A beginners guide to ECSS

(and its relationship to Project Management, Quality Management and your project)

Summary

The purpose of this presentation is:

a) Introduce the **ECSS** (**E**uropean **C**ooperation for **S**pace **S**tandardization) Standards

b) Give you an overview of what they are and how to find them

c) Give you some practical advice on how to start using them and introducing them to your project/ company

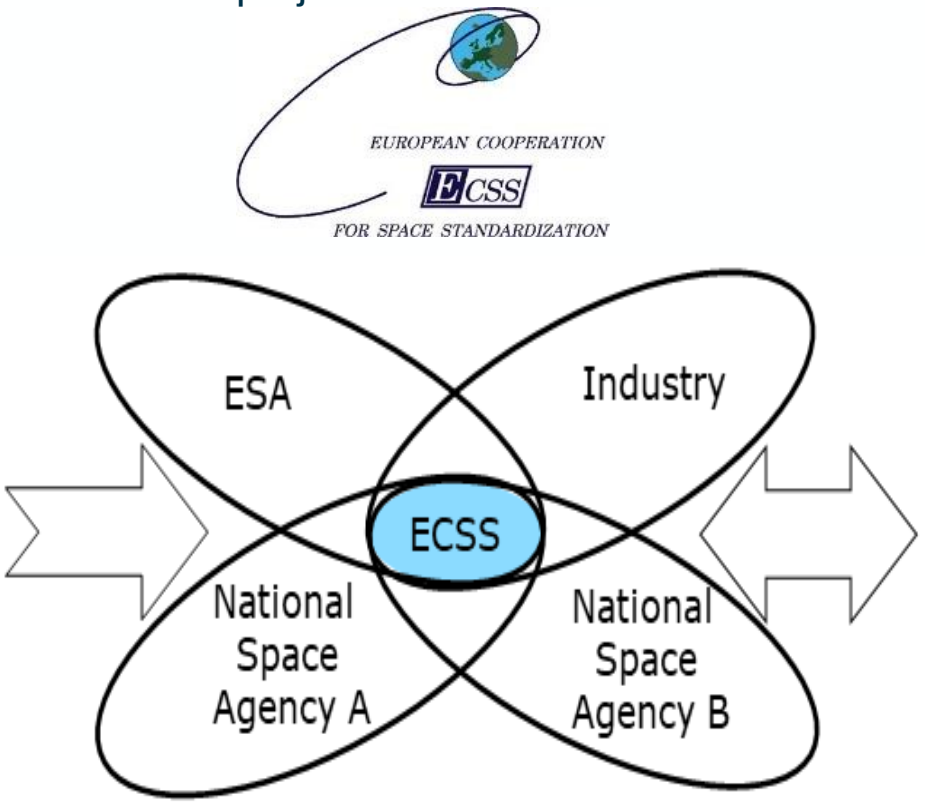
This is an introductory presentation designed to give you a **basic** working knowledge of the system and how it fits into your project.

The ECSS

The **ECSS** was established in 1993 to develop and maintain a coherent set of common standards for use in all European space activities. It is a cooperative undertaking of the European Space Agency, National space agencies and European industry associations - governed by its members. It addresses all essential elements (Project management, Engineering and Product assurance) for the successful implementation of space programmes and projects.

Voting Members

National Space Agencies



Observers

Standards

At present many standards exist: e.g., **ISO**, **MIL-STD**, **NTSS, CEN, IEEE**

ECSS is the European system of standards for space related activities BUT can be applied to any commercial area.

ECSS standards are based on requirements and each requirement concerns the need to be fulfilled, NOT the means to be used to fulfil it. That way the fulfilment of the requirements is not constrained by a companies infrastructure and usual practices.

In addition, they are continually harmonised with international standards and/or working practices. In some cases they refer out to other standards (like MIL-STD)

All contractors working on ESA projects are obliged to use the standards, which are typically made applicable in the contract documentation. The ECSS is also commonly adopted in the commercial space programmes of both European and American Large Scale Integrators (LSIs).

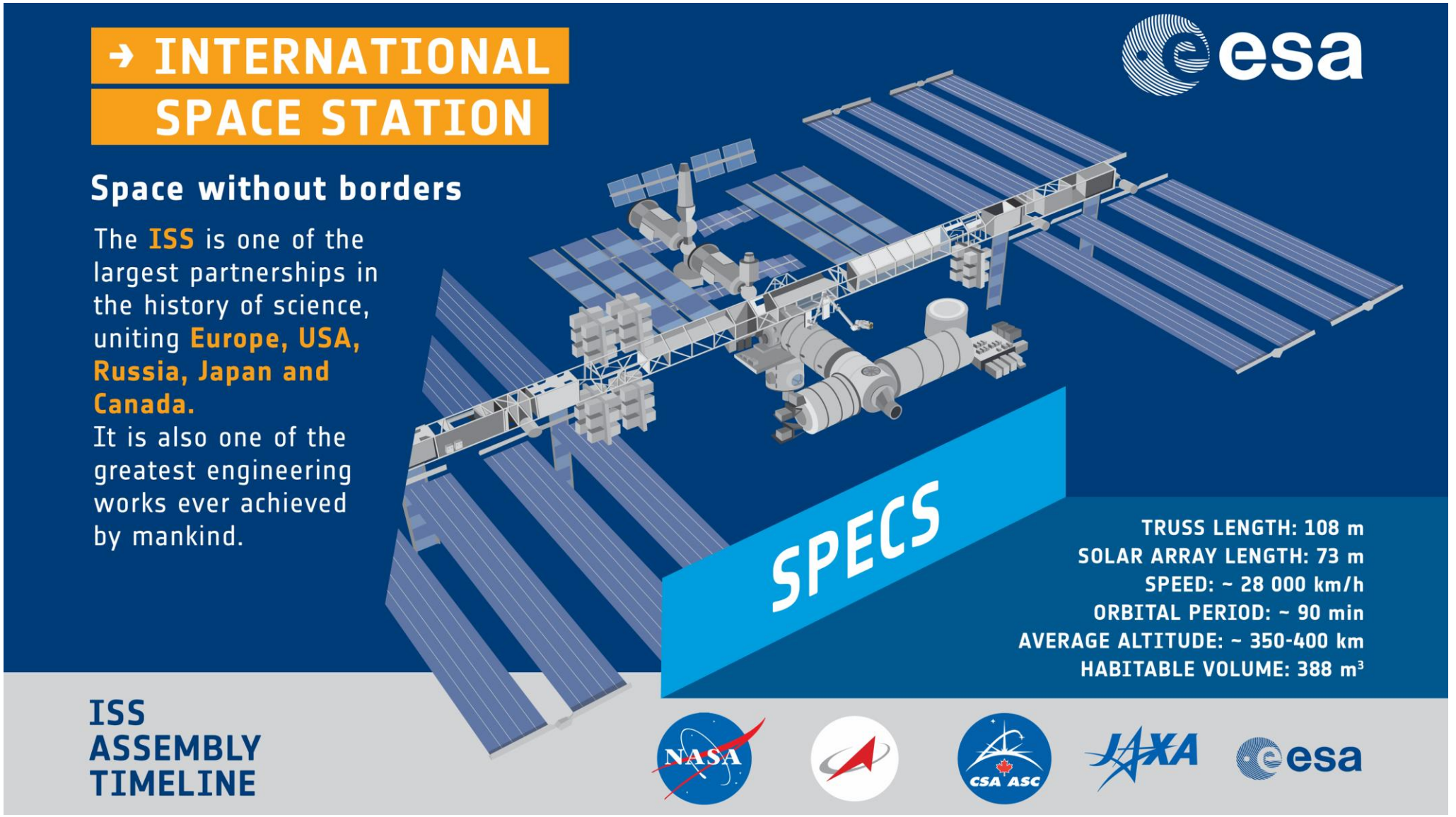
Even where they are not obliged, using ECSS can help prevent costly mistakes.

