mentioned in descriptive text (i.e. non-normative statements). In ECSS standards, "Bibliography" is always the last section in the standard.

Applying the above rules, it can be clearly differentiated what is what is normative and what is informative in an ECSS standard, and therefore what is **by default** part of the contract and what is not.

A particular contract, however, may, if so explicitly stated in the contract or in one of the normative documents of the contract, make normative any non-normative part, or the other way around.

5.2.4.2.2   The meaning of the terms used in normative statements

Terms defined in a standard, may be accompanied by a context tag, as <<context>>. If so, the given definition is applicable only in the context specified by the tag. Otherwise, the definition is applicable generically in any context in which the term is used in the standard.

The meaning of a term used in a normative statement (e.g. a requirement) has a direct impact in the scope of the normative statement. Therefore it is important that everybody has the same understanding of such a meaning. The logic below applies to ESA relevant standards (including ECSS):

- If a term used in a document is defined in the document itself (i.e. in Clause 3), this definition applies.

- If the term is not defined in the own document, but it is defined in the Glossary of terms, this definition applies.

- If the term is not defined in both the own document and the Glossary of terms, the definition of the Oxford English Dictionary (valid version at the time of signing the contract) applies.

5.2.5   Organization of the information within a standard

5.2.5.1   Organization of the descriptive and normative material

ECSS standards includes the minimum descriptive material necessary to understand or to put the normative statements (e.g. requirements) in context. As explained in 5.2.4.2.1, descriptive material is not part of the contract. It is provided only for further explanation, but it does not introduce additional obligations neither modify the existing ones. Therefore from the contractual point of view it can be ignored.

In ECSS, descriptive and normative material are presented in separate clauses or sub-clauses, except in the case of the NOTES, which are located just after the requirement(s) they refer to.

All the normative statements (definitions, requirements, permissions and definitions) are in the body text of the standard, not in annexes. The only exception are DRDs, which are normative and they are detached in annexes. DRDs are explained in 5.2.5.3.

5.2.5.2   Annexes

Annexes can be descriptive or normative. The title of the annex always specifies if the annex is normative or descriptive (informative).

An informative annex does not contain any normative material at all.

A normative annex includes at least one normative statement, and can also contain informative material. As explained before, the only possible normative annexes are DRDs.

5.2.5.3   DRDs (Document requirement definition)

A DRD is a normative annex which specifies the contents of a deliverable document required by the standard. The following clarifications are important:

- A DRD specifies the "content", but not the "table of contents". This means that the DRD specifies all the information to be provided, but not the format of the document in any sense. The deliverable document can include the information structured in a complete different way as listed in the DRD, in any format, and even several deliverable documents can be merged in one single one, as far all the information specified is provided.

- The DRD only specifies the content. The requirements to produce the deliverable document, who has to do it, when, how often needs to be updated, an so, are requirements in the body text of the standard, and not in the DRD. In fact, the first clause of every DRD annex is a reference to the requirement in the body text requiring the DRD.

- There are two types of DRDs:
    — DRDs associated to specific project reviews. Normally, they are required for a given project review, and updated in subsequent ones. Level 2 standards include a table of the DRDs of this type in the discipline, organized by reviews. See Table 7-7, Table 8-14 and Table 9-12.
    — DRDs associated to specific events. The production of these DRDs is triggered by the occurrence of a given event, and therefore they are de-synchronized with the project reviews. For example, a transport plan shall be produced when a transportation is taken place. See Table 7-8 and Table 8-15.

5.2.6   Anatomy of an ECSS standard

In ECSS, non-numbered chapters or parts of a document are called "Sections". Numbered chapters are called "Clauses". Clauses are so called because they are either normative, or they support the understanding or the application of normative statements.

An ECSS standard is organized always as follows:

- A number of Sections, as follows:
    — Cover page contains always a meaningful title, and the identifying number, in accordance with 4.3.2.2.
    — Foreword (including disclaimer and drafting, reviewing and approval details) and copyright information.
    — The table of contents, listing all section and clauses until level 4. It includes also a List of Figures and a List of Tables.
    — ECSS standard may or may not include an Introduction. The Introduction contains always *informative material* on e.g. the importance of the standard, its history, or the communities contributing to its drafting. The Introduction is not relevant for the application of the standard.

- A number of Clauses, as follows:

  1. Clause 1 is *always* "Scope". The scope is intentionally kept as brief as possible, specifying only what the standard covers, and when and for what the standard is applicable (or is not).

  2. Clause 2 is *always* "Normative references". In ECSS, "Normative references" has a very specific and precise meaning, probably different than in other documents. See 4.3.2.2 for a discussion on this meaning.

  3. Clause 3 is *always* "Terms, definitions and abbreviated terms". See 6.2.1.1bfor the use of terms and definitions in ECSS.

  4. Clause 4 is *normally* an informative clause explaining the approach taken by the standard, or supporting the requirements for a better understanding. In this case, Clause 4 is called "Principles", "Background" or "Overview". In the few standards in which this background or support is not considered necessary, Clause 4 is directly used for Requirements.

  5. Clauses after Clause 4, if they exist, are used for Requirements (except in the case 6. Below).

  6. The last Clause of each standard needing pre-tailoring is reserved for the pre-tailoring table. This table lists all the requirements of the standard, one by one, stating their applicability to nine type of product types (Space system, Space segment/subsystem, Space equipment, Launch segment/subsystem, Launch equipment, Ground segment/subsystem, Ground equipment, Ground Support Equipment GSE, and Software).

  7. Annexes. A complete explanation on annexes is provided in 4.3.2.5.2 and 4.3.2.5.3.

- A section called "Bibliography", at the very end of the document. See 4.3.2.3b for a detail discussion.

5.2.7 The "ODSI" paradigm

ECSS standards, and specially Level 2, are intentionally generic. To be able of being suitable for the majority of the projects and adaptable to most of the potential suppliers, they cannot specify a precise and specific way of organizing activities. Instead of this, many requirements, especially those dealing with supplier organization, follow the "ODSI" (Organize – Document - Submit for approval – Implement) paradigm, which can be summarized as follows:

a. **Organize** the activity in your own way

b. **Document** how you have organized the activity in your own way. The relevant aspects to be documented are normally covered by a DRD.

c. **Submit** to your customer the document describing your organization, for approval. Approval of your customer is important to ensure a consistent organization through all the project actors such that your way of organizing is not conflicting with other areas.

d. Once approved, **Implement** the documented organization. In the practical world, the organization may have been implemented before, but from a formal point of view, the implementation of a requirement applying the "ODSI" principle is considered valid only after approval by the customer.

For example, ECSS-M-ST-10C # 5.1.3 states:

> h. *"The supplier shall establish the Work Breakdown Structure (WBS) for his work share, incorporating the WBS of his lower tier suppliers, in conformance with Annex C"*

> k. *The WBS shall be subject to customer approval"*

By following the ODSI principle, high flexibility is given to the suppliers to use their own solutions. This is a merit for already established suppliers (because they does not need to change their proven organizations to satisfy ECSS), but newcomers may have difficulties in understanding what it is actually expected from them. ECSS also solve this problem by proposing in many cases a valid solution in the informative part of the standard (normally in Clause 4). In the example above, an example of WBS implementation is given in Clause 4.3.5. So, a new statement can be added to the "ODSI" principle:

e.   If you need help to organize yourself to comply with a. above, find guidance material in the standard itself, normally in Clause 4.

Section 7 includes many examples of this way of specifying organization requirements.

5.2.8   Application of ECSS standards

5.2.8.1   Tailoring

ECSS system is designed for a generic space project. When the ECSS standards and requirements need to be applied to a particular project, they obviously need an adaptation to the specificities of the project. This adaptation process is called Tailoring.

It is expected that tailoring is done first by the top level customer, normally an Space Agency, to identify the requirements applicable to the project. However, this is not the end of the story. It is also expected that every customer, at each level of the customer-supplier chain, performs the appropriate tailoring to flow down the requirements to each of his suppliers by issuing a SRD/PRD, as already outlined in 4.3.4.4, when explaining the customer-supplier model.

It is well known that this is not always the case. In many occasions the customer gives to the supplier the complete set of ECSS standard and requirements for the supplier to identify what is applicable to him. This is not the way proposed in ECSS. ECSS-S-ST-00, the highest standard in the ECSS hierarchy of documents, where the tailoring is performed by the customer at each level.
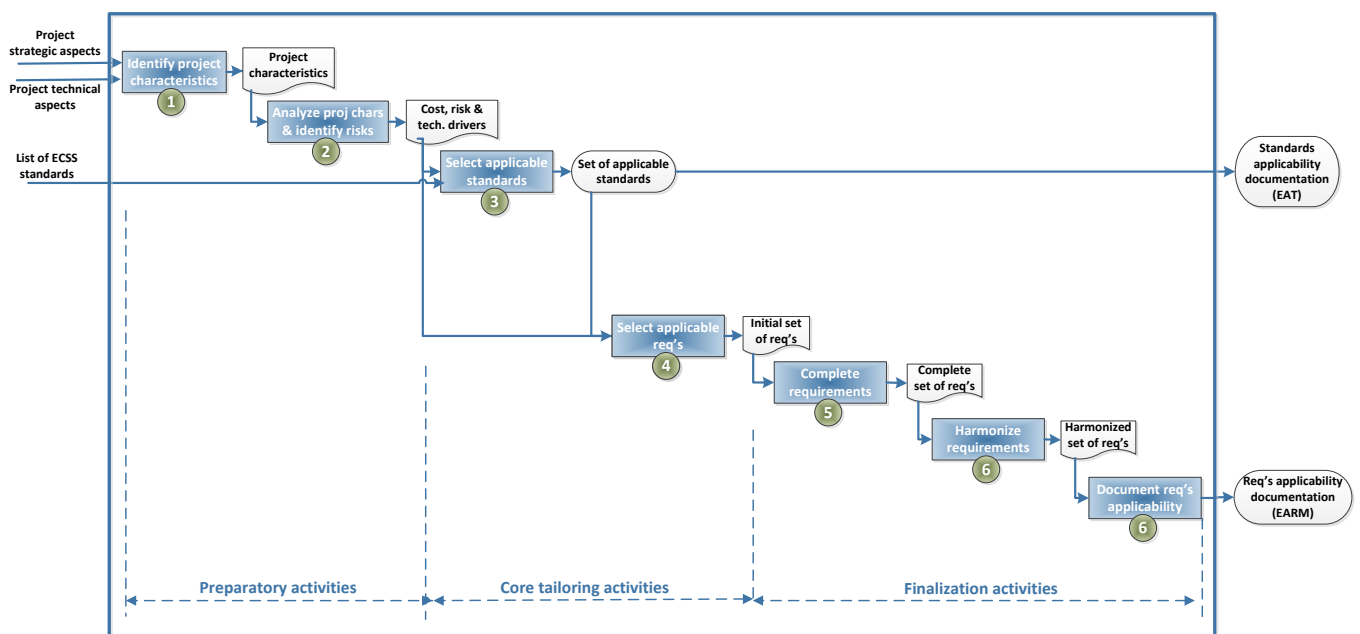
Figure 5-9: Generic tailoring process

The generic tailoring process to be performed by the highest customer (in the present case, ESA) proposed in ECSS-S-ST-00, represented in Figure 5-9, is performed in 7 steps, grouped in three activity blocks: Preparatory activities, Core tailoring activities and Finalization activities.

- **Preparatory activities** are those to recognize the parameters that should lead the tailoring itself.

  — During **Step 1**, taking as inputs the project strategic and technical aspects, the project characteristics are derived.

  — During **Step 2**, these project characteristics are analyzed to identify the project risks and technical drivers.

- **Core tailoring activities** can start now that the project has all the elements supporting the tailoring decisions to be made.

  — During **Step 3**, the project cost, and the risk and technical drivers identified before can be used to tailor the list of ECSS standards. It is not yet time to open the books, only the list is tailored at this step. The output of this activity is the list of ECSS applicable standards, a document that normally is under configuration control by the project. ECSS proposes to materialize this list in a table call the EAT (ECSS Applicability Table), shown in Table 5-1, and that includes also the appropriate justification.

  > NOTE   This tailoring activity required by ECSS corresponds to the tailoring of the LEAS required by ESA, and explained in 4.3.3.1.

  — Now is the moment of opening the books. During **Step 4** all ECSS applicable standards are analyzed, provision by provision (requirements, recommendation and permissions) to decide on their applicability. Each of these requirements can be accepted as is, modified, deleted, or even sometimes added if some generic requirements were missing in ECSS. In the latter three cases, justification should be provided. In the case of modified or new requirements, the whole text of the new requirement needs to be provided also.

  The result of this activity will be the initial set of applicable requirements.

Table 5-1: Example of EAT

Standard	Applicability (A / M / /NA)	Justification (including justification of the use of other standard instead of)

A:	Standard applicable without modifications
M:	Standard applicable with modification. For each of these standards, the generation of a EARM is expected.
NA	Standard not applicable at all

- **Finalization activities** are all the activities to complete and document the SRD/PRD, which include:

  — During **Step 5**, requirements specific to the particular project or application are added. Specific requirements are those specifying the very characteristics of your mission, and therefore cannot be standardized. For example, that a mass analysis shall be performed is a generic requirement. That the maximum mass of the S/C shall be 3000 Kg is a specific one.

  The output of this step will be the complete raw set of applicable requirements.

— During **Step 6**, the complete raw set of requirements is harmonized. ECSS is a consistent set of standards, so no harmonization is needed. However, when adding new some conflicts may have been introduced. It is time now of resolving these conflicts.

The output of this step is the final set of applicable requirements.

— The last step, **Step 7**, is to document all the process, clearly stating which requirements have been modified, deleted or added, in which manner and why. The resulting file is called Requirement applicability documentation, and ECSS expects that is materialized in a matrix called EARM (ECSS applicability Requirement Matrix), shown in Table 5-2. ECSS also expects that this information is provided to the ES as feedback, to help improving the standards.

Table 5-2: Example of EARM

THE COMPLETE SET OF REQUIREMENTS IN THE STANDARDS IN COLUMN 1 ARE APPLICABLE, WITH THE MODIFICATIONS STATED IN COLUMNS 2 TO 6					
1. ECSS Standard	2. ECSS Req. identifier	3. Org. Req. identifier	4. Applicability (M/D/N)	5 Modified or New requirement (Full text)	6. Justification
NOTE: Column 3 is provided to give the users the capability of using their own requirement identification system, in parallel with the identification of the requirement in the applicable standard (Column 2).			**M**: Requirement applicable with **M**odification **D**: Requirement **D**eleted, not applicable **N**: **N**ew requirement (requirement added)		

5.2.8.2   The ECSS DOORS database

DOORS is a commercial software by IBM for managing requirements. It is specially oriented to keep full traceability between requirements when they are flow down to suppliers, so that at any level of the costumer-supplier chain, any requirement can be traced top [from which requirement(s) it derives from] and down [which requirement(s) are derived from it]. This permits the assessment of the impact of any non-compliance at any level, including which other top, down or at the same level requirements are affected.

When flowing down the requirements, they can be also tailored, so DOORS can be used as a tailoring tool (even if this is not its main purpose).

In essence, DOORS is a requirement database management tool, which means that, once the license is bought, it is still necessary:

- For the complete ECSS system:
  — To establish the desired structure of the database to feel your user needs
  — To feed the tool with the requirements applicable to a project.

  DOORS is a powerful, versatile, full of capabilities tool, but this characteristics imply that it is complex. This complexity makes that both the structure establishment and the filling with a set of requirements, can be done in many different ways, depending on the user needs and approach. As a consequence,

implementation of ECSS requirements by different ECSS members could be done in a different manner, and a supplier may receive from two different customers two different DOORS implementations of the same ECSS requirements. This would partially spoil all the effort put in the development of a single set of standards for all Europe.

To avoid this situation, ECSS decided to provide users not only with the ECSS standards, but also by an official release of the ECSS standards in DOORS, normally called the "ECSS DOORS database".

The ECSS DOORS database is released twice a year, and can be downloaded free of charge from the ECSS Website. Please note that however, to be able to use it, you should buy the corresponding license to IBM and to train your personnel.

- For a particular project: The ECSS DOORS database need to be tailored to the specificities of the procurement. This tailoring is done, at highest customer level, following the process explained in 5.2.8.1. Since **the use of the ECSS DOORS database is left to the decision of a project**, a supplier may receive the applicable requirements in a DOORS format, or otherwise.

  In any case, any supplier is reminded that this requirement database shall be tailored by him to the next level suppliers.

5.3 Other standards in the SRD/PRD

5.3.1 Overview

As explained in 4.3.4.1a.2, the SRD/PRD may include a large variety of documents, depending on the nature of the project. It is not possible to list here the project specific documents that a generic project may include, but there is a number of generic documents that it is worthy to mention.

The main generic documents are ESSB, CCSDS, ESCC and PSS documents, described in the sections below. Other documents that the SRD/PRD may also make applicable refer mainly to specific technologies or protocols used by the project, for example MIL-1553-B (Digital time division command) and IPv4 (the Internet protocol)

5.3.2 ESA-only documents (ESSB)

ESSB are documents published by ESA, and of application limited to ESA. ESSB stands for "ESA Standardization Steering Board", which is the highest standardization body in ESA. There are not many ESSB documents, because ESA prefers to use standards wider recognized (as ECSS or CCSDS), but there are some few occasions where this way is unavoidable.

When ESA produced an ESSB document, ESA uses as much as possible the ECSS logic and approach to ensure that ESSB documents are perfectly integrated and do not break the ECSS consistency. That means that section 4.3.2 is generally applicable also for ESSB documents, except subsection 4.3.2.2 (denomination of documents), which follows a similar schema as in Figure 5-10.
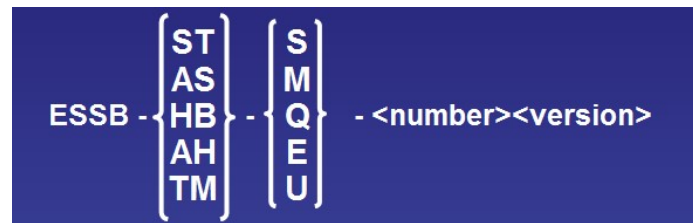
Figure 5-10: Denomination of ESSB documents

In this figure:

a. **<ST, AS, HB, AH, TM> is the type of document**: ST for standard, AS for external document adopted as standard, HB for handbook, AH for external document adopted as handbook, and TM for technical memorandum.

b. **<S, M, Q, E, U> represents the branch:** S is used for the ECSS system documents; M, Q, E and U for Management, Product assurance, Engineering and Sustainability documents, respectively.

c. **<number> is one groups of three digits**.

> NOTE   In ESSB documents, the discipline is not indicated in the title number of the document.

d. <version> is a letter from "Issue 1" onwards.

It may include also a Revision index (Rev. x), from 1 onwards.

5.3.3   CCSDS documents

CCSDS are worldwide (not only European) documents covering only communications and data handling, which means that CCSDS documents may be relevant for a limited number of contracts.

It is important to note that ECSS E50 and E70 disciplines (the ECSS disciplines dealing with communications and data handling) do not overlap with CCSDS, because if a subject is covered by a CCSDS document, the ECSS policy is to rely on it and generally not to develop documents in that area.

5.3.4   ESCC documents

ESCC stands for European Space Components Coordination, and it is an organization producing standards for EEE components, and certifying such components and their manufacturers against those standards. With this initiative, one of the ESCC objectives is to ensure reliable EEE components for Space application.

ECSS Q60 discipline (EEE components) does not overlap with ESCC, because ESCC standards (called "specifications" by ESCC) are applicable to EEE components and their manufacturers, and therefore of limited application to Space projects. A space project only needs to understand that using EEE components certified by ESCC is a guaranty of reliability. Following this principle, the SRD/PRD includes the specifications for a number of EEE components, and lists of qualified/certified components (the EPPL and the QPL) and manufacturers (EQML and the ESA approved manufacturers).

5.3.5   PSS documents

PSS documents are documents published by ESA in the eighties and nineties, some of them may still be made applicable by the SRD/PRD. They will be eventually superseded by ECSS documents, but at the present some few of them are still used in space projects.

6
ECSS documents and their application in ESA projects

6.1　Overview

The standards in the LEAS are generally applicable to any ESA Space project, irrespective of the size of the project or the supplier. Generally applicable means that they shall be considered, but tailoring shall be performed to adapt the standardization system to the actual needs. This tailoring will not depend directly on the size of the project or supplier, but on the type of product, project phase and a number of programmatic parameters as e.g. assumable risk.

> NOTE　　For the LEAS, see 4.3.3.1. and 4.3.4.1a.2.

The present section describes first the contents of the ECSS documents (normative and non-normative) so that the reader can acquire a general view of the coverage of ECSS in general, per discipline, and per document. The reader is reminder that, by default (i.e. unless otherwise specified in the contract), only standards are applicable, being the handbooks and TMs non-normative documents providing only guidance.

Once the content of all the documents is clarified, this section explains the standards (i.e. only the normative documents) from the point of view of their applicability, presenting the most generic standards in ECSS (normally not tailored in most of the projects) and point to the specific ones to help in deciding on their tailoring in accordance with the above described parameters. It is important to understand that this guide does not perform the tailoring itself, it only provides information to an actor to understand the tailoring approach followed by his/her customer, and gives guidance to this actor to perform the tailoring for his/her suppliers.

6.2　General description of the ECSS system of documents and their contents

6.2.1　General description of the S and M standards and their content

6.2.1.1　Description of the S branch

The S branch describes all the ECSS system and its application in Space projects, and specifies the normative provisions applicable to any Space project. It is therefore applicable to the Space, Launch and Ground segments. It is not divided in disciplines, and includes only two documents:

a.　ECSS-S-ST-00 is the highest level document in the ECSS hierarchy of standards. It works both:

— As a handbook, explaining the principles of the ECSS system and its application. In this sense, it is a summary of the present guide.

— As a standard, specifying very high level requirements on the application of the system. This requirements can be summarized in two principles:

o The customer produces a Project Requirement Document [SRD/PRD] by performs the tailoring of the ECSS system and adding the specific project requirements,, and

o The supplier responds with an Implementation Document (ID) describing how the requirements in the SRD/PRD will be implemented.

b. ECSS-S-ST-00-01 "Glossary of terms", with the terms and definitions of general applicability in ECSS. The applicability of this document is as follows. If a term is used in an ECSS document, the applicable definition is the one defined in the own document (Clause 3), if it exists. Otherwise, the applicable definition is the one defined in the Glossary, if it exists. If the definition is not in the own document, nor in the Glossary, the Oxford English Dictionary definition applies.

6.2.1.2 Description of the M branch

6.2.1.2.1 Overview of the M branch

The M branch covers the processes and requirements to achieve a successful completion of the project in terms of cost, schedule and technical performance, by following a structured approach throughout all stages of its life cycle and at all levels of the customer-supplier chain.

A general view of the documents in the M branch is presented in Figure 5-2. As it can be seen there, there are five disciplines, containing a Level 2 standard each, except M10, which contains a Level 2 and a Level 3 standard. There are not non-normative documents (i.e. HBs and TMs) in the M branch. The following sections describe the five M disciplines, and their documents.

6.2.1.2.2 The M10 "Project planning and implementation" discipline

M10 "Project planning and implementation" discipline, which scope covers the management processes (including the corresponding documentation) and requirements for minimizing the technical, scheduling and economic risk of the project by organizing it in phases, defining project breakdown structures, establishing responsibilities in accordance with a project organizational structure, and ensuring coherency of all the project activities.

a. Level 2 standard

The entry point to this discipline is the Level 2 standard ECSS-M-ST-10 "Project planning and implementation", which specifies the generic requirements for the processes and activities related to the scope of the discipline stated above. Among others, it requires that a project is divided in well-defined phases, and that formal reviews are organized at given milestones (normally at the end of each phase) to control the progress of the project and to make decisions on moving to the next phase.

b. Level 3 documents

The only Level 3 standard in this discipline is ECSS-M-ST-10-01 "Organization and conduct of reviews". This standard specifies the very specific requirements on how to organize and perform a formal project review, to ensure a coherent approach and consistent decisions through the whole project and at any level of the contractual chain.

c. Non-normative documents (HBs and TMs):

None.

6.2.1.2.3   The M40 "Configuration and information management" discipline

M40 "Configuration and information management" discipline, which scope covers the processes (including documentation) and requirements to manage the information and documentation, and the configuration of products within a space project, to ensure a consistent approach at all levels of the customer-supplier chain.

a.   The Level 2 standard

The entry point and only standard in this discipline is the Level 2 standard ECSS-M-ST-40 "Configuration and information management", specifying the generic requirements for the processes and activities related to the scope of the discipline stated above.

It is important to understand how the three ECSS domains (Engineering, PA and Management) are covered for Software. SW engineering is covered by E40. SW PA is covered by Q80. SW is mainly documentation, which means that SW management is a specific case of documentation management. Therefore, in ECSS, Software management configuration is a part of ECSS-M-ST-40.

b.   Level 3 documents, and non-normative (HBs and TMs) documents:

None.

6.2.1.2.4   The M60 "Cost and schedule management" discipline

M60 "Cost and schedule management" discipline, which scope covers the management processes (including documentation) and requirements to optimize the use of resources for a successful timely completion of the project, including definition of breakdown structures (cost, contract), and risk. It consist mainly in two interrelated areas:

—   Schedule management, covering the process and requirements to define the project schedule, and to control and report on deviations.

—   Cost management, covering the process and requirements for financial management, and cost estimation, planning, control and reporting.

a.   The Level 2 standard

The entry point and only standard in this discipline is the Level 2 standard ECSS-M-ST-60 "Cost and schedule management", specifying the generic requirements for the processes and activities related to the scope of the discipline stated above.

b.   Level 3 documents, and non-normative (HBs and TMs) documents:

None.

6.2.1.2.5   The M70 "ILS" discipline

M70 "Integrated logistic support (ILS)" discipline, which scope covers the management processes (including documentation) and requirements to identify and provide logistic support to operate a product and maintain it in operative conditions for the expected lifetime, maximizing the use of resources and minimizing the risk through the complete lifecycle of the product.

It is important to understand that ILS activities are not only important for recurrent products, but also for single-unit products, to ensure that logistic support is not compromised at a given stage for shortcuts or saving at other stage.

a.   The level 2 standard

The entry point and only standard in this discipline is the Level 2 standard ECSS-M-60 "ILS", specifying the generic requirements for the processes and activities related to the scope of the discipline stated above.

b.   Level 3 documents, and non-normative (HBs and TMs) documents:

    None.

6.2.1.2.6   The M80 "Risk management" discipline

M80 "Risk management" discipline, which scope covers the processes (including documentation) and requirements for the management of the integrated risk of a project, by identifying potential risks in any project area (including management, technical [PA and engineering] and programmatic), and at any level, and keeping these risks within certain defined boundaries.

a.   The Level 2 standard

    The entry point and only standard in this discipline is the Level 2 standard ECSS-M-80 "Risk management", specifying the requirements to cover the scope of the discipline stated above, by requiring the definition of a risk policy and responsibilities, and specifying a standard generic methodology for risk management (risk identification, assessment, decision and reduction).

b.   Level 3 documents, and non-normative (HBs and TMs) documents:

    None.

6.2.2   General description of the Q standards and their content

6.2.2.1   Overview of the Q branch

The Q branch covers all process and requirements ensuring to ensure the success of the mission with an acceptable level of confidence. Note that, in accordance with this statement,

A general view of the documents in the Q branch is presented in Figure 5-3 and Figure 5-4. As it is seen there, it is divided in the following 7 disciplines:

a.   Q10 "Product assurance", which includes the PA process and requirements for any product, except Software (covered by the Q80 discipline)

b.   Q20 "Quality assurance", which includes the QA process and requirements for any product, except Software (covered by the Q80 discipline)

c.   Q30 "Dependability", including the processes and requirements for any product to ensure a level of reliability, availability and maintainability compatible with the mission objectives. The term "Dependability" is used here as synonymous of RAM (Reliability + Availability + Maintainability).

d.   Q40 "Safety", which includes the processes and requirements for any product to ensure a level of safety compatible with the mission objectives.

e.   Q60 "EEE components", which includes the processes and requirements to ensure a level of confidence of the EEE components used in a project, compatible with the mission objectives.

f.   Q70 "PPM&P", which includes the processes and requirements to ensure a level of confidence of the materials, mechanical parts and processes used in a project, compatible with the mission objectives.

g.   Q80 "Software PA", which includes the PA and QA requirements for software

As shown in Figure 5-3, PA requirements are split between Q10 and Q80. Disciplines Q30 and Q40 together form what is known as RAMS (Reliability, Availability, Maintainability and Safety). Note that there is not a Q50 discipline (for historical reasons).

6.2.2.2   The Q10 "PA" discipline

The Q10 discipline covers the Product Assurance processes (including the corresponding documentation) and requirements to be applied to any space product, *except* software (but see ECSS-Q-ST-10-04 below).

a.   Level 2 standard

The entry point to the discipline is the Level 2 document, ECSS-Q-ST-10 "Product assurance". This document specifies the PA processes to be applied to any product except Software. Besides the requirements for the PA plan (following the ODSI principle), ECSS-Q-ST-10 includes requirements on PA manager responsibilities, and on some PA functions (e.g. audits, documentation/configuration management, quality records and audits). It requires also to implement a critical item control system, and a non-conformance control system. However, the implementation details of these systems are not required here, but in the corresponding Level 3 standards.

b.   Level 3 standards, covering the implementation details of specific PA processes:

1.   ECSS-Q-ST-10-04 "Critical item control" – This standard specifies the process for the control of the critical items including Software. The reason is that critical items shall be controlled jointly in an unified system, and a separate control of hardware and software products is not meaningful.

2.   ECSS-Q-ST-10-09 "Nonconformance control", specifying the process for the control of nonconformances of product other than Software. Nonconformances of Software products are covered by ECSS-Q-ST-80 "SW Product Assurance" itself.

c.   Non-normative documents (HBs and TMs):

None.

6.2.2.3   The Q20 "QA" discipline

The Q20 discipline covers the Quality Assurance processes (including the corresponding documentation) and requirements to be applied to any space product, *except* software.

a.   Level 2 standard

The entry point to the discipline is the Level 2 document, ECSS-Q-ST-20 "Quality assurance". This document specifies the generic QA processes to be applied to any product except Software. Besides the requirements for the QA plan (following the ODSI principle), ECSS-Q-ST-20 includes requirements on a number of QA functions and responsibilities, like Traceability, Metrology, Statistical control, QA design and verification, Procurement, MAI, Testing, and acceptance and delivery. It addresses **some** areas covered by other Q documents (e.g. critical item control and NCR systems, alerts, and C3), but instead of repeating the requirements, jus refer to the corresponding standards

It also contain requirements on typical Q20 activities, like Storage, handling and transportation, and utilization of OTS equipment, but the implementation details are covered by the corresponding Level 3 standards (ECSS-Q-ST-20-08 and -20-10 respectively, see below).

It includes also specific QA requirements for GSE. However, it does not include requirements for SW, which are covered by the Q80 branches.

b.   Level 3 standards, covering the implementation details of specific QA processes:

1.   ECSS-Q-ST-20-07 "QA and safety for space test centres", that is applicable *only* to the qualification of test centres.

2. ECSS-Q-ST-20-08 "Storage, handling and transportation of S/C hardware" (self-explanatory title)

3. ECSS-Q-ST-20-10 "Off-the-self item utilization in space systems", casually known as "OTS utilization", covers the process to procure products from the market, that is, products that, developed or not for space applications, they have not been developed for the specific application covered by the project.

c. Non-normative documents (HBs and TMs):

    None

6.2.2.4   The Q30 "Dependability" discipline

The Q30 discipline includes the Dependability (i.e. Reliability, Availability and Maintainability) processes (including the corresponding documentation) and requirements to be applied, *including* the dependability for functions implemented in software.

a. Level 2standard

    The entry point to the discipline is the Level 2 document, ECSS-Q-ST-30 "Dependability", that specifies the processes to ensure that the product reach the levels of dependability specified by the project. It is important to understand that the levels themselves are not specified by the standard, but they are specific to each project. The standard specifies the processes to ensure that those levels will be reached. It also defines, together with ECSS-Q-ST-40, the levels of Criticality, used by many other standards.

    The processes defined in this standard require the performance of a number of dependability analysis. For some of them, a specified methodology is also required. For some others, the analysis is required, but the method is not specified, and only some guidelines are given in specific handbooks (see c. below).

b. Level 3 standards, which may fall in one of these two categories:

    1. Level 3 standards specifying analysis methodologies. They include:

        (a) ECSS-Q-ST-30-02 "FMEA/FMECA" (Failure mode & effect criticality analysis"

        (b) ECSS-Q-ST-30-09 "Availability analysis"

    2. Level 3 standards specifying hard figures for the reliability calculations. Only one standard in this category exists:

        (a) ECSS-Q-ST-30-11 "Derating for EEE components", which specifies, for the main families of EEE components, the derating factors to be applied for flight applications.

c. Non normative documents (HBs and TMs), which fall in one of the following categories:

    1. Handbooks giving guidelines on analysis methodologies. They include:

        (a) ECSS-Q-HB-30-01 "Worst case analysis handbook"

        (b) ECSS-Q-ST-30-03 "Human dependability handbook"

    2. Handbooks and TMs giving guidance on reliability data:

        (a) ECSS-HB-30-08 "Component reliability data sources, and their use"

        (b) ECSS-TM-30-12 "End-of-life parameters drift for EEE components

6.2.2.5   The Q40 "Safety" discipline

The Q40 discipline includes the Safety processes (including the corresponding documentation) and requirements to be applied *including* the safety for functions implemented in software.

Safety is understood here in the wide sense, i.e. it refers to the protection of flight and ground personnel, the launch vehicle, payloads, ground support equipment, the general public, properties (public and private), space system and associated segments, and the environment.

a.   The Level 2 standard

The entry point to the discipline is the Level 2 document, ECSS-Q-ST-40 "Safety", that specifies the processes to ensure that the hazards related to the product and all associated on ground and in-flight processes and operations are kept under control. It also defines, together with ECSS-Q-ST-30, the levels of Criticality, used by many other standards.

The processes defined in this standard require the performance of a number of safety analysis. Some of them are already covered by the Q30 discipline (e.g. FMEA/FMECA) and therefore they are not repeated, just pointed from here. For those not covered, the methodology may be required or not. In the former case, a Level 3 standard specifying the methodology exists (see b. below). In the latter case, a methodology is proposed (but not required) via a TM (see c. below).

b.   Level 3 standards, specifying an analysis methodology:

1.   ECSS-Q-ST-40-02 "Hazard analysis"

2.   ECSS-Q-ST-40-12 "Fault tree analysis". This document in fact adopts the methodology specified in IEC 61025, and adds some few requirements on when the analysis is required.

c.   Non-normative document (only one TM), proposing a methodology that can be used (or not) as such, or as a guideline, namely ECSS-Q-HB-40-04 "Sneak analysis", published in two books (Parts 1 and 2).

6.2.2.6   The Q60 "EEE components" discipline

The Q60 discipline includes all processes (including documentation) and requirements for the selection, control, procurement and use of EEE components (and exceptionally, design), to ensure that the project will meet its mission requirements with an acceptable level of confidence. Three levels are considered. The higher is the level, the more demanding are the applicable requirements for the EEE components, so that three set of requirements are specified for EEE components Class 1, Class 2 and Class 3.

The engineering of EEE components (including design) is covered by the E20 "Electric and electronics" discipline.

It is important to understand that:

—   The three EEE classes are subjective, in the sense that hard figures of reliability cannot be assigned to each class, however experience shows that using the requirements corresponding to a higher Class provides a higher level of confidence.

—   The Class to be used is not defined by any ECSS standard, but by the project itself taking into account, among others, the risk and economic constraints. Once the Class to be applied is defined for a given procurement, ECSS provides the requirements applicable to that Class. An important remark is that the ESA policy is not to use Class 3 components in any Space project.

a.   The Level 2 standard

The entry point of this discipline is the Level 2 document ECSS-Q-ST-60 "EEE components", that specifies the general processes for the selection, control, procurement and use of EEE components, in

three set of requirements, in Clauses 4 (Class 1), 5 (Class 2) and 6 (Class3). There is a complete parallelism among the three chapters with some few (but relevant) differences applicable only to a given Class.

Besides the requirement s for a Component Control Plan (following the ODSI principle), Chapter 4 (for Class 1 components) requires a Part Control Board and the management of a Declared component List. They also include requirements for:

— Component and manufacturer selection (using the EPPL as preferred source), Component evaluation (i.a.w. a Component Evaluation Plan following the ODSI principle), Manufacturer evaluation (against ESCC specifications) and Parts approval (documented in a PAD)

— Procurement (including screening, lot acceptance, inspection and testing), relifing of components in stock, handling and storage, QA requirements (normally pointing to the corresponding QA standards), and requirements for specific components (pointing to Level 3 standards covering these components).

Clause 5 (for Class 2 components) alleviates some requirements. The quality levels are less demanding and the following is not required: A component plan (a compliance matrix can be used instead), part type reduction activities, use of the EPPL, and Manufacturer assessment. A PAD is not required under certain conditions. A precap and destructive physical analysis is required only for certain type of components. Requirements on lot acceptance and alerts are also alleviated.

Clause 6 (for Class 3 components) introduces also additional alleviations. Since Class 3 components are not used in ESA programmes, they are not covered here.

When specific families of EEE components, or specific processes applicable to EEE components, need special attention, they are detached in separate documents and pointed from this standard (see b. and c. below).

b.   Level 3 standards, which may fall in one of the following categories:

   1.   Specifying (generic or specific) processes for specific families of EEE components:

      (a)   ECSS-Q-ST-60-02 "ASIC and FPGA development" (see also point b. below)

      (b)   ECSS-Q-ST-60-05 "Procurement requirements for hybrids"

      (c)   ECSS-Q-ST-60-12 "Design, selection, procurement and use of MMIC"

   2.   Specifying specific process applicable to any kind of components:

      (a)   ECSS-Q-ST-60-14 "Relifing procedure". Relifing refers to the process and constraints to expand the useful life of an unused component beyond its declared life.

      (b)   ECSS-Q-ST-60-15 "Radiation hardness assurance"

   3.   A third category exist represented by ECSS-Q-ST-60-13 "Commercial EEE components", which is the tailoring matrix of ECSS-Q-60 for commercial components. Since tailoring matrices are not published as independent documents in ECSS, this is an exceptional approach in the system, that was followed here as an interim measure to avoid a re-publication of ECSS-Q-60. However, this standard will be eventually merged and integrated into ECSS-Q-ST-60.

c.   Non-normative document (only one HB) giving guidelines for a specific process, for a specific family of components, namely ECSS-Q-ST-60-02 "Radiation effect mitigation for ASIC and FPGA" (see also point b.1.(a) above).

6.2.2.7 The Q70 "MMP&P" discipline

The Q70 discipline includes all processes (including documentation) and requirements for the selection, procurement, evaluation, utilization and control (and exceptionally design) of materials, mechanical parts and processes to be used at all levels in the production of space systems.

a. The level 2 standard

    The entry point of this discipline is the Level 2 standard ECSS-Q-ST-70 "MMP&P", that specifies the generic processes for this discipline in three Clauses that can be perfectly mapped to each other: Clause 4 (Materials), 5 (Mechanical parts) and 6 (Processes). This standard addresses, among others, the generic requirements for the selection of materials and processes. However, the specific requirements are detached in ECSS-Q-ST-70-71 "Materials, processes and their data selection".

    The engineering of materials (including design) is covered by the E32 "Mechanical-Structural" discipline, and in particular by the ECSS-E-ST-32-08 "Materials engineering" standard. This standard complements ECSS-Q-ST-70 and ECSS-Q-ST-70-71, and the three standards should be used together.

    Specific parts and processes needing special attention are detached in separate documents (see b. and c. below).

b. Level 3 standards in this discipline are very numerous. They specify requirements for many processes and parts. However, as it can be also seen in Figure 5-3 (View B), all these documents can be classified in seven categories, as follows:

    1. For the selection of materials and processes, the only Level 3 standard is ECSS-Q-ST-70-71 that, as explained before, should be used jointly with the Level 2 standard ECSS-Q-ST-70.

    2. Cleanliness processes (3 standards), specifying requirements for the control of the cleanliness of on-ground facilities and flight hardware.

    3. Material testing (about 10 standards), covering specific tests processes for materials, ranging from standards covering a high range of tests (e.g. NDT), to standards covering a single test process (e.g. Flammability testing).

    4. Material processes (about 6 standards), covering specific material processes of very different nature, from surface processes (e.g. black anodizing, painting), to control processes (e.g. control of limited self-life materials).

    5. Assembling processes (about 8 standards), covering processes such as welding (including corrosion), soldering, crimping, and wire wrapping.

    6. Parts, specifying requirements for PCBs (3 standards), coaxial cables (1 standard) and threaded fasteners (1 standard). Note that the engineering aspects of threaded fasteners are covered by the E32 branch, and in particular there is a handbook providing guidelines on their design, ECSS-E-HB-32-23 "Threaded fasteners HB".

    7. Planetary protection cleaning processes (6 standards), specifying the methodology of the cleaning and sterilization processes for flight hardware for planetary missions susceptible of *biological* forward (contaminate the planet with contaminants from Earth) or backward (contaminate the Earth with contaminants from a planet) contamination. Note that the cleaning processes to be applied in accordance with the mission are not defined in this discipline, but in the U20 "Planetary protection" discipline. E70 discipline only covers how these processes are performed.

c.   Non-normative documents (HBs and TMs) in this discipline include only two documents, in the following categories:

   1.   Material testing (1 TM), providing non-normative processes for testing kinetic outgassing of materials

   2.   Parts (1 HB), providing guidance on termination of optical fibres

6.2.2.8   The Q80 "Software PA" discipline

The Q80 discipline covers the Product Assurance and Quality Assurance processes (including the corresponding documentation) and requirements to be applied to any piece of software to be used in a space project, which includes Flight SW, Ground SW, SW for GSE, simulation SW, and non-deliverable SW which affects the quality of the deliverable product.

Therefore, the discipline is only applicable to the development, maintenance, verification & validation, and use (including re-use) of the "software component".

The engineering processes for Software are covered by the E40 "Software engineering" discipline. However, when dealing with software, is not possible in certain cases to clearly differentiate between engineering and PA processes, and therefore the division line between Q80 and E40 is artificial. That implies that these two disciplines depend on each other and shall be used together.

a.   The Level 2 standard

   The entry point to this discipline is the Level 2 standard ECSS-Q-ST-80 "Software PA". This standard capitalize all the SW PA and QA requirements needed for any space application, and for any generic development cycle (which means that to cover the different SW development approaches no specific standards are needed, only tailoring guides of Q80). Therefore, the only standard in the discipline is the Level 2 standard. All the other documents in the branch are handbooks.

   Rules to tailor ECSS-Q-ST-80 are contained in an annex of the own standard, specifying how to tailor the document in accordance to criticality of the function implemented by the software.

b.   Level 3 standards

   None.

c.   Non-normative documents (only HBs), providing acceptable means of compliance with specific requirements in the standard, particularly on:

   1.   Software re-use (1 HB): Q-HB-80-01 "Reuse of existing SW". It is important not to confuse with "designing SW intended for re-use" (mainly covered by E-ST-40 with some additional clauses in Q-ST-80). This HB provides guidelines on the processes to be follow to re-use SW which was written for a different project. "Designing SW intended for re-use" is excluded from the scope of this HB.

   2.   SW assessment processes (2 HBs):

      (a)   Q-HB-80-02 "SW process assessment and improvement", published in 2 parts).

      (b)   Q-HB-80-03 "Methods and techniques to support the assessment of SW dependability and safety".

   3.   SW metrication (1 HB): Q-HB-80-04 "SW metrication programme definition and implementation".

6.2.3   General description of the E standards and their content

6.2.3.1   General overview of the E branch

The E branch includes the engineering functions for all the disciplines covered. These engineering functions include the design, development, verification and operation.

A general view of the documents in the E branch is presented in Figure 5-5 and Figure 5-6. As it is seen there, it is divided in the following 11 disciplines and sub-disciplines:

a.   E10 "System engineering", which includes *for segment other than Ground Segment (i.e. Space and Launch segment)*, the System Engineering function, and functions other than System Engineering, but that they need to be performed at system level. The system engineering function for Ground Segment is covered by the E70 discipline.

b.   E20 "Electric and electronics", which includes *for the space and launch Segment*, the electrical, electronic, electromagnetic, and microwave engineering functions and processes. to power generation, storage and distribution, electric and electromagnetic effects, and RF power.

c.   E31 "Mechanical - Thermal control", includes *for the space and launch segment*, the engineering functions related to the thermal control subsystem.

d.   E32 "Mechanical – Structural" covers *for the space and launch segment*, the engineering functions related to the structural integrity of the Space product.

e.   E33 "Mechanical - Mechanisms" includes *for the space (and optionally launch) segment*, the engineering functions related to elements with relative motion.

f.   E34 "Mechanical - Environmental control and life support" (o more synthetically, ECLS), includes *for the space and launch segment*, the engineering functions related to subsystem supporting alive beings onboard, and its equipment and parts.

g.   E35 "Mechanical – Propulsion" includes *for the space and launch Segment*, the engineering functions related to propulsion subsystems, and their equipment and parts

h.   E40 "Software engineering" includes, for *all (Space, launch and Ground) segments*, the engineering functions related to Software.

i.   E50 "Communications" includes the engineering functions related to onboard, Space-to-Space and Space-to-Ground communications. It does not cover the Ground-to-Ground communications.

j.   E60 "Control engineering" includes the engineering functions related to the Space and Launch segment orbit and attitude control subsystem, and its equipment and parts.

k.   E70 "Ground system and operations", includes the system engineering function for the ground segment, and the engineering functions to be performed by all segments for the correct operation of the space and the launch segments.

Note that "Optics" is intentionally not covered by the ECSS engineering standards, since requirements on optics are very mission specific.

6.2.3.2   The E10 "System engineering" discipline

The E10 discipline covers the engineering processes (including the corresponding documentation) and requirements to be applied to other than the Ground Segment (i.e. to the space and launch segments), in order to:

— Exercise the System Engineering (SE) function.

In ECSS this function is considered divided in the following five sub-functions: Requirements engineering, Functional analysis, Design & configuration, Verification, and SE Integration & control. This discipline covers, therefore, all process and requirements related to these five functions.

Note in b.1.(a) below that analysis can be also performed with the purpose of verification.

— Exercise engineering functions other than SE, but that they need to be exercise at system level and transmitted from system level to lower levels.

a.   The Level 2 standard

The entry point for this discipline is the Level 2 standard ECSS-E-ST-10 "System engineering". Besides the requirements for the SE plan (following the ODSI principle), this document specifies the generic system engineering processes related to each of the five SE sub-functions mentioned above. When a topic related to any of these sub-functions has entity enough to be addressed separately, it is detached in a separate document (see b.1 and c.1 below). E-ST-10 also contains some information (non-normative) on the typical SE activities during the project phases.

b.   The Level 3 standards may therefore, fall in one of the following categories:

1.   Level 3 Standards covering the system engineering function:

(a)   ECSS-E-ST-10-02 "Verification", covering all the generic requirements to implement the verification SE sub-function. It is important to note that this is one of the most important ECSS documents, and it is pointed from many other M, E and Q standards. It is applicable to *Space, Launch and Ground* segment

See below in b.1.(a) that a handbook exists to support the application of this standard.

This standard defines four ways of verification: Testing, Verification analysis, Review of Design (RoD) and Inspection.

(b)   ECSS-E-ST-10-03 "Testing", which is part of the Verification SE sub-function. This document covers the generic testing requirements *for the Space segment only*, at the level of System (pre-launch), Element and Equipment. Testing requirements specific to a given technology are not included here, and they are covered by the corresponding technology standard.

(c)   ECSS-E-ST-10-06 "Technical requirement specification", which is part of the Requirements engineering SE sub-function. This document specifies the generic requirements to be met by a TS and by the requirements contained in it, and is applicable to *Space, Launch and Ground* segment.

(d)   ECSS-E-ST-10-24 "Interface management", which is part of the SE Integration and Control sub-function. This document specifies the generic requirements to manage functional and physical interfaces among all interrelated items of a product tree, and is applicable to *Space, Launch and Ground* segments

2.   Level 3 standards covering engineering topics not SE function related, but need to be exercised at system level:

(a)   ECSS-E-ST-10-04 "Space environment", which specifies the natural environment at different space regimes, and the models and rules for determining the induced environment. It is therefore applicable to *Space and Launch* segments.

(b) ECSS-E-ST-10-09 "Reference coordinate system", which specifies the different coordinate systems that can be used, and their mutual interrelationship and transformation rules. It is applicable to *Space, Launch and Ground* segment.

(c) ECSS-E-ST-10-11 "Human factors engineering", which specifies engineering provisions to ensure crew safety, and crew and ground personnel wellbeing, best performance and problem avoidance in space systems and payload operations. It is applicable to *Space and Ground* segment.

(d) ECSS-E-ST-10-12 "Calculation of radiation received and its effects", which specifies a method to calculate the radiation received by different elements (including humans) depending on the environment and shielding, and impose hard limits for this radiation. It is applicable at *Space* segment.

See below in b.2.(a) that a HB exists providing guidance on how to apply this standard.

c. Non-normative (Handbooks and Technical Memoranda):

1. Non-normative documents providing guidance on exercising the system engineering function:

(a) ECSS-E-HB-10-02 "Verification HB", giving guidance on how to apply ECSS-E-ST-10-02 "Verification", providing guidelines requirement by requirement.

(b) ECSS-E-HB-10-03 "Testing HB", giving guidance and proposing hard figures for the tests specified in ECSS-E-ST-10-03 "Testing".

(c) And the following TMs for models and data exchange, associated with the SE Integration and Control sub-function: ECSS-E-TM-10-20 "Product data exchange", ECSS-E-TM-10-21 "System modelling and simulation", ECSS-E-TM-10-23 "Space system data and repository", and ECSS-E-TM-10-25 "Design model data exchange".

2. Non-normative documents providing guidance on engineering topics not related to SE function, but need to be exercised at system level:

(a) ECSS-E-HB-10-12 "Calculation of radiation received and its effects HB", giving guidance on how to apply ECSS-E-ST-10-12 "Calculation of radiation received and its effects".

(b) ECSS-E-ST-10-10 "Logistics engineering HB"

6.2.3.3 E20 "Electric and electronics" discipline

The E20 discipline covers the engineering processes (including documentation) and requirements for the Space and Launch segments, related to power generation, storage, conditioning, control, protection and distribution, electric and electromagnetic effects, and RF systems.

a. The Level 2 standard

The entry point to this discipline is the Level 2 standard ECSS-E-ST-20 "Electric and electronic", which specifies all the generic requirements for electrical interfaces and electrical design. It includes also a clause per each of the main electrical areas mentioned above. The specific requirements and guidance are covered in separate documents. This general philosophy is applied with no exception in the E20 branch, so please note the comment in b.1.(b) below.

b. Level 3 Standards (normative documents):

1. Related to electric and electromagnetic effects:

(a) ECSS-E-ST-20-06 "S/C charging"

See in b.1.(b) below that there is a handbook to support the application of this standard.

(b)   ECSS-E-ST-20-07 "EMC".

See in b.1.(a) below that two HBs exist to support the application of this standard.

Note also that, by virtue of the application of the above mentioned philosophy, ECSS-E-ST-20-07 "EMC" contains only the specific EMC requirements. The generic EMC requirements are specified in the Level 2 standard ECSS-E-ST-20.

2.   Related to electrical power generation, storage, conditioning and distribution: ECSS-E-ST-20-08 "PVA and components", and ECSS-E-ST-20-20 "I/F requirements for electrical power".

See in c.2.(a) below that a HB exists to support the application of the latter.

3.   Related to RF systems: ECSS-E-ST-20-01 "Multipaction design and test".

c.   Non-normative documents (HBs – There are not TMs in the E20 discipline):

1.   Related to electric and electromechanic effects:

(a)   ECSS-E-HB-20-07 "EMC HB" and ECSS-E-20-03 "Magnetic cleanliness HB", to support the application of ECSS-E-ST-20-07 "EMC".

(b)   ECSS-E-HB-20-05 "High voltage HB", to support the application of ECSS-E-ST-20-06.

2.   Related to electrical power generation, storage, conditioning and distribution:

(a)   ECSS-E-HB-20-02 "Li-ion batteries" (to support the application of some requirements in the Level 2 document ECSS-E-ST-20),

(b)   ECSS-E-HB-20-20 "I/F for electrical power HB", supporting the application of ECSS-E-ST-20-20.

6.2.3.4   The E31 "Mechanical - Thermal control" sub-discipline

The E31 sub-discipline covers the engineering processes (including documentation) and requirements for the Space and Launch segments, related to the thermal control subsystem, and its equipment and parts. Note that therefore this discipline does not cover the thermal environment or thermal testing requirements.

a.   The Level 2 standard

The entry point is the Level 2 standard ECSS-E-ST-31 "Thermal control", which specifies the generic requirements for the design, verification, production and use of the thermal control subsystem of the Spacecraft, organized by type of requirement (Mission, Functionality/Performance, I/F, Design, Verification, Production, In-service). Specific equipment or specific topics are covered by separate documents.

> NOTE   A common mistake is to assume that this standard specifies the thermal environment or thermal tests. Please note that this is not the case.

b.   Level 3 standards:

The only Level 3 standard in this discipline is ECSS-E-ST-31-02 "Two-phase heat transport equipment", casually known as "Heat-pipes", specifying the qualification and acceptance of this type of equipment.

c.   Non-normative documents (HBs – There are not TMs in the E31 sub-discipline):

There are two handbooks supporting the application of some requirements in the Level 2 standard:

1.   ECSS-E-HB-31-01 "Thermal design data HB", which consists of 16 volumes of figures, coefficients and formulas supporting the design of thermal control sub-systems.

2.   ECSS-E-HB-31-03 "Thermal analysis HB"

6.2.3.5   The E32 "Mechanical – Structural" sub-discipline

The E32 sub-discipline covers the engineering processes (including documentation) and requirements for the Space and Launch segments, related to the structural integrity of the Spacecraft, its equipment and parts, and the associated GSE.

a.   The Level 2 standard

The entry point is the Level 2 standard ECSS-E-ST-32 "Structural", which specifies the mechanical concepts, environment. constrains, loads, effects, processes, material, capabilities and data systems to be considered to ensure the structural integrity of the Spacecraft. It is organized by type of requirement (Mission, Functionality/Performance, I/F, Design, Verification, Production, In-service, Data exchange). Processes and topics which need specific requirements are detached in separate documents.

b.   Level 3 standards

    1.   Related to the general structural design and testing:

        (a)   ECSS-E-ST-32-02 "Structural design and verification of pressurized HW" (self-explanatory title).

        (b)   ECSS-E-ST-32-03 "Structural finite elements models", which is a complement of the previous one, and specifies the requirements that the finite elements models for the structural calculation of HW shall meet.

        (c)   ECSS-E-ST-32-10 "Structural factors of safety (FOS)", which specifies hard numbers to be used as FOS, and how to use and combine these factors, for several structural materials and for different intended applications.

        (d)   ECSS-E-ST-32-08 "Structural materials", which specifies requirements for the mechanical characteristics of the materials used in mechanical applications. This standard works together with ECSS-Q-ST-70 and ECSS-Q-ST-70-71, which specifies the corresponding QA requirements for such materials.

    2.   Related to specific structural testing methods

        There is only one ECSS standard in this category, ECSS-E-ST-32-11 "Modal survey assessment", which specify the method and result assessment of for the modal survey test (modal survey is a vibration test to identify the dynamic characteristics). It is important to note that modal survey test is not required by any ECSS standard, and therefore it needs to be performed only on a case by case basis, upon customer request and under the conditions of the particular contract. This standard specifies the test method and assessment to be followed, if the test is requested by the customer.

    3.   Related to specific processes for control of structural integrity

        There is only one ECSS standard in this category, ECSS-E-ST-32-01 "Fracture control", which specifies the control mechanisms (Organizational, Technical and QA) to ensure that fracture does not propagate beyond maximum allowable. This standard is kept compatible with the corresponding NASA one.

c.   Non-normative documents (HBs – There are not TMs in the E32 sub-discipline):

    All HBs in the E32 sub-discipline are supporting specific requirements of the Level 2 standard ECSS-E-ST-32, either:

1.   Providing approved data for the structural calculations:

(a)   ECSS-E-HB-32-20 "Structural design data" (which consists of 8 volumes providing data for different types of materials and manufacturing processes),

(b)   ECSS-E-HB-32-21 "Adhesive bonding"

(c)   ECSS-E-HB-32-22 "Insert design".

2.   Providing approved calculation methods:

(a)   ECSS-E-HB-32-23 "Threaded fasteners". Please note that a standard for threaded fasteners QA exists, ECSS-Q-ST-70-46 "Manufacturing and procurement of threaded fasteners".

3.   Providing acceptable calculation and verification (including analysis and test) methods:

(a)   ECSS-E-HB-32-24 "Buckling HB

(b)   ECSS-E-HB-32-25 "Shock analysis and testing"

(c)   ECSS-E-HB-32-26 "S/C Mechanical load analysis"

6.2.3.6   The E33 "Mechanical - Mechanisms" sub-discipline

The E33 sub-discipline covers the engineering (and in some cases PA/QA) processes (including documentation) and requirements for the Space (and optionally Launch) segment, related to the development and use of *on-board* elements with relative motion, either for functioning several times or only once.

a.   Level 2 standard

None.

Please note that, together with E60, they are the only 2 ECSS disciplines without Level 2 standard.

b.   Level 3 standards

1.   ECSS-E-ST-33-01 "Mechanisms", which specifies the generic requirements for the development and operation of any kind (multiple or single "shoot") of mechanism to be flown. The standard is organized by type of requirement (Mission, Functional/Performance. Constraints, I/Fs, Design, Verification, and Production).

2.   ECSS-E-ST-33-11 "Explosive sub-systems and devices", which specifies the generic requirements for the development, use and assurance of "one-shot" sub-systems and devices using an explosive element as an actuator, to be flown, and the corresponding GSE. The standard is organized by type of requirements (Mission, Functional/Performance, I/F, Design, Verification, In-service, Safety, QA [transport & storage], PA) and by type of product (Materials, Non-explosive components, Explosive components, Actuators, GSE).

c.   Non-normative documents (HBs and TMs)

None.

6.2.3.7   The E34 "Mechanical – Environmental control and life support (ECLS)" sub-discipline

The E34 sub-discipline covers the engineering processes (including documentation) and requirements related to the sub-system to ensure a safe and comfortable environment for alive beings (including humans) on board, and its equipment and parts.

a.   The Level 2 standard

The entry point and only ECSS standard in this discipline is ECSS-E-ST-34 "Environmental control and life support (ECLS)", which contains the requirements for functional objectives of the ECLS sub-

system, and requirements for the safety of on-board life. The standard is organized by type of requirement (Mission, Functional, Design, I/Fs, Verification, PA & Safety).

This standard is therefore only applicable to systems with alive beings (including humans) on-board.

b.   Level 3 standards

There are not Level 3 standards in ECSS, but the Level 2 standards rely upon PSS standards containing the specific requirements for e.g. oxygen, water or food to be provided on-board.

c.   Non-normative documents (HBs and TMs)

None.

6.2.3.8   The E35 "Mechanical - Propulsion" sub-discipline

The 35 sub-discipline covers the engineering processes (including documentation) and requirements related to traditional propulsion sub-systems, their equipment, parts and associated GSE, for both Space and Launch segments. Traditional propulsion refers to solid, liquid (including gas) and electric propulsion.

a.   The Level 2 standard

The entry point to this sub-discipline is the Level 2 standard ECSS-E-ST-35 "Propulsion", which specifies the generic requirements applicable to a traditional propulsion sub-system, i.e. those requirements common to solid, liquid (including gas) and electric propulsion. Propulsion general requirements include requirements for the general development, interfaces, design (including performances, envelops, transients, sizing and dimensioning, Imbalance, TVC, design for Cleanliness, Plume, Leakage, aging, Instruments and hardness, and control system), GSE, Verification, Production and Utilization

Processes and requirements specific to each type of propulsion are specified in separate Level 3 standards.

The standard is organized by type of requirement (Mission, Development, I/Fs, Design, Verification, Production, In-service, Materials, GSE).

b.   Level 3 standards may fall in two categories

1.   Generic standards for specific types of propulsion:

(a)   ECSS-E-ST-35-01 "Liquid and electric propulsion for S/C"

(b)   ECSS-E-ST-35-02 "Solid propulsion for S/C and launchers"

(c)   ECSS-E-ST-35-03 "Liquid propulsion for Launchers"

2.   Level 3 standards for specific processes for liquid and electric propulsion

(a)   ECSS-E-ST-35-06 "Cleanliness for S/C propulsion HW"

(b)   ECSS-E-ST-35-10 "Compatibility testing for liquid propulsion systems"

c.   Non-normative documents (HBs and TMs)

None.

6.2.3.9   The E40 "Software Engineering" discipline

The E40 discipline covers the engineering processes (including the corresponding documentation) and requirements to be applied to any piece of software to be used in a space project, which includes Flight SW, Ground SW, SW for GSE, simulation SW, and non-deliverable SW which affects the quality of the deliverable product.

Therefore, the discipline is only applicable to the development, maintenance, verification & validation, and use (including re-use) of the "software component".

The PA and QA processes for Software are covered by the Q80 "Software PA" discipline. However, when dealing with software, is not possible in certain cases to clearly differentiate between engineering and PA processes, and therefore the division line between Q80 and E40 is artificial. That implies that these two disciplines depend on each other and shall be used together.

a.   The Level 2 standard

The entry point to this E40 discipline is the Level 2 standard ECSS-E-ST-40 "Software Engineering". This standard capitalize all the SW engineering requirements needed for any space application, and for any generic development cycle (which means that to cover the different SW development approaches no specific standards are needed, only tailoring guides of E40). Therefore, the only standard in the branch is the Level 2 standard. All the other documents in the branch are non-normative (HBs and TMs), see c. below.

Since the output of SW engineering activities involves always documentation, every requirement includes an "expected output" with the documents expected, and the project review when the document should be delivered. These documents are normally part of a DRD. A table ion the standard also shows which documents are included in which DRDs.

Rules to tailor ECSS-E-ST-40 are contained in an annex of the own standard, specifying how to tailor the document in accordance with criticality of the function implemented by the software.

b.   Level 3 standards:

None.

c.   Non-normative document (HB and TMs):

1.   ECSS-E-HB-40 "SW engineering HB", to support the application of the generic requirements in the Level 2 standard ECSS-E-ST-40.

2.   ECSS-E-HB-40-01 "Agile SW development HB", that provides guidelines for (1) tailoring ECSS-E-ST-40 for the Agile development approach, and (2) the limits for using Agile.

3.   ECSS-E-TM-40-07 "Simulation modelling platform" which provides non-normative provisions for both the interfaces and the development of SW simulators.

6.2.3.10   The E50 "Communications" discipline

The E50 discipline covers the engineering processes (including the corresponding documentation) and requirements to be applied in the Space and Launch segment for the development of an end-to-end data communication sub-system for the Space Network (i.e. on-board and space-to-space) and Space Link (i.e. space-to-ground) communications.

a.   The Level 2 standard

The entry point for this discipline is the Level 2 standard ECSS-E-ST-50 "Communications", which specifies the terminology, engineering activities and generic functional and performance requirements of the on-board communication sub-system (including the communication links used during assembly, integration and test, and operational phases) for the Space Network and Space Link, covering the Ground Network (ground-to-ground communications) only for those few aspects necessary for the provision of the end-to-end communication services. The specific requirements and protocols are defined in Level 3 standards.

b.   Level 3 standards (normative)

1.   Level 3 standards covering specific requirements in the Space Link (Space-to-Ground):

(a)   For telemetry: ECSS-E-ST-50-01 "Telemetry synchronization and channel coding", and ECSS-E-ST-50-03 "Telemetry transfer frame protocol"

(b)   For telecommand: ECSS-S-ST-50-04 "Telecommand protocols synchronization and channel coding"

(c)   For Ranging and Doppler: ECSS-E-ST-50-02 "Ranging and Doppler tracking"

(d)   For the communication layer: ECSS-E-ST-50-05 "RF and modulation"

Note that the second group of two digits of the identifier of all these standards starts by "0".

Be aware that the three standards for telemetry and telecommand (ECSS-E-ST-50-01, -03 and -04) include mainly requirements restricting the use of the corresponding CCSDS communication standards.

2.   Level 3 standards covering specific on-board (Space Network) protocols (and therefore mandatory *if and only if* the corresponding protocol is used):

(a)   Space protocols derived from non-space protocols: ECSS-E-ST-50-13 "I/F and comm protocol for MIL 1553", and ECSS-E-ST-50-15 "CAN bus protocol"

(b)   Original space specific protocols: ECSS-E-ST-50-11 "SpaceFibre" and ECSS-E-ST-50-12 "SpaceWire",

(c)   ECSS-E-ST-50-14 "Spacecraft discrete I/F", which specifies not only the protocol, but it goes even to the physical layer.

Note that the second group of two digits of the identifier of all these standards starts by "1".

3.   Level 3 standards specifying super-protocols running on top of "SpaceFibre" and "SpaceWire" (and therefore mandatory *if and only if* the corresponding super-protocol is used): ECSS-E-ST-50-51 "SpaceWire protocol identification", ECSS-E-ST-50-52 "SpaceWire remote memory access", and ECSS-E-ST-50-52 "SpaceWire CCSDS packet transfer".

Note that the second group of two digits of the identifier of all these standards starts by "5".

c.   Non-normative documents (HB – There are not TMs in the E50 discipline):

The Level 2 and the complete set of Level 3 communication standards provides several possible solutions and combinations to build a communication link, but the precise set of standards to define such a link is project dependent and it is not specified by ECSS. The guidance and practical examples to help a particular project to build this set are given by ECSS-E-HB-50 "Communication guidelines".

6.2.3.11   The E60 "Control engineering" discipline

The E60 discipline covers the Space and Launch engineering processes (including the corresponding documentation) and requirements to be applied for the development of the AOCS sub-system, and its equipment and parts.

a.   Level 2 standard

None.