Objectives of the ECSS

The primary objectives of using the **ECSS** system of standards are:

- to reduce risk and guarantee interoperability and interface compatibility
- to facilitate clear and unambiguous communication between all parties
- to improve the quality and safety of space projects and products,
- to achieve and ensure cost effective space programmes and projects in Europe
- to improve the to improve the competitiveness of European space industry

When Standards are followed

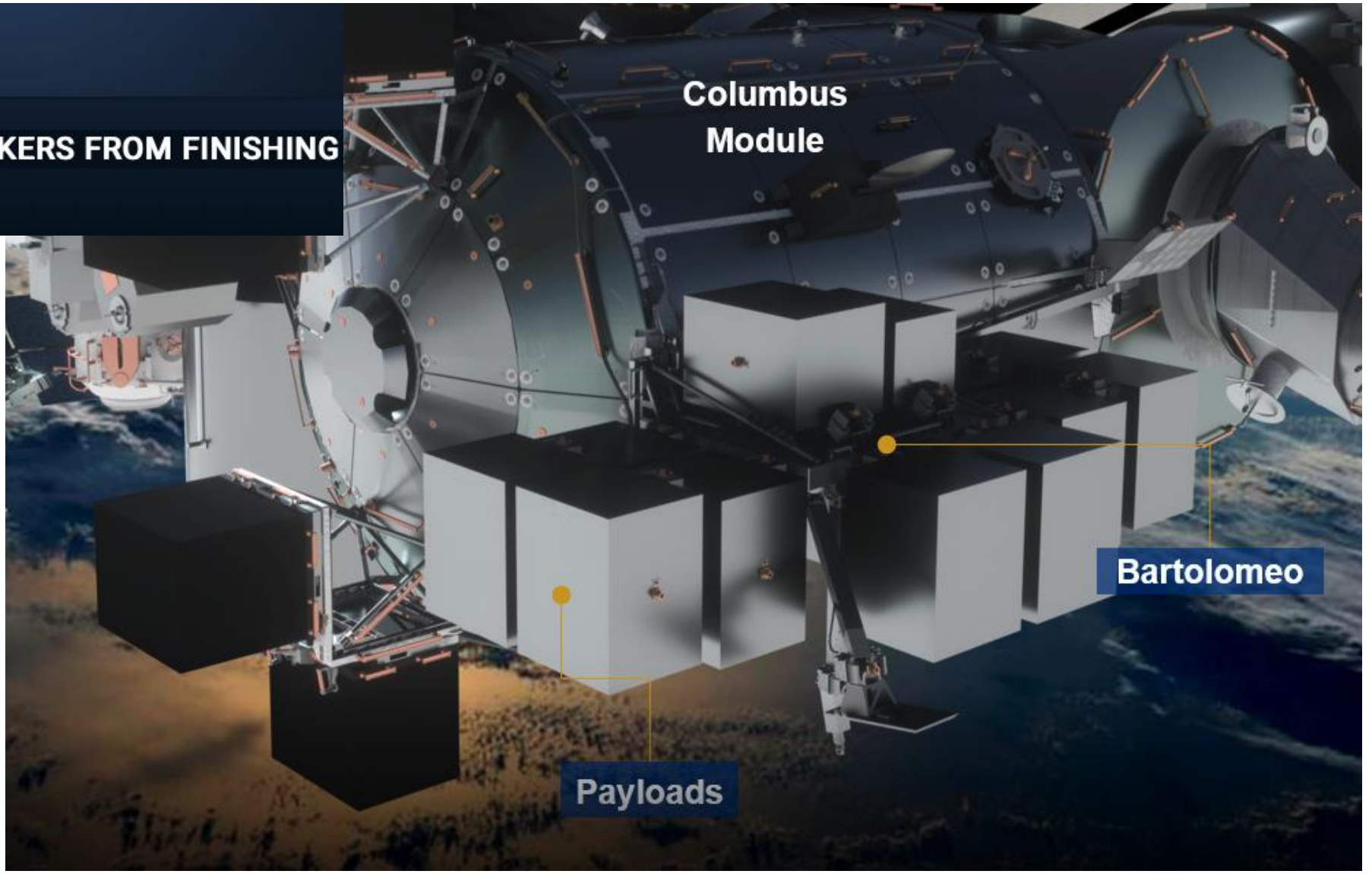


When Standards are not followed

SPACEFLIGHT INSIDER

CABLE ISSUES PREVENT SPACEWALKERS FROM FINISHING BARTOLOMEO INSTALLATION

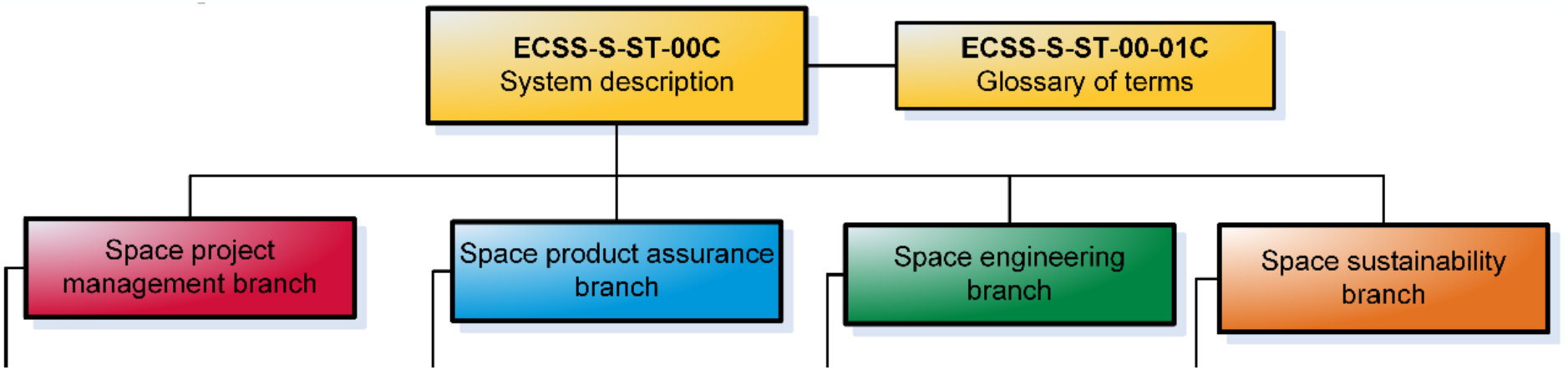
JANUARY 27TH, 2021



The ECSS documentation structure – the Branches

There are **four main branches** of the ECSS system (designated **M**, **Q**, **E**, **U**) plus an overlying instructional branch (designated **S**):