NOTE   Together with E33, they are the only 2 ECSS disciplines without Level 2 standard.

b.   Level 3 standards, which can be classified in the following three categories:

1. Control performances: ECSS-E-ST-60-10 "Control performances", which defines performance indicators and requires how to specify and verify them, for any kind of product (from equipment to subsystem).

2. AOCS equipment, which define the parameters and capabilities, and require how to measure and specify them, and how to build the corresponding TS for:

   (a) Star sensors, in ECSS-E-ST-60-20 "Star sensors terminology and performances"

   (b) Gyros, in ECSS-E-ST-60-21 "Gyros terminology and performances"

3. AOCS (Attitude and orbit control sub-system) functions: ECSS-E-ST-60-30 "AOCS", which define the parameters and capabilities of a generic AOCS, and require how to measure and specify them, and how to build the corresponding TS.

c. Non-normative documents (HBs – No TMs in the E60 discipline), which may fall in the same categories that Level 3 standards i.e.:

   0. General: ECSS-E-HB-60 "Control engineering HB", putting all the discipline in context, and explaining the three above mentioned areas covered by the discipline.

   1. For control performances: ECSS-E-HB-60-10 "Control performances guidelines", providing guidelines for the application of ECSS-E-ST-60-10 "Control performances" for the Space Segment (the Launch Segment is not covered by the HB).

   2. For AOCS equipment: None.

   3. For AOCS functions: None.

6.2.3.12 The E70 "Ground systems and operations (GSO)" discipline

The E70 discipline covers the engineering processes (including the corresponding documentation) and requirements to be applied for the ground segment, and to be performed by all segments for the correct operation of the space and the launch segments. It is important to emphasize therefore that the E70 discipline is not only applicable to the Ground Segment, but also (specially the Level 3 standards) to the Space and (in some cases) to the Launch segment.

a. The Level 2 standard

   The entry point to this discipline is the Level 2 standard ECSS-E-ST-70 "GSO", which consists mainly in two interrelated parts:

   — Operations engineering (Clause 5), specifying the engineering processes to prepare and carry out operations of a the Space Segment.

   — Space segment engineering (Clause 6), specifying the engineering processes to design, implement and maintain a ground segment.

   A third clause (Clause 7) specify the phasing of all these tasks. In particular, it identify the outputs from the early phases that will be instantiated as Space segment design requirements. Therefore this standard contains requirements mainly for Phase E and for the Ground Segment, but not only. Some few are applicable to all phases of the Space Segment.

b. Level 3 standards

   There is a number of Level 3 standards *applicable to both the Space and Ground Segment* described here and shown in Figure 6-1):

   1. For on-board application:

(a) ECSS-E-ST-70-01 "On-board control procedures (OBCP)", standardizing the engineering processes and lifecycle for OBCP development, and the on-board and ground OBCP capabilities, and defining different levels of OBCP depending on the interfaces with onboard systems.

(b) ECSS-E-ST-70-11 "Space segment operability", specifying requirements for the on-board functions, to ensure that unmanned S/C can be operated in nominal and contingency situation.

2. For the operations database (and therefore applicable to the complete ground and space segment):

(a) ECSS-E-ST-70-31 "Monitoring and control data definition", that specifies the mission specific data to be provided, for the complete life-cycle from low-level testing parts and equipment to in-flight operations, to be used by ground systems to perform space system integration, testing and mission operations

3. For the user interface:

(a) ECSS-E-ST-70-32 "Test and operations procedure language", specifying requirements to be satisfied by any language used to define procedures, and define a specific reference language (not mandatory) called PLUTO "Procedure language for users in tests and operations".

4. For the Ground-Space segments I/F:

(a) ECSS-E-ST-70-41 "TM & TC packet utilization" (casually known as PUS "Packet utilization standard") defines the application level on-board/ground I/F by identifying operational concepts for a generic mission, and specifying a set of on-board services that fulfil these concepts.

c. Non normative (HBs and TMs) documents:

None.
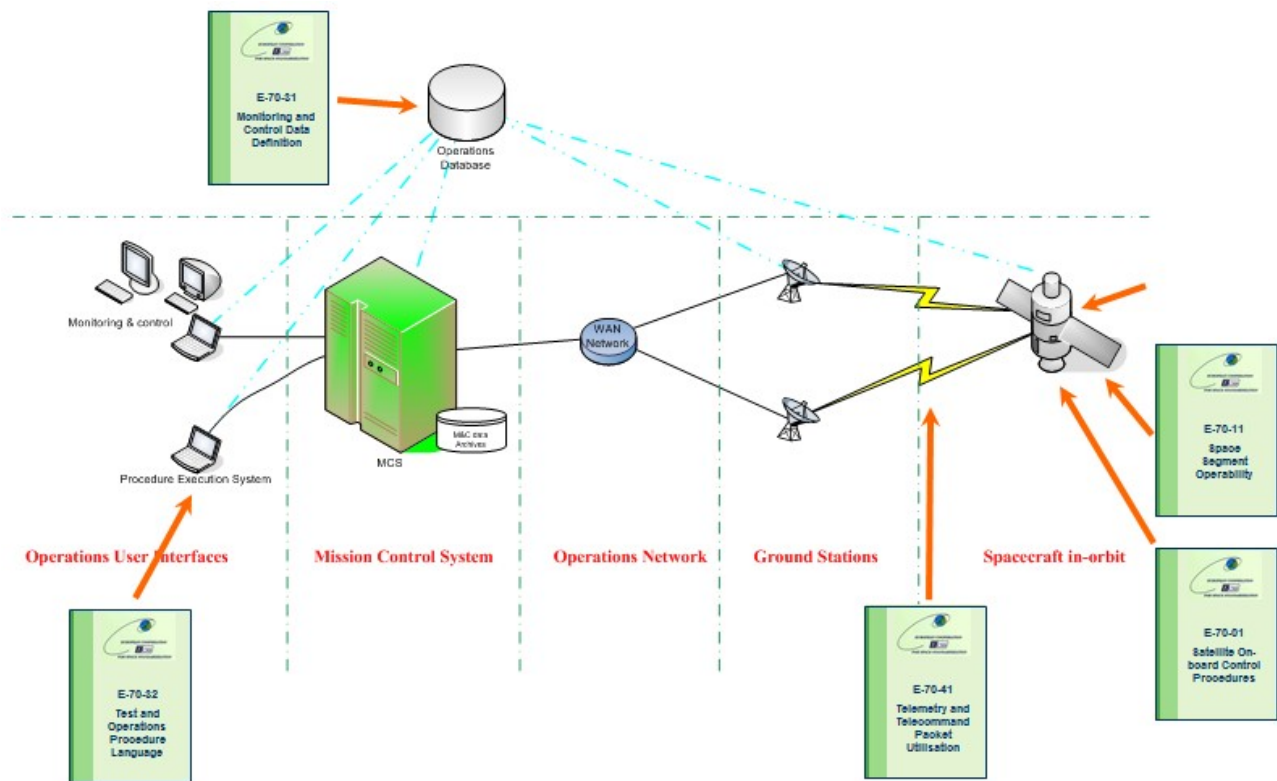
Figure 6-1: Level 3 standards in the E70 discipline

6.2.4 General description of the U standards and their content

6.2.4.1 General description of the U branch

The U branch includes the Management, PA and Engineering functions for a number of disciplines with the objective of ensuring a sustainable present and future use of Space, in the field of space debris mitigation, planetary protection and space situation awareness. As it can be seen, the U branch is not a domain oriented discipline, but a transversal one compiling the requirements of the three domains (management, PA and engineering) on a given area of sustainability.

A general view of the U branch is presented in Figure 5-7. As it is seen there, it is divided in three disciplines, described in the sections below.

6.2.4.2 The U10 "SDM" discipline

The U10 "Space debris mitigation" discipline scope includes, for the Space and Launch segments, the organizational, design and operation aspects to ensure that both the generation of space debris and the casualty hazard in a re-entry are minimized.

a. The Level 2 standard

The entry point and only standard in this discipline is ECSS-U-AS-10 "Space debris mitigation". Note that this document is actually an adoption notice of ISO 24113 "Space debris mitigation", adopting all its requirements, with very few modifications. The standard includes the generic requirements for the scope of the discipline stated above.

b. The Level 3 standards and non-normative documents (HBs and TMs)

At the present time, there is no Level 3 standards nor non-normative documents in this discipline. However, ISO has published several documents covering specific topics on implementing the generic requirements on ISO 24113, and therefore is very likely that ECSS will adopt some of these documents as Level 3 standards, or as HBs.

6.2.4.3 The U20 "Planetary protection" discipline

U20 "Planetary protection", which scope includes the Space segment organizational, design and PA requirements to minimize the risk of onwards (Earth-to-Planet) and backwards (Planet-To-Earth) *biological* contamination.

a. The Level 2 standard

    The entry point and only standard in this discipline is ECSS-U-20 "Planetary protection", which includes the generic requirements for the scope of the discipline stated above. They include, among others, the cleanliness and sterilization processes that are mandatory depending of the mission and the function of a specific piece of hardware, but the processes themselves are not described here, but they are specified in separate Level 3 documents in the Q70 branch (see ECSS-Q-ST-70-53, -54, -55, -56. -57 and -58).

b. The Level 3 standards and non-normative documents (HBs and TMs)

    None

6.2.4.4 The U30 "SSA" discipline

U30 "Space situation awareness", which includes for the Space, Launch and Ground segments, the organizational, interfaces, PA and technical requirements to ensure a reliable and timely information of the situation of a given space sector and moment, in respect to Space weather, S/C population, and Space debris tracking.

There are not at the moment any ECSS document in the U30 discipline.

6.3 General applicability of ECSS standards in ESA projects

6.3.1 General applicability of the S and M standards in ESA projects

The ECSS S and M standards contain very generic requirements not specific to any kind of project, and therefore will be generally applicable to any ESA project.

> NOTE   *The vast majority* of the documents required by ECSS S and M standards are also required by the ESA contract itself, in particular by the "ESA General Condition of Tender" and the "General Clauses and Conditions for ESA Contracts". They are therefore "applicable" even to present an offer to an ESA ITT.
>
> This overlapping between ECSS S&M standards and ESA contractual requirements is further covered in 4.2.4.

The following policy for pre-tailoring and tailoring is followed in ESA projects:

a.   Pre-tailoring

Since the S and M requirements are very generic and therefore generally applicable to any contract, it is worthy to perform a generic pre-tailoring of them to the ESA needs, and make the result generally applicable to any ESA project. This document is called the "Generic MaRD" (Generic Management Requirements Document).

The "Generic MaRD" is an internal ESA document produced and maintain by TEC-QR. It can be found in the ESA intranet.

b.   Tailoring

Therefore, it is expected that every project make applicable the ECSS S and M requirements by taking the "Generic MaRD" as the starting point, and tailoring it for the specificities of the to produce the "Project MaRD". **It is expected no tailoring or a very minimum tailoring of the MARD**.

If some tailoring is considered necessary, a general overview of the ECSS S and M requirements is provided in section 7.

6.3.2   Applicability of the Q standards in ESA projects

6.3.2.1   Applicability of the ECSS Q level 2 standards

The ECSS Q *Level 2* standards contain generic requirements so that, as the S and M standards, will be generally applicable to any ESA projects, with the pre-tailoring and tailoring considerations below.

> NOTE   *Some few documents* required by the ECSS-Q standards are also required by the ESA contract itself. See Table 4-4 and **Error! Reference source not found.**.

a.   Pre-tailoring

Since all the ECSS Q Level 2 standards are generally applicable to any ESA contract, it is worthy to perform a generic pre-tailoring of them to the ESA needs, and make the result generally applicable to any ESA project. This document is called the "Generic PARD" (Generic PA Requirements Document).

The "Generic PARD" is an internal ESA document produced and maintain by TEC-QR. It can be found in the ESA intranet. It is important to recall that currently it covers only the ECSS-Q *Level 2* standards.

b.   Tailoring

Therefore, it is expected that every project make applicable the requirements in the ECSS Q level 2 standards by taking the "Generic PARD" as the starting point, and tailoring it for the specificities of the project (hopefully a minimum tailoring), to produce the "Project PARD". The following considerations can help in doing such a tailoring.

ECSS Q standards are structured, as shown in Figure 5-1, in seven disciplines, each of them with one Level2 standard. The following discussion may help in tailoring the list:

1.   ECSS-Q-ST-10 "Product assurance" (PA) and ECSS-Q-ST-20 "Quality assurance" (QA) are generic standard that will be always applicable. However, they do not covered PA and QA SW specific issues, which are covered by ECSS-Q-ST-80 "Software PA".

An important aspect is that ECSS-Q-ST-80 needs to be made applicable only for "SW alone" (i.e. not yet integrated with hardware), or for SW integrated with hardware that for any reason needs to be re-qualified.

2. ECSS-Q-ST-30 covers "Dependability", i.e. Reliability, Availability and Maintainability. ECSS-Q-ST-40 covers "Safety". Both together cover the generic requirements for RAMS, and therefore they are generally applicable to any ESA project.

3. ECSS-Q-ST-60 "EEE components", covers the selection, control, procurement and use of components, and it is applicable in the cases that the contract includes EEE components themselves, or parts containing EEE components. Since this includes the vast majority of the cases, it can be considered that the standard is generally applicable to ESA projects.

    An important aspect is that the standard considers three quality classes of EEE components, Class 1 to 3, and includes requirements for any of these classes. The standard, however, does not requires which class to be used, and it is expected that the policy for using each class is defined by every project. In ESA projects, EEE components Class 3 are never used.

4. ECSS-Q-ST-70 "Materials, mechanical parts and processes" (MMP&P), is obviously generally applicable to any ESA project.

A higher level of detail of the requirements in the ECSS-Q Level 2 documents is provided in section 8.2.2.

6.3.2.2   Applicability of the ECSS Q level 3 standards

ECSS-Q Level 3 standards are not covered by the PARD, and therefore every project needs to make their own assessment. The following guidelines may support this assessment:

a. Pre-tailoring

    Pre-tailoring per product type of the ECSS-Q Level 3 can be performed by using the Pre-tailoring table in ECSS-S-ST-00-02 "Tailoring and pre-tailoring of ECSS documents".

b. Tailoring

    For their potential applicability, the ECSS-Q Level 3 standards can be categorized as follows:

Table 6-1: Applicability of ECSS-Q Level 3 standards

#	Category and general rules for application	Subcategories	Standards
1	**PA and QA standards of generic application** They cover specific PA and QA processes made generally mandatory by the Level 2 standard. *They are therefore applicable to all ESA projects.*	<u>Standards for generic PA, QA & RAMS processes.</u> They cover processes that are typically part of Q-ST-10 and Q-ST-20, but they have been detached in individual standards	o Q-ST-10-04 "Critical item control" o Q-ST-10-09 "Nonconformances control system" o Q-ST-20-08 "Storage, handling & transportation of S/C hardware" o ECSS-Q-ST-30-02 "FMEA/FMECA" o ECSS-Q-ST-40-02 "Hazard analysis"
		<u>Generic standards for EEE components</u> Standards for EEE components, generally applicable	o ECSS-Q-ST-30-11 "Derating of EEE components" (see NOTE 1) o ECSS-Q-ST-60-14 "Relifing of EEE components" (see NOTE 2) o ECSS-Q-ST-60-15 "Radiation hardness assurance"
		<u>Generic standards for materials, parts and processes</u> Standards for materials, mechanical parts and processes, generally applicable	o ECSS-Q-ST-70-71 "Materials, processes and their data selection" (to be used always jointly with ECSS-Q-ST-70) o Cleanliness standards: ECSS-Q-ST-70-01, -05 and -50. o Control of limited self-life materials
2	**Standards of specific applicability** They cover specific aspects made mandatory by the level 2 standards only for specific cases and situations. *They are applicable in the specific cases and situations stated in the right column*	<u>Standards for specific categories of EEE components</u> *to be made applicable only if it is expected that the project/procurement includes these specific components*	o Q-ST-60-02 (ASIC and FPGA) o Q-ST-60-05 (Hybrids) o Q-ST-60-12 (MMIC).
		<u>Standards for processes specific to Planetary protection</u> *to be made applicable only in missions to celestial bodies subject to biological contamination, or coming back from those celestial bodies*	o Q-ST-70-53 "Compatibility test for sterilization processes" o Q-ST-70-54 "Ultra-cleaning of flight HW" o Q-ST-70-55 "Microbiological examination…" o Q-ST-70-56 "Vapour-phase bio-burden reduction…" o Q-ST-70-57 "Dry-heat bio-burden reduction" o Q-ST-70-58 "Bio-burden control in cleanrooms"
		<u>Standards for "off-the-shelf" items:</u> *To be made applicable only if it is expected that "off the self" items are going to be used.*	o ECSS-Q-ST-20-10 "Off the shelf item utilization", applicable only if the project includes OTS items. o ECSS-Q-ST-60-13 "COTS EEE components", applicable only if commercial EEE components are used. This standard is a version of the level 2 (ECSS-Q-ST-60), tailored for commercial components

#	Category and general rules for application	Subcategories	Standards
3	**Standards for particular processes, generally applicable.** They cover a number of particular processes, mainly for testing and manufacturing, of general use. Include all the Q-70 Level 3 standards not covered above. *The policy is to make all of them generally applicable (unless one particular one is clearly not applicable to the particular application). They will be actually used only if the corresponding manufacturing or testing process is performed*	Material testing	o Q-ST-70-02 "Testing vacuum outgassing test for…" o Q-ST-70-04 "Thermal testing for evaluation of MMP&P" o Q-ST-70-06 "Particle and UV radiation testing" o Q-ST-70-15 "NDT or NDI" (to be published) o Q-ST-70-20 "Susceptibility to red-plague corrosion" o Q-ST-70-21 "Flammability testing" o Q-ST-70-29 "Determination of Offgassing for manned S/C" o Q-ST-70-36 "Mat. Selection for Stress corrosion cracking" o Q-ST-70-37 "Susceptibility of metals to stress corrosion" o Q-ST-70-45 "Mechanical testing of metallic materials"
		Material processes	o Q-ST-70-03 "Black anodizing of metals…" o Q-ST-70-09 "Measurements of thermos-optical properties" o Q-ST-70-13 "Measurement of peel & pull-out strength…" o Q-ST-70-31 "Application of paints and coatings…" o Q-ST-70-16 "Adhesive bonding…" (To be published)
		Assembling processes	o Q-ST-70-07 "Verif & appr. automatic machine wave soldering" o Q-ST-70-08 "Manual soldering of hi-rel electrical connections" o Q-ST-70-14 "Corrosion" o Q-ST-70-26 "Crimping of hi-rel electrical connections" o Q-ST-70-28 "Repair & modification of PCBs o Q-ST-70-30 "Wire wrapping of hi-rel. electrical connections" o Q-ST-70-38 "Hi-rel soldering for surface mount and mixed o Q-ST-70-39 "Welding of metallic materials"
		Parts (including PCBs)	o Q-ST-70-10 "Qualification of PCBs" o Q-ST-70-11 "Procurement of PCBs" o Q-ST-70-12 "Design rules for PCBs" o Q-ST-70-18 "Prep., assembly & mounting of RF coaxial cables" o Q-ST-70-46 "Manufac. & procurement of threaded fasteners"
4	**Applicable "on request".** They cover specific aspects not made mandatory by the level 2 standards, which means that *they will be applicable only if required by the project.*	This category includes the RAMS methodologies (except FMEA/FMECA, which is generally applicable)	o ECSS-Q-ST-30-09 "Availability analysis" o ECSS-Q-ST-40-02 "Hazard analysis" o ECSS-Q-ST-40-12 "Fault tree analysis".

#	Category and general rules for application	Subcategories	Standards
5	**Applicable only to test centre certification**		o ECSS-Q-ST-20-07 "QA requirements for test centres"
NOTE 1:	Derating is a process of designing a product such that its EEE components operates <u>during normal operation</u> at a reduced level of stress (the derating factor) to increase reliability and ensure useful life and design margins. This standard defines the derating factors for a large number of EEE components.		
NOTE 2:	Relifing is the process of verifying the quality and reliability of a part <u>on storage</u> to increase its useful life. This standard specifies the process and conditions for relifing of EEE parts.		

6.3.3 General applicability of the E standards in ESA projects

6.3.3.1 Applicability of the ECSS E Level 2 standards

a. Pre-tailoring

ECSS-E standards are organized by technical disciplines, and therefore their applicability is more linked to the technical specificities of the project than S, M and Q documents. Therefore, to make a pre-tailoring document, generally applicable to all ESA projects (as MaRD for M documents and PARD for PA level 2 documents) is not possible.

Pre-tailoring of the list of ECSS-E Level 2 standards can be performed by using the Pre-tailoring table in ECSS-S-HB-00-02 "Tailoring of ECSS documents".

> NOTE   *Some few documents* required by the ECSS-E standards are also required by the ESA contract itself. See Table 4-4 and **Error! Reference source not found.**.

b. Tailoring

Final tailoring has to be done using the technical expertise of the project or project support personnel. In general, tailoring of the list of ECSS E Level 2 documents from the pre-tailoring should be simple. Reference is done to the coverage of the documents, as explained in 6.2.3.

6.3.3.2 Applicability of the ECSS-E Level 3 standards

ECSS-E Level 3 need to be assessed for their applicability by every project. The following guidelines may support this assessment:

a. Pre-tailoring

Pre-tailoring per product type of the ECSS-E Level 3 can be performed by using the Pre-tailoring table in ECSS-S-ST-00-02 "Tailoring of ECSS documents".

b. Tailoring

For their potential applicability, the ECSS-E Level 3 standards can be categorized as follows:

Table 6-2: Applicability of ECSS-E Level 3 standards

#	Category and general rules for application	Subcategories	Standards
1	**Standards of generic applicability at any level of the contractual chain** *They are generally applicable to all ESA projects*	<u>Standards for generic SE functions</u> Applicable to any engineering activity	o E-ST-10-02 "Verification" o E-ST-10-03 "Testing" o E-ST-10-06 "Functional specification" o E-ST-10-24 "I/F management"
		<u>Generic standards, applicable at any level of the contractual chain</u>	o E-ST-10-12 "Radiation dose o E-ST-10-11 "Human factors" o E-ST-20-05 "ESD" o E-ST-20-07 "EMC" o E-ST-20-20 "I/Fs for electrical power" o E-ST-32-01 "Fracture control" o E-ST-32-10 "FOS" o E-ST-32-03 "Finite elements analysis" (to be used in conjunction with E-ST-32) o E-ST-32-10 "Materials"
2	**Generic standards applicable at system level** Standards imposing to make selection at agency or prime level *They are generally applicable to all ESA projects, but no need to flow them down to subcons* *The selected requirements are flowed down via Tech Specs*		o E-ST-10-04 "Space environment" o E-ST-10-09 "S/C coordinate system" o E-ST-70-41 "PUS" o E-ST-60-10 "Control performances"

3	**Standards of specific applicability** They cover specific aspects made mandatory by the level 2 standards only for specific cases and situations. *They are applicable in the specific cases and situations stated in the right column*	Standards for specific equipment	o E-ST-20-08 "PVA and components" o E-ST-31-02 "Heat pipes" o E-ST-60-20 "Star sensors" o E-ST-60-21 "Gyros" o E-ST-50-1x On-board communication protocols o E-ST-50-5x On-board comms super-protocols over SpaceWire
		Standards for specific type of equipment	o E-ST-20-01 "Multipaction", applicable only if RF equipment o E-ST-32-02 "Pressure vessels" o E-ST-33-01 "Mechanisms" o E-ST-33-11 "Explosive devices" o E-ST-50-0x Space-to-Ground communication standards
		Standards for specific applications (subsystems)	o E-ST-35-01 "Liquid & electric prop for S/C" o E-ST-35-02 "Solid prop for S/C and launchers" o E-ST-35-03 "Liquid prop for launchers" o E-ST-35-06 "Cleanliness for S/C propulsion HW" o E-ST-35-10 "Compatibility testing for liquid propulsion" o E-ST-60-30 "EOCS"
4	**Standards generally applicable, to be actually used only under request** *They are generally applicable, but they will not be used unless so explicitly requested by the customer*	Standards generally applicable if structural issues are implied	o E-ST-32-11 "Modal survey

6.3.4 General applicability of the U standards in ESA projects

The only documents in the U branch so far are ECSS-U-AS-10 "Space debris mitigation" (which is an adoption notice of the ISO 24113 "Space debris mitigation") and ECSS-U-ST-20 "Planetary protection".

This documents are applicable at system level, and if it is necessary to flow down the requirements, they will be done by including the particular requirements in the TS. Therefore, they are not applicable at equipment level.

7
Application of ECSS-S and ECSS-M requirements in ESA projects

7.1 Introduction

Section 6 gives general guidelines for the tailoring of the list of documents to a particular application, without entering in individual requirements. If a higher level of granularity is necessary to make a final decision on the application of a particular standard, or tailoring at the level of individual requirements is necessary, this Section 7 provides the details for standards in the S and M branches.

This Section 7 is also a reference to understand the documentation required by documents in the S and M branches. A simple approach to comply with these documentation requirements is presented in Annex A.

7.2 General overview of the ECSS S and M requirements

7.2.1 General overview of the requirements of the S standards

The S branch comprises the following documents:

a. ECSS-S-ST-00 (ECSS System), which can be summarized in two main requirements:

    1. The customer shall tailor:
       o The list of standards, and produce a List of Applicable standards
       o For each standard in the list of applicable standards, the list of requirements, and produce an Applicability matrix.

    2. The supplier shall respond with a Compliance matrix.

b. ECSS-S-ST-00-01 is the ECSS Glossary of terms. Its use is explained in 5.2.4.2.2.

7.2.2 General overview of the requirements of the M standards

The M branch consists of 5 "Level 2" standards and 1 "Level 3" standard. Figure 7-1 represents a map of these six standards, showing the normative and descriptive parts.

A general explanation of the contents of each M document is provided in 6.2.1.2.

- The Level 2 standards (ECSS-M-ST-10, -40, -60, -70 and -80) contain more generic requirements. To remain generic, the five M Level 2 standards widely apply the "ODSI" principle (see 5.2.7). Table 7-1 to Table 7-5 are a detailed summary of the requirements of these standards. Requirements applying the

"ODSI" principle are shadowed in green. Note that most of them include a reference to a DRD to comply with "ODSI step b". Also, most of them are supported by guidance material in accordance with "ODSI step e". Descriptive clauses are provided as shown in Figure 7-1 to include the guidelines.

As it can be seen, the majority of the requirements in M branch follow the ODSI principle. Those ones not following that principle refer mainly to requests and reports, where the ODSI principle is meaningless.

- The only Level 3 standard is ECSS-M-ST-10-01 "Organization and conduct of reviews". The number and objective of the project reviews are covered in ECSS-M-ST-10 (Level 2), covering ECSS-M-ST-10-01 only the details to perform a generic project review. A detailed summary is in Table 7-6.
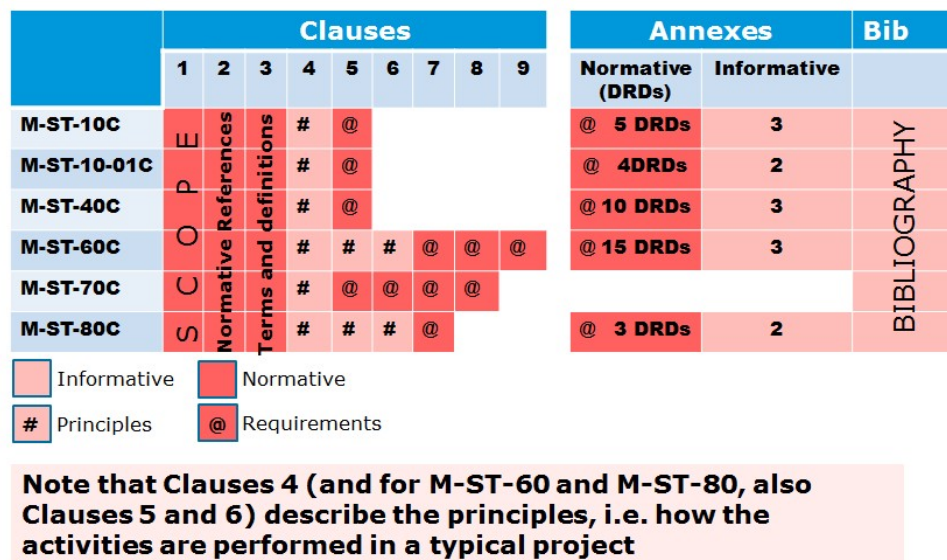
Figure 7-1: Map of contents of the ECSS M standards

The following are relevant remarks to Table 7-1 to Table 7-6:

a. The Product Tree (PT) and the Function Tree (FT) shall be completely mapped between them (not necessarily product-function one to one, but many to many). In fact, both trees are produced by the System Engineer, and the PT is a file in the Design Definition File (DDF). However, the FT and the DDF are DRDs in E-ST-10 "System engineering" (in the E branch), while the PT is a DRD in M-ST-10 "Project Planning and implementation" (in the M branch). The reason why the PT is not in the E branch is that, even being a document produce by System engineering, the project manager shall exercise ownership of it. The document is fundamental for configuration control at all levels, and the CIL "Configuration Item List" (listing all the items under configuration control and also in the M branch) shall refer each item in the list to items in the PT.

b. OBS are part of the WBS, but while the WBS refer to the functional responsibilities, the OBS refer to the contractual ones.

c. ECSS does not include a specific Software documentation management standard. The reason is that software is mainly documentation, and therefore the requirements of ECSS-M-ST-40 "Configuration and documentation management" are fully applicable to SW configuration management.

d. Economic conditions (EC) are defined as "reference period of time during which a set of financial elements are applicable". Therefore, the EC are not the conditions themselves, but the period in which these conditions apply.

e. Integrated Logistic Support (ILS) is the set of activities to provide inputs to the management, PA, design, manufacturing, testing, integration and operation, to ensure that the logistic aspects are taken into account to maximise the rate benefit/effort. It does not include the planning of the logistics, but how the logistics will impact the project life.

Table 7-1: Summary of the requirements in ECSS-M-ST-10C(R1)

Clause & Req	Requirements	DRD (Annex)	Supporting guidance
5.1 Project planning			
5.1.1	Tailoring by the customer	-	Also required in S-ST-00-02
5.1.2	Project management Plan (PMP)	A	4.1
5.2 Project organization			
5.2.1	Organization structure	Part of the PMP	4.2.1 & 4.2.2
5.2.2	Communication & reporting		4.2.3
5.2.3	Audits		4.2.4
5.3 Project breakdown structures			
5.3 a to g	Product tree [NOTE a]	B	4.3.4
5.3 h to l	Work Breakdown Structures (WBS) [NOTE b]	C	4.3.5, Annex H
5.3 m to o	Work Packages Descriptions	D	4.3.6
5.3 p to r	Organization Breakdown Structure (OBS)[NOTE b]	Part of WBS	4.3.7
5.4 Project phasing			
5.4 a to d	Project phases & reviews (including criteria to next phase)	-	4.4
NOTE [1]: The WBS refer to the functional responsibilities, while the OBS refer to the contractual responsibilities			

Table 7-2: Summary of the requirements in ECSS-M-ST-40C

Clause & Req	Requirements[NOTE c]	DRD (Annex)	Supporting guidance
5.2 Configuration Management(CM) planning			
5.2.1	**CM plan (CMP)** - (incl. info security & classification)	A	4.1.2
5.2.2	**CM interfaces** - (with Proj management, Eng, PA, IDM, …)	-	4.2.2
5.3 Configuration management (CM) implementation			
5.3.1	**Configuration identification** - (C.I. definition, selection, baseline, marking, …)	Part of CMP	4.3.2 & Annex K (C.I. Selection)
	Configuration Item List CIL	B	
5.3.2	**Configuration control** - (Change proc, classif, dispo, …)	Part of CMP	4.3.3 (change proc, classif, CCB…)
	Change request	G	
	Change proposal	H	
	RFD & RFW	I & J	
5.3.3	**Configuration status accounting**	Part of CMP	General guideline in 4.3.4 (incl. as-designed and as-build data lists)
	Conf. Status accounting report	F	
	As designed — Conf Item Data List (CIDL)	C	
	As designed — SW Conf File (SCF)	E	
	As-build Conf. List	D	
5.3.4	**Configuration verification** - ("AsBuilt" against "AsDesign" @ various reviews)	Part of CMP	
5.3.5	**Audits of the CM system**		
5.3.6	**C.M. for operational phases** – (Activities during phases E & F)		
5.3.7	**Implementation of info/doc management** (incl. creation, review, delivery, archiving, retrieval)		4.3.8 (including TDP) & Annex L (Tech data) Annex M (Digital Sign.)

Table 7-3: Summary of the requirements in ECSS-M-ST-60C

Clause & Req	Requirements		DRD (Annex)	Supporting guidance
7 - Cost & schedule management common requirements				
7.1	**Project structure**			
	7.1.1 Cost breakdown structure (CBS) – Cost categories		A	Info in the DRD itself
	7.1.2 Business agreement structure (BAS)	Both covering all elements of the WBS (see ECSS-M-10 Annex C)	-	4.2.3
	7.1.3 Country/Company structure (CCS)		-	Normally combined with the BAS
7.2	**Risk management** - C&S contribution to Risk mngmnt (ECSS-M-80)		-	
8 – Schedule management requirements				
8.1	**Schedule definition** – Schedule, critical path, dependencies, calendar, KIP, MIP		-	Clause 5.1
8.2	**Schedule control** – Baseline and actual schedule, performance measurement & evaluation, trends		B	Clause 5.2
8.3	**Schedule reporting**		C	
9 – Cost management requirements				
9.1	**Contractual and financial interfaces**			
	9.1.1 Audited rates & cost structure – To be approved & audited by Nat. Auth.		-	Some info in 6.2
	9.1.2 Economic conditions (EC)[1] – Cost info to be referred to the EC defined by customer		-	
	9.1.3 Currency & exchange rates		-	
	9.1.4 Contract change procedure - CCNs		O	Some info in 6.2.3
9.2	**Cost estimating and planning**			
	9.2.1 Cost estimating - Plan (Annex F) and Report (Annex G), proprietary data		F & G	6.3.1
	9.2.2 Project financial info – Company price breakdown form (CPBF)		D	
	9.2.3 Develop. cost plan (DCP) – based on Prod. Tree, WBS, CBS & CPBF		-	Some info in 6.3.2
	9.2.4 Milestone payment plan		H	Some info in 6.3.3
	9.2.5 Price variation mechanism – Supplier proposes, customer approves		-	6.3.4
	9.2.6 Geographic distribution – To meet the customer geo. distri. constraints		E	Some info in 6.3.5
9.3	**Cost control**			
	9.3.1 Original BCP (baseline cost plan) – BCP for cost reim. & Fix price		K & L	Some info in 6.4.1
	9.3.2 Current baseline cost plan (CBCP) – To report on the update the OBCP		K & L	
	9.3.3 EAC & ETC – Report for cost reim. (Annex M) and Fix Price (Annex N)		M & N	Some info in 6.4.2
	9.3.4 Price variation mechanism control – Report on computation of 9.2.5		-	Some info in 6.4.3
	9.3.5 Geo distribution control – Report on Actual distribution (see 9.2.6)		E	Some info in 6.4.4
	9.3.6 Inventory control – Inventory control plan		-	Info in 6.3.6 and 6.4.5
	9.3.7 Financial audits (for cost reimbursement) – Customer right to audit suppliers		-	Some info in 6.4.6
	9.3.8 Payment milestone achievement – Way to certify & document payment		-	Some info in 6.4.7
9.4	**Cost management reporting**			
	9.4.1 Cost & manpower report (for cost reimbursement)		J	
	9.4.2 Inventory report		I	

Table 7-4: ECSS-M-70A

ECSS-M-70A is still in version A, which means that it does not necessarily follows the rules explained in the present guide, and it may not be fully consistent with the rest of ECSS standards (version C or later). It is therefore not considered in the present guide until updated (see 5.2.4.1.3 and 7.2.2e).

Table 7-5: Summary of the requirements in ECSS-M-ST-80C

Clause & Req	Requirements	DRD (Annex)	Supporting guidance
7 – Risk management requirements			
7.2	**Risk management process**		
	7.2.1 Risk policy	A	
	- Resources, goals & constraints		Info in 5.1
	- Strategy, approach and goal ranking		Info in 5.1 and 5.2.1
	- Risk scoring and index scheme, and action criteria		Info in 5.2.1 and 5.2.2
	- Decision		Info in 5.2.3
	- Communication		Info in 5.2.4
	7.2.2 Risk management plan (RMP)	B	
	- Organization and responsibilities		Info and guidelines in 6.2 and 6.3
	- Decision, criteria and tools		Info in 6.4
	- Documentation and processes		Info in 6.5
	7.2.3 to 7.2.5 Risk scenarios – To be identified, assessed & analyzed for acceptability		Risk register example in Annex D
	7.2.6 Risk reduction – i.a.w. the risk policy in Annex A		
	7.2.7 Determination of reduced risk – To understand the impact of mitigation actions		
	7.2.8 Resolved, acceptable & overall risk assessment – i.a.w. RMP (Annex B)		
	7.2.9 Unresolved risk – Disposed as in the RMP (Annex B)		
	7.2.10 Residual risk – Accepted/disposed as in the RMP (Annex B)		
	7.2.11 Risk report	C	
7.3	**Risk management implementation**		
	7.3.1 Risk implementation (at any level customer-supplier) and integration		NOTE: The summary of all these requirements is "Implement your RMP"
	7.3.2 Cost effective, at project level		
	9.3.3 Risk management process - to be monitored		
	9.3.5 Lessons Learnt on Risk management - to be performed		

Table 7-6: Summary of the requirements in ECSS-M-ST-10-01C

7.3 Documentation

7.3.1 ECSS-S and M documentation linked to project reviews

As it can be seen from Table 4-4 and **Error! Reference source not found.**, many documents are required by both the ESA contract and the ECSS standards, which means that compliance with the ESA contract requirement implies compliance with many ECSS ones.

There is, however, a dimension covered by the M standards that is not considered in the contract: evolution with time. As the project is developing, situation changes in respect to the initial one, and this implies that many of the documents presented at the time of the contract would need to be updated during project execution. Table 7-7, taken from ECSS-M-ST-10C Annex F, includes this information for the main DRDs in the M branch, against the project reviews in which they need to be delivered and subsequently updated.

Some of these documents include common pieces of information, and many are interrelated among them, so than some are based or have to refer others. This permits to organize the documents in groups of interrelated deliverables. The following is a discussion on M deliverable documents linked to project reviews. Figure 7-2 supports such a discussion.
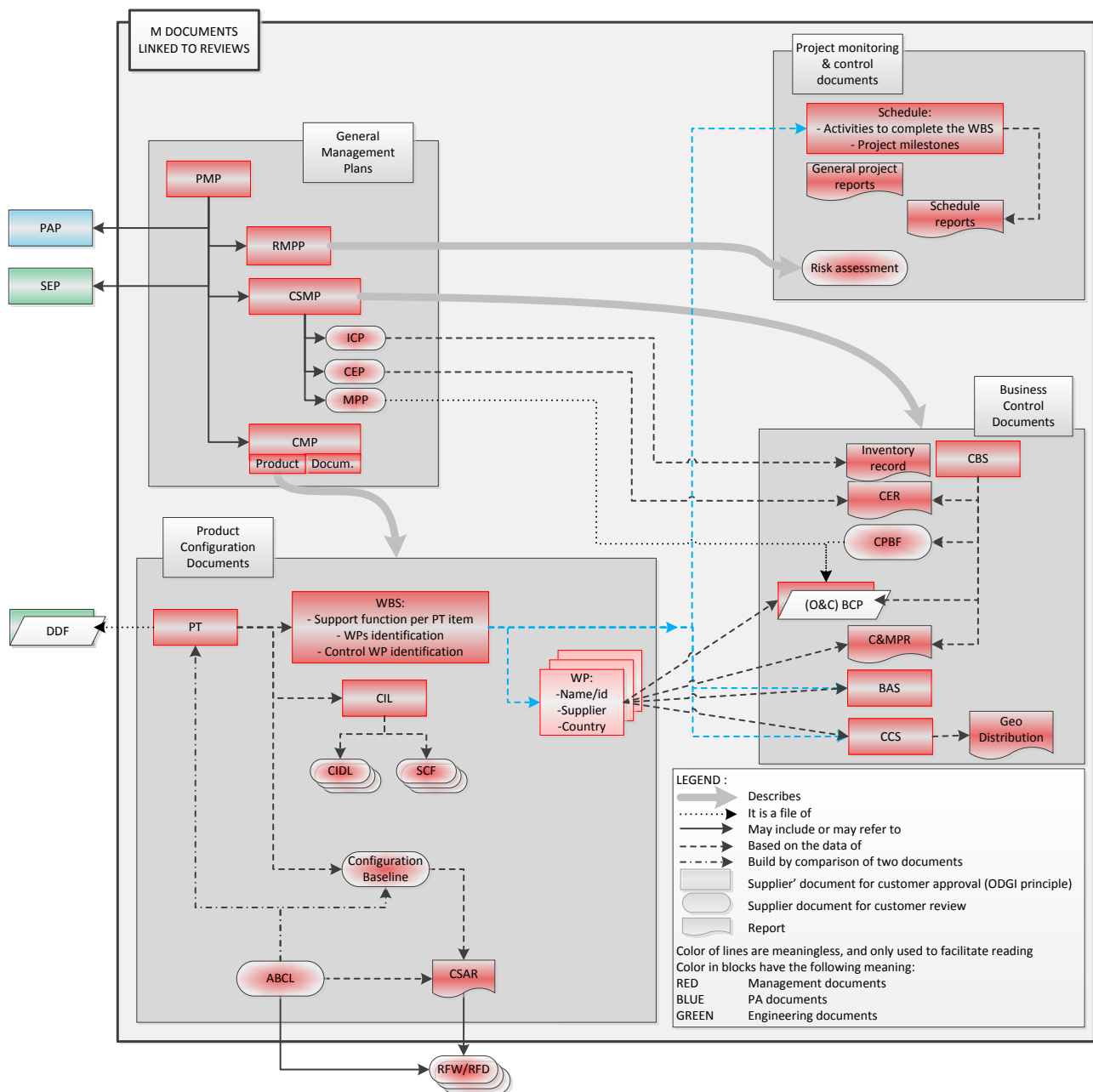
Figure 7-2: Groups of and relation between M documents linked to project reviews

Table 7-7: Main DRDs in the M branch linked to project reviews

Document Title [1]	Required by [2]	Described in [3]	Description of the document [4]	MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR	MCR
The general management plans — Project management plan		M-ST-10, Annex A			X	X	X									
Configuration management plan		M-ST-40, Annex A			X	X	X									
Cost & schedule management plan																
ILS approach																
Risk management policy document		M-ST-80, Annex A		X	X	X	X									
Risk management plan		M-ST-80, Annex B		X	X	X	X									
Product tree		M-ST-10, Annex B			X	X	X	X	X	X						
Work breakdown structure		M-ST-10, Annex C			X	X	X									
Work package description		M-ST-10, Annex D			X	X	X									
Schedule		M-ST-60, Annex B		X	X	X	X	X	X	X	X	X				
Cost estimate report		M-ST-60, Annex G			X	X	X									
Configuration item list		M-ST-40, Annex B						X	X							
Configuration item data list		M-ST-40, Annex C						X	X	X	X					
As-built configuration list		M-ST-40, Annex D								X	X					
Software configuration file		M-ST-40, Annex E						X	X	X	X	X				
Configuration status accounting reports		M-ST-40, Annex F						X	X	X	X					
Risk assessment report					X	X	X	X	X	X	X	X				

a. **The General management plans, including:**

1. **The PMP** "Project Management Plan", which is the highest M deliverable, and includes:

   (a) General management issues:

   (1) Objectives and constrains of the project

   (2) Project organization, including project manager, key personnel, specialists, authority and hierarchy, roles and responsibilities, interface with suppliers and other projects.

   (3) Project breakdown structures, describing the approach to define the project WBS, and pointing the document describing the WBS themselves.

   (4) A description of the ILS approach

   (b) Interfaces with other management areas, including the following documents or pointers them: the Configuration management Plan (CMP, see 2 below), the Cost and schedule management plan (CSMP, see 3 below), ILS approach (see 4 below), the Risk management and plan (RMPP, see 5 below).

   (c) Interfaces with other project areas, including the following documents or pointers to them: the Product Assurance Plan (PAP, see Table 8-14) and the System Engineering Plan (SEP, see Table 9-12).

2. **The CMP**, or Configuration management plan, describing how all the configuration management activities, both for the product and for the documentation and information, will be performed.

3. **The CSMP**, or Cost & Schedule management Plan, describing the approach used to ensure cost and schedule management. It may include or point to the following documents:

   (a) **The CEP** or Cost estimating plan, explaining the organization and processes for cost estimation

   (b) **The MPP** or Milestone payment plan, defining the plan for payment events.

4. **The ILS approach**, defining the approach use for ILS.

5. **The RMPP** or Risk management Policy and Plan composed of two documents which can be released together or independently:

   (a) **The Risk management policy**, defining the resources, goals, strategy, margins, ranking/scoring/index schemes, action/acceptance criteria and communication approach.

   (b) **The Risk management plan,** describing the processes and metrics to apply the risk management policy.

b. **The Product Configuration documents**, including:

1. **The Product Tree** (PT), is a description of the hierarchical partitioning of a deliverable product down to an agreed level. Important remarks are:

   (a) Each item in the tree is identified by its name, an identification code, the supplier and the applicable specification.

   (b) Items may include HW or SW.

   (c) All the items of the PT selected to be under configuration control are so identified (see 4 below)

   (d) All items which are recurrent products are so identified.

2. **The WBS**, that:

    (a) <u>For each of the items in the PT</u>, includes a sub-tree with the support functions defined by the customer, and the necessary services and tasks to produce the deliverables. For example, defining for each item in the PT the management, the PA and engineering tasks.

    (b) Identifies the Work packages (WP) by referring the items in the WBS in each WP, ensuring that that the WPs cover the total work scope. Detailed description of each WP is not done here (see 3 below).

3. The description of each **Work Packages** identified in the WBS (see 3.b above), including among others the name of the package, manager in charge, supplier and supplier country, description of the included (and excluded) tasks, deliverables, location and start and end dates.

4. The **Configuration item list** (CIL), listing the items (HW or SW) of the PT which have been identified to be under configuration control [see b.1.(b) above]., with name, code, quantity, supplier and applicable specification.

5. Each item in the CIL is described in a **Configuration Item Data List** (CIDL), listing all the relevant data of the item under configuration control.

6. Each item SW in the CIL is described in the **SW configuration file** (SCF)

7. **The configuration baseline** (CB), is a set of documents, to be agreed between customer and supplier, reflecting the actual configuration of the product. The initial CB refers to the "as-design" product, but it will need to be updated to refer to the "as-built" product when the latter differs from the former.

8. The **As-built configuration list** (ABCL), reflecting the actual status of the product "as-built", listing the differences with the "as design", and justifying these differences by making reference to the corresponding RFW/RFD.

9. The **Configuration status accounting report** (CSAR), collecting and summarizing the necessary information to support a meaningful configuration management.

c. The **Business control documents**, including:

1. The **Cost breakdown structure** (CBS), that is the breakdown of all the cost concepts of the project to categories to be used for cost management, with clear differentiation between direct and indirect costs. Figure 7-3 shows an example.
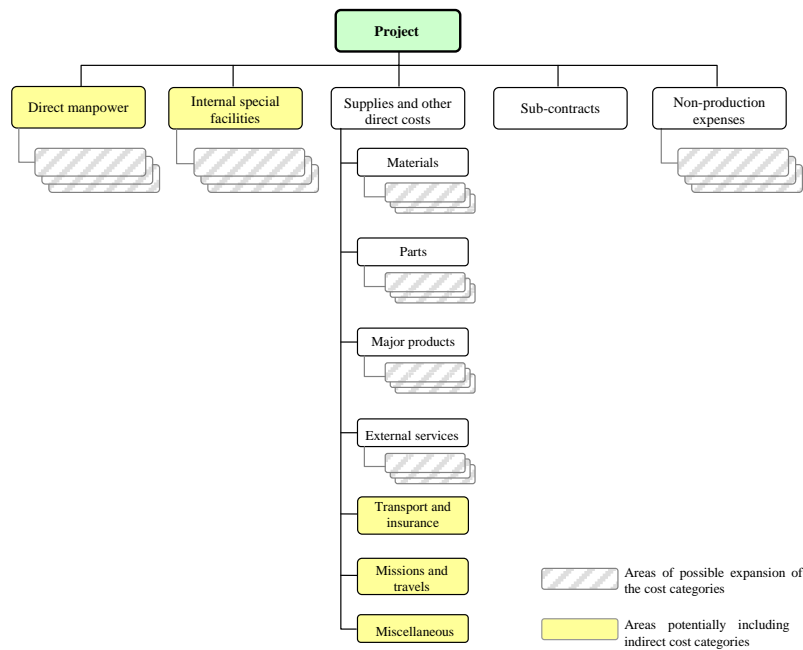
Figure 7-3: Example of CBS

2. **The CPBF** (Company price breakdown forms), which shows the manpower and cost data broken down according to the categories defined in the CBS.

3. **The BAS** (Business Agreement Structure) [called Contract Structure in ESA/REG/001 Annex IV], is a breakdown structure of the of suppliers indicating their reporting lines and the WPs assigned to each supplier. An example is in Figure 7-4. It has to be completely mapped to the WBS as shown in, and fully consistent with the defined Work packages (since the WP also contain information on suppliers).
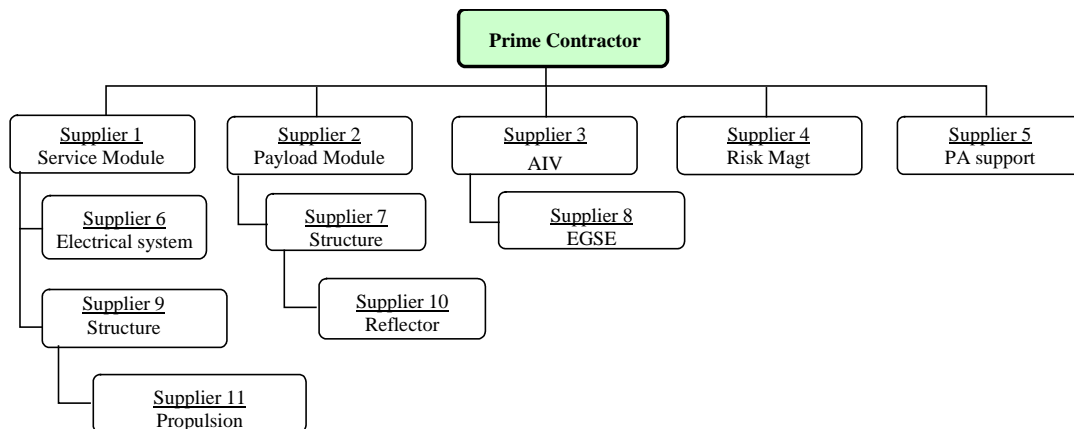
Figure 7-4: Example of BAS
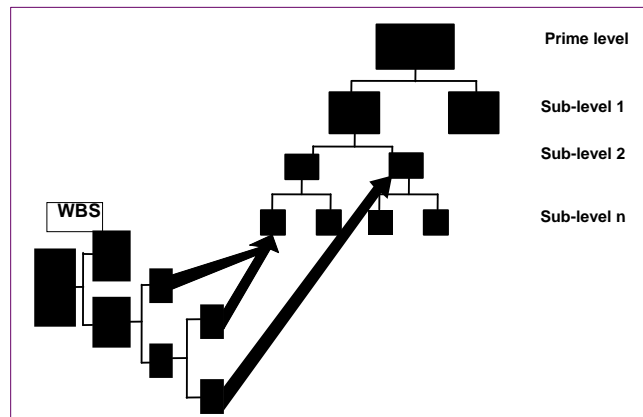
Figure 7-5: BAS mapped to the WBS

4. **The CCS** (Country/Company structure), which shows the relationship between suppliers in the BAS and the country where the work is performed. If this relationship is simple, the CCS is normally combined with the BAS in a single document.

5. The **Cost estimate report**, which reports, for each of the cost items identified in the CBS, the estimation method, quality of the estimate, hypothesis, sensitivity analysis (influence to the total cost), cost risk analysis, and recommendations.

6. The actual **Cost and Manpower report** is only necessary for cost reimbursement contracts. It gives a detailed status on the expenses incurred by the supplier.

7. The **Baseline Cost Plans** (BCP) document the contractually agreed cost and manpower.

8. EAC and ETC

d. The **Project Monitoring, schedule and control** documents, including:

1. The **Project Schedule**, which consist on a timed network of activities (showing their interdependencies) against defined milestones, preferably in a Gant-Chart, and identifying the critical path:

   (a) The network of activities are derived from the **WBS**.

   (b) The milestones depend on the project, but typically include the start and end of each phase and the project reviews (see **PMP**), production/test/delivery reviews (see **PMP**), payment milestones (see **payment plan**), and CFE delivery dates.

2. The progress reports (not relevant for the contract), including:

   (a) General Project **Progress reports**,

   (b) The **Schedule Progress report**, including the work actually performed against the original Project Schedule, trend analysis for the milestones, justification of deviations, remedy actions and status of deliverable items.

3. **Risk assessment report**, explaining how the **risk policy and plan** has been applied and followed for the identification and mitigation of risks, and listing all the registered risks, with their rank, rating and trend.

7.3.2 M documentation linked to events

Table 7-8 lists the M deliverable documents linked to specific events, their corresponding triggering events, and the documents where they are required.

Table 7-8: M deliverable documents linked to specific events

Document title [1]	Required by [2]	Specified in [3]	Description of the document [4]	Triggering event [5]
Change request (CR)		M-ST-40 Annex G		When an organization request for a project change to existing requirements
Change proposal		M-ST-40 Annex H		When an organization proposes a major change to an approved baselined data or to the business agreement (the contract)
Request for deviation (RFD)		M-ST-40 Annex I		When an organization requests the departure from a customer requirement which is part of the approved configuration baseline. The RFD is used also to agree (if so) this deviation.
Request for waiver (RFW)		M-ST-40 Annex J		When an organization requests the use or the delivery of a product that does not conform to its approved configuration baseline. The RFW is used also to agree (if so) this waiver.
Contract Change Notice (CCN)		M-ST-60 Annex O		When a contractual change happens

7.3.3 M documents produced during a project review

A third category of documents considered for the M branch are those produce as a result of the project review itself. Table 7-9 lists these documents.

Table 7-9: M deliverable documents produced as a result of a project review

Document title		Required by	Purpose
Review procedure		M-ST-10-01 Annex A	To state the purpose and organization of the review, and to define the review data-package
Review item discrepancy (RID)		M-ST-10-01 Annex B	To record identified problems and questions arising from the assessment of the review documentation. One RID per identified problem/question.
Review team report		M-ST-10-01 Annex C	To summarize the findings of the review team, and to identify issues brought to the attention of the Review Authority for resolution
Review authority report		M-ST-10-01 Annex D	To summarize the major findings of the review, and to record recommendations and decisions

8
Application of ECSS-Q requirements in ESA projects

8.1 Introduction

Section 6 gives general guidelines for the tailoring of the list of documents to a particular application, without entering in individual requirements. If a higher level of granularity is necessary to make a final decision on the application of a particular standard, or tailoring at the level of individual requirements is necessary, this Section 8 provides the details for standards in the Q branch.

This Section 8 is also a reference to understand the documentation required by documents in the Q branch. A simple approach to comply with these documentation requirements is presented in Annex B.

8.2 Requirements of the Q standards

8.2.1 Overview

The Q branch consists of seven disciplines (see Figure 5-1): Q10 (Product Assurance), Q20 (Quality assurance), Q30 (Dependability), Q40 (safety), Q60 (EEE components), Q70 (MMP&P) and Q80 (SW Product Assurance). Each of these disciplines contains one Level 2 standard, and any number of Level 3 standards (i.e. one, several or no-one).

8.2.2 The seven Level 2 standards in the Q branch

The seven Level 2 standards (one per discipline) contain more generic requirements. To remain as generic as possible, they apply in as far as possible the "ODSI" principle (see 5.2.7).

A General description of these documents is provided in 6.2.2. A more detailed description is provided by Table 8-1 to Table 8-7, which are a summary of the requirements of these standards. In these tables, those requirements adhering to the **"ODSI" principle have been shadowed in green**. As it can be seen, it is not possible to use this principle as much as for the management standards, and it is mainly used for general plans.

Note that the requirements adhering to the "ODSI" principle include a reference to a DRD to comply with "ODSI step b", and most of them are supported by guidance material in accordance with "ODSI step e". Observe also, however, that reference to DRDs is not exclusive of those requirements, and many others require the generation of documentation in accordance with a DRD (although in this case the document itself does not need customer approval).

Table 8-1: Summary of the requirements in ECSS-Q-ST-10 "Product assurance"

Clause & Req		Requirements subject	DRD (Annex)	Supporting guidance
5.1 PA planning	5.1.1	PA organization, personnel (including appointment of a PA manager), responsibilities, authority and reporting line	PAP in Annex A	4.1 and 4.2
	5.1.2	PA manager interfaces		
	5.1.3	PA plan describing all PA (Q10, 20, 30, 40, 60, 70 & 80) activities		
5.2 PA implementation	5.2.1	PA manager responsibilities		4.3
		Including Qualification Status List	Annex B	
	5.2.2	PA reporting (obligation and content of the report)		
	5.2.3	PA audits (audit plan, and audit execution)		
	5.2.4	Critical item control (*pointer to Q-ST-10-04*) and associated risk		
	5.2.5	PA documentation management		
	5.2.6	Quality records showing evidence of successful PA activities		
	5.2.7	PA contribution to configuration management		
	5.2.8	Nonconformance control (*pointer to Q-ST-10-09*)		
	5.2.9	Notification and investigation of alerts, and PA manager role	Alert status list. No specific DRD See NOTE	

NOTE: ECSS requires to participate in the alert system of the customer (ESA in this case). The alert system of ESA implies the use of the "Alert Status List" by the supplier.

Table 8-2: Summary of the requirements in ECSS-Q-ST-20 "Quality assurance"

Clause & Req		Requirements subject	DRD (Annex) or other docs.	Supporting guidance
5.1 QA mt	5.1.1	QA plan	Annex A	4.1
	5.1.2	Personnel training and certification program & records	Part of QA plan	
5.2 QA General requirements	5.2.1 & .2	Crit. Item control & NCR system (*pointers to Q-ST-10-04 & -09*)		
	5.2.3	Alerts (*pointer to Q-ST-10*)		
	5.2.4	Acceptance Authority Media (e.g. stamps) system		
	5.2.5	Traceability system establishment for products, docs & data		
	5.2.6	Metrology and calibration system establishment		
	5.2.7	Handling, storage and preservation (*pointer to Q-ST-20-08*)		
	5.2.8	Statistical Q control and analysis		
5.3 Design & Verification	5.3.1	Design rules on produceability, repeatability, inspectability & testability and operability		
	5.3.2.3 & .5	Design reviews & Control of design changes		
	5.3.2.1, .2 & .4	Verification system establishment, Qualification process (including by similarity, testing and status)		
5.4 Procure ment	5.4.1	Procurement sources selection and records	Procurement document defined in 5.4.2c	
	5.4.2	Procurement documentation and traceability		
	5.4.3	Procurement sources surveillance		
	5.4.4	Receiving inspection requirements		
5.5 MAI (Manufacturing, Assembly and Integration)	5.5.1	MAI Planning documentation (including MIP definition)	MAI docs defined in 5.5.1e	
	5.5.2	Manufacturing readiness review and purpose		
	5.5.3	Processes control, including special processes and statistical		
	5.5.4	Use of workmanship standards	DRD in Annex C	Ex. in Annex E
	5.5.5	Materials & part control		
	5.5.6	Equipment control (tooling and computer-aid)		
	5.5.7	C³ (Cleanliness and contamination control) methods (*pointing to Q-ST-70-01*), levels, materials and facilities		
	5.5.8	Inspection system set-up, including MIP selection		
	5.5.9	Control of temporary facilities / Logbooks		
	5.5.10	MAI records establishment		
	5.5.11	ESD (on ground) protection programme	EN-61340-5-1 or ANSI-ESD-S20.20	
5.6 Testing	5.6.1	Test facilities suitability	Test procedures in E-ST-10-03 Ann A Reports in 5.6.3.2a	
	5.6.2	Test equipment (testing V&V, and testing SW config. control)		
	5.6.3	Test documentation: Procedures and Reports		
	5.6.4	Test performance monitoring and witnessing against test plan		
	5.6.5	Test reviews		
5.7 Acceptance & delivery	5.7.1	Acceptance and delivery process establishment		
	5.7.2	EIDP mandatory for each deliverable end item	Annex B	Ex. in An.F & G
	5.7.3	DRB composition & functions, and CoC	CoC in Annex D	Ex. in Annex H
	5.7.4	Packaging, marking and labelling		
	5.7.5	Delivery: Outcoming inspection and docs		
5.8 GSE	5.8.1 & .2	GSE design, verification and Configuration Control	EIDP for GSE defined in 5.8.4	
	5.8.3	GSE procurement, manufacturing, integration & test		
	5.8.4	GSE acceptance & delivery (including DRB & EIDP for GSE)		
	5.8.9	Maintenance plan		

C3 = Cleanliness & Contamination control	CoC = Certificate of conformity	DRB = Delivery review board
EIDP = End Item Data Package	ESD = Electrostatic discharge	GSE = Ground support equipment
MAI = Manufacturing, Assembly & Integration	MIP = Manufacturing inspection point	V&V = Verification & Validation

Table 8-3: Summary of the requirements in ECSS-Q-ST-30 "Dependability"

Clause & Req			Requirements subject		DRD (Annex) or other docs.	Supporting guidance
4 **Dependability programme**	4.1 & 4.2		Dependability management integration with PA management			
	4.3		Dependability programme plan		Annex C	
	4.4		Dep. risk management integrated with project risk management			
	4.5		Dep. critical item control, including a Pointer to *Q-ST-10-04*			
	4.6 & 4.7		Design reviews and Lessons learnt			
	4.8		Dep. report integration with PA reports			
5 **Dependability engineering**	5.1		Dep. Integration in the project (design, MAIT, operations…)			
	5.2		Dep. Integration in the Technical Spec.			
	5.3.1	**Design**	Design critical areas and success criteria			
	5.3.2		Criticality classification on SEVERITY OF CONSEQUENCES			
	5.3.3		Failure tolerance			
	5.3.4		Reqs to integrate dependability into the design			
	5.4		Classification of critical functions		No specific DRD	
	5.5 & 5.6		Dep. Involvement in testing and operations			
	5.7		Implementation of a Dep. Recommendations system			
6 **Dependability analysis**	6.1		Identification and classification of undesired events			
	6.2		Assessment of failure scenarios			
	6.3		Dependability analysis against phases			Annex A
	6.4.2.1	**Methods**	**Reliability**	**Reliability predictions** and models	Annex E	
	6.4.2.2			When **FMEA/FMECA** – *Method specified in Q-ST-30-02*		
	6.4.2.3			When **HSIA** –Part of FMEA/FMECA -> *Pointer to Q-ST-30-02*		
	6.4.2.4			When **Contingency analysis** – Contents in Annex D	Annex D	
	6.4.2.5			When **Fault tree analysis** – *Method in ECSS-Q-ST-40-12*	FTA	
	6.4.2.6			When **Common cause analysis** –Contents in Annex I; "Check list" in Annex L	Annex I	Annex L
	6.4.2.7			When **WCA** – Content in the Annex; Guidelines Method in HB; "Check list" of inputs in TM	Annex J	Method *Q-HB-30-01* Help: *Q-TM-30-12*
	6.4.2.8			**Part stress analysis** on EEE comp. using *Q-ST-30-11 (Derating)*	Part stress anal.	
	6.4.2.9			**Zonal analysis** at system level, contents in Annex G	Annex G	
	6.4.2.10			**FDIR analysis** at system level, contents in Annex F	Annex F	
	6.4.3		When **Maintainability analysis** – Contents in the Annex		Annex H	
	6.4.4		Availability analysis – *Method in Q-ST-30-09*		Avail. analysis	Method Q-ST-30-09
	6.5		Criteria for Dep. Critical Item List (see also 4.5)			
7 **Dependability testing & demonstration, and data collection**			Reliability and availability testing and demonstration Maintainability demonstration Data collection			

Dep = Dependability	EEE = Electric, electronic & electromechanic	FMEA/FMECA = Failure modes & effects (criticality) analysis
MAIT = Manufacturing, assembly integration and Test	PA = Product assurance	WCA = Worst case analysis

Table 8-4: Summary of the requirements in ECSS-Q-ST-40 "Safety"

NOTE: Guidelines on applicability of individual requirements to manned/unmanned vehicles are given in **ANNEX F**