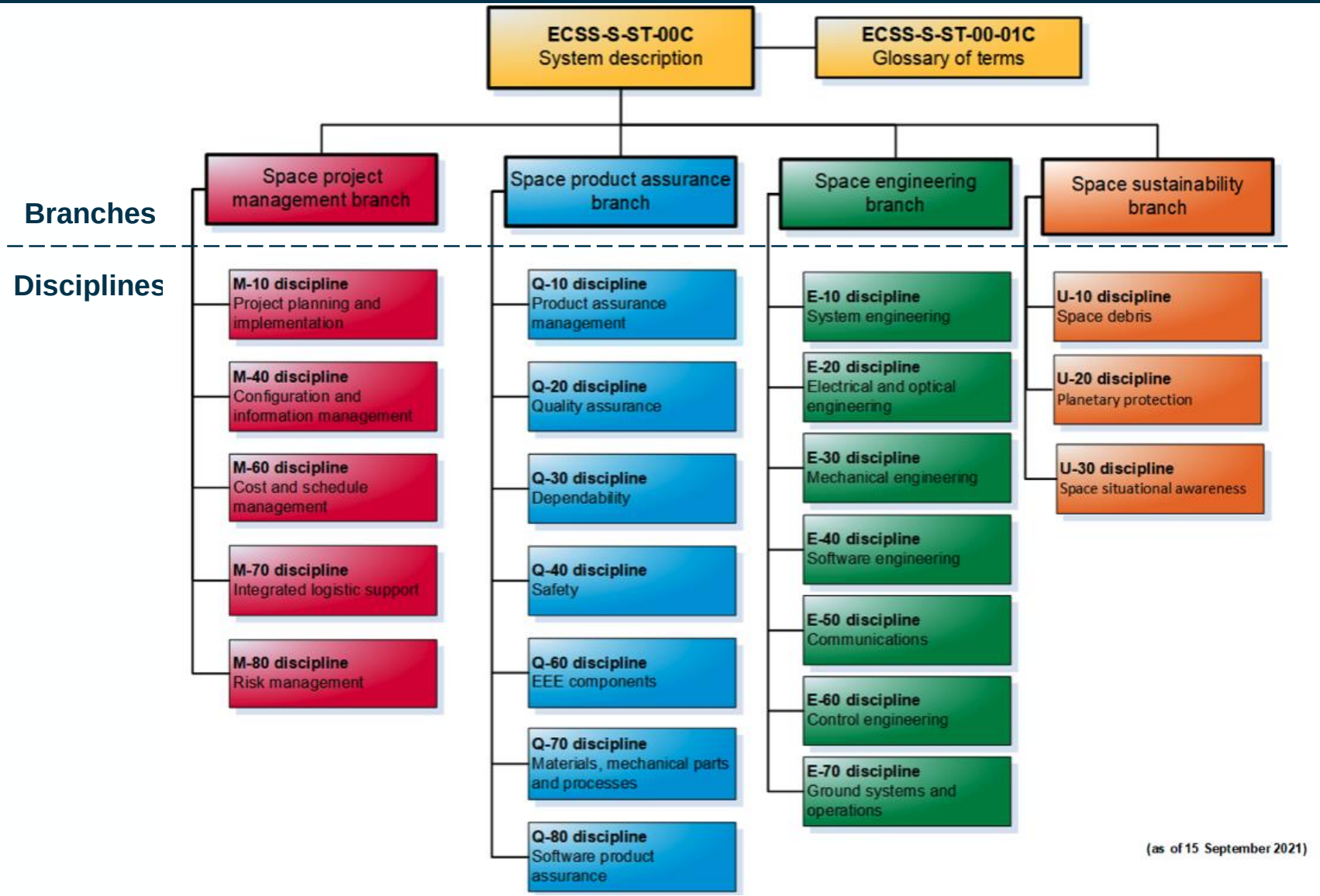
- ***S*** – *System*
- **M** – Project management
- **Q** – Product Assurance
- **E** – Engineering
- **U** – Space Sustainability



Focus first on 3 branches:

- The **M** branch addresses **project management** and has many useful templates. (contains 6 Standards).
- The **Q** branch addresses **Product and quality assurance** but many standards are directly relevant to engineers (e.g. material and processes). (contains 62 Standards, 10 Handbooks, 4 Technical Memoranda).
- The **E** or **Engineering** branch is responsible for definition of the end product, verification that customer's technical requirements are achieved and in conformance with the regulation and company constraints. (contains 66 Standards, 46 Handbooks, 6 Technical Memoranda).

The ECSS documentation structure – the Disciplines



The branches in turn are subdivided into "disciplines".

For example, there are seven disciplines in the Engineering Branch covering different areas (designated **E-10** to **E-70**). These are:

E-10 System engineering,
E-20 Electric, electronics & optics,
E-30 Mechanical,
E-40 Software Engineering,
E-50 Communications,
E-60 Control Engineering and
E-70 Ground Systems and Operations.

ECSS document types

In essence the ECSS is a large document database containing three basic types of documents. These are:

Standards (ST)

Normative documents

Content limited to verifiable **requirements** – state **what to do**

For direct use in invitations to tender and business agreements – Compliance often asked (via compliance matrix)

Handbooks (HB)

Non-normative documents*

Provide guidelines and/or a collection of technical data memoranda: **How to do it!**

Technical memoranda (TM)

Non-normative documents*

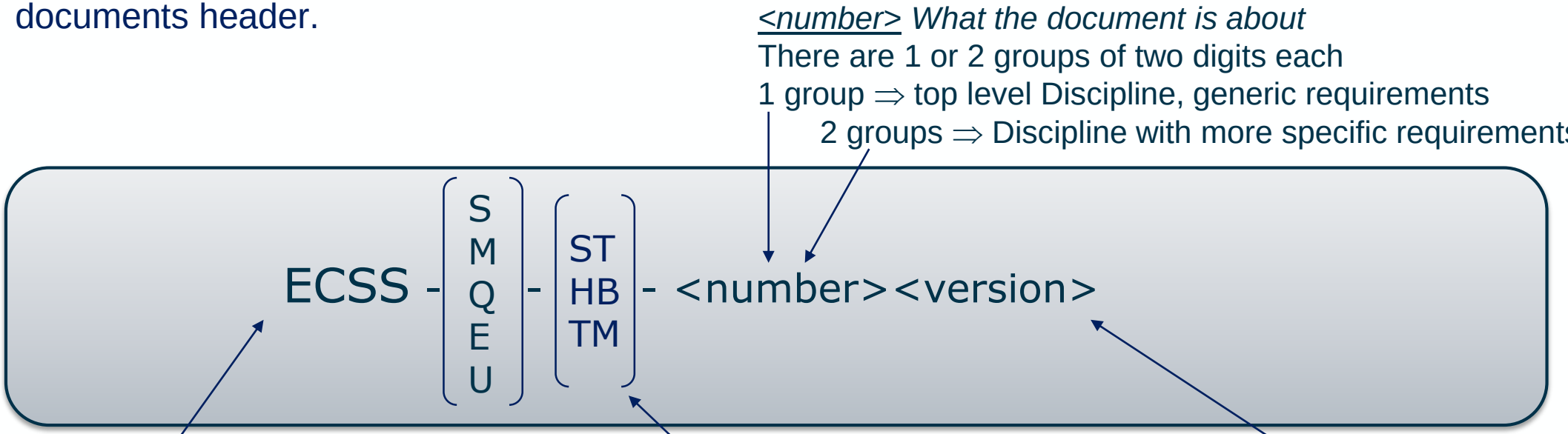
Provide useful information or data to the space community

Content not mature enough to become a standard or a handbook: **Guidelines**

**Non-normative means additional information or advice that isn't a formal part of the standard.*

Denomination of ECSS documents

Its fairly easy to navigate through the ECSS web pages to find the documents that you want. The key is in the documents header.



<u><*number*></u> *What the document is about*
There are 1 or 2 groups of two digits each
1 group ⇒ top level Discipline, generic requirements
2 groups ⇒ Discipline with more specific requirements

<u><*version*></u> is a letter from A onwards

An ECSS Document

<u>Branch</u>
System
Management
Quality
Engineering
U Sustainability

<u>Type</u>
***St**andard,*
***HandB**ook or*
***T**echnical **M**emoranda*

Example:
E-ST-50 Communications (standard)
E-HB-50A Communications (handbook)
E-ST-50-05C Radio Frequency and modulation (standard)

Structure of an ECSS standard

- **Change Log, [introduction]**
1. **Scope**
   Clear and concise identification of the coverage
   and applicability of the standard
2. **Normative reference**
   Listing only documents referenced from the requirements
3. **Terms, definitions and abbreviated terms**
4. **[Principles and/or background]**
   containing only informative/guidance material
5. **Requirements**
   containing the normative provisions
   it may contain some NOTES and a few guidance sub-clauses with only guidance material
6. **[more requirements]**

n. **[pre-tailoring (per product type and project phase)]**

only mandatory if the standard is subject to pre-tailoring

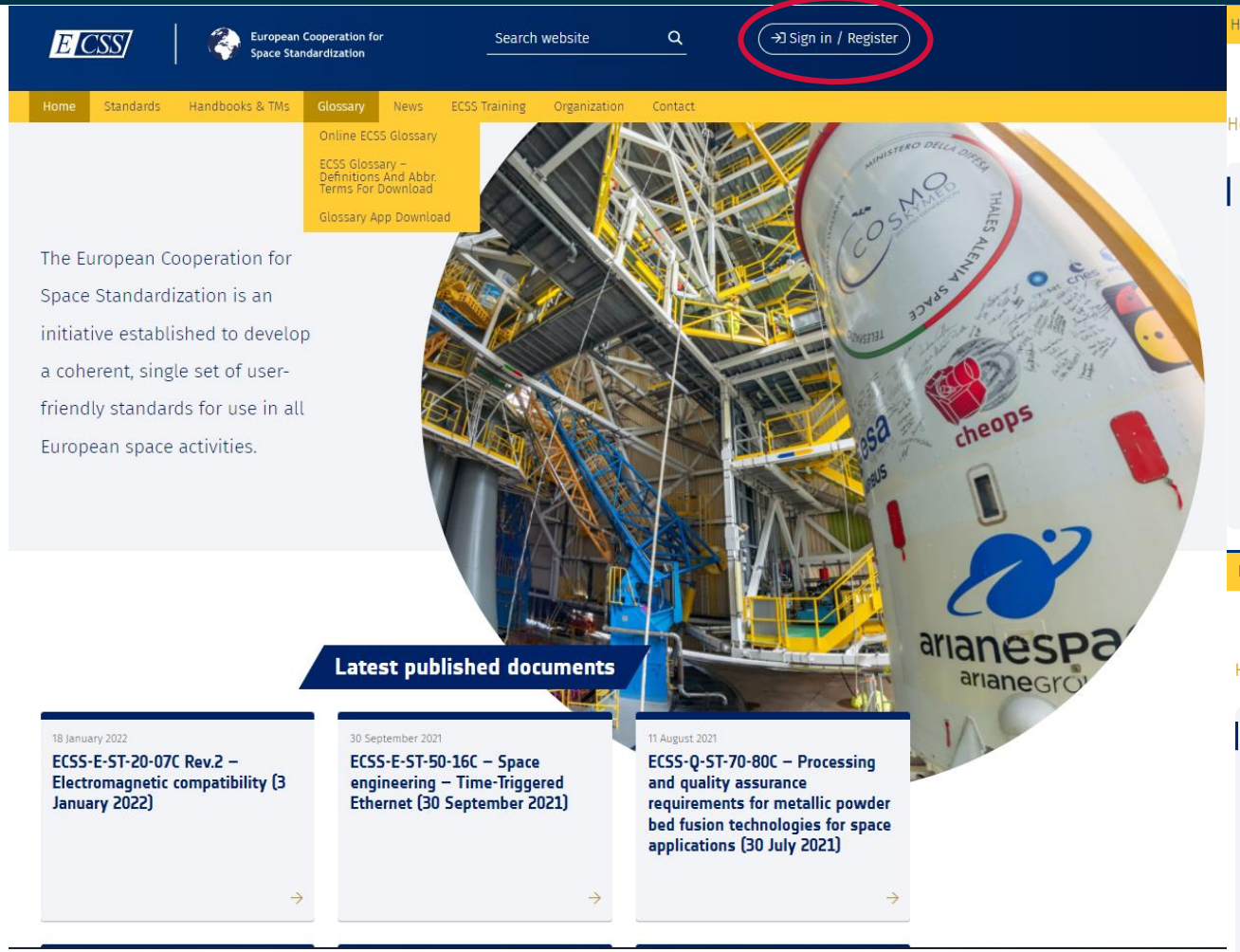
- **[Annexes]**
  - Normative annexes (DRDs) –always first
  - Informative annexes
- **Bibliography**

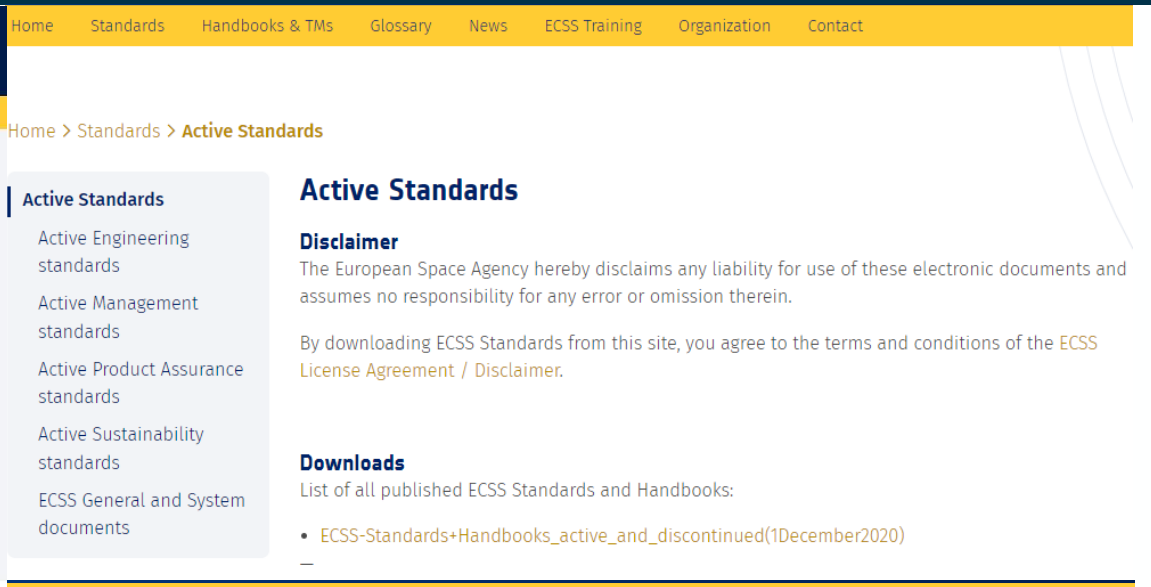
normative reference := reference to another standard explicitly done from a requirement. If a document is not mentioned in the normative clauses of the standard it SHALL NOT be listed in normative reference.

All the interesting stuff!

DRD := Document Requirements Definition
Normative annexes (they are requirements).
Specify the content of a deliverable document, not the format, only the information to be provided.

How do I access ECSS information ?



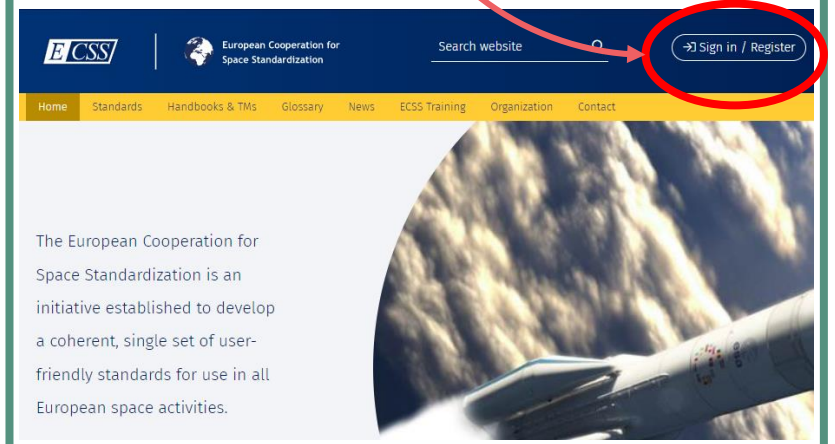


Home page: www.ecss.nl

How to register and logging in (create account)

1

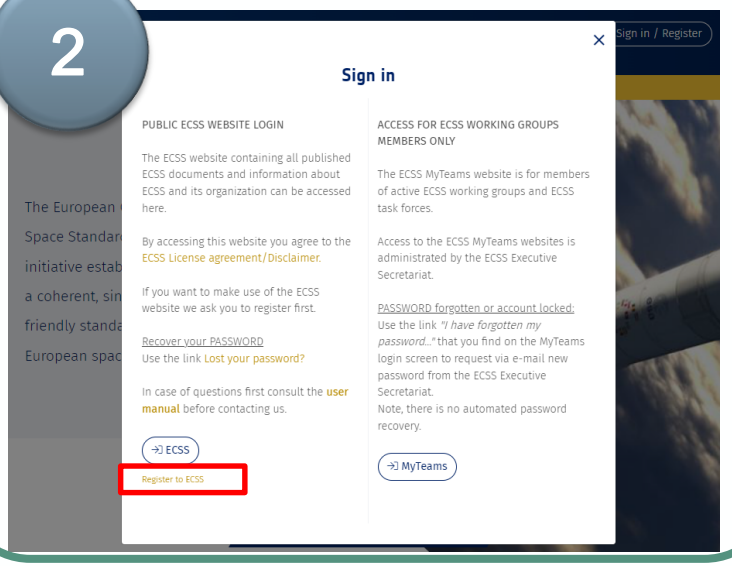
Go to ecss.nl and click on the ***Sign in / Register*** button