Clause & Req		Requirements subject		DRD (Annex) or other docs.	Supporting guidance
5. Safety programme	5.1 & 5.3	Scope and regulations to be met			Annex G "European legislation"
	5.2	Safety programme plan		B	4.2 & 4.3
	5.4	Organization (Safety manager and authority, audits and boards)			
	5.5	Safety risk contribution to project risk -> *Pointer to Q-ST-80*			
	5.6	Safety critical items -> *Pointer to Q-ST-10-04*			
	5.7.1	Detail task requirements to be performed during project PHASES			
	5.7.2 & 5.7.3	Safety meetings and Safety reviews			
	5.9	Safety training (coverage, needs identification, briefings, …)			
	5.10	Accident-incident reporting			
	5.11 Documentation	Data package – Specified in the requirement itself RFW/RFD – *Pointer to M-ST-40* Lessons learnt, Critical Items – *Pointer to Q-ST-10-04*			
6. Safety engineering	6.2	Requirement traceability and justification			N/A @ equipment level
	6.3.3 & 6.3.6	Design	Design requirements for **Hazard** reduction, control & detection		
	6.3.4		Environment		
	6.3.5		Design to avoid safety risks from external services		
	6.3.7 & 6.3.8		Debris and re-entry requirements – *Pointers to U AS-10*		
	6.3.9		Planetary protection (biological) requirements		
	6.3.10		Specific design requirements for manned missions		
	6.3.11		Design for safe access		
	6.4.1	Risk	Criticality classification on SEVERITY OF CONSEQUENCES		
	6.4.2		Requirements for Failure tolerance (including redundancy)		
	6.4.3		Design for minimum risk: - Factor of safety – *Pointer to E-ST-32-10* - Fracture control – *Pointer to E-ST-32-01* - Materials – *Pointer to Q-ST-70*		
	6.4.4		Probabilistic		Annex E
	6.5	Safety critical functions, including: - EEE components, *Pointer to Q-ST-60* - SW criticality, which include pointers to *E-ST-40* and *Q-ST-80*			
	6.6	Safety for flight & ground operations, and for GSE			
7. Safety analysis	7.5.1 & 7.5.2	When **Safety analysis (**incl. **Hazard analysis),** and for what		Annex D	
	7.5.3	**Safety risk analysis**, to support Project Risk (*M-ST-80*)		Safety risk analysis	
	7.5.4.2	Supporting analysis	When **Warning time analysis**, and for what	WTA	
	7.5.4.3		When **Caution and warning analysis**, and for what	CWA	
	7.5.4.4		When **Common cause** and **Common-mode failure** analysis	CC & CMF	
	7.5.4.5		When **Fault Tree analysis** – *Pointer to Q-ST-40-12*	Fault tree anal.	
	7.5.4.6		**Human error analysis**	Human error anal.	
	7.4.4.7		**FMEA/FMECA** – *Pointer to Q-ST-30-02*	FMEA/FMECA	
	7.4.4.8		**Zonal analysis -**	Zonal analysis	
8. Safety verification		Safety verification tracking log		Annex C	
		Reporting and Safety reviews; Safety critical functions; DoC			
GSE = Ground support equipment		DoC = Declaration of Conformity			

Table 8-5: Summary of the requirements in ECSS-Q-ST-60 (EEE components)

Clause & Req		Requirements subject		DRD (Annex) or other docs.	Supporting guidance
ECSS-Q-ST-60 "EEE components"					
4.1 Comp. prog. Manag.	4.1.2.1	Identify the organization for component management			
	4.1.2.2	Component control plan (may be part of the PA plan)		Annex A	
	4.1.3	Part control board (PCB) composition and activities			
	4.1.4	Declared component list (DCL), to be under config. control		Annex B	
	4.1.5	GSE			
4.2 Selection, evaluation & approval	4.2.1	Generic requirements for the selection of components			
	4.2.2.2	Rules for the selection, including **report for pure tin in cavities**		Report	
	4.2.2.3	Preferred sources (e.g. EPPL)			
	4.2.2.4	Radiation hardness assurance plan		4.2.2.4g	
		Equipment radiation analysis document		4.2.2.4h	
	4.2.2.5	Derating *(pointer to Q-ST-30-11)*			
	4.2.3.1	Evaluation, of the component	Evaluation plan	4.2.3.1d	
			Evaluation report		
	4.2.3.2	Manufacturer assessment *(pointer to ESCC 20200)*			
	4.2.3.3	Constructional analysis & test -> part of evaluation report			
	4.2.3.4	Determination of the evaluation testing			
	4.2.4	Part approval process, including a PAD (Part approval document)		Annex D	
4.3 Component procurement	4.3.1	Quality levels to be met, manufact. responsibility & conf. cont.			
	4.3.2	Procurement specification preparation and config. controlled		Annex C	
	4.3.3	Screening testing, and its quality levels			
	4.3.4	Precap inspection for critical components and non-space qualified		Precap spec	
	4.3.5	Rules for lot acceptance			
	4.3.6	Buy-off inspection for non-space qualified		Buy-off spec.	
	4.3.7	Incoming inspection content and incoming inspection document		Inc. insp. proc.	
	4.3.8	Radiation Verification Testing (RVT), i.a.w. 4.2.2.4g		RVT report	
	4.3.9	Destructive physical test sample size		Dest. Test report	
	4.3.10	Relifing (see Q-ST-60-)			
	4.3.11	Manufacturer documentation – minimum period to be kept			
4.4 Handling & storage		See Q-20-08			
4.5 Comp QA	4.5.1	Establishment of a quality system *(Pointer to Q-ST-20)*			
	4.5.2	NCR system (-> Q-ST-10-09)			
	4.5.3 & 4.5.4	Alert management and traceability *(Pointer to Q-ST-20)*			
4.6 Specific components		*Pointers to Q-ST-60-02, Q-ST-60-05, Q-ST-60-12*			
5 – Class 2		The same requirements as above, particularized for Class 2 components			
6 – Class 3		The same requirements as above, particularized for Class 3 components			

Table 8-6: Summary of the requirements in ECSS-Q-ST-70 (MMP&P)

Clause & Req		Requirements subject	DRD (Annex) or other docs.	Supporting guidance
4 **General req's for M, MP and P**	4.1.2	MMP&P plan	Q-ST-10 An.A	
	4.1.3	Responsibilities & functions of the MMP&P manager and MPCB		
	4.2	Establishing and managing Declared M, MP & P lists	A, B & C	
	4.3	Compliance with mission, flight and life cycle constrains		
	4.4	C3: *Pointer to ECSS-Q-ST-70-01*		
	4.5	Safety: *Pointer to ECSS-Q-ST-40*		
	4.6	Assessment of materials for GSE		
	4.7	Selection of materials: *Pointer to ECSS-Q-ST-70-71*		
5 **Materials control**	5.1	Criteria for the selection: Thermal Vacuum, Offgassing, toxicity, flammability, radiation, ESD, corrosion, compatibility, …		
	5.2	Selection in accordance with previous use, data sources and validation		
	5.3	Declared material list (repetition of req 4.2)		
	5.4	Critical analysis: specific RFD for MMP/P when not meeting project reqs	D	
	5.5.2	Evaluation phase (only if required by critical analysis), at PDR	Eval. program / Eval report	Fig 4-1 / Table 4-1
	5.5.3	Validation phase (@ CDR) and validation programme	Val. program	
	5.5.4	Approval phase & Deviation request -> *Pointer to ECSS-Q-ST-10-09*		
	5.6	Procurement i.a.w. procurement specs, and procurement planning		
	5.7.1-5.7.3	Use: validation before use, traceability, packaging and storage		
	5.7.4 & 5.7.5	Limited life materials. Relifing: *Pointer to ECSS-Q-ST-70-22*		
6 **Mech. Parts control**		Repetition of the requirements in Clause 5, particularized for Mechanical Parts		
7 **Processes control**		Repetition of the requirements in Clause 5, particularized for Processes		

MMP&P = Materials, mechanical parts & processes GSE = Ground support equipment ESD = Electrostatic discharge
RFD = Request for deviation CDR = Critical design review i.a.w. = in accordance with

Table 8-7: Summary of the requirements in ECSS-Q-ST-80 (SW product assurance)

NOTE: Mandatory tailoring of individual requirements against SW CRITICSALITY is given in **ANNEX D**

Clause & Req			Requirements subject		DRD (Annex) or other docs.	Supporting guidance
5. SW PA programme		5.1	Organization and responsibilities (incl. SW PA manager & training)		Part of SW PAP	
	SW PA programme	5.2.1	SW PA programme plan (SW PAP)		Annex B	
		5.2.2	SW PA reporting (including a SW PA milestone report)		Annex C	
		5.2.3 & 5.2.4	Audits and alerts – *Pointer to Q-ST-10*			
		5.2.5	SW problems			
		5.2.6	Nonconformances		Part of SW PAP	Q-HB-80-04
		5.2.7	SW quality models			
		5.3.1	Risk – *Pointer to M-ST-80*			
		5.3.2	Critical items – *Pointer to Q-ST-10-04*			
		5.4	SW Supplier selection and control		Part of SW PAP	
		5.5	SW procurement			
		5.6	Methods, tools and development environments	Plan	Part of SW PAP	
				Report	Part of PA rep.	
		5.7	Assessment & improvement processes			Q-HB-80-02
6. SW process assurance		6.1	Development life cycle		Part of SW PAP	
	PA for SW engineering	6.2.1	Documentation (production of plans and procedures)			
		6.2.2	SW dependability and Safety – **Criticality** – *Pointer to Q-ST-30, -40*			Q-HB-80-03
		6.2.3	Handling of critical SW		Plan: Part of SW PAP	
		6.2.4	SW configuration management – *Pointer to M-ST-40*		Report: Part of PA rep	
		6.2.5	Process metrics (establishment, and minimum metrics)			
		6.2.6	SW PA verification (incl. reviews, inspections&independent SW V)		Part of PA rep.	
		6.2.7	Re-use existing SW, incl. a SW re-use file		Q-ST-80 #6.2.7	Q-HB-80-01
		6.2.8	Automatic code generation (incl. V&V documentation)		Part of PA rep	
	PA x engineering process	6.3.1	System requirements impacting SW			
		6.3.2	SW requirement analysis			
		6.3.3	SW architecture		Plan: Part of SW PAP	
		6.3.4	Coding		Report: Part of PA rep	
		6.3.5	Testing and validation			
		6.3.6	SW delivery & acceptance			
		6.3.7	Operations and operational requirements			
		6.3.8	Maintenance (organization, plan, procedures, reports & records)		Maint. plan	
7. SW Quality		7.1	Quality objectives and (quantifiable) metrication		Part of SW PAP	
		7.2	Product quality (Reqs baseline, documentation, Test & validation)		Part of PA rep	
		7.3	Reqs to produce SW to be re-used *(-> E-ST-40)*			
		7.4	Ground **HW** for operational SW (procurement, selection & maintenance)			
		7.5	Firmware (programming, marking and calibration)		Part of SW PAP	

PPR&R = Plan, procedures, reports and records	PAP = Product assurance plan	SW = Software / HW = Hardware

8.2.3 The Level 3 standards in the Q branch

8.2.3.1 Overview

They are many Level 3 standards in the Q branch. Although all of them are less generic than the Level 2, not all are equally generic. Table 6-1 provides a classification of them, depending on how their genericity can be used to decide on their application. Table 8-8 to Table 8-10 group them in accordance with this criteria, and provide a summary of their requirements.

8.2.3.2 ECSS-Q Level 3 standards of generic application

The ECSS-Q Level 3 standards of generic application cover (see Table 6-1):

- Standards for generic PA, QA & RAMS processes. They are detailed in Table 8-8

- Standards of generic applications for EEE components. They are detailed in Table 8-9

- Standards of generic application for materials, mechanical parts and processes (MMP&P). They are detailed in Table 8-10.

Table 8-8: ECSS-Q Level 3 standards for generic PA, QA & Dependability processes

Clause & Req		Requirements subject	DRD (Annex) or other docs.	Supporting guidance
ECSS-Q-ST-10-04 "Critical-item control"				
5.1	General req's	Identify, classify and manage critical items via a Critical Item List. Reduce the criticality of the items by design or procedural	Critical Item List in Annex A	4.1 and 4.2
5.2	Implementation	Procedural mandatory steps to implement requirements in 5.1		
5.3	Control activity integration	1. Identification of necessary inputs by a Top-down approach 2. Bottom-up integration of lists 3. Activities per review (PDR, CDR, AR)		Annexes B, C & D
ECSS-Q-ST-10-09 "Non-conformance control system"				
5.1	Detection	Early detection & actions to be taken, including NCR generation	NCR in Annex A	
5.2	NRB	NRB composition, process and functioning, including NC classification, analysis and disposition		
5.3	P&C Action	Preventive and corrective actions determination		
5.4	NC close-out	NRB, RFW & RFD actions implementation, and NC close-out		
5.5	Documentation	NCs to be reported in NCRs	NCR in Annex A	
		Periodic provision of the updated "NCR status list"	Annex B	
		NCs database establishment and use		
		Periodic analysis of records, causes and trends		
6	Specific NCR requirements	Specific NCR requirements for EEE components, Software, and operations (procedures, expected behaviour and human errors)		
NC = Nonconformance		NCR = NC Report NRB = NC Review Board	RFW/RFD = Request for Waiver/Deviation	
ECSS-Q-ST-20-08 "Storage, handling and transportation of S/C hardware"				
4	General requirements for Storage, handling & transportation	- Requirement to the designer of the hardware - NCR -> *pointer to Q-ST-20-09* - Safety -> *Pointer to Q-ST-40* - General req's on environmental conditions and protection - For GSE, identification of countries where it is being used - Training -> *Pointer to Q-ST-20*		
5. Storage	5.2 & 5.3	**Storage plan** and Storage procedure	Annex A	
	5.4	Storage configuration	No specific DRD	
	5.5: Activities	- Pre-storage review (PSR), mandatory before storage - Storage area conditions - Traceability: Storage logbook - Packing, unpacking, periodic inspections & testing - GSE storage, and SW running during storage - Refurbishment & maintenance procedure *per item* - Post-storage activities	Q-ST-20 Ann C 5.5.6.a	
	5.6 Re-testing	Pointer to E-ST-10-03		
6. Handling	6.2. MGSE	- Fixing points inspections; Identification of unsafe configurations - MGSE re-use: analysis to be performed - Loose items - Ready for use criteria, and maintenance plan covered in the UM - MGSE logbook - validation and certification (V&C)	Analysis report User manual Q-ST-20 Ann C Proof of V&C	
	6.3. Operational	- Handling procedure to be produced and available - Leader, personnel, briefing, safety perimeter, before operation - Attachment points inspection, RFU criteria, before operation - Non-interruptible sequences specific req's	Handling proc.	
	6.4 Quality	QA witnesses		
Transport	7.1 and 7.2	Categories of goods and transports		
	7.3.	Responsibilities before, during & after transport		
	7.4	FMEA or risk analysis (R.A.) -> pointer to Q-ST-30-02/M-ST-80	FMEA or R.A.	

	7.5	Consent to transport (CTT) meeting, and movement plan		CTT Movement plan	Annex C Annex B
	7.6	Escort: when is necessary, role and duties			
	7.7 – 7.9	Loading, packaging and marking			
ECSS-Q-ST-30-02 "FMEA/FMECA"					
4/5	How to perform a FMEA/FMECA	FMEA/FMECA report	A	- EEE Parts FM in Annex G - Product design FM in Annex H - HSIA checklist in Annex I	
		FMEA worksheet	B		
		FMECA worksheet	C		
6	Project lifecycle: When and for what to perform a FMEA/FMECA				
7	HSIA: When and for what – HSIA report		D		
8	How to apply FMECA to processes	Process FMECA report	E		
		Process FMECA worksheet	F		
ECSS-Q-ST-40-02 "Hazard analysis"					
5	How to perform a Hazard analysis		-	Chapter 4 and Ann. A, B & C	

Table 8-9: ECSS-Q Level 3 standards of generic application for EEE components

Clause & Req		Requirements subject	DRD (Annex) or other docs.	Supporting guidance
ECSS-Q-ST-30-11 "Derating of EEE components"				
5		Requirements for applying the derating factors		
6		Derating factors for various families of EEE components		
ECSS-Q-ST-60-14 "Relifing of EEE components"				
4		Environmental parameters for storage of EEE components		Annex B: ESD storage
5		Timing parameters: When to apply relifing, and for how long		
6.1	Control parameters	Tests (Generic and per EEE family) to be performed		
6.2		Non-conformances: Process (*pointer to Q-ST-10-09*) and criteria		
6.3		Date code determination and marking		
6.4		Relifing report	Annex A	
6.5		Original CoC management		
ECSS-Q-ST-60-15 "Radiation hardness assurance (EEE components)"				
NOTE: This document is applicable to ESA via an Adoption Note, which modify the values of few requirements. However, this does not affect the general explanation given here.				
5.1 - TID		TID environment definition (using E-ST-10-04) and specification, at SRR/PDR	Annex A	
		Definition of sensible EEE families		
		Assessments, test and calculations to be performed, and when		
		WCA for EEE sensible to in-orbit performance degradation -> *pointer to Q-ST-30*	Q-ST-30 Ann J	See Q-ST-30
		TID Analysis and report, available for review	Annex B	4.3, 4.4 & 4.5
		Non-conformances -> *Pointer to Q-ST-10-09*		
5.2 - TNID		Same type of requirements than for TID	Annex A Q-ST-30 Ann J Annex B	See Q-ST-30 4.3, 4.4 & 4.5
5.3 SEE		Same type of requirements than for TID, except that a WCA is not required	Annex A Annex B	4.3 & 4.5
		SET criticality analysis (FMECA) for analog ICs	Q-ST-30-02 An.A Q-ST-60-15 An.B	4.4
TID = Total ionizing dose		SEE = Single event effect	SRR = System requirements review	
TNID = Total non-ionizing dose		SET = Single event transient	PDR = Preliminary design review	

Table 8-10: ECSS-Q Level 3 standards of generic application for MMP&P

Clause & Req	Requirements subject	DRD (Annex) or other docs.	Supporting guidance
ECSS-Q-ST-70-71 "Materials, processes, and their data selection"		
NOTE: This standard complements Q-ST-70. Both standards are intended to be used together.		
4.2.- Materials	Specifies requirements for Metals and their alloys (Aluminium, Copper, Nickel, Titanium, Steels, Stainless steels, filler metals, Magnesium, Beryllium, refractory alloys, Silver, Osmium, superalloys), Optical and Adhesive materials, Paints, and Inks, Lubricants, Compounds and sealant, plastics, elastomers, thermoplastics, Thermosets, Ceramics, and materials for cables and wires. The requirements are specified, or by reference to other standards		
4.3. Processes	Specifies requirements for Adhesive bonding, Composite manufacture, Encapsulation, Painting, Cleaning, Welding and brazing, Crimping, Soldering, Surface treatments, Anodizing, Chemical conversion, Plating, Machining, Forming, Heat treatments, Marking, Casting, Processes for PCBs, Wires and Optical fibres, and Inspection. The requirements are specified, or by reference to other standards		
ECSS-Q-ST-70-01 "Cleanliness and contamination control" (C3)		
5.1. C3 program	Establishment of a "**Contamination req spec**", and when (incl. budgets)	Annex A	
	Establishment of a **C3 plan**, and when (incl. predictions & modelling techniques)	Annex B	
	Cleanliness control process		
5.2 Phasing	Design: includes general requirements, and requirements for the selection of materials, generally pointing to other Q-70 standards (*Q-70-29* and *-70-02* for outgassing, *70-05* for particulate contamination, and *-70-53* and *-70-55* for biological contamination)		
	MAIT: General requirements for C3 in Manufacturing, Assembly & Integration, and Testing. Audits to be performed -> *pointer to Q-ST-10*		
	Pre-launch and launch: General req's, and specific reqs for launch site design		
	Mission general requirements on C3.		
5.3. Environments — Cleanrooms	Cleanroom design: air supply, filters, **Cleanroom classification** per particle levels, and monitoring of cleanroom air		
	Surface particulate and molecular levels		
	Temperature, pressure, humidity and bioburden (*pointer to Q-ST-70-58*) control		
	Maintenance and access control		
	Vacuum facilities: Requirements for procedures, contamination risk, materials and pre-test to be performed		
5.4 Activities	Cleaning methods, tools and materials		
	Monitoring of particulate and molecular contamination Monitoring of vacuum facilities, launch and in-space contamination		
	Verification: parameters, frequency, DoC delivery, NCR (*Pointer to Q-ST-10-09*) Requirements for bake-out and purging	Cleanliness DoC	
	Cleanliness requirements for packaging, transportation and storage		
C3 = Cleanliness & contamination control	DoC = Declaration of conformity	NCR = Nonconformance report	
MAIT = Manufacturing, assembly, integration and testing		

8.2.3.3 ECSS-Q Level 3 standards of specific applicability

The ECSS-Q Level 3 standards of specific applicability (see Table 6-1) cover:

- Standards for specific EEE component families. They are detailed in Table 8-11.

- Standards for planetary protection processes. They are detailed in Table 8-12.

NOTE   Planetary protection is covered by ECSS-U-20. Among others, it specifies which processes to be applied for planetary protection in several cases and missions. However, the processes themselves are not detailed there, but covered by the standards in Table 8-12.

- Standards for "off-the-self" items. They are detailed in Table 8-13.

Table 8-11: ECSS-Q Level 3 standards for specific EEE component families

Clause & Req		Requirements subject	DRD (Annex) or other docs.	Supporting guidance
ECSS-Q-ST-60-02 "ASIC and FPGA development"				
4. Programme management	4.1 General	Need to establish a development programme and organization		
	4.2 Control plan	Need to establish an ASIC and FPGA control plan (ACP)	Annex A	
	4.3 Planning tools	- Need to establish & maintain ASIC & FPGA development plan - Need to establish a Verification plan - Need to establish a Design Validation plan (DVP)	Annex B Annex E Annex F	
	4.4 ESR	Need to establish an Experience Summary Report	Annex I	
5. Engineering	5.2 General	General requirements on development & development flow		Fig 5-1
	5.3 Definition	- All system configurations, used to establish the Req. Spec (ARS) - Feasibility assessment, and feasibility& risk analysis (FRA) report - System requirement review, its objectives and contents	Annex C Annex D	
	5.4 Architecture	- Definition activities, documents in an Architecture def. report - Verif and optimiz. activities, documented in a Ver.&Opt. report - Establishment of a Preliminary data Sheet - Preliminary design review, its objectives and contents	5.4.2 5.4.4 Annex G	
	5.5 Design	- Design entry activities, documented in a Design Entry Report - Netlist generation activities, documented in a Netlist Gen. Report - Netlist verif. Activities, documents in a Netlist Verif. Report - Update of the data sheet - Detailed Design Review, its objectives and contents	5.5.3 5.5.4 5.5.5 Annex G	
	5.6 Layout	- Layout Generation activities, documented in a Layout Gen.Report - Layout Verif. activities, documented in a Layout Verif. Report - Establishment of a Design Validation Plan (DVP) - Update of the data sheet - Establishment of a Draft Detail Spec - Critical Design Review, its objectives and contents	5.6.2 5.6.3 Annex F Annex G Annex H	
	5.7 Prototype	Production test activities, documented in a Production test report	5.7.2	
	5.8 Validation & release	- Validation activities, documented in a Validation report - Radiation test to be performed - FM production preparation activities, documents in a release rep. - Production of an Experience Summary Report - Update of the Req. Spec. and Data Sheet _ Qualification/acceptance review, their objectives and contents	5.8.1 5.8.3 Annex I Annex H&G	
6. QA	6.1 General	Pointers to Q-ST-20 (for QA), Q-ST-30 (for criticality) and Q-ST-60 (for EEE components)		
	6.2 Reviews	Reviews to be performed (SSR, PDR, DDR, CDR, QR/AR) and how		
	6.3 Risk	Requirements on risk assessment and management		
7	Documentation	Requirements on doc management, and docs to be released (see above)		Annex J
8	Deliverables	General conditions to release the deliverables		Annex J

Table 8-12: ECSS-Q Level 3 standards for Planetary Protection processes

Clause & Req		Requirements subject	DRD (Annex) or other docs.	Supporting guidance
ECSS-Q-ST-70-53 "Material and HW compatibility test for sterilization processes"				
5.1	Specifying test	- Request of the test by the CUSTOMER	Annex A	
		- Test proposal by the SUPPLIER	Annex B	Clause 4 Annex D
		- General requirements on facilities, equipment and test procedure		
5.2	Preparing and performing the test	- Test configuration, cleaning, handling, storage & identification - Provide inspection/test methods & samples before/after the test - Performance, parameters, margins and cycles of the test		
5.3	Results Recording and reporting	- Report to be supplied to the customer - Test records retention time, and contents - Acceptance criteria (customer/supplier agreed before the test)	Annex C 5.3.2b	
ECSS-Q-ST-70-54 "Microbial examination of flight HW and cleanrooms"				
5.1	Specifying test	- Request of the test by the CUSTOMER	Annex A	
		- Test proposal by the SUPPLIER	Annex B	Annexes D, E, F & G
		- General requirements on facilities, equipment and test procedure		
5.2	Validation	Test procedure, to be validated against customer requirements		
5.3	Preparing & performing the test	- Identification of locations - Minimum data to be provided for each assay - Personnel trained on microbiology	5.3.2.1b	
5.4	Results Recording and reporting	- Report to be supplied to the customer - Test records retention time, and contents - Quality records - Acceptance criteria (customer/supplier agreed before the test)	Annex C 5.4.1c 5.4.1b	
ECSS-Q-ST-70-56 "Vapour phase bioburden reduction for flight HW"				
5.1	General	Bioburden reduction agent		
		Bioburden reduction Spec, to be provided by the CUSTOMER	Annex A	
		Bioburden reduction proposal, to be provided by the SUPPLIER	Annex B	
		Bioburden reduction report	Annex C	
5.2	Product reqs	- Compatibility test *(Pointer to Q-ST-70-53)* - Cleanliness: particul., molec. & bioburden *(pointer to Q-ST-70-55)* - Packaging - Labelling, and biological conditions for the Release		
5.3	Process reqs	- Procedure obligation, and conditions for controlled ambient - Procedure obligation, and conditions for vacuum environment - Procedure obligation, and conditions for overkill - Cycle requirements		
5.4	Equipment	General requirements on installation & equipment capabilities		

Table 8-13: ECSS-Q Level 3 standards for "off-the-self" items

Clause & Req		Requirements subject	DRD (Annex) or other docs.	Supporting guidance	
ECSS-Q-ST-20-10 "Off-the-self items utilization"					
5.1	Documentation	Need to establish OTS plan (preliminary, at SRR)	Annex A		
		OTS spec, part of the equipment spec. (preliminary, at SRR)	Equip. spec		
		OTS item evaluation dossier, during market investigation	Annex B	Annex B.2.3	
5.2.1	OTS identif.	Market investigation and, criticality identification and data collection			4.1.1
5.2.2	Preliminary "make-or-buy"	Based on market investigation and in the criteria identified in the standard, make a preliminary "make or buy" decision		Figure 4.1	
5.3.1	Characteriz.	Perform a characterization. Output: **"make or buy" decision**			4.1.2
5.3.2 OTS PA	Dependability	Criticality vs. reliability assessment of the OTS items (incl. FMECA) OTS reliability figure. Derating to be applied.	Parts of Annex B		
	Safety	Criticality vs. safety assessment of the OTS items			
	EEE				
	MMP&P				
5.4	Engineering	- Structural and mechanical and thermal evaluation - Electrical, power, Data handling, RF, EMC, high energy (*pointers to E-ST-20, E-ST-50-14, E-ST-50-05, E-ST-10-12 and Q-ST-60*) - Maintenance			
5.6.1	Procurement	Documentation. Single batch approach. Configuration control		4.1.3	
5.6.2	Qualification	Verification (*Pointer to E-ST-10-02*). Establish a Qualification program	Qualif. program		
ECSS-Q-ST-60-13 "COTS EEE components"					
Summary		Q-ST-60-13 is a version of Q-ST-60, tailored for COTS EEE components. For its contents, see Q-ST-60.			

8.2.3.4 ECSS-Q Level 3 standards for particular processes, generally applicable

They cover a number of particular processes of general use, mainly for testing and manufacturing. They include all the ECSS Q-70 standards not covered above. Table 6-1 shows that all them can be classified in four categories: Material testing, Material processes, Assembling processes and Parts. For further reference, see Table 6-1.

Each of these standard specifies a complete particular process, so that it is fully applicable, or not applicable at all. In other words, it is not tailorable.

8.2.3.5 ECSS-Q Level 3 standards applicable "on-request"

They cover specific aspects not made mandatory by the level 2 standards, which means that they will be used only if required by the project. For further reference, see Table 6-1.

This category includes the RAMS methodologies (except FMEA/FMECA, which is generally applicable), i.e.:

- ECSS-Q-ST-30-09 "Availability analysis"
- ECSS-Q-ST-40-12 "Fault tree analysis".

Each of these standard specifies the conditions and methodology for performing these kind of analysis, and therefore they are fully applicable (if so required by the project), or not applicable at all.

8.3 Q documentation

8.3.1 Q documents linked to project reviews

The following documents are linked to project reviews:

Table 8-14: ECSS-Q documents linked to project reviews

Document [1]		Required by [2]	Described in [3]	Description of the document [4]	Project reviews											
					MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR
The seven high level Q plans	PA plan	Q-ST-10 #5.1.3	Q-ST-10, Annex A	Describes the supplier PA organization, activities, processes and procedures, with regard to the specified mission objectives. It contains or refers to the other six high level plans described below.		P	P	X	X			X*				
	QA plan	Q-ST-20 #5.1.1	Q-ST-20, Annex A	Describes the supplier QA organization, activities, processes & procedures, with regard to specified mission objectives.		X	X	X	X							
	Dependability programme plan	Q-ST-30 #4.3	Q-ST-30, Annex C	Describes how disciplines and activities (organization, planning, predictions, analysis, demonstrations and reports) are coordinated to meet the dependability requirements. It also defined the methods and techniques for this purpose.		X	X	X								
	The Safety programme plan	Q-ST-40 #5.2	Q-ST-40, Annex B	Describes the safety tasks, organization and personnel, schedule implementation, interfaces & safety verification.	X	X	X	X	X	X	X	X	X	X		
	The EEE components QA plan ONLY NEDED FOR CLASS 1 COMPONENTS	Q-ST-60 #4.1.2.2	Q-ST-60, Annex A	Defines the supplier organization and activities (suppliers control, procurement, radiation control, component selection and evaluation, data management) to ensure that component management is in line with the specified cost, delays and quantities key drivers.												
	The MMP&P plan	Q-ST-70 #4.1.2	Q-ST-10, Annex A	**Integrated in the PA plan.**		P	P	X	X							
	The Software PA programme plan	Q-ST-80 #5.2.1	Q-ST-80, Annex B	Provides information of the supplier organization and technical approach to the execution of the SW PA programme (developed SW products, the organization, resources, reporting, models to be used, SW risk management, supplier management, tools), the SW PA activities (cycle, documentation management, metrics, SW re-use) and the SW QA activities.			X	X	X	X	X	X				

Document [1]	Required by [2]	Described in [3]	Description of the document [4]	Project reviews											
				MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR
Qualification status list	Q-ST-10 #5.2.1	Q-ST-10 Annex B	summarizes <u>for each configuration item</u> the status achieved with respect to the planned qualification.		P	X	X	X	X						
Alert status list	Q-ST-10 #5.2.9d	-	ECSS requires the supplier to participate in the alert system of the customer (ESA in this case), which implies the use of the Alert status list by the supplier.		X	X	X	X	X	X	X				
Critical item list	Q-ST-10-04 #5.1	Q-ST-10-04 Annex A	lists all the critical items			P	X	X	X	X		X			
NCR status list	Q-ST-10-09 #5.5	Q-ST-10-09 Annex B	provides a complete representation of the status of all non-conformances, for each product, at any time NOTE: Individual NCRs are not linked to project reviews, see Table 8-15.												
EIDP (End Item Data Package) EIDP for GSE	Q-ST-20 #5.7.1 Q-ST-20 #5.8.4	Q-ST-20 Annex B Q-ST-20 #5.8.4	collects, <u>for each deliverable configuration item</u>, all data related to manufacturing, assembly, integration and test (including or referring to MoM, certificates, NCRs, ABCL, RFW&RFD, logbook, lower level EIDP, non-installed items), providing so the necessary traceability. It is the basis for the acceptance of the product. NOTE: The EIDP is also linked to a specific event (the delivery of an end item), see Table 8-15.							X					
Storage plan	Q-ST-20-08 #5.2 & #5.3	Q-ST-20-08 Annex A	NOTE: The delivery of the final version of the Storage Plan is needed for Pre-storage Review as specified in the clause 5.4.1. This review is not part of the formal project reviews. But it is to some extend linked to QR or AR and can take place before or after one of these reviews depending on model philosophy (PFM or QM+FM)				P	X	X	X (See NOTE in column [4])		X			
OTS plan	Q-ST-20-10 #5.1.1a	Q-ST-20-10 Annex A	defines the OTS item process selection, characterization and qualification activities												

Document [1]		Required by [2]	Described in [3]	Description of the document [4]	Project reviews											
					MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR
The OTS specification (as part of the equipment spec)		Q-ST-20-10 #5.1.2					X	X								
The OTS qualification plan (part of the overall qualification plan)		Q-ST-20-10 #5.6.2	E-ST-10-02 Annex X													
FMEA/FMECA report		Q-ST-30 #6.4.2.2 Q-ST-40	Q-ST-30-02, An.A		X	X		X	X		X					X
Can be combined with FMEA/FMECA	Reliability predictions	Q-ST-30 #6.4.2.2	Q-ST-30 Annex E	Compares possible architecture solutions regarding reliability criteria during trade-off, and to provide failure probability data in order to compare with the reliability targets and to provide inputs for risk assessment. It provides an indication of the reliability apportionment result used in the prediction.	X	X		X	X		X					
	Part stress analysis	Q-ST-30 #6.4.2.8	No specific DRD	Ensures that the Q-ST-30-11 derating rules have been applied	X	X		X	X		X					
	Failure detection isolation and recovery (FDIR)	Q-ST-30 #6.4.2.10	Q-ST-30 Annex F	Ensures at system level that the autonomy and failure tolerance requirements are fulfilled	X	X		X	X		X					
	Worst Case analysis (WCA) WCA for EEE radiation (TID & NTID)	Q-ST-30 #6.4.2.7 Q-ST-60-15 (#5.1m & #6.1m)	Q-ST-30 Annex J	Demonstrates that the item being analysed performs within specification despite particular variations in its constituent part parameters and the imposed environment.	X	X		X	X		X					
	Contingency analysis	Q-ST-30 #6.4.2.4	Q-ST-30 Annex D	Identifies the failure, identify the cause, control the effect and indicate how recovery of the mission integrity can be achieved, and to identify the methods of recovery of the nominal or degraded functionalities, with respect to project dependability policy.	X	X		X	X		X					
	Common cause analysis	Q-ST-30 #6.4.2.6 Q-ST-40 #7.5.4.4	Q-ST-30 Annex I	Identifies the root cause of failures that have a potential to negate failure tolerance levels	X	X		X	X		X					
	Availability analysis	Q-ST-30 #6.4.4	Informative method in Q-ST-30-09	Analysis to assess the availability of the system, identifying potential outages, their causes, probabilities and duration.	X	X		X	X		X					

Document [1]	Required by [2]	Described in [3]	Description of the document [4]	Project reviews											
				MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR
Safety verification tracking log	Q-ST-40 #8.5.1	Q-ST-40, Annex C	Is part of the Safety Data Package, and collects all the open safety verification items at the end of the production and qualification phase						X	X					
Safety analysis report ((including hazard report)	Q-ST-40 #7.5.1	Q-ST-40, Annex D	documents the results of the safety analysis, and contains the hazard reports			X	X	X	X	X	X	X	X	X	
Safety risk analysis report	Q-ST-40 #7.5.3			X	X	X	X	X	X	X	X	X	X		
Fault tree analysis report	Q-ST-40 #7.5.4.5	*Informative method in Q-ST-40-12*							X	X	X				
Declared component list	Q-ST-60 #4.1.4	Q-ST-60, Annex B	lists all the EEE components to be used.						X	X	X	X			
Component procurement spec	Q-ST-60 #4.3.2	Q-ST-60, Annex C	is the component technical specification baseline.						X	X					
Equipment radiation analysis report	Q-ST-60 #4.2.2.4	Q-ST-60, #4.2.2.4h	identifies the radiation sensitive components NOTE: This report is NOT the Radiation analysis report (see below)												
Radiation hardness assurance plan	Q-ST-60 #4.2.2.4	Q-ST-60, # 4.2.2.4g	Produced only in the case of radiation sensitive components												
Component evaluation plan	Q-ST-60 #4.2.3.1	Q-ST-60, #4.2.3.1d													
Part approval document (PAD)	Q-ST-60, #4.2.4	Q-ST-60 Annex D	Provides information about component identification and evaluation: its approval status, its procurement inspections and tests performed and its radiation hardness data						X	X					
Documents for ASIC and FPGA (several)	Q-ST-60-02 #4.2, #4.3, #4.4, #5.3, #5.4, #5.5, #5.6, #5.7, #5.8,	Q-ST-60-02 Annexes A to H, and in the mentioned paragraphs	Documents to control and implement the development process, and to specify the corresponding requirements						X	X	X	X			
Relifing report	Q-ST-60-14 #6.4a	Q-ST-60-14 Ann A	Gives, when a test for relifing purposes is performed, the detailed references of the lot tested, describe the relifing tests performed, give the results obtained and the date of tests						X						

Document [1]	Required by [2]	Described in [3]	Description of the document [4]	Project reviews											
				MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR
TID/TNID/SEE environment definition	Q-ST-60-15 #5.1 Q-ST-60-15 #6.1 Q-ST-60-15 #7.1	Q-ST-60-15 Annex A	documents in a single place the particle fluxes (shielded and unshielded), the TID and TNID versus shielding dose curves, and the LET spectra.			P	X								
TID/NTID/SEE Radiation analysis report	Q-ST-60-15 #5.1 Q-ST-60-15 #6.1 Q-ST-60-15 #7.1	Q-ST-60-15 Annex B	documents in a single place all baseline information (data, assumptions, methods and techniques) used for the radiation analysis, and the results obtained.				P	X							
Declared material (mechanical parts / processes) list	Q-ST-70 #4.2	Q-ST-70 Annexes A, B and C	list the materials (mechanical parts / processes) to be used.					X	X	X	X				
Materials (mechanical parts / processes) evaluation programme	Q-ST-70 #5.5.2 Q-ST-70 #6.5.2 Q-ST-70 #7.5.2	Q-ST-70 #5.5.2 Q-ST-70 #6.5.2 Q-ST-70 #7.5.2	ONLY IF REQUIRED BY CRITICAL ANALYSIS.					X							
Materials (mechanical parts / processes) validation programme	Q-ST-70 #5.5.3 Q-ST-70 #6.5.3 Q-ST-70 #7.5.3	Q-ST-70 #5.5.3 Q-ST-70 #6.5.3 Q-ST-70 #7.5.3							X						
Contamination requirement specification	Q-ST-70-01 #5.1	Q-ST-70-01 Annex A	establishes cleanliness and contamination levels to be achieved at MAIT, launch and mission stages.			X	X	X	X	X					
Contamination and cleanliness control (C3) plan	Q-ST-70-01 #5.1	Q-ST-70-01 Annex B	establishes the data content requirements to achieve the contamination levels defined in the Contamination requirement specification			X	X	X	X						
SW PA milestone report	Q-ST-80 #5.2.2	Q-ST-80 Annex C	reports on the software product assurance activities performed during the past project phases			X	X	X	X	X	X				
SW Re-use file	Q-ST-80 #6.2.7	Q-ST-80 #6.2.7	only if EXISTING SW IS INTENDED TO BE RE-USED NOTE: The SW re-use file is defined in E-ST-40, but it is mentioned here because reuse of existing SW is typically a PA activity			X	X	X							
SW Maintenance plan	Q-ST-80, #6.3.8	Q-ST-80, #6.3.8	includes the maintenance procedures, reports, records, and SW V&V.							X	X	X			

8.3.2 Q documents linked to specific events

The following is a list of the Q documents linked to specific events, to be provided by the supplier, and the corresponding triggering events.

Table 8-15: ECSS-Q documents linked to specific events

Document [1]	Required by [2]	Described in [3]	Description of the document [4]	Triggering event [5]
Personnel training & certification records	Q-ST-20 #5.1.2	No specific DRD	Records of the training relevant to the procurement, received by each staff	To be made available when so required
Procurement document	Q-ST-20 #5.4.2a & b	Q-ST-20 #5.4.2c	Document identifying all requirements applicable to the supplies, with traceability to the lower level suppliers	To be made available when so required
QA MAI documents	Q-ST-20 #5.5.1a, b, c & d	Q-ST-20 #5.5.1e	Document containing the planning of manufacturing, assembly and integration operations and inspections in the manufacturing plan or flow chart for the product, including the sequence of operations and associated inspections and tests. It includes the identification of MIPs, with reference to the MAI procedures, cleanliness levels and temperature and humidity requirements.	To be made available when so required
Logbook, and Storage logbook MGSE logbook	Q-ST-20 #5.5.9 Q-ST-20-08 #5.5 Q-ST-20-08 #6.2	DRD: Q-ST-20 Annex C	Document in which the data related to the integration and testing of a configuration item are recorded in chronological order to provide the necessary events traceability at any time during the programme life cycle, beginning with the first qualification or acceptance test. It is part of the EIDP.	Any event related to the integration and testing of a configuration item
ESD on-ground protection programme	Q-ST-20 #5.5.11	EN-61340-5-1 or ANSI-ESD-S20.20	ESD on-ground control plan	Design, manufacture, test, storage and transport. To be made available when so required
Test procedures	Q-ST-20 #5.6.3	E-ST-10-03 Annex A	Self-explanatory title	
Test records	Q-ST-20 #5.6.3	Q-ST-20 #5.6.3.2a	Self-explanatory title	
Certificate of Conformity (CoC)	Q-ST-20 #5.7.3g	DRD: Q-ST-20 Annex D	Document that declares the conformance of an end item in all respect with the applicable specification(s), drawing(s) and requirements. It is part of the EIDP.	Before delivering an end item

Document [1]	Required by [2]	Described in [3]	Description of the document [4]	Triggering event [5]
End item data package (EIDP) EIDP for GSE	Q-ST-20 #5.7.2 Q-ST-20 #5.8.4	DRD: Q-ST-20 Annex B Q-ST-20 #5.8.4	The end item data package is the collection of the data related to the manufacturing, assembly, integration and test of a deliverable configuration item which provides the necessary traceability and events record. It constitutes the basis to support the acceptance of the product. NOTE: The EIDP is also linked to project reviews, see Table 8-15	Before delivering an end item
NCRs	Q-ST-10-09 #5.1	DRD: Q-ST-10-09 Ann A	Document providing all relevant information on nonconformances	When a nonconformance is reported
Item Refurbishment & maintenance proc.	Q-ST-20-08 #5.5.6	5.5.6a	It is part of the storage procedure	For each item to be refurbished and maintained
MGSE re-use analysis report	Q-ST-20-08 #6.2	No specific DRD	Report of the analysis performed to ensure that MGSE produced in the context of a project/procurement can be re-use in the context of a second one.	Before re-using any MGSE
MGSE user manual	Q-ST-20-08 #6.2	No specific DRD	Self-explanatory title	Before using any MGSE
Proof of MGSE Verification and Validation	Q-ST-20-08 #6.2	No specific DRD	Self-explanatory title	Before using any MGSE
FMEA or Risk analysis for P2 transport products	Q-ST-20-08 #7.4	DRD: Q-ST-30-02 Ann A or M-ST-80	FMEA or Risk analysis performed for P2 transport products, to decide if T1 transport needs to be used instead of T2 transport	Before transporting P2 goods
Consent to transport (CTT)	Q-ST-20-08 #7.5	No specific DRD	Document consenting a transport to be performed	Before any transport
Movement plan	Q-ST-20-08 #7.5	No specific DRD	Document planning a transport, including driver(s), escort(s), nominal and alternative routes, stops, and dates	Before any transport
OTS item evaluation dossier (one per OTS item)	Q-ST-20-10 #5.1	DRD: Q-ST-20-10 Ann B	Provides a detailed incremental overview of the OTS item since the initial selection up to the OTS item qualification and approval.	When the decision to select a specific OTS item is made
Classification of critical functions	Q-ST-30 #5.4	No specific DRD	List of critical functions, classifying them by criticality	Before end of phase B
Zonal analysis	Q-ST-30 #6.4.2.9 Q-ST-40 #7.5.4.8	Q-ST-30 Annex G	Evaluates the consequences due to potential subsystem-to-subsystem interactions inherent in the system installation	
Maintainability analysis	Q-ST-30 #6.4.3	Q-ST-30 Annex H	Provides an indication of the maintainability apportionment result used, and demonstrates conformance or identifies nonconformances with the maintainability requirements.	

Document [1]	Required by [2]	Described in [3]	Description of the document [4]	Triggering event [5]
Warning Time Analysis	Q-ST-40 #7.5.4.2		Evaluates the safety critical situations identified in the hazard analysis, to support the implementation of hazardous situations detection and warning devices or contingency procedures	During the concept definition phase, and the design and development phase, when there is a need to implement hazardous situations detection and warning devices or contingency procedures
Caution and Warning Analysis ONLY FOR HUMAN FLIGHTS	Q-ST-40 #7.5.4.3		Identifies the emergency, warning and caution parameters, the safing function and capabilities, the limit sensing requirements and the applicability of individual caution&warning functions to the mission phases	During the concept definition phase, and the design and development phase
Human error analysis	Q-ST-40 #7.5.4.6		Identifies human operator error modes, their effects, and the countermeasures to prevent those errors	When safety analysis identifies operator errors as a potential cause of catastrophic or critical hazard
Component evaluation report	Q-ST-60 #4.2.3.1	Q-ST-60, #4.2.3.1	Reports on the results of the application of the component evaluation plan	Before using components
Precap spec	Q-ST-60, #4.3.4,		Spec for a preliminary customer inspection in the manufacturer premises	Before procuring non-space qualified components, or for critical space qualified components
Buy-off spec	Q-ST-60, #4.3.6		Spec for a final customer inspection in the manufacturer premises	Before procuring non-space qualified components, or for critical space qualified components
Incoming inspection spec (or procedure)	Q-ST-60, #4.3.7c	Q-ST-60, #4.3.7b, d & e	Spec for an incoming inspection to be performed to all components	Before receiving any component
Radiation verification testing report	Q-ST-60, #4.3.8		Reports the RVT results. RVT to be performed only when component radiation sensitivity is suspected to be inadequate. This criteria, and the RVT itself is part of the Radiation hardness plan.	When performing a RVT
Destructive physical test report	Q-ST-60, #4.3.9		Reports the Destructive physical test results. This test is to be performed for all the categories in 4.3.9a, and for critical components	When performing a Destructive physical test
Cleanliness declaration of conformity (DoC)	Q-ST-70-01 #5.4.3.1	-	Document declaring that the cleanliness is as specified	When one of the conditions specified in #5.4.3.1e are met

Document [1]	Required by [2]	Described in [3]	Description of the document [4]	Triggering event [5]
Proposal for test for PP: - Sterilization Material & HW compatibility - Microbial examination of HW & cleanrooms	Q-ST-70-53 #5.1.1e Q-ST-70-54 #5.1	Q-ST-70-53 Annex B Q-ST-70-54 Annex B	Are the supplier response to a test customer request, and define the test activity.	Upon a request i.a.w. Annex A of Q-ST-70-53 or -70-54 is presented by the customer
Test report and test records for PP: - Sterilization Material & HW compatibility - Microbial examination of HW & cleanrooms	Q-ST-70-53 #5.3 Q-ST-70-54 #5.4	Q-ST-70-53 Ann C & 5.3.2b Q-ST-70-54 Ann C & 5.4.1c	Report and test records of the above tests.	When one of the above tests is performed
Proposal for process for PP: - Vapour phase bioburden reduction	Q-ST-70-56 #5.1	Q-ST-70-56 Annex B	Are the supplier response to a process customer request, and define the process activity.	Upon a request i.a.w. Annex A of Q-ST-70-56 is presented by the customer
Process report for PP: - Vapour phase bioburden reduction	Q-ST-70-56 #5.1	Q-ST-70-56 Annex C	Report results of the above processes	When one of the above processes is performed

9
Application of ECSS-E requirements in ESA projects

9.1 Introduction

Section 6 gives general guidelines for the tailoring of the list of documents to a particular application, without entering in individual requirements. If a higher level of granularity is necessary to make a final decision on the application of a particular standard, or tailoring at the level of individual requirements is necessary, this Section 9 provides the details for standards in the E branch.

This Section 9 is also a reference to understand the documentation required by documents in the E branch. A simple approach to comply with these documentation requirements is presented in Annex B.

9.2 Requirements of the E standards

9.2.1 Overview

The E branch consists of eleven disciplines and sub-disciplines (see Figure 5-1): E10 (System engineering, SE), E20 (Electric and electronics), E31 (Thermal control), E32 (Structural), E33 (Mechanisms), E34 (Environmental control and life support, ECLF), and E35 (Propulsion), E40 (Software engineering), E50 (Communications), E60 (Control engineering) and E70 (Ground systems and operations, GSO).

> NOTE   Sub-disciplines E31, E32, E33, E34 and E35 are often referred to as a single discipline E30 "Mechanical".

Each of these disciplines and sub-disciplines contains one Level 2 standard, and any number of Level 3 standards (i.e. one, several or no-one), with the exception of E33 (Mechanisms) and E60 (Control engineering), which do not contain Level 2 standard (only several Level 3 each). That means that there are in total nine Level 2 standards in the E branch.

9.2.2 The nine Level 2 standards in the E branch

The ten Level 2 standards (one per discipline or sub-discipline, except for E33 and E60) contain more generic requirements. To remain as generic as possible, they apply in as far as possible the "ODSI" principle (see 5.2.7) but as it can be seen, it is not possible to use this principle as much as for the management or the quality standards, and when used, it is mainly used for general plans. A general description of each of these documents can be found in 6.2.3. A more detailed description is provided by Table 9-1 to Table 9-9, which

are a summary of the requirements of these standards. In these tables, **those requirements adhering to the "ODSI" principle have been shadowed in green**.

Note that the requirements adhering to the "ODSI" principle include a reference to a DRD to comply with "ODSI step b", and most of them are supported by guidance material in accordance with "ODSI step e". Observe also, however, that reference to DRDs is not exclusive of those requirements, and many others require the generation of documentation in accordance with a DRD (although in this case the document itself does not need customer approval).

Table 9-1: Summary of the requirements in ECSS-E-ST-10 "System engineering"

Clause & Req			Requirements subject	DRD (Annex)	Supporting guidance
5.1 SE plan			SE plan (SEP)	Annex D	Clause 4
5.2 Requirement engineering	Process	5.2.1	Derivation of requirements. Consistency and robustness		
		5.2.2	Up and down requirements traceability		
		5.2.3.1	Technical spec (-> E-ST-10-06)	E-ST-10-06 Ann A	E-ST-10-06
		5.2.3.2 – 5.2.3.8	Consolidation, analysis, verification & validation and maintenance of requirements		
		5.2.3.9	Requirement baseline, to be established		
5.3 Analysis		5.3.1 System analysis	In phase 0, Analyse MSD to produce an **MDD (mission def. doc)**	Annex B	
			Functional analysis to produce a **Function Tree**	Annex H	
			Produce a **DDF**, and justify it in a **DJF**	Annexes G&K	
			Produce physical architecture and the Product Tree *(-> M-ST-10)*	M-ST-10 Ann B	
			All analysis documented in an Analysis report	Annex Q	
		5.3.2 Environment	Establishment of the environment(s), qualification&acceptance criteria, design&test factors and margins, account for design induced effects		
		5.3.3 trade-off analysis	Perform trade-off for: system concept, design, processes, make-or-buy, technologies, architecture, CIs, planning, verification methods		
			Document all **trade-off reports**	Annex L	
			Alternative system concepts, in the **System Concept Report**	Annex C	
		5.3.4	Methods tools & models, in the SEP, and validated & maintained	Part of the SEP	
5.4 Design & configuration	Design	5.4.1.1	Establish the design (incl. interfaces,-> E-ST-10-24)		
		5.4.1.2	Establishment and apportioning of **Technical budgets**	Annex I	
			Margin policy	Part of the SEP	
		5.4.1.3	Design methods, tools & models	Part of the SEP	
	Configur.	5.4.2.1	Configuration coverage (physical, functional, SW, I/F, budgets, lower level), to be included in DDF		
		5.4.2.2	Configuration baseline, under configuration control		
		5.4.2.3	Definition of the Assembly hierarchy and sequence		
5.5 Product verification			Verification performed i.a.w. *-> E-ST-10-02*		
			Verification to cover all product (HW, SW, MITL, Ops, scenarios)		
5.6 SE Integration and control		5.6.1	General requirements on management of SE activities		
			Make compatible the SEP and project schedule		
			Engineering data: ensure exchange and define repository		
			Interfaces i.a.w. *-> E-ST-10-24*		
			Coordinate system, to be defined in the SEP i.a.w. *-> E-ST-10-09*	Part of the SEP	
			Technology plan management & technology maturity *-> E-ST-11*	Annex E	E-HB-11
			SE contribution to risk management		

CI = Configuration item	I/F = Interface	MITL = Man-in-the-loop	SEP = System engineering plan
HW = Hardware	SW = Software	DDF = Design definition file	DJF = Design justification file

Table 9-2: Summary of the requirements in ECSS-E-ST-20 "Electric & electronics"

Clause & Req			Requirements subject	DRD (Annex)	Supporting guidance
4. General requirements		**4.1 Interfaces**	General reqs on **signal I/F** (to be standardized, noise discrimination, damage prevention)		
			General reqs on **telecommands** (Critical commands, command independency & stability, …)		
			General reqs on **telemetry** (minimum telemetry monitoring)		
	4.2 Design	**Safe design**	Failure containment, redundancy, critical functions protection, SPF		
		Data processing	Margins on memory, comm throughput, unused blocks		
		Connectors	Protections, error preventing, SPF reqs, Mech. stress release		
		Testing	Test points accessibility and protection. Test of specific functions		
5. Electrical Power		**Documentation**	DJF includes the design rep, PSA, WCA, FMECA, Analysis & diagrams	Annex D	
		5., 5.3 & 5.4 Power subsystem	Function, engineering process and budgets		
			Failure containment and redundancy		
			Electrical power interfaces		
		5.5 Generation	Photovoltaic assemblies and their components: **-> E-ST-20-08** Solar arrays specification, design, power computation, & mechanisms		
		5.6 Storage	Batteries, cells, storage, safety. Use & **Battery user manual** (Annex D)		
		5.7 Power Condit. &Control	BUS: Failure, design, Reqs for regulated & unregulated buses, fuses, impedance, under & over voltage		
			BCDM: charging, minimum energy, protections, failure		
			Converters & regulators		
			Payload interaction		
		5.8 Power distribut. & protect.	Grounding, stability, protection, failures, transients, resets		
			Hardness: physical, mechanical, protection, testing,		
		5.9 Safety	*-> IEC 60479 "Effects of current on human beings and livestock"*		
		5.10 High Voltage	Reqs on HV equipment		
6 EMC		**Documentation**	DJF includes the design rep, PSA, WCA, FMECA, Analysis & diagrams		
		6.2 EMC Policy	EMC programme establishment		
			EMC control plan (for sub-system and equipment)	Annex A	
			EMC Advisory Board (if EMC identified as critical during Phase A)	Part of Ann A	
	6.3 System EMC	**Safety margin**	Critical circuits, **critical points list** and margins	CPL (No DRD)	
		Inter/Intra EMC	EMC inter&intra system, Protected bands *(->E-ST-50-05)* & Environment		
		Radiation hazard	EMC safety		
		S/C charging	Performances under arc discharges. S/C protection programme	SCPP (No DRD)	6.3.4.2a
		RF compatib.	Compatibility with antennae		
		S/C DC	S/C DC magnetic field emission		
		Design	Bonding, grounding, wiring and detailed reqs *(->E-ST-20-07)*		
		6.4 Verification	EM effects verification plan and report (EMEVP and EMEVR)	Annexes B&C	
			Safety margin demonstration, and detailed reqs verif *(->E-ST-20-07)*		
7 RF		**7.2 Antennae**	Engineering, structure (categories, elements, technologies) & I/Fs		
		7.3 RF power	Multipaction *(->E-ST-20-01)*, thermal handling, Corona and qualification		
		7.4 Passive intermod.	PIM identification & Passive intermodulation Verif. and Qualif.		

NOTE 1: This standard includes, at the end of each main clause, a table listing all the requirements of the clause and stating for each requirement, the verification method(s), and the verification point(s). This approach is not followed by any other ECSS doc.

NOTE 2: Requirements on EMC are shared between Clause 6 of the present standard (the generic EMC reqs), and the Level 3 standard E-ST-20-07 "EMC" (the specific EMC reqs)

CPL = Critical Point List   PIM = Passive Intermodulation products   SCPP = S/S Protection programme   SPF = Single point failure

Table 9-3: Summary of the requirements in ECSS-E-ST-31 "Thermal control"

Clause & Req	Requirements subject		DRD (Annex)	Supporting guidance
4.1 Mission	Thermal conditions, constrains and parameters at ground, launch and ascent, Space, Docking, Re-entry, Post-landing			
4.2 Performance	Dimensioning, design, acceptance & qualification. TCS specification Ranges (high and cryogenic temperature)			
4.3 External I/Fs	Thermal I/Fs control document		Annex D	
	I/Fs with Mechanical, electrical, AOCS, TM/TC, OBDH, Launcher, GSE			
4.4 Design	**TCS detailed design file**		Annex F	
	Budgets, Materials, EEE components, Lifetime, Testability, Flexibility, Accessibility, RAMS			
4.5 Verification — **Verification**	**Mathematical model specification** (see also 4.9.4a & b)		Annex A	
	Thermal & Geometrical model description		Annex B	
	TCS analysis report, for each thermal analysis		Annex C	
	Verification of performance by TBT. Verification by test of CCS and TPS			
Thermal Balance Test (TBT)	Performance	TBT specification	Annex E	
		TBT procedure and report (-> *E-ST-10-02* & *E-ST-10-03*)	E-ST-10-02 An B E-ST-10-03 An C	
	Success criteria and test correlation			
4.6 Production & Manufacturing	Procurement, manufacturing process, Integration, Identification, Quality (->Q-ST-20), CCC (->Q-ST-70-01), Repair, Storage-Handling-Transport (->Q-ST-70-08)			
4.7 In-service	TCS to support commissioning, CSS to support in-orbit operation			
4.8 PA	PA reqs -> *Q-ST-10, Q-ST-20, Q-ST-40, Q-ST-70*			
4.9 Deliverables	Delivery of HW. Docs to be delivered. Inputs to higher level.			
TCS = Thermal control subsystem	TBT = Thermal balance test	CSS = Cryogenic control subsystem		

Table 9-4: Summary of the requirements in ECSS-E-ST-32 "Structural"

Clause & Req			Requirements subject	DRD (Annex)	Supporting guidance
4.2 Mission			Duration (lifetime), environment (natural and induced, mechanical, …) Loads (events, combination, limit, design limit)		
4.3 Functionality			Strength, yielding, buckling, stiffness, dynamic and thermal behaviour, damage tolerance, tolerances, electrical & EMC, dimensional stability		
4.4 Interfaces			Minimum internal and external I/Fs to consider		
4.5 Design	**Inspectability**		Inspection reqs / NDI *(->Q-ST-70-15)* / Fracture control *(->E-ST-30-01)*		
	Usability		Interchangeability, Maintainability, Dismountability		
	Materials & Parts		**Selection** *(-> E-ST-32-08, Q-ST-70* series)*,		E-HB-32-20
			Allowables,	Annex H	
			Metals, Non-metals, Composite, Adhesive		
	Mech properties		Mass & inertia, ablation, Protection vs micrometeorites, Venting		
	Margins & Factors		MOS, FOS *(->E-ST-32-02, E-ST-32-10)*, Scatter factors, **Loads**	Annex B	
4.6 Verification	**By Analysis**	**Analysis**	Method, models *(->E-ST-32-03)*, tools and data		
		Type of Analysis	**Modal & dynamic response**,	Annex J	
			Stress & Strength	Annex K	
			Alignment budget	Annex L	
			Acoustic, Fluid interaction, Thermo- & Aeroelastic,		
			Fatigue,	Annex D	
			Fracture control *(->E-ST-32-01)* **analysis, plan & item list**,	Annexes E,F&G	
			Inertia&Mass, **Mass summary**	Annex N	
			Buckling	Annex M	E-HB-32-25
			Dimensional stability	Annex C	
		Analysis of Parts	Joints: Welded, Riveted, **Bonded**, **Bolted**		E-HB-32-21 E-HB-32-23
			Inserts		E-HB-32-22
	Test	**Test**	Objectives, data, model philosophy, **test-analysis correlation**	Annex O	
			Test prediction	Annex P	
			test evaluation	Annex Q	
		Purpose	Development, Qualification, Acceptance tests		
		Type of Test	Static, Modal survey *(-> E-ST-32-11)*, Dynamic, Acoustic, Fatigue, Noise, NDT *(->Q-ST-70-15)*, Thermo-elastic, Cycling, Ageing, …		
4.7 Manufacturing			Manufacturability. Manufacture process, drawings, and tooling,. Assembly, storage , cleanliness and safety		
4.8 In-service			Ground & in-orbit (BIT) inspection, maintenance and repair		
4.9 Data exchange			Dataset, Configuration *(->M-ST-40)*, Exchange (Design-Struct-Manufact)		
			Mathematical models *(->E-ST-32-03)*	Annex I	
			Traceability, **CAD model**	Annex A	
MOS = Margin of safety		FOS = Factor of safety		BIT = Bilt-in-testing		

Table 9-5: Summary of the requirements in ECSS-E-ST-34 "ECLS"

Clause & Req	Requirements subject	DRD (Annex)	Supporting guidance
Mission and system	Mission: Req's identification, Mission phases		
	System: Multi-ECLS subsystem phases, Reusable systems		
General requirements	Forms of life: Humans, Other than humans		
	ECLS subsystem engineering: Humans, Other than humans		
	Environmental conditions, to be taken during Phase A		
Functional	Maintain environment, control total pressure, nominal thermal, oxygen, CO and CO2, trace gases and odour, airborne particles & microorganisms		
	Respond to environmental contingencies: Uncontrolled pressurization, depressurization, fire, radiation, and hazard atmosphere.		
	Provide resources: inert diluent gas, Oxygen, breathing gas, water & food		
	Manage waste: CO2, waste water, and gas, liquid & solid wastes,		
	Support extra-vehicular activity (EVA) operations		
	Provide health related services: Monitoring, medical assistance, time control & gravity counter measures		
Design	Data management control: sensors, I/F with OBDM, visual and acoustic		
Interfaces	Internal and external I/Fs		
	I/Fs with ground support equipment (GSE)		
	Mission interfaces: I/F with flight system, SW & data system, Thermal, biological, mechanical, electrical, on-board equipment, , human		
Verification	Verification programme		
	Verification by similarity, by inspection, by analysis		
PA and safety	To be applied to design, production & testing, utilization, GSE		
	Hardware and integration procedures, to be identified		
Deliverables	Documentation: TS for the next level suppliers	E-ST-10-06 Ann A	

Table 9-6: Summary of the requirements in ECSS-E-ST-35 "Propulsion"

Clause & Req			Requirements subject	DRD (Annex)	Supporting guidance
4.2 Mission			Minimum mission reqs to consider		
4.3 Development			Inputs and outputs of the development phase		
4.4 Interfaces			Internal & external I/F of propulsion subsystem		
4.5 Design	**General design**		Minimum TRL / Replace-ability of sub-system and parts		
	Performance		**Performance analysis report**	Annex A	
			Thrust, Impulse, Masses and mass history, burning time (solid prop)	Parts of Ann A	
	Reference envelope		Operational envelope definition and use / Qualification points		
	Transients		**Transient analysis report**	Annex G	
			Transient phenomena, characteristics & sequence definition & evaluation		
	Sizing		FMECA *(->Q-ST-30-02)*, Margin policy establishment, SEF modes		
	Dimensioning		Loads, calculation methods, data in the DJF, Failure modes as inputs		
	Imbalance		Minimum imbalance effects to take into account		
	TVC		TVC characteristics over the operating range, by analysis and test		
	Contamination		**Cleanliness analysis report** *(->E-ST-35-06)*	E-ST-35-06 Ann A	
			Sources of contamination, External contamination protection		
			Internal (propellant & fluids, components & replacement, filters, icing)		
	Plume effect		**Plume effect analysis**	Annex D	
	Leak		Fire&Explosion risk / Internal&External leakage / Leakage budget		
	Environment		Environment impact on the propulsion subsystem		
	Ageing		Aging effects determination & assessment by analysis and test		
	Parts	**Instrumentation**	**Instrumentation plan**	Annex L	
			Qualification, redundancy, data storage, mounting and location		
		Harness	Spurious, Redundancy, shielding, Connectors, **Harness spec**	No specific DRD	
	Control system		Loop stability, Design selection parameters, FMECA,		
4.6 GSE			Safety, I/F, **Propulsion system – GSE I/F spec**	No specific DRD	
			Mechanical and electrical GSE basic design requirements		
4.7 Materials			Material list establishment *(-> E-ST-32-08 & Q-ST-70)*		
4.8 Verification			General requirements on Verification by Analysis and by Test		
4.9 Manufacturing			General req's on Tooling, Marking, and Manufacturing processes		
4.10 In-service			Req's on Ground operations, Anomalies, operability and EOL		
4.11 Additional documentation	Analysis reports		**Gaugin analysis report**	Annex B	
			Thermal analysis *(addendum to E-ST-31 Annex DRD)*	Annex C	
			Nozzle & discharge flow analysis report	Annex E	
	Model-ling		**Mathematical modelling for propulsion analysis**	Annex I	
			Mathematical model req's *(addendum to E-ST-32 DRD)*	Annex J	
			Mathematical model description *(addendum to E-ST-32 DRD)*	Annex K	
	Propulsion user manual			Annex H	
SEF = Single event failure		TVC = Thrust Vector Control		EOL = End Of Life	

Table 9-7: Summary of the requirements in ECSS-E-ST-40 "Software engineering"