a) If you do not have an account:
click on the
Register to ECSS button

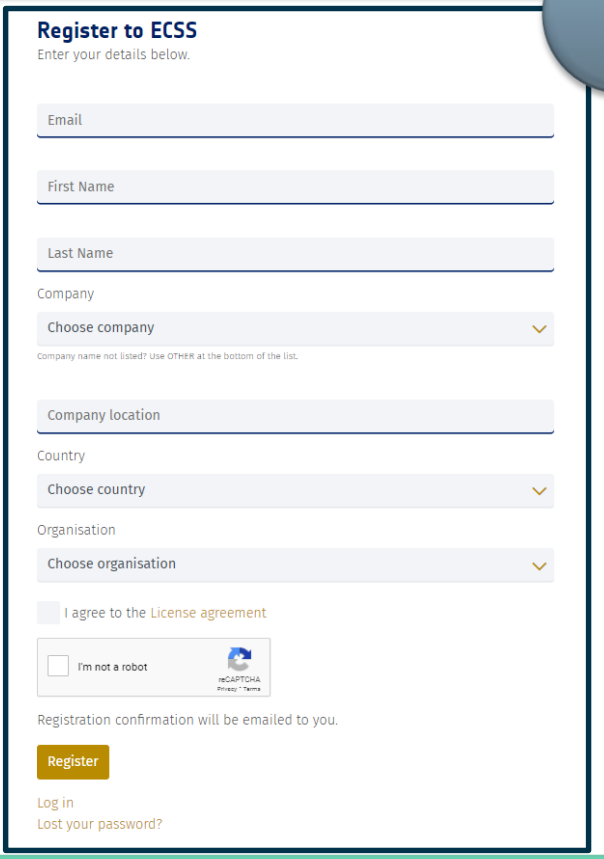
b) If you have an account:
click on the ***ECSS*** button

2



a) If you do not have an account: fill in the ***Register to ECSS form:***

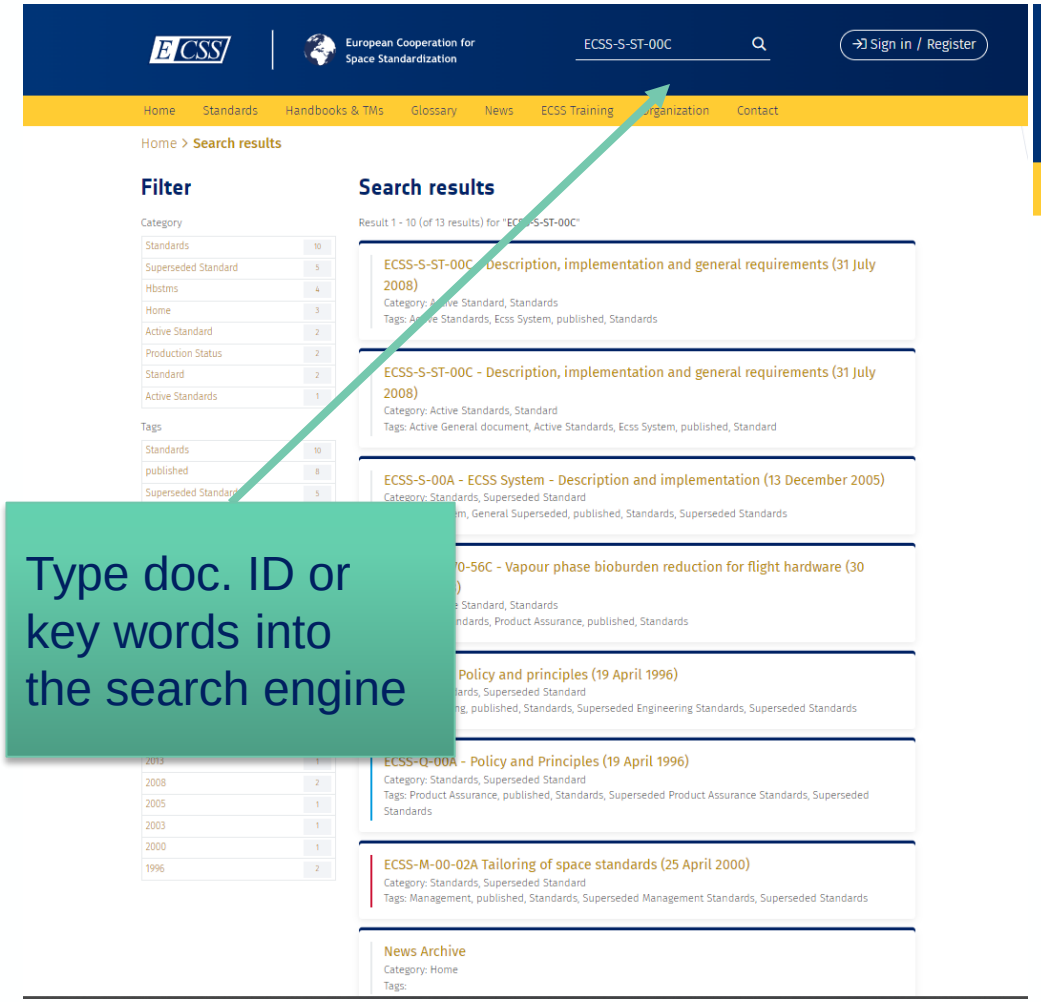
3



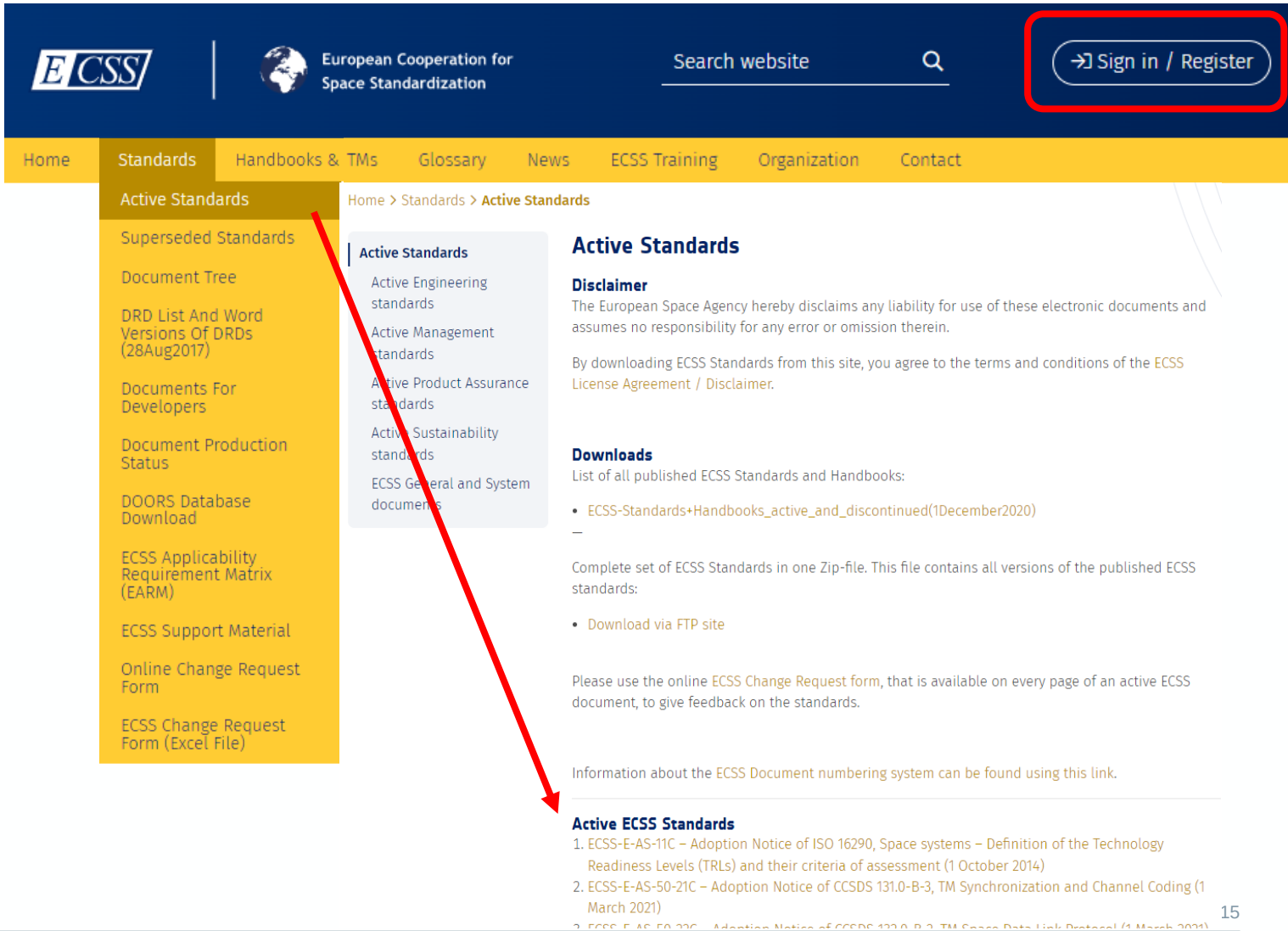
b) If you have an account: fill in ***username and password***