Clause & Req		Requirements subject	DRD (See Part 2 of the Table)	Supporting guidance
5.2 Sys. Req process	**Analysis**	Specification & Identification of requirements related to SW and HMI		E-HB-40 "Software guidelines"
	Verification	Specification and validation planning and installation & acceptance requirements		
	Integration & control	SW version, media of delivery, support, I/F specification, databases, OBCP, Reuse		
	Review	**SRR to be conducted**		
5.3 SW management process	**Lifecycle mngt**	SW lifecycle definition, Maintenance I/F., Automatic code , Procuremt, Baseline changes		
	Joint review	Joints reviews to be performed, and their objectives		
	Project review	SRR, PDR, CDR, QR and AR, to be performed		
	Tech. reviews	TRR and Test Review board responsibilities		
	Review phasing	Review phasing for flight & ground SW, and synchronization with system reviews		
	I/F mngt	I/F management procedures are to be defined		
	Tech budget&margin	Technical budget and margin philosophy (to be specified) and methods (to be agreed)		
	Compliance	Compliance matrix (of the reqs of the present standard), to be provided by the supplier		
5.4 Req's & Architec.	**SW req. analysis**	TS to include all E & Q SW req's / In-flight mods, to be analysed / SW logical model		
	SW arch. design	SW architect definition, computational model, SW behaviour description, SW I/F development, SW for re-use and reuse of existing SW, SW integration plan		
	Conducting a PDR	A PDR is to be conducted		
5.5 Design & implem.	**Design of SW items**	Detail design of SW items, I/Fs, model, method, real-time SW and its consistency. Behaviour description technique, SW user manual, SW test plan / **DDR to be conducted**		
	Coding & Testing	SW unit development and testing, and their documentation		
	Integration	SW integration test plan development and implementation		
5.6 SW va-lidation	**Implementation**	Validation process to be established / ISVV organization to be selected		
	Val vs. Tech Spec	Validation spec vs TS / User manual updating / **CDR to be conducted**		
	Val. vs. Req Baseline	Validation spec vs Req. Baseline / User manual updating / **QR to be conducted**		
5.7 Deliv. & accept.	**Delivery & instal.**	SW preparation, training & support, and installation procedures & report		
	Acceptance	Acceptance test planning & execution, executable code generation, traceability to baseline, **AR to be conducted**		
5.8 SW Verif	**Implementation**	Verification process to be established / ISVV organization to be selected		
	Activities	Verification of: Req's Baseline, TS, SW Architecture, SW detail design, Code SW unit testing, SW integration, SW validation, SW documentation, behaviour modelling		
		Evaluation of validation, Real-time SW analysis, Technical budgets set-up		
5.9 SW operation	**Implementation**	Operational testing establishment, Operation support plans, Problem handling proc's		
	Operational testing	Operational testing execution, Operational req's demonstration, SW release		
	SW operation support	Operation support plan execution and problem handling proc's followed		
	User support	Assistance to User, User request handling, Work-around procedures		
5.10 SW Maintenance	**Implementation**	Maintenance processes established and implemented, Long-term maintenance		
	Problem analysis	Problem analysis and subsequent modification requests		
	Mod implementation	SW Modification management		
	Maintenance reviews	**MR to be conducted**, and change baseline establishment		
	Migration	Migration plan, preparation and finalization notification / **Post-operation review**		
	Retirement	Retirement plan, retirement requirements, notification / Data accessibility		
ISVV = Independent SW Verification & Validation		MR = Maintenance Review		

Table 9-7 (Part 2): DRDs in ECSS-Q-ST-40

Ann	Title	Purpose	Called from
B	SW system spec (SSS)	Specifies the customer reqs. Part of Baseline. Input to SRR	E40 #5.2, 5.3 / Q80 #7.1, 7.2
C	SW I/F req doc (IRD)	Specifies I/F customer reqs. Part of Baseline. Input to SRR	E40 #5.2
D	SW Req Spec (SRD)	Specifies functional and non-functional reqs. Part of the TS	E40 #5.4, 5.8 / Q80 #6.3, 7.1, 7.2
E	I/F control doc (ICD)	Describes external I/Fs. Part of TS	E40 #5.4, 5.5 & 5.8
F	SW Design Doc (SDD)	Describes SW architect. and detail design. Part of DDF	E40 #5.4, 5.5, 5.8 / Q80 #7.2
G	SW Release Doc (SRelD)	Describes limitations & restriction of SW. Part of DDF	E40 #5.7 & Q80 #6.2
H	SW User Manual (SUM)	Provides instructions for the SW user. Part of DDF	E40 #5.5, 5.6
I	SW Verif. Plan (SVerP)	Describes verif. approach and organization. Part of DJF	E40 #5.8 / Q80 #6.2
J	SW Valid. Plan (SValP)	Describes valid. Approach and organization. Part of DJF	E40 #5.6, 5.8 / Q80 #6.2, 6.3
K	SW (U/I) test Plan (SUITP)	Describes the Unit/Integration test plan. Part of the DJF	E40 #5.4, 5.5 / Q80 6.2, 6.3
L	SW Valid. Spec (SVS)	Describes valid. methods w.r.t TS & Baseline. Part of DJF	E40 #5.6, 5.8 / Q80 #6.2 & 6.3
M	SW Verif. Report (SVR)	Present results of verif. Activities. Part of DJF	E40 #5.3, 5.7, 5.8 / Q80 #6.2, 7.1, 7.2
N	SW Reuse File (SRF)	Present analysis of existing SW to be reused. Part of DJF	E40 #5.4 / Q80 #5.5, 6.2
O	SW Develop. Plan (SVP)	Described the develop. approach to define the SW items	E40 #5.3 / Q80 #5.6, 5.7, 6.3
P	SW Review Plan (SRevP)	Describes the SW formal reviews to be conducted	E40 #5.3

Table 9-8: Summary of the requirements in ECSS-E-ST-50 "Communications"

Clause & Req			Requirements subject	DRD (Annex)	Supporting guidance
5.2 Engineering		Req. engineering	**Space Comm System Req Spec**	Annex A	
		Analysis	Analysis of feasibility+ Margins + rates + links + criticality + Data flows + architecture + parameters = **Comms system analysis document**	Annex C	
		Design	**Comm System baseline definition + Comm System Architec. Design** + Comm system Detail Design + Comm System profile	Annexes B+E+F+G	
		Implementation	Delivery of the system + **Comm System Verification Plan**	Annex D	
		Verification	Verification test report (->E-ST-10-03)	E-ST-10-03 Ann A	
			Declaration of acceptance (by Customer + Supplier)	No specific DRD	
		Operations			
S/C external Comms.	5.3 Space Comm System		Bandwidth allocation, Congestion (lost data), Cessation of emission		
	5.4 Telecommand		Command-ability, distribution, authentification, encryption, ITB, ack.		
	5.5 Telemetry		Telemetry-ability, acquisition, identification, ITB, ITB, stamping		
	5.6 ace link	5.6.2 - 5.6.10 General	Gen req's on Space link integrity, operability, optimization		
		5.6.11 Performance	Doppler rates, trumbling, Tolerances, Failure modes, BER, Downlink & Rejection rates, delay, probability of accepting corrupted frames		
		5.6.12 Frequency	Band selection, Unwanted emissions, Power flux limits		
		5.6.13 Protocol	Identifiers (S/C, link, data unit, sequence), Error detection, ARQ		
		5.6.14 Service	Services and functions to be provided		
5.7 S/C Network	5.7.1 General		Deterministic Capabilities, Mechanisms, Redundancy, WC environment, Error prob.		
	5.7.2 Services		Services and functions to be provided		
	5.8 Ground Network		Security, Error rates, Redundancy, Availability		
ITB = In-the-blind		BER = Bit Error Rate		ARQ = Automatic repeat request	

Table 9-9: Summary of the requirements in ECSS-E-ST-70 "GSO"

Clause & Req			Requirements subject	DRD (Annex)	Supporting guidance
5 – Ops engineering	5.2 Req. analysis & concept development		5.2.1 - Inputs to include (among others) the **Operations Customer Req Document**	OCRD in Ann A	4.2, 4.4 & 4.5
		5.2.2 – Process description	Mission analysis -> **Mission analysis report**	MAR in Ann B	
			Operational analysis to produce the **Mission Ops Concept Document**	MOCD in Ann C	
			I/Fs def. — Identify the space segment operability req. in the SSORD	No specific DRD	
			Deliverable items to be identified in CFISRD	CFISRD in Ann J	
			Ops engineering plan (OEP) to be developed	OEP in An.D	
			Contribution to GS & ground system TS		
			Ops validation plan to be produced	OVP in An.F	
			5.2.3 – Outputs: All the docs. mentioned above		
	5.3 – Mission ops data production		5.3.1 – Inputs to include (among others) the **Space segment user manual**	SSUM in An.E	
			5.3.2 – Process description: Produce the Mission ops plan & the Ops procedures	MOP in An.G Ops Proc in An.I	
			5.3.3 – Outputs: All docs mentioned above		
	5.4 – Missions ops data validation		Inputs, process description and outputs of the activities in the right column		
	5.5 – Ops teams build-up & training				
	5.6 – Operational validation				
	5.7 – Operational config. management				
	5.8 – Operations execution		Inputs, Ops execution description and outputs. During Ops execution, anomalies to be reported in an Ops Anomaly report (OAR)	OAR in An.H	
	5.9 – Space segment disposal ops		Inputs, space segment disposal description & outputs		
6 – GS engineering	6.2 – GS definition		Inputs, GS definition process description and outputs One of the inputs shall be the **GS Customer Req Doc**	GSCRD in An.A	4.3, 4,4 & 4.5
	6.3 – GS production		Inputs, process description and outputs of the activities in the right column		
	6.4 – GS AIT and verification				
	6.5 – GS maintenance				
	6.6 – GS disposal				
7 – GSO lifecycle	7.2, 7.3, 7.4, 7.5, 7.6 & 7.7 For each phase (A, B, C, D, E and F):		7.x.1 – Purpose of the phase (A, B, C,.D, E or F)		
			7.x.2 – Process during phase (A, B, C, D, E or F)		
			7.x.3 – Milestones and reviews of the phase (A, B, C, D, E or F)		

9.2.3 The Level 3 standards in the E branch

As explained in there is a number of Level 3 standards in the E branch. Their content is mainly technical and a general description of it is given in 6.2.3. Details of most of them is relevant only for the specialist, and therefore not expanded here. However, there is a number of documents which need to be known in certain detail because, although structurally they are Level 3 standards, they work as level 2 for different reasons:

- E-ST-10-02 "Verification", which specifies the verification process of the ECSS requirements. Verification is one of the five SE functions covered by E-ST-10 (which is a Level 2 standard), and therefore E-ST-10-02, being structurally below E-ST-10, it is a Level 3 standard. However, verification is an activity impacting or interfacing with the vast majority of the other ECSS standards, to be performed by experts at any level and in any branch, so deserving to be specifically covered here.

- E-ST-33-01 "Mechanisms" is also a level 3 standard. However there is no Level 2 standard in this sub-discipline, and this documents can be considered as such.

The following tables detail the contents of these two documents.

Table 9-10: Summary of the requirements in ECSS-E-ST-10-02 "Verification"

Clause & Req		Requirements subject		DRD (Annex)	Supporting guidance	
5.1 – Verification process		**Verification process =** **Planning + Execution & reporting + Control & close-out**			4.1.1 & 4.1.2	
5.2 - Verif. planning	**5.2.1 - Approach**	Reqs to be formally verified, to be defined and agreed, & for them:	Approach to be defined in the VP	VP in Annex A	4.2.1	E-HB-10-02 "Verification HB"
			Strategy (including VM) to be specify in the VCD	VCD in Annex B		
		They shall include all the reqs in the TS				
	5.2.2 - Methods	Analysis, Test, RoD and Inspection. Test -> E-ST-10-03 By test: all critical functions, and SW integrated in its HW No test or inspection => Risk assessment			4.2.2	
	5.2.3 - Levels	To be specified in the VCD. Traceability between levels			4.2.3	
	5.2.4 - Stages	Qualification, acceptance, pre-launch, in-orbit, post-landing Qualification programme versus product category (heritage)			4.2.4	
	5.2.5 - Models	To be specify in the VP			4.2.5	
	5.2.6 - Tools	Tools shall also be verified, and specially the GSE, the SVF, simulators and test facilities			4.2.6	
	5.2.7 - Phasing	Verification milestones, i.a.w. Table 9-12				
5.3.2 – Execution & reporting documentation		Responsibilities, to be defined Test (including TRR & PTR) -> E-ST-10-03 Non-conformances -> Q-ST-10-09 Results, recorded in Reports (Analysis Rpt, Test Rpt, RoD Rpt, Inspection Rpt. If 2 methods simultaneously, then Verif Rpt		ARpt in E-ST-10 TRpt in Annex C RRpt in Annex D IRpt in Annex E VRpt in Annex F	4.3 & 4.1.3	
5.4 Control & close-out	**5.4.2 - VCB**	All verif. process, to be monitored by the VCB = customer+supplier Final close-out, endorsed by the VCD and to be agreed by customer			4.4 & 4.1.3	
	5.4.3 – Re-verification	Extent of re-verification, defined by supplier and agreed by customer, and implemented I n the VCD				
	5.4.4 – Control & close-out docs	VCD to be continuously updated		VCD		
VCB = Verification control board		VP = Verification plan		TRR = Test readiness review	RoD = Review of design	
VCD = Verification control document		VM = Verification matrix		PTR = Post-test review	SVF = SW validation facilities	

Table 9-11: Summary of the requirements in ECSS-E-ST-33-01 "Mechanisms"

Clause & Req			Requirements subject	DRD (Annex)	Supporting guidance
4.2 General	**Mission**		A "Specific mechanism specification" (SMS) to be established	SMS in Annex A	
	Units		S.I. of units to be used		
	Product characteristics		Marking and labelling / use only qualified Parts & components / Interchangeability / Maintainability		
	Reliability		Reliability demonstration / Failure safe / Fracture control for critical fasteners / Structural reliability -> E-ST-32		
	Redundancy		SPF identification & elimination / Active elements to be redundant Redundancy concepts to be agreed with customer		
	Flushing & purging		Provisions to operate the mechanism in air Use only lubricants qualified in respect to the residual humidity		
4.3 Mission & environments			Every mission phase and related mission requirements, to be considered		
4.4 Functional	**System performance**		Functional performance, to conform the system requirements		
	Mechanism function		Kinematic reqs, mechanical I/F, position accuracy, tolerances, movement envelope, movement interference		
4.5 Constrains	**Materials**		Materials selection -> Q-ST-70, Q-ST-70-71 & E-ST-32-08 Req's on corrosion, dissimilar materials, stress corrosion, fungus protection, flammability, toxicity and instability, radiation, …		
	Operational constraints		Document operational constrains in the "**Mechanism user manual**"	Annex D	
			Oscillatory over a complete revolution / **Ops procedures** to be defined	No specific DRD	
4.6 Interfaces			Thermo-mechanical I/Fs		
4.7 Design	**Tribology**		General req's on lubrication, lubricants and surfaces in contact		
			Req's for dry and fluid lubrication (amount of lubricant, outgassing, …)		
			Req's for tribological components (life, pre-loading, cables)		
	Thermal control		Req's for thermal design & sizing, and multi-layer insulation		
	Mech. Design & sizing		Structural: Loads, limit loads, allowables, MOS & FOS		
			Functional: Actuators, torques, uncertainty factors, torque dimensioning		
			Elements: Replaceable elements, status monitoring, contact surfaces, latching, stops, bearings, gears, clearances, threaded parts, venting		
	Pyrotechnics		For pyro -> E-ST-33-11		
	Electrical & electronics		Electrical characteristics, Disturbances, brush motors, power		
			Insulation of wires and windings, dielectric and grounding		
			Connectors, electrical protections and wires		
			ESD (->E-ST-20-06) and EMC (-> E-ST-20-07)		
	Control systems		Gain margins, stability, phase margin, damping, eigenmodes & aliasing		
4.8 Verification	**General verific.**		-> E-ST-10-02 (including production of a Verif. Matrix [VM])	VM in E-10-02 An.B	
	By analysis		WCA, thermal, Structural, Pre-load, functional, hertzian contact, functional, FMECA, gear, shock, disturbances, control, lubrication, lifetime, hygroscopic, EM, radiation, and electrical analysis		
	By test	**Test plan**	Test programme to be agreed with customer		
		Develop.	Reqs on models and characterization tests		
		Qualific.	Structural, thermal, functional, shock, solid & liquid lubrication, electrical, control, and lifetime tests, life test models, profiles and duration, accelerated test, post-test inspection, success criteria		
		Accept.	Setting and stabilization, acceptance & dielectric tests, success criteria		
4.9 - PA & manufacturing			General req's on manufacturing process, drawings and assembly		
4.10 Deliverables			Supplier to provide the "**Mechanism design description** (MDD)"	Annex B	
			Supplier to provide the "**Mechanism analytical verif.** (MAV)"	Annex C	
			Supplier to provide the "**Mechanism user manual** (MUM)"	Annex D	

9.3 E documentation

9.3.1 Overview

The situation with the E documentation is slightly different than for M and Q documents. E documents are always technical documents either for the definition of the mission, for the planning of the engineering activities, for the justification of the selection of a given engineering solution, or to support the implementation of the selected solution. That implies that all E documents belong to one of the following folders (which are in turn also DRDs):

• Mission document

• System engineering plan

• Design justification file

• Design definition file

This means that E documents are produced when a specific engineering activity is performed, but they are always reviewed during project reviews.

9.3.2 E documents linked to project reviews

The following documents are linked to project reviews:

Table 9-12: ECSS-E documents linked to project reviews

Document		Required by	Described in	Description of the document	Project reviews												
					MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR	MRR
Mission description doc. (MDC)		E-ST-10 #5.3.1a	E-ST-10 An.B	Provides inputs for the later selection of the best concept meeting the mission statement.	X	X											
System engineering plan	System engineering plan (SEP)	E-ST-10 #5.1a, #5.3.4a	E-ST-10 An.D	It defines the approach, methods, procedures, organization and resources. to co-ordinate and manage all technical activities to specify, design, verify, operate and maintain a system or product	X	X	X	X	X	X	X						
	Technology plan	E-ST-10 #5.6.7b	E-ST-10 An.E	It defines the approach, methods, procedures, organization and resources to evaluate the ability of a critical technology to meet the intended requirements.		X	X	X									
	Technology matrix	E-ST-10 #5.6.7a	E-ST-10 An.F	It presents, for each technical req/function, the list of technologies or technological elements with the potential to meet this requirement. It summarizes candidate technologies per individual requirement		X	X	X									
	Verification plan	E-ST-10-02 #5.2.8.1b	E-ST-10-02 An.A	It contains the overall verification approach, the model philosophy, the product matrix, the verification strategies for the req's (the interrelation between different methods/levels/stages of verification to be used to demonstrate status of compliance to requirements), the test, inspection, analysis and RoD programme with the relevant activity sheets and planning, the verification tools, control methodology, involved documentation, management and organization		X	X	X	X	X	X						
	AIT QM/FM plan	E-ST-10-03 #4.3.3.2a	E-ST-10-03 An.A	It is the master plan for the product AIT process and describes the complete AIT process, demonstrating (together with the verification plan) how the requirements are verified by inspection and test					X	X	X	X					
	Coordinated system doc	E-ST-10-09 #5.2.2a	E-ST-10-09 An.A	It documents the coordinate systems and their inter-relationships, throughout the product tree and the project/mission life.		X	X	X	X	X							
	HCD process plan	E-ST-10-11 #4.4.2a	E-ST-10-11 An.A	It defines the approach, methods, procedures, resources and organization for the integration of the human in the loop for space system products.													

Document		Required by	Described in	Description of the document	MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR	MRR
	I/F requirement doc.(IRD)	E-ST-10-24 #5.3a	E-ST-10-24 An.A	For a product, the IRD is a specific type of technical req spec that defines the req's for an I/F or a collection of I/Fs		X	X	X									
Design definition file	Design definition file (DDF)	E-ST-10 #5.3 & #5.4	E-ST-10 Annex G	It establishes the technical definition of a system or product complying with its technical requirements spec (see E-ST-10-06 Annex A)		X	X	X	X	X							
	Function tree	E-ST-10 #5.3.1b	E-ST-10 Annex H	It establishes the technical definition of a system or product complying with its technical requirements spec (see E-ST-10-06 Annex A)		X	X	X									
	Spec tree	E-ST-10 #5.2.3.1c	E-ST-10 Annex J	It defines the hierarchical relationship of all technical requirements specifications for the different elements of a system or product.			X	X									
	Technical budget	E-ST-10 #5.4.1.2a	E-ST-10 Annex I	It defines for each key engineering parameter of a system or product, the nature of this parameter, its measure, specified value, metrics req's and current actual or computed value and assessed value.		X	X	X	X	X	X						
	Prel. TS for next lower level	E-ST-10-06 #5.2.3.1b	E-ST-10-06 An.A	It establishes the intended purpose of a product, its associated constraints and environment, the operational and performance features for each relevant situation of its life profile, and the permissible boundaries in terms of technical requirements		X	X										
	Final TS for next lower level	E-ST-10-06 #5.6.4a					X	X									
	I/F control document (ICD)	E-ST-10-24 #5.4d	E-ST-10-24 An.B	It defines the design of the interface(s) ensuring compatibility among involved interface ends by documenting form, fit, and function			X	X	X	X	X	X	X	X			
	I/F definition doc (IDD)	E-ST-10-24 #5.4b.1	E-ST-10-24 An.C	It documents the current design of an interface end			X	X	X	X	X	X	X	X			
	Product user manual (PUM)	E-ST-10 #5.4.1.4c	E-ST-10 Annex P	It provides information on design, operations and data of the product needed by the user to handle, install, operate, maintain and dispose the product during its life time.							X	X	X	X	X	X	X
Design justification file	Design justification file (DJF)	E-ST-10 #5.3 & #5.4	E-ST-10 Annex K	It presents the rationale for the selection of the design solution, and to demonstrate that the design meets the baseline requirements		X	X	X	X	X							
	Requirement traceability matrix w.r.t next lower level	E-ST-10 #5.2.2b	E-ST-10 Annex N	It defines the relationships between the requirements of a deliverable product defined by a technical requirements specification and the apportioned requirements of the product's lower level elements.		X	X	X									

Document	Required by	Described in	Description of the document	Project reviews												
				MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR	MRR
Requirement justification file	E-ST-10 #5.2.1e	E-ST-10 Annex O	Collects the set of docs recording and describing the needs and constrains from different trade-offs, and the ones demonstrating how the req's of the TS at each level satisfy these needs.	X	X	X	X									
System concept report	E-ST-10 #5.3.3c	E-ST-10 Annex C	It describes the technical characteristics of alternative system concepts, performances, architectures, driving technologies, interfaces, risk, their evaluation and classification, and later addresses the selected concept.	X	X											
Trade-off reports	E-ST-10 #5.3.3b	E-ST-10 Annex L	It provides the SE point of view on alternative design solutions, an evaluation and a classification of the alternative design solutions, and the justification of their ranking	X	X	X	X	X								
Verification control doc (VCD) (including the Verification Matrix)	E-ST-10-02 #5.2.8.2b, #5.4.4.1b	E-ST-10-02 An.B	It lists the requirements to be verified with the selected methods in the applicable stages at the defined levels Note [1] – At PRR, SRR & PDR, it is limited to the Verification Matrix		[1]	[1]	[1]	X	X	X	X	X	X	X	X	X
Test spec	E-ST-10-03 #4.3.3.3a	E-ST-10-03 An.B	It details the test requirements applicable to any major test activity, defining the test purpose and approach, the item under test and set-up, the GSE, tools, instrumentation and measurement accuracy, conditions, sequence, facility, pass/fail criteria, documentation, participants and test schedule.						X	X	X	X	X	X	X	X
Analysis report	E-ST-10 #5.3.1j E-ST-10-02 #5.3.2.2	E-ST-10 Annex Q	It describes, for each analysis, the relevant assumptions, utilized methods, techniques and results		X	X	X	X	X	X	X	X	X	X	X	X
Test procedure	E-ST-10-03 #4.3.3.4a	E-ST-10-03 An.C	It gives directions for conducting a test activity in terms of description, resources, constraints and step-by-step procedure, and provides detailed step-by-step instructions for conducting test activities							X	X	X	X	X		
Test report	E-ST-10-02 #5.3.2.1b	E-ST-10-02 An.C	It describes test execution, test and engineering assessment of results & conclusions in the light of the test req's (including pass-fail criteria).							X	X	X	X	X	X	X
RoD report	E-ST-10-02 #5.3.2.3b	E-ST-10-02 An.D	It describes each verification activity performed for reviewing documentation.						X	X						

Document		Required by	Described in	Description of the document	Project reviews												
					MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR	MRR
	Inspection report	E-ST-10-02 #5.3.2.4b	E-ST-10-02 An.E	It describes each verification activity performed for inspecting hardware or software					X	X	X						
	Verification report	E-ST-10-02 #5.3.2.5b	E-ST-10-02 An.F	It reports, when more than one verification method has been used to verify one req, the approach followed and how the verification methods were combined to achieve the verification objectives					X	X	X	X	X	X	X	X	X
	HFE analysis & verify. report	E-ST-10-11 #4.11.2.2a	E-ST-10-11 An.B	It defines the scope, methods, procedures, resources and organization for the performance of HFE analyses and for the related simulations especially when using the DHM and the DMU.													
	HFE continuous assessment process report	E-ST-10-11 #4.10.1.1h	E-ST-10-11 An.C	It collects the results of the implementation of the HCD process plan (specifically the synthesis of the DRDs of ECSS-E-ST-10-11, Annex B and D included) in the various stages of the process.													
	HFE test report	E-ST-10 #4.10.3.3d and 4.10.3.4f	E-ST-10-11 An.D	It collects the results of a test where human subjects are used to evaluate the proposed solution either during the development or verification phase.													
EMC control plan		E-ST-20 #6.2.2a	E-ST-20 Annex A	It defines the approach, methods, procedures, organization and resources to design, produce and verify a product to operate within its specified electromagnetic environment & performance characteristics				X									
EM Effects verification. plan		E-ST-20 #6.4.1b	E-ST-20 Annex B	It defines the approach, methods, and procedures to verify electromagnetic effects.													
EM effects verification report		E-ST-20 #6.4.1c	E-ST-20 Annex C	provides reporting of all activities in relation with the verification of the effects of the electromagnetic environment.													
Battery user manual		E-ST-20 #5.6.4b	E-ST-20 Annex D	It is the instantiation of PUM (E-ST-10 An.P) for batteries													
Electric hazard mitigation plan		E-ST-20-06 #5a	E-ST-20-06 An.A	It plans the activities to ensure that the risk of hazards of unwanted electrical effects is adequately analysed and that adequate counter-measures are taken where necessary.													
SCD for PVA (SCD-PVA)		E-ST-20-08 #5.2b	E-ST-20-08 An.A	It contains the specific project dependent requirements for PVA, SCA,													

Document	Required by	Described in	Description of the document	Project reviews												
				MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR	MRR
SCD for SCA (SCD-SCA)	E-ST-20-08 #6.1.2b	E-ST-20-08 An.B	BSC, CVG or EPD, and together with the requirements of E-ST-20-08 (which contains the generic requirements), constitutes the whole set of requirements for the qualification and acceptance.													
SCD for BSC (SCD-BSC)	E-ST-20-08 #7.1.1.2b	E-ST-20-08 An.C														
SCD for CVG (SCD-CVG)	E-ST-20-08 #8.3.1.2b	E-ST-20-08 An.D														
SCD for EPD (SCD-EPD)	E-ST-20-08 #9.2.1.2.2b	E-ST-20-08 An.E														
Process identification doc (PID)	E-ST-20-08 #6.2a, #7.2a, #8.4a, #9.3.2a	E-ST-20-08 An.F	It is the instantiation of the PID (see Q-ST-20) for the PVA, SCA, BSC, or CVG													
Data doc package (DDP)	E-ST-20-08 #5.7a, 6.6a, 7.7a, 8.9a, 9.8a	E-ST-20-08 An.G	It collects the data related to the manufacturing, integration and test of the PVA, SCA, BSC, CVG and protection diode, providing traceability and events records													
[Thermal] Mathematical model spec (TMM)	E-ST-31 #4.5.2.1d	E-ST-31 Annex A	Specifies requirements for development and delivery of thermal mathematical models to be used for thermal analysis at system level.				X	X								
Thermal and geometrical model description	E-ST-31 #4.5.2.1e	E-ST-31 Annex B	Describes the TMM and GMM to be used as an input for the sub-system thermal analysis cases. To be updated before each analysis campaign.		X	X	X	X	X	X						
TCS analysis report	E-ST-31 #4.5.2.1f #4.5.3.1f	E-ST-31 Annex C	Contains a full mathematical analysis of the thermal control system leading to the thermal sub-system definition, including redundancy strategy, operational concept and hardware definition. To be updated or re-issued for CDR, AR, TBT prediction, TBT evaluation, and flight prediction.		X	X	X	X	X	X	X					
TCS interface control document	E-ST-31 #4.3.1b	E-ST-31 Annex D	Describes the thermal control sub-system interfaces to other sub-system and to the system. To be updated at CDR and SR.		X	X	X	X	X	X						
TCS thermal balance test spec	E-ST-31 #4.5.3.1a	E-ST-31 Annex E	Describes the requirements applicable for the thermal balance test including purpose, test approach and test article. It can be combined with the system thermal vacuum test spec.					X								

Document	Required by	Described in	Description of the document	Project reviews												
				MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR	MRR
TCS detailed design description	E-ST-31 #4.4.1c	E-ST-31 Annex F	Describes the detail design of the thermal control sub-system Possible update for Phase D			X	X	X								
Computer aided design model description and delivery (CADMDD)	E-ST-32 #4.10a	E-ST-32 Annex A	There is one per CAD model, and describes it and explains how to use it, providing traceability of changes between delivered models				X	X								
Design loads (DL)	E-ST-32 #4.10b	E-ST-32 Annex B	Provides detailed description and traceability of the design load cases and design life cycles to justify the mechanical design of a structure			X	X	X	X							
Dimensional stability analysis (DSA)	E-ST-32 #4.10c	E-ST-32 Annex C	Analyses the effect of the environment on the stability behaviour of the structure (e.g. thermo-elastic deformation, 1g-0g effect, micro-slipping due to launch loads).				X	X	X							
Fatigue analysis (FA)	E-ST-32 #4.10.d	E-ST-32 Annex D	Reports the verification by analysis of the fatigue life of the structure					X	X							
Fracture control analysis (FCA)	E-ST-32 #4.10e	E-ST-32 Annex E	Reports the verification by analysis for the items defined in the PFCIL, FCIL and FLLIL					X	X							
Fracture control plan (FCP)	E-ST-32 #4.10f	E-ST-32 Annex F	describes the foreseen implementation of the applicable fracture control requirement for the concerned structural component				X	X								
Fracture critical item list (FCIL) Potential FCIL (PFCIL) Fracture limited life item list (FLLIL)	E-ST-32 #4.10g	E-ST-32 Annex G	The PFCIL describes the classification of structural items for the fracture control requirements. The FCIL and FLLIL are sub-sets of the PFCIL				X	X	X							
Materials and mechanical parts allowables	E-ST-32 #4.10h	E-ST-32 Annex H	collects the mechanical allowables and other relevant physical properties of the applied structural materials and mechanical parts				X	X								
Mathematical model description and delivery (MMDD)	E-ST-32 $4.10i	E-ST-32 Annex I	There is one per math model, and describes it and explains how to use it, providing traceability of changes between delivered models				X	X	X							
Modal and dynamic response analysis (MDRA)	E-ST-32 #4.10j	E-ST-32 Annex J	Describes in detail the methods and results of the structure modal analysis (free vibrations) and structure response under dynamic loads (transient, sinusoidal, random.).				X	X	X							
Stress and strength analysis (SSA)	E-ST-32 #4.10k	E-ST-32 Annex K	Describes in detail methods and results of the structure analysis under static or quasi-static loads, and outlines strength analysis formulae.				X	X	X							

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Document	Required by	Described in	Description of the document	Project reviews												
				MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR	MRR
Structure alignment budget (SAB)	E-ST-32 #4.10l	E-ST-32 Annex L	Provides the alignment figures for each configuration for the studied structural item, the data measured at various step of the manufacturing of the structure and uncertainties on these figures				X	X	X							
Structure buckling (SB)	E-ST-32 #4.10m	E-ST-32 Annex M	Describes the analyses and the tests for buckling verification and reports their results, and the structure buckling modes & allowables				X	X	X							
Structure mass summary (SMM)	E-ST-32 #4.10n	E-ST-32 Annex N	Provides the mass properties (i.e. mass, COG location and inertia matrices) for each structure and system configuration			X	X	X	X							
Test analysis correlation (TAC)	E-ST-32 #4.10o	E-ST-32 Annex O	Provides a summary of test predictions, test results, correlation criteria and correlation between test and analytical data						X	X						
[Structure] Test evaluation (TE)	E-ST-32 #4.10p	E-ST-32 Annex P	Provides the documentation to assess the structure performance based on the test data						X	X						
[Structure] Test prediction (TP)	E-ST-32 #4.10q	E-ST-32 Annex Q	Provides the analysis prediction of response of the tested article to the specified test environment and loads.					X	X							
Specific mechanisms spec (SMS)	E-ST-33-01 #4.2.2a	E-ST-33-01 An.A	For each individual mechanism, it specify the requirements specific to the particular application.													
Mechanism design description (MDD)	E-ST-33-01#4.10a	E-ST-33-01 An.B	It provides with a comprehensive understanding of the mechanism design and functionality.													
Mechanisms analytical verification (MAV)	E-ST-33-01 #4.10b	E-ST-33-01 An.C	It provides with a comprehensive functional and performance analysis of the mechanism.													
Mechanism user manual (MUM)	E-ST-33-01 4.10c	E-ST-33-01 An.D	It provides with a comprehensive set of information and instructions for storage, transportation, handling, integration at subsystem or system level, and on ground and in-orbit operation of the mechanism.													
Propulsion performance analysis report (AR-P)	E-ST-35 #4.5.2.2.1a #4.5.2.2b, #4.5.2.4a #4.52.5a, 4.5.2.6b #4.5.2.7b & 4.11a	E-ST-35 Annex A	It analyses and establishes the performance of a propulsion subsystem or component and establishes a record of their performance evolution.													