Downloading

Download **ECSS-S-ST-00C** "ECSS System, description, implementation and general requirements"



Type doc. ID or key words into the search engine

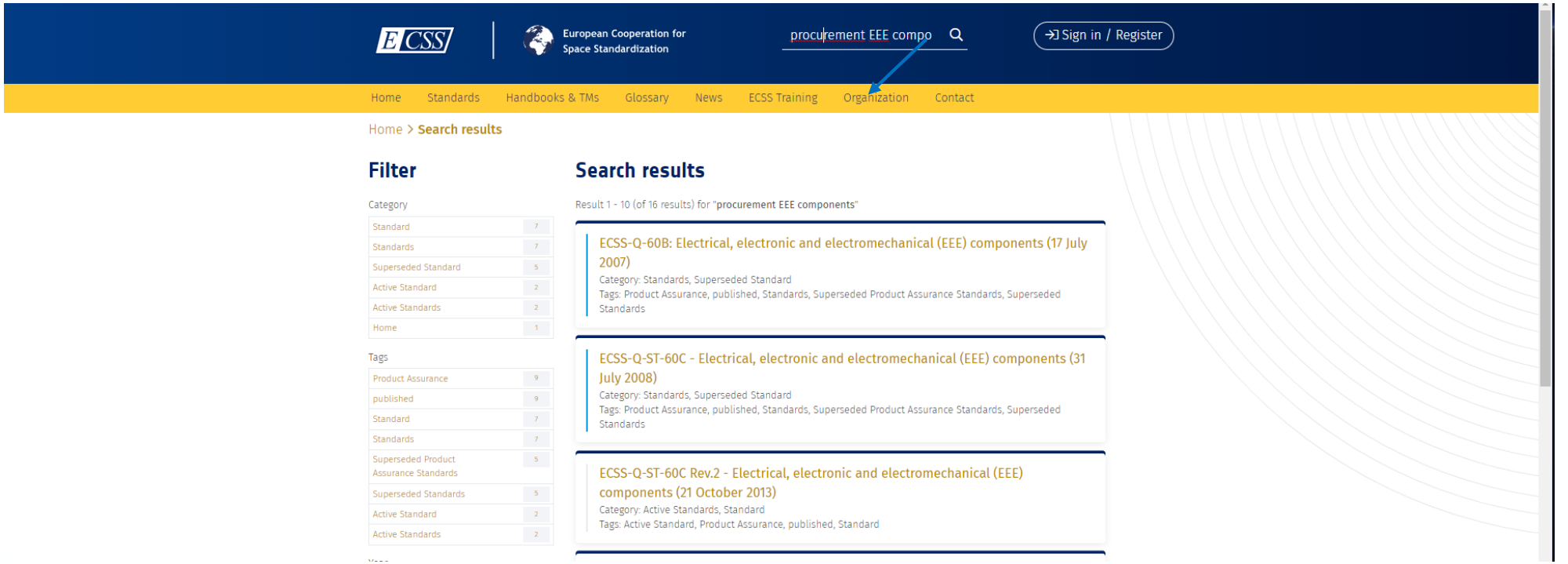


Finding documents is easy – an example:

“I'm new to the space business, I need to procure some components .. can I go to Radio Shack ?”

…well probably not

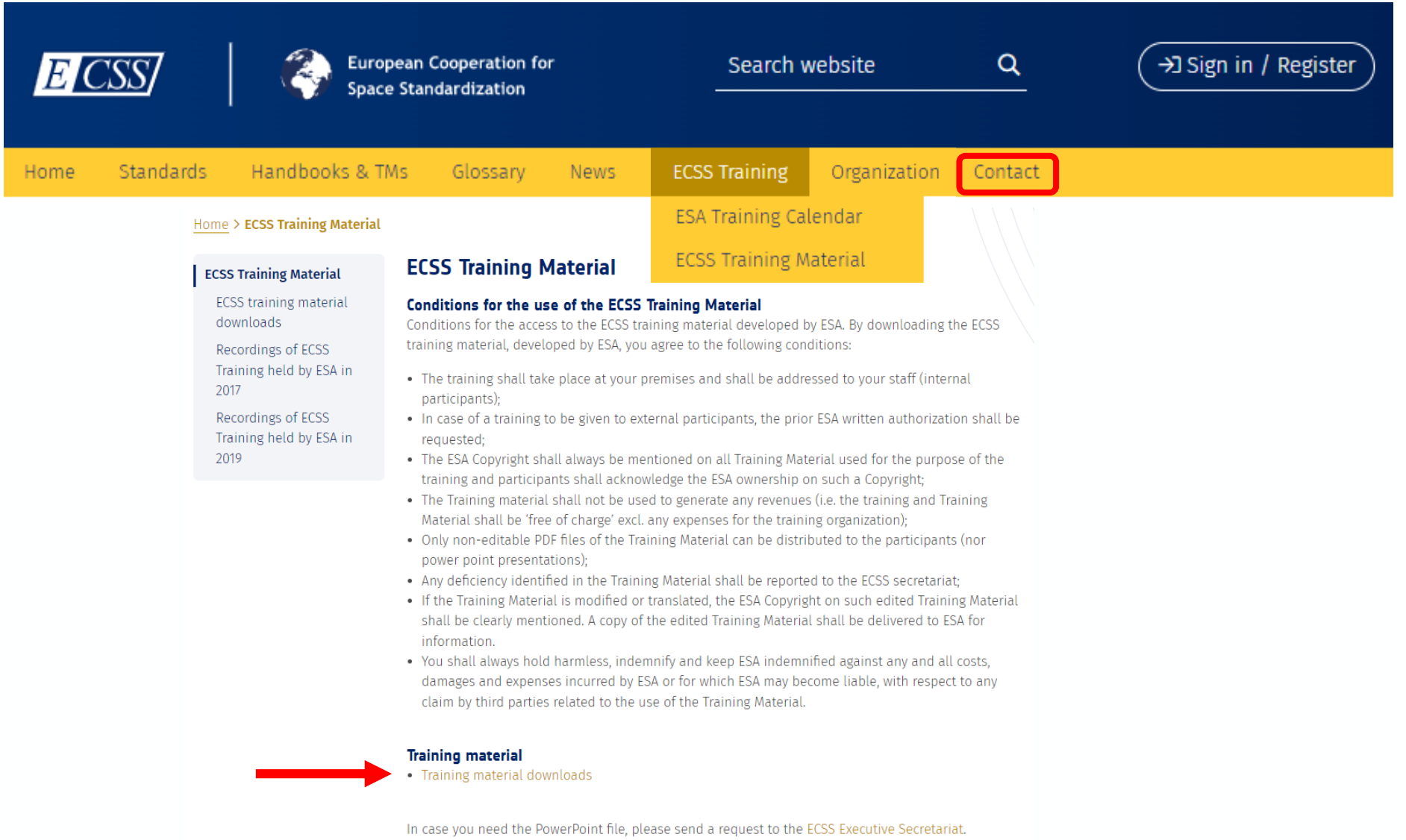
Its EEE so look in the EEE components discipline, or type in keywords (e.g. *procurement EEE components*) into the search engine



You need

ECSS-Q-ST-60: Requirements for the **selection, control, procurement and usage** of EEE components at equipment level

Need more help .....



So, where to START?

Starting to use ECSS can be daunting

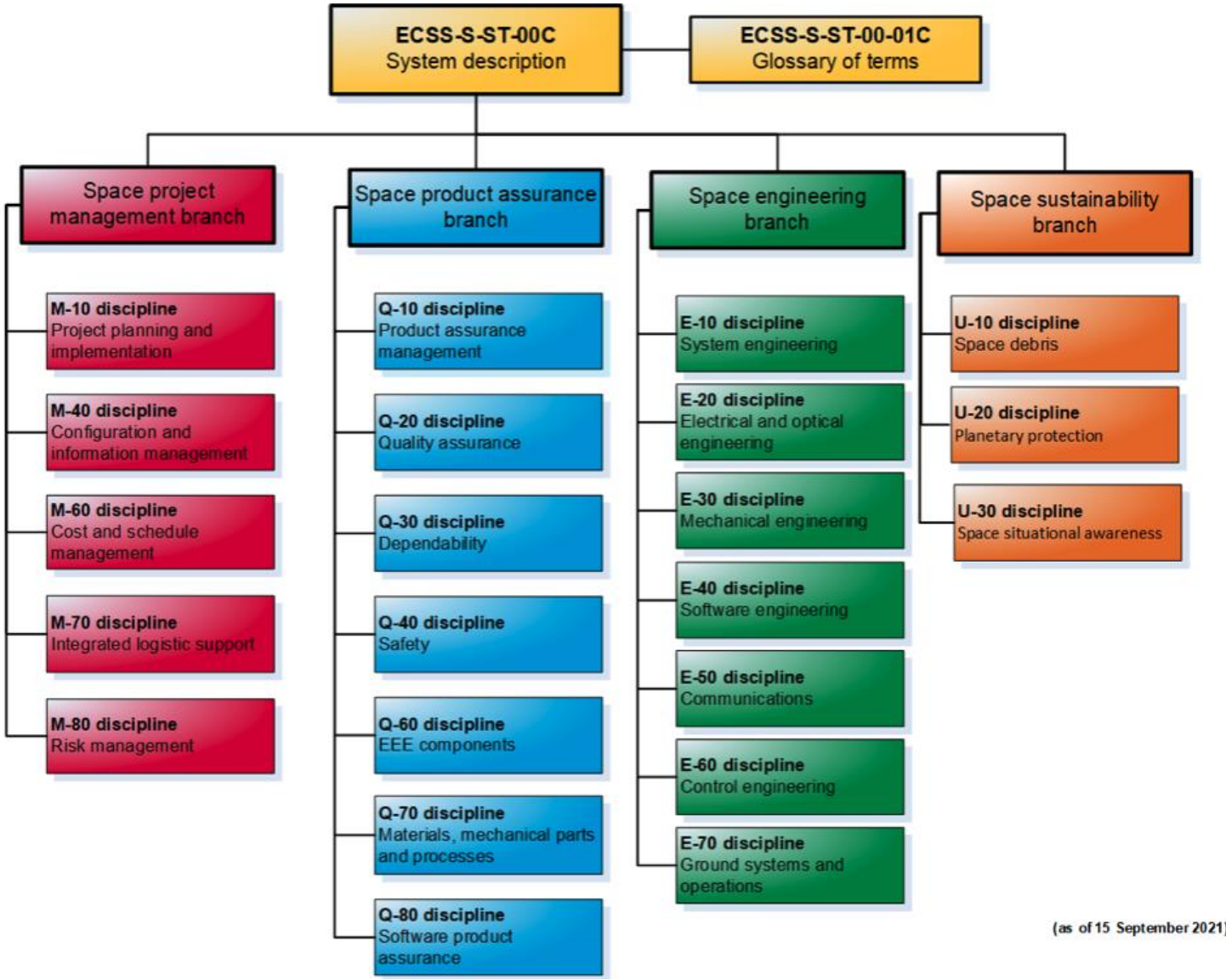
To be compliant with all in one step is **impractical** and **not cost effective**. It will also stop your development for some months!

Gradually introduce ECSS standards to your product, company and way of working

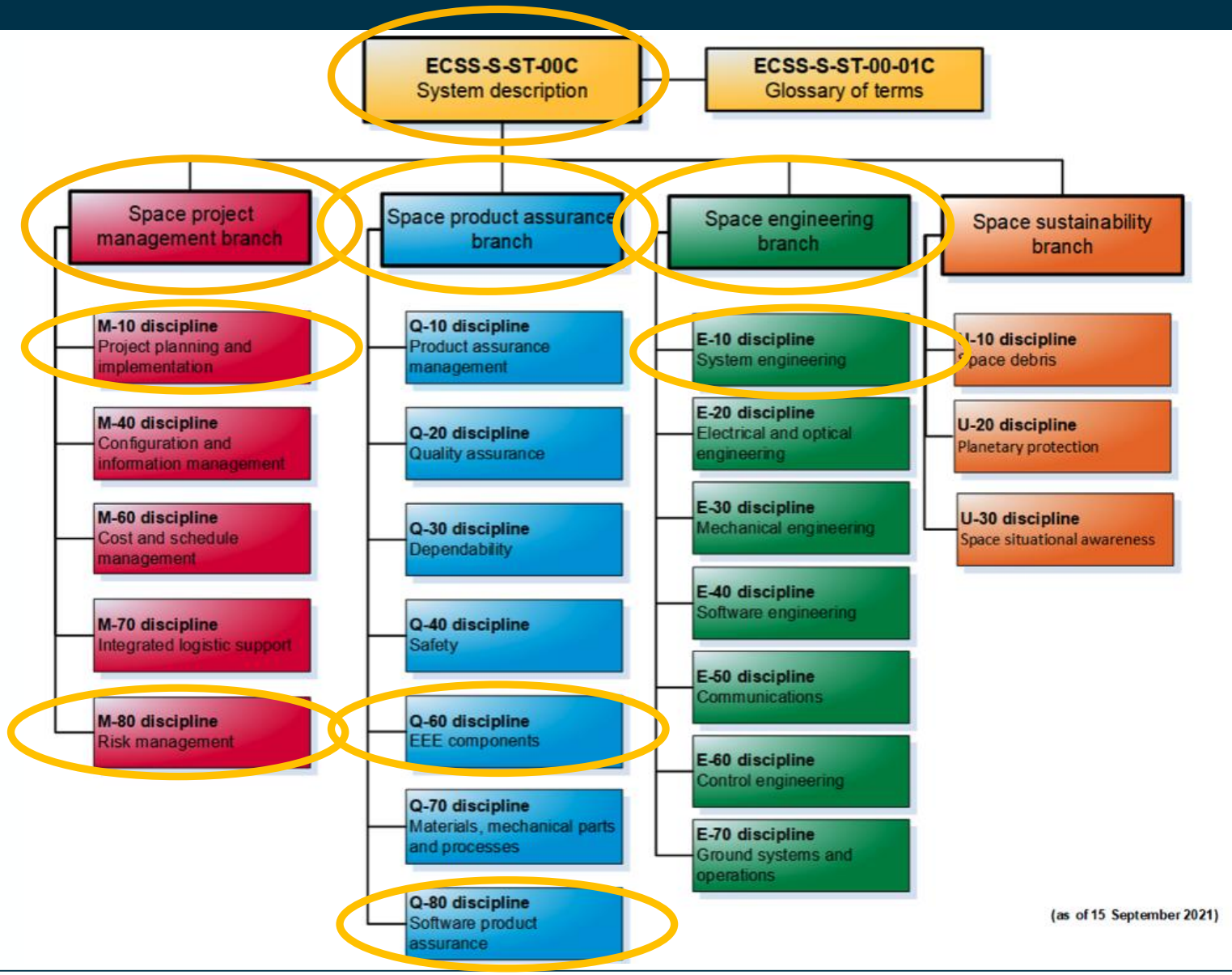
Start with an **awareness**, progress to using the key principles of the main standards applicable to your project and as you go up in TRL so become more rigorous in the implementation and expand the scope of the documents you are compliant with

Use the PECS/ RPA funding to help!
We encourage you to develop a few TRL steps at a time. Each step / activity you are encouraged to have a requirement consolidation task – ECSS form part of those requirements.