Document	Required by	Described in	Description of the document	Project reviews														
				MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR	MRR
Gauging analysis report (AR-G)	E-ST-35 #4.11a	E-ST-35 Annex B	It analyses and describes the gauging system of a propulsion subsystem and its performance													
[Propulsion] thermal analysis	E-ST-35 #4.11a	E-ST-31 Annex A + E-ST-35 Annex C	Same that for the TCS thermal analysis													
Plume analysis report (AR=Pl)	E-ST-35 #4.5.10a & #4.11a	E-ST-35 Annex D	It analyses and describes the plume, including. shape, structure, composition, electromagnetic properties, particulate trajectories													
Nozzle and discharge flow analysis report (AR-N)	E-ST-35 #4.11a	E-ST-35 Annex E	It analyses and describes the nozzle and discharge flow in view of e.g. life-time, particle impingement, erosion, flow separation, shocks, heat transfer, performance assessment, and plasma characteristics.													
Sloshing analysis report (AR-S)	E-ST-35 #4.11a	E-ST-35 Annex F	It analyses and describes the sloshing, with the objective to e.g. design baffles in a tank, design the PMD, provide input data for coupled analysis with the control system, and evaluate the proper functioning of and the effects of sloshing on the propulsion sub-system.													
Propulsion transients analysis report (AR-Tr)	E-ST-35 #4.5.4.1b & 4.11a	E-ST-35 Annex G	It analyses and describes the transient operations of a propulsion subsystem, including ignition, chill-down, shut-down, effects of valve opening and closing, cross-talk between thrusters, start-up and shut-down of turbo-machinery, and system priming													
Propulsion subsystem user manual (UM)	E-ST-35 #4.11a	E-ST-35 Annex H	It provides the instructions and procedures for the use of a propulsion subsystem													
Mathematical modelling for propulsion analysis (MM-PA)	E-ST-35 #4.5.2.1b & 4.11a	E-ST-35 Annex I	It describes the mathematical models used for the analysis of a propulsion subsystem, equipment or component.													
[Propulsion] mathematical model requirements	E-ST-35 #4.11a	E-ST-31 Annex A + E-ST-35 Annex J	Same than for [Thermal] mathematical model specification													
[Propulsion] Mathematical model description and delivery	E-ST-35 #4.11a	E-ST-32 Annex I + E-ST-35 Annex K	Same than for Mathematical model description and delivery (MMDD)													

Document	Required by	Described in	Description of the document	Project reviews												
				MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR	MRR
Propulsion system instrumentation plan	E-ST-35 #4.5.14.1.1a & 4.11a	E-ST-35 Annex L	It identifies the instrumentation to be used to perform the required test measurements													
[Solid propulsion] Dynamic analysis report (AR-DY)	E-ST-35-02 #4.3.1 & #4.3.4b	E-ST-35-02 An.A	It analyses and establishes the characteristic of the environment, dynamic and acoustic, induced by the solid propulsion sub-system.													
[Solid propulsion] Material safety data sheet (AR-MSDS)	E-ST-35-02 #4.3.7d	E-ST-35-02 An.B	It gives the safety parameters for the solid propulsion subsystem.													
Propulsion cleanliness requirements analysis (CLA)	E-ST-35-06 #4.1, #4.2.1b, #4.2.2.3; #4.4, #4.5b & #9.a1	E-ST-35-06 An.A	It defines the requirements for particulate, non-volatile residues, visual cleanliness and dryness of spacecraft propulsion components, sub-systems, GSE and the environmental for assembly testing and handling.													
Propulsion cleaning technique selection (CTS)	E-ST-35-06 #4.1l2, #4.2.2.3, #4.3.1a, #4.5c, #5.1a, #5.5.1.a, #6.4.4 & 9a.2	E-ST-35-06 An.B	It specifies the cleaning techniques for a spacecraft propulsion component, subsystem and related GSE.													
Propulsion cleanliness certificate (CC)	E-ST-35-06 #4.1k, #4.4, #4.6a, #6.1, #6.4.1a & 9a.3	E-ST-35-06 An.C	It provides evidence that the subject meets the cleanliness requirements, reports the test results and identifies the responsible authority.													
Liquid propulsion compatibility assessment and applicability report (CAAR)	E-ST-35-10 #4.1, #4.2.1b, #5.2, #6.7, #6.10.2b & #7a.1	E-ST-35-10 An.A	It identifies potential material combination issues, and justifies and verifies already known solved problems													
Liquid propulsion compatibility testing report (CTLP)	E-ST-35-10 #5.1.2e, #6.1.4.3b, #6.7, # 6.10.2c & # 7a.2	E-ST-35-10 An.B	It gives the reasons for performing the compatibility tests, specifies the compatibility tests, presents a compatibility test plan, and presents the results of the compatibility tests.													
SW system specification (SSS)	E-ST-40 #5.2, #5.3 Q-ST-80 #7,1, #7.2	E-ST-40 Annex B	It contains the customer requirements allocated to software, being so the highest level description of the SW			X										
SW I/F requirements document (IRD)	E-ST-40 #5.2.4.3	E-ST-40 Annex C	It is an instantiation of the IRD (E-ST-10-24 An.A) for SW.			X										

Document		Required by	Described in	Description of the document		Project reviews												
						MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR	MRR
SW requirements specification (SRS)		E-ST-40 #5.4, #5.8 Q-ST-80 #6.3, #7.1, #7.2	E-ST-40 Annex D	It is a major constituent of the technical specification (TS) and describes the functional and non-functional requirements applicable to the software item.					X									
SW I/F control document (ICD)		E-ST-40 #5.4, 5.5, 5.8	E-ST-40 Annex E	It is an instantiation of the ICD (E-ST-10-24 An.B) for SW					X	X								
SW design document (SDD)		E-ST-40 #5.4, 5.5, 5.8 Q-ST-80 #7.2.2.3b	E-ST-40 Annex F	It is part of the DDF (E-ST-10 Annex J), and describes the SW architecture, detailed design and internal I/F					X	X								
SW release document (SRelD)		E-ST-40 #5.7.2.1 Q-ST-80 #6.2.4.3	E-ST-40 Annex G	is a constituent of the DDF (E-ST-10 Annex K), and describes a given SW version in terms of known problems, limitations or restrictions with respect to its approved baseline								X	X					
SW user manual (SUM)		E-ST-40 #5.5, #5.6	E-ST-40 Annex H	It is an instantiation of the PUM (E-ST-10 Annex P) for SW								X	X	X				
SW Verification plan (SVerP)		E-ST-40 #5.8 Q-ST-80 #6.2.6.2	E-ST-40 Annex I	It is an instantiation of the VP (E-ST-10-02 An.A) for SW						X								
SW Validation plan (SValP)		E-ST-40 #5.6, #5.8 Q-ST-80 #6.2, #6.3	E-ST-40 Annex J	It is a constituent of the DJF (E-ST-10 Annex K) and defines the organizational aspects and management approach to the implementation of the validation tasks.						X								
SW unit test plan	(SUITP)	E-ST-40 #5.4, #5.5 Q-ST-80 #6.2, #6.3	E-ST-40 Annex K	Both docs are part of the DJF (E-ST-10 Annex K), and describe the test plans for the SW unit or SW integration, respectively						X								
SW integration test plan										X	X							
SW validation specification (SVS)		E-ST-40 #5.6, #5.8 Q-ST-80 #6.2, #6.3	E-ST-40 Annex L	It is actually two docs: SVS w.r.t. the TS, and SVS w.r.t. Req Baseline. Both are part of DJF (E-ST-10 An.K), and describe the tests, analysis, RoD and inspections to be performed	wrt TS						X							
					wrt RB							X	X					
SW verification report (SVR)		E-ST-40 #5.3, 5.7, 5.8 Q-ST-80 #6.2, 7.1, 7.2	E-ST-40 Annex M	It is a constituent of the DJF (E-ST-10 Annex K), and gathers the results of all the software verification activities to be executed along the software development life cycle according to the SVerP							X	X	X	X	X	X		
SW reuse file (SRF)		E-ST-40 #5.4 Q-ST-80 #5.5, #6.2	E-ST-40 Annex N	It is a constituent of the DJF (E-ST-10 Annex N), and documents the analysis to be performed on existing software intended to be reused							X	X	X					

Document	Required by	Described in	Description of the document	Project reviews													
				MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR	MRR	
SW development plan	E-ST-40 #5.3 Q-ST-80 #5.6, 5.7, 6.3	E-ST-40 Annex O	It is a constituent of the management file (MGT), and describes the management and development approach for SW items to be defined by a SW supplier to set up a SW project i.a.w. the customer reqs.			X	X									
SW review plan (SRevP)	E-ST-40 #5.3.3.2b	E-ST-40 Annex P	It is part of the DJF (E-ST-10 Annex K), and describe the activities to be performed for SW during a formal project review (see M-ST-10-01)			X	X									
Comm's system req's doc. (CSRD)	E-ST-50 #5.2.1.3a	E-ST-50 Annex A	States the top level assumptions, constraints and comm. system requirements for a given mission, as an input for its design													
Comm's system baseline definition (CSBD)	E-ST-50 #5.2.3.3a	E-ST-50 Annex B	Top level comm. design document defining the comm. system to be developed													
Comm. system analysis document (CSAD)	E-ST-50 #5.2.2.3a & #5.2.2.3b	E-ST-50 Annex C	It captures the results of the analysis and testing of the comm. system													
Comm. system verification plan (CSVP)	E-ST-50 #5.2.2.3, #5.2.3.3c & #5.2.4.3	E-ST-50 Annex D	It describes the verification strategy and identifies the specific tests to ensure compliance with req's in the CSRD and CSBD													
Comm. system architectural design document (CSADD)	E-ST-50 #5.2.3.3a, #5.2.4.3b & 5.2.4.3f	E-ST-50 Annex E	It describes the architectural design of the comm. system defined in the CSBD, at the level that its functionality & operation can be understood, and req's for the system components can be elaborated													
Comm. system detailed design document (CSDDD)	E-ST-50 #5.2.3.3 & #5.2.4.3	E-ST-50 Annex F	It details the design of the comm. system, including the design of each system component included in the CSADD.													
Comm. system profile document (CSPD)	E-ST-50 #5.2.3.3a & #5.2.5.3a	E-ST-50 Annex G	It defines the frequencies, protocols and protocol options, address assignments, channel assignments, spacecraft identifier assignments, space link bandwidth allocations, and onboard bus bandwidth allocations used in the comm. system													
Comm. system operations manual (CSOM)	E-ST-50 #5.2.3.3d	E-ST-50 Annex H	It formally describes all procedures for the (normal and contingency) operations of the comm. system.													
S/C-Earth station I/F control doc.	E-ST-50-05 #8.2.2e	E-ST-50-05 An.A	It controls all the relevant parameters describing the I/F between the S/C and the Earth stations.			X	X	X								

Document	Required by	Described in	Description of the document	Project reviews												
				MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR	MRR
[Star sensor] Functional mathematical model (FMM)	E-ST-60-20 #5.12f	E-ST-60-20 An.A	It serves as an input for detailed AOCS analysis and detailed performances simulations													
AOCS design definition file	E-ST-60-30 #5.5.2b	E-ST-60-30 An.A	It is the instantiation of the DDF (E-ST-10 Annex G) for AOCS		x		X	X	X							
AOCS design justification file	E-ST-60-30 #5.5.2c	E-ST-60-30 An.B	It is the instantiation of the DJF (E-ST-10 Annex K) for AOCS					x	X							
AOCS algorithms and functional description	E-ST-60-30 #5.5.2d	E-ST-60-30 An.C	It details the functionalities of the AOCS algorithms, with a formalism that can be understood without software expertise					x	X							
AOCS Verification plan	E-ST-60-30 #5.5.2e	E-ST-60-30 An.D	It is the instantiation of the VP (E-ST-10-02 Annex A) for AOCS					x	X							
AOCS user manual	E-ST-60-30 #5.5.2f	E-ST-60-30 An.E	It gathers all the instructions and recommendations needed for the monitoring and control of the AOCS functional chain during flight.						x	X						
[GSO] Customer requirements document (CRD)	E-ST-70 #5.2.1b & #6.2.1b	E-ST-70 Annex A	It provides all essential top-level assumptions, constraints and operational requirements for the mission for the supplier(s) of the GS and/or Ops to design the GS and/or to develop an Ops concept.													
[Ops] Mission analysis report (MAR)	E-ST-70 #5.2.2.1c	E-ST-70 Annex B	It details all the information on the mission characteristics, in particular its orbit and attitude, for the planning and execution of mission Ops, so providing input to the spacecraft and mission design.													
[Ops] Mission operations concept document [MOCD]	E-ST-70 #5.2.2.2b	E-ST-70 Annex C	It defines the operations concepts for the various phases of the mission, covering both the space segment and the ground segment.													
Ops engineering plan (OEP)	E-ST-70 #5.2.2.4a.4	E-ST-70 Annex D	It defines the approach, methods, procedures, organization and resources to co-ordinate and manage all technical activities to prepare for, validate and execute mission Ops i.a.w. the customer's reqs													
[Ops] Space segment user manual	E-ST-70 #5.3.1b	E-ST-70 Annex E	It provides the space segment design and operational data that is used by the GS and Ops suppliers to prepare and implement mission Ops													
Ops validation plan (OVP)	E-ST-70 #5.2.2.6c	E-ST-70 Annex F	It defines how the GS and Ops are validated, subsequent to GS AIT, in order to satisfy the operational requirements contained in the customer requirements document (CRD).													

Document	Required by	Described in	Description of the document	Project reviews												
				MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR	MRR
[Ops] Mission operations plan (MOP)	E-ST-70 #5.3.2k	E-ST-70 Annex G	It contains all the rules, procedures and timelines during all mission phases, to implement the in-orbit Ops for the mission, and for conducting the contingency operations.													
Ops anomaly report (OAR)	E-ST-70 #5.8.2.4e	E-ST-70 Annex H	It documents a departure from expected performance of the space or ground segments, during operation, providing the information to allow to propose a workaround solution or further recovery action.													
Ops procedures	E-ST-70 #5.3.2l	E-ST-70 Annex I	Elementary component of the MOP, defining the actions to achieve a specific operational objective.													
[Ops] Customer furnished items and services reqs doc (CFISRD)	E-ST-70 #5.2.2.3g	E-ST-70 Annex J	It identifies the deliverable items and support services from the operations customer during all phases: operations preparation, operations validation, pre-and post-launch mission operations													

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Annex A
ESA training programme on ECSS

A.1 Description of the programme

The ESA training on ECSS is organized at three different levels, depending on the generality-specificity of the training:

a. Training at Level 1:

    1. Scope: The ECSS system

       It explains how the ECSS system of documents works, how is applied to Space projects, and hoe the individuals and ECSS organizations can contribute to and influence the ECSS system of documents. Section 5.2 of this guide is a part of this training.

    2. Modules and duration: 1 session of ½ day. This module is available in two formats:

       (a) Traditional training, presented by a trainer.

       (b) Multimedia self-training, which can be downloaded by the trainee and followed without the help of a trainer.

    3. Addressees: All technical and non-technical personnel dealing with standards at any level. It includes:

       (a) Users of the ECSS system, e.g. project engineers and scientist, support engineers, and legal and administrative personnel dealing with contract.

       (b) Potential authors of the ECSS system, e.g. experts in any area of expertise covered by ECSS, working in organizations in ECSS countries

b. Training at Level 2:

    1. Scope: The ECSS disciplines

       It explain one by one all the ECSS disciplines from a system point of view. In general, it does not go at the level of individual documents. It describes the standards, HBs and TMs covered by each discipline, how the interface each other and with related documents of other disciplines, and the intention and approach of the requirements on them.

    2. Modules at duration: It consists on a number of modules, of an approximate duration of ½ day each. At the present, the following modules are available:

#	Name	#	Name
M	Project management	E10	System engineering
Q10/20	PA/QA	E20	Electric and electronics
Q30	Dependability	E31	Thermal control
Q40	Safety	E32	Structural
Q60	EEE components	E33	Mechanisms
Q70	MMP&P	E40	Software engineering
Q80	Software PA	E60	Control engineering
U10	Space debris mitigation	E70	GSO

3. Addressees: Technical personnel who need to have a system view of the ECSS system of documents, or any of its disciplines, e.g. project managers, system and project engineers, PA managers, project controllers. *It is not addressed to experts.*

c. Training at Level 3

1. Scope: Individual ECSS topics, at the detailed necessary to be used by experts.

Normally, an ECSS topic is covered by one or some few ECSS documents, e.g. CCC (Cleanliness and Contamination Control, covered by 3 ECSS standards), Testing (covered by a standard and a HB).

2. Modules and duration:

It is the intention of ESA to cover by Level 3 training only some few selected topics. The reason is that the training material is to be developed by experts, and applied also by experts, sometimes working closely with the developers, so that the working environment is the best place for a training on the job. There are, however, some few exceptions, where the developer community is not in so close relation with the community that has to apply the documents. ESA will develop ECSS training at Level 3 only when this situation is identified.

Due to the different nature of the different modules, the duration may vary from between modules, but typically is 1,5 days per module.

At the present time, the following topics have been identified as candidates for Level 3 training:

(a) ESA pointing error HB. This HB is not an ECSS document, but an ESA one. It is presented here, as part of the ESA training on ECSS for two reasons: (1) It intention is to help to apply the ECSS standards E-ST-10 and E-ST-30, and (2) The interest of all the ECSS community (ESA and non-ESA experts) on this training.

(b) Testing, covering the testing standard (E-ST-10-03) and the testing HB (E-HB-10-03).

(c) PUS (Packet utilization standard), addressing the coverage of E-ST-70-41, and its application and tailoring for different missions

(d) CCC (Cleanliness and contamination control) covering Q-ST-70-01, Q-ST-70-05 and Q-ST-70-12.

3. Addressees: It is addressed to experts and to personnel directly applying the documents in projects.

A.2   Sessions

ESA organized training sessions at ESTEC, covering all the Level1 and all Level 2 modules annually. Level 3 modules are only organized under demand.

Participation in the ESTEC sessions for non-ESA personnel is possible under certain conditions:

1.   ESA personnel have priority, therefore availability is subjected to ESA needs.

2.   ESA will respond only to requests from ESA-NSO (National Space Offices from ESA countries). ESA-NSO may include in their requests their own personnel, or personnel from Industry and institutions of their own country.

3.   Nationals from non-ESA countries will not be accepted, unless an special agreement between ESA and their organizations so allows it.

A.3   Training material

All the training material is publicly and freely available in pdf format for download in ECSS website (www.ecss.nl), clicking on "Standards" (in the orange band on the top), and then in "Training material" (in the blue area on the left).

It is important to note that, as stated in each module, the material is ESA property and therefore is subjected to ESA copyrights, which includes, among others, that *the material cannot be modified at all*.

The complete set of conditions of the ESA copyrights are as follows:

Annex B
Proposed simplified standardization documentation

It is a general principle (both for ESA and for ECSS) that, except in some few casas, the required content of a deliverable document is mandatory, but not the format nor the way the information is organized in the document. It is also permitted to merge two or more documents in a single one as far as the complete information required by the several documents is covered by the latter.

It is also important to note that, in accordance with the ECSS principles, deliverable documentation requirements are, as any other requirement, not tailorable to the size of the project or organization, but on the type of product, project phase and a number of programmatic parameters as e.g. assumable risk. In line with this, this guide does not present a pre-cooked tailoring of the contents themselves, but a simplification *of the format* of the documents such that the overall content is kept. The objective of the approach followed is to merge close-related deliverable documents in one single one, containing the information of all the documents, but avoiding repetition of the common contents. Since DRDs in ECSS (see 5.2.5.3) only require the information to be delivered, not the format, this approach is perfectly compliant with ESA and ECSS requirements.

The simplification of the deliverable documents presented here may not be of the interest of large companies (but they can also use it if so desired), because different document are prepared by different people, and sometimes by different departments. However, it may be of high interest for small organizations, where a very reduced number of people has to prepare all the documents to be delivered.

The proposed deliverable documents are presented in Table B-1 (for ECSS S and M), Table B-2 (for Q) and Table B-3 (for E). Each entry includes the proposed name of the document, its purpose and objective, the ECSS and ESA documents covered by it, and delivery time.

This annex covers only deliverable documents linked to the ESA contract itself and with project reviews. **It does not covered deliverable documents linked to specific events**, which are expected to be delivered when the associated event take place. The list of such deliverables and their associated events, for S&M, and Q documents, are covered respectively in Table 7-8 and Table 8-15.

Table B-1: Proposed simplified System and Management documents

Document name	Purpose and mandatory references	Delivery at	ESA docs covered	ECSS docs covered
Technical requirements compliance matrix	Declaration of compliance to the standards and requirements specified in the contract	Tender presentation	Technical requirements compliance matrix ([1]#Annex B)	Technical requirements compliance matrix (S-ST-00 #9.3)
SRD/PRD to the lower level suppliers	Demonstrate that the requirements are appropriately flowed down to the next level suppliers	Tender presentation	SRD to the lower level suppliers ([1] Annex C.B)	PRD to the lower level suppliers S-ST-00 #9.a & M-ST-00 #5.2.1
Evidence of subcon compliance with SRD/PRD	Demonstrate that subcons will be able to do the work	Tender presentation & update @ Project reviews	Evidence of subcon compliance with SRD ([1] Part 3.D.1.ii)	Requirement traceability matrix "RTM" (E-ST-10 Annex N)
Management and administration proposal (MAP)	- Describes the general management activities - It shall refer to the **PA plan** (PAP) and to the **SE Plan** (SEP)	Tender presentation & update @ Project reviews	Management and administration proposal "MAP" ([1] Annex C.A)	Project Management Plan "PMP" (M-ST-10 #5.1.3a / Annex A)
			ILS approach (part of the MAP)	ILS approach (Part of the PMP)
			Risk management policy and plan (part of the MAP)	Risk management policy and plan "RMPP" (M-ST-80 Annexes A&B)
			Configuration management plan (part of the MAP)	Configuration management plan "CMP" (M-ST-40 Annex A)
			Cost & schedule management plan "CSMP"(Part of the MAP)	Cost & schedule management plan "CSMP" (Part of the PMP)
			N/A	Inventory control plan "ICP" (M-ST-60 #9.3.6)
			Cost estimation system ([1] Part 3 #F.1.ii)	Cost estimation plan "CEP" M-ST-60 Annex F
			Milestone payment plan	Milestone payment plan "MPP" M-ST-60 Annex H
			Project review programme	N/A
			Project organization breakdown structures ([1] Annex C.C)	Project organization breakdown structures (Part of the PMP)
			Key personnel ([1] Part 3 D.2 - 2nd bul)	Key personnel (Part of the PMP)

Document name	Purpose and mandatory references	Delivery at	ESA docs covered	ECSS docs covered
Work and Contract Breakdown Structures and Packages (WCBSP)	- Presents an exhaustive breakdown of the **Product Tree** (see **DDF**) elements (including the functions to be performed and services to be provided), dividing the project in manageable work packages (WPs), describing them in detail. - It shall refer to: + the **Product tree** **+ the PDRs to lower level suppliers**	Tender presentation & update @ Project reviews	Work breakdown structures (WBS), including the WP, control WP and DIL ([1] Annex D.D)	Work breakdown structures (WBS) (M-ST-10 #5.3h & Annex C)
				Work package (WP) (M-ST-10 #5.3n & Annex D)
			Contract Structure ([1] # Annex C.E	Business Agreement Structure (BAS) (M-ST-60 #7.1.3a &b)
			Geo & company breakdown ([1] Annex C.D)	Geographical distribution report (M-ST-60 #9.2.6a & 9.3.5a & Annex E)
Configuration management document	- Lists all the items identified in the **Product Tree** (see **DDF**) to be kept under configuration control (both HW and SW), describes individually each of them and specifies which documents constitute the documentation baseline. - It shall refer to the **Product Tree**	Tender presentation & update @ Project reviews NOTE: The CIDL and the SCF need not to be delivered at tender presentation, only at the updates at project reviews	Configuration management document, which includes the Configuration baseline and the CIL ([1] #4.1.2.3e7)	Configuration Item List (CIL) (M-ST-40 #5.3.1.2b & Annex B)
				Configuration baseline (CB) (M-ST-40 #5.3.1.3a & b)
			N/A	Configuration item data list (CIDL), one per HW item in the CIL (M-ST-40 #5.3.3.2a & Annex C)
			N/A	Software configuration file (SCF), one per SW item in the CIL (M-ST-40 #5.3.3.2b & Annex D)
Cost & price breakdown document		Tender presentation and update @ project reviews	Cost Breakdown Structure (CBS) ([1] Annex B.E & #4.1.2.3e.5)	Cost Breakdown Structure (CBS) (M-ST-60 #7.1.1a & Annex A)
Financial proposal	- It shall refer to: + the Product Tree + The payment milestone plan (in the Project monitoring schedule & control	Tender presentation and update @ project reviews	Financial proposal, including:	
			-Company rates & overheads	
			-Company price breakdown form	Company price breakdown form "CPBF" (M-ST-60 9.2.2a & Annex D)
			-Project manpower & price breakdown	
			-Total contract price	Cost estimation report
			-Company manpower & price	

Document name	Purpose and mandatory references	Delivery at	ESA docs covered	ECSS docs covered
			-Company manpower & cost plan	
			-Company price projection vs payment plan	
			- High rel parts procurement	
Project monitoring schedule and control			Project monitoring schedule & control (which includes among others the payment milestone plan)	Project monitoring schedule and control
Risk assessment			Risk assessment	Risk assessment
Schedule				

Table B-2: Proposed Simplified Product Assurance documents

Document name	Purpose and mandatory references	Delivery at	ESA docs covered	ECSS docs covered
Master product assurance plan (Master PAP)	- Describes the supplier PA organization, activities, processes and procedures to perform all the PA and QA activities relevant to the contract - The "ODSI" principle applies - It shall refer to the OTS qualification plan (part of the overall qualification plan)	Tender presentation and update @ project reviews	PA/QA/Safety aspects ([1] Annex B)	PA plan (Q-ST-10 #5.3.1 & Annex A)
				QA plan (Q-ST-20 #5.1.1 & Annex A
				SW PA programme plan (Q-ST-80 #5.2.1 & Annex B)
				SW Maintenance plan Q-ST-80, #6.3.8
				Safety programme plan (Q-ST-40 #5.2 & Annex B)
			N/A	Dependability programme plan (Q-ST-30 #4.3 & Annex C
			Hi-rel parts procurement ([1] Annex E)	EEE components programme plan (Only needed for Class 1 compon.) (Q-ST-60 #4.1.2.2 & Annex A)
			-	Radiation hardness assurance plan Q-ST-60 #4.2.2.4g
			-	Component evaluation plan Q-ST-60 #4.2.3.1d
			Logistic plan ([1] Annex D)	Logistic plan (Part of the PMP)
			Storage plan ([1]	Storage plan (Q-ST-20-08 #5,2, #5.3 & Annex A)
			Transportation plan ([1] Annex D)	N/A
			N/A	OTS plan Q-ST-20-10 #5.1.1a & Annex A)
			N/A	C3 plan (Q-ST-70-01 #5.1 & Annex B)
			N/A	Contamination requirement spec (Q-ST-70-01 Annex A)

Document name	Purpose and mandatory references	Delivery at	ESA docs covered	ECSS docs covered
			N/A	MMP&P evaluation programme Q-ST-70 #5.5.2, #6.5.2 & #7.5.2
			N/A	MMP&P validation programme Q-ST-70 #5.5.3, #6.5.3 & #7.5.3
Qualification status list	summarizes <u>for each configuration item</u> the status achieved with respect to the planned qualification.	Project reviews	N/A	Qualification status list Q-ST-10 #5.2.1 & Annex B
Critical item list	lists all the critical items	Project reviews	N/A	Critical item list Q-ST-10-04 #5.1 & Annex A
NCR status list	provides a complete representation of the status of all non-conformances, for each product, at any time	Project reviews	N/A	NCR status list Q-ST-10-09 #5.5 & Annex B
EIDP (End Item Data Package) (including EIDP for GSE)	collects, <u>for each deliverable configuration item</u>, all data related to manufacturing, assembly, integration and test (including or referring to MoM, certificates, NCRs, ABCL, RFW&RFD, logbook, lower level EIDP, non-installed items), providing so the necessary traceability. It is the basis for the acceptance of the product.	Project reviews (also when delivering an item)	N/A	EIDP Q-ST-20 #5.7.1, #5.8.4 & Annex B
FMECA report (including HSIA)	Presents the result of the FMECA. FMECA is performed in accordance with the SOW.	Project reviews	N/A	
Declared MMP&P list	Lists the materials, mechanical parts and processes used or intended to be used in the project.	Project reviews	N/A	Q-ST-70 Annexes A, B and C

Table B-3: Proposed simplified Engineering documents

Documents to be delivered in the E branch is very much dependent of the type of product. Therefore, the documents listed below are to be delivered only if relevant for the type of contract.				
Document name	**Purpose and mandatory references**	**Delivery at**	**ESA docs covered**	**ECSS docs covered**
Mission assessment and system concept ONLY IN PHASE 0+A	Present the result of the analysis of the Mission Statement document such that justifies the selection of the concept system	Tender presentation and update @ project reviews	Mission assessment ([1] Annex B)	Mission Description document "MDD" (E-ST-10 Annex B)
			Concept of design ([1] Annex B)	System concept report (E-ST-10 Annex C)
Complete System engineering plan (CSEP)	Defines the approach, methods, procedures, resources and organization to coordinate and manage all the definition, design, verification, and maintenance activities during the complete lifecycle of the project, highlighting the risks, critical elements, technologies, re-utilization and standardization.	Project reviews	N/A	System engineering plan "SEP" E-ST-10 Annex D
				Verification plan "VP" E-ST-10-02 An.A (& others verification plans DRDs)
				AIT plan (E-ST-10-03 Annex A)
				HCD process plan (E-ST-10-11 An.A)
				EMC control plan and EM Effect Plan (E-ST-20 Annexes A and B)
				Electric hazard mitigation plan E-ST-20-06 Annex A
				Fracture control plan "FCP" E-ST-32 Annex F
				SW development plan E-ST-40 Annex O

Document name	Purpose and mandatory references	Delivery at	ESA docs covered	ECSS docs covered
Technology plan and matrix ONLY IN PHASES 0+A & B	Defines the approach, methods and resources used to evaluate technologies, and use them to evaluate competitor critical technologies	Tender presentation and update @ project reviews	N/A	Technology plan (E-ST-10 Annex E)
			TRL assessment ([1] Annex B)	Technology matrix (E-ST-10 Annex F)
Design definition file "DDF"	Establish the technical definition of a product, compiling all the information on "as-design" functional and physical architecture and characteristics	Tender presentation and update @ project reviews	Design definition (Mechanical, Thermal, Electrical, Software, Interfaces, Integration and test logic) ([1] Annex B)	Design definition file "DDF" (E-ST-10 Annex G)
				I/F control document "ICC" (E-ST-10-24 Annex B)
				Interface definition document "IDD" (Or "Single-end ICD") (E-ST-10-24 Annex C) & others ICDs DRDs
				Interface identification document "IID" (E-ST-10-24 Annex D)
			N/A	Function tree (E-ST-10 Annex H)
			Product Tree ([1] Annex D.B)	Product Tree (M-ST-10 Annex B)
			System budgets ([1] Annex D.B)	Technical budget (E-ST-10 Annex I)
			Specification tree ([1] Annex D.B)	Specification tree(E-ST-10 Annex J)
			N/A	Preliminary and final TS for next level supplier (E-ST-10-06 An.A)
				Product user manual "PUM" E-ST-10 Annex P (& others user manual DRDs)

Document name	Purpose and mandatory references	Delivery at	ESA docs covered	ECSS docs covered
Design justification file "DJF"	Presents the rational for the selection of the design solution	Project reviews	N/A	Design justification file "DDF" (E-ST-10 Annex K)
				Requirement traceability matrix w.r.t next lower level E-ST-10 Annex N
				Requirement justification file E-ST-10 Annex O
				System concept report E-ST-10 An.C
				Trade-off reports (E-ST-10 Annex L)
				Verification control doc "VCD" (including verification matrix) E-ST-10-02 Annex B
				All analysis reports E-ST-10 An.Q (& others analysis report DRDs)
				All test specs E-ST-10-03 Annex B (& others test specs DRDs)
				All test procedures E-ST-10-03 An.C (& others test procedures DRDs)
				All test reports E-ST-10-02 An.C (& others test reports DRDs)
				RoD reports E-ST-10-02 Annex D
				Inspection report E-ST-10-02 An.E
				Verification report E-ST-10-02 An.F