Today's plan


ECSS-S-ST-00C
System description
ECSS-S-ST-00-01C
Glossary of terms
Space project management branch
M-10 discipline
Project planning and implementation
M-40 discipline
Configuration and information management
M-60 discipline
Cost and schedule management
M-70 discipline
Integrated logistic support
M-80 discipline
Risk management
Space product assurance branch
Q-10 discipline
Product assurance management
Q-20 discipline
Quality assurance
Q-30 discipline
Dependability
Q-40 discipline
Safety
Q-60 discipline
EEE components
Q-70 discipline
Materials, mechanical parts and processes
Q-80 discipline
Software product assurance
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
Space sustainability branch
U-10 discipline
Space debris
U-20 discipline
Planetary protection
U-30 discipline
Space situational awareness
(as of 15 September 2021)

Today's plan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Control engineering
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Ground systems and operations
U-10 discipline
Space debris
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Planetary protection
U-30 discipline
Space situational awareness
(as of 15 September 2021)

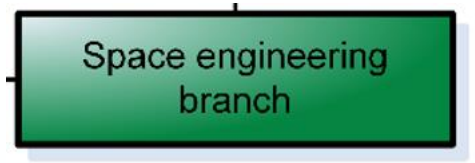
Getting started

Setting up Project Management

- Planning and Implementation
- Reviews
- Risk

Setting up a Quality Management System

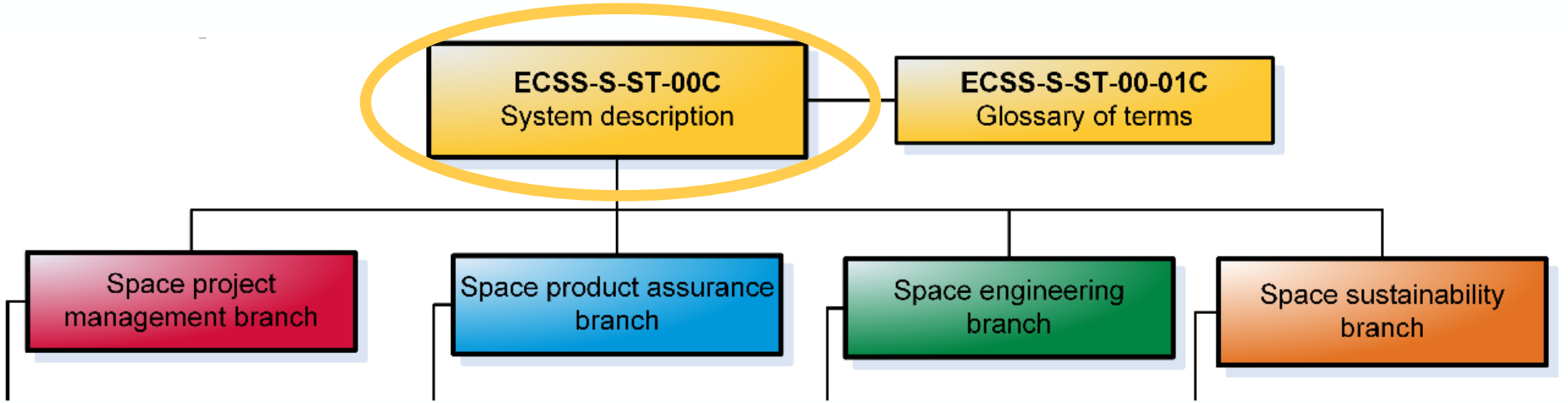
- Product assurance management
- Quality assurance management
- Electrical, electronic and electromechanical (EEE) components
- Procurement of printed circuit boards (PCBs)
- Software PA



Engineering Standards and best practices

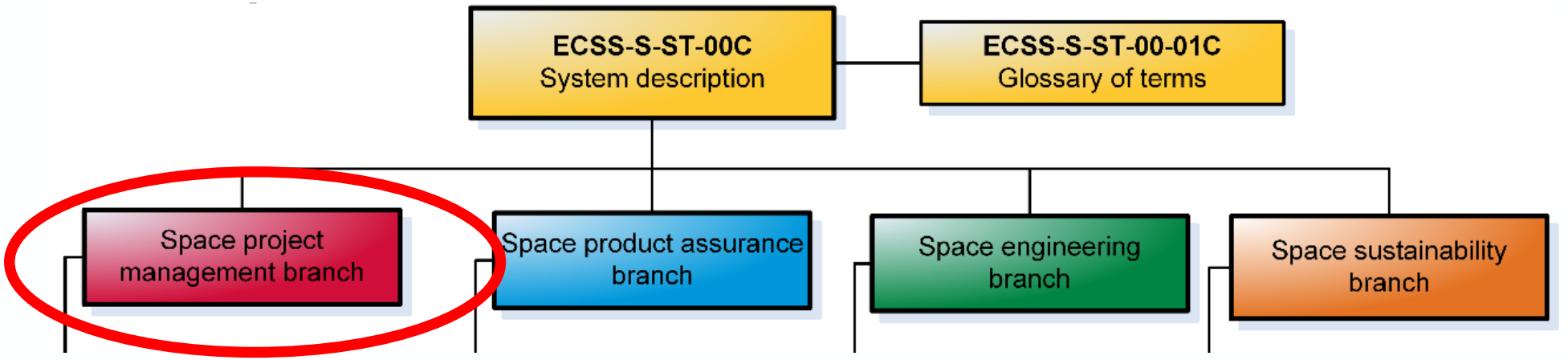
- Technological Readiness Levels
- The Space Environment (example radiation)
- Testing

ECSS General system description [S-Branch]



The **S Branch** covers the ECSS description, implementation and general requirements.

Space Project Management [M-Branch]



The **M Branch** addresses all aspects of Management needed for a project (setting up a project, reviews, costing etc.).

Space Project Management [M-Branch]

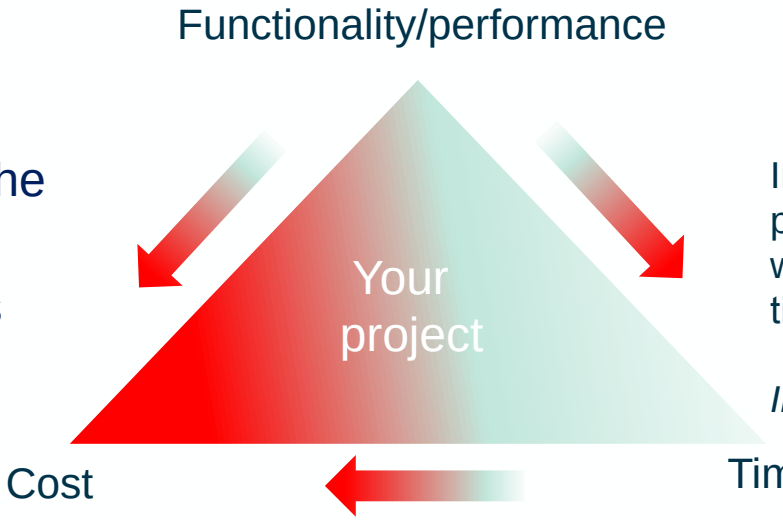
The Discipline	What it addresses	Where to find it
Project phases and implementation	Principles and requirements of project phasing and planning management	**ECSS-M-ST-10C Rev.1** **ECSS-M-ST-10-01C**
Configuration & information management	Managing the information/documentation and configuration of products within a space programme or project.	ECSS-M-ST-40
Cost and schedule management	Provides the requirements for cost and schedule management	ECSS-M-ST-60
Integrated logistic support	Identification and provision of logistical support to maintain a product in its operational conditions for the expected lifetime	ECSS-M-ST-70
Risk management	Defines the principles and requirements for integrated risk management on a space project	**ECSS-M-ST-80**

★ *Recommend to start reading*

Space Project Management [M-Branch]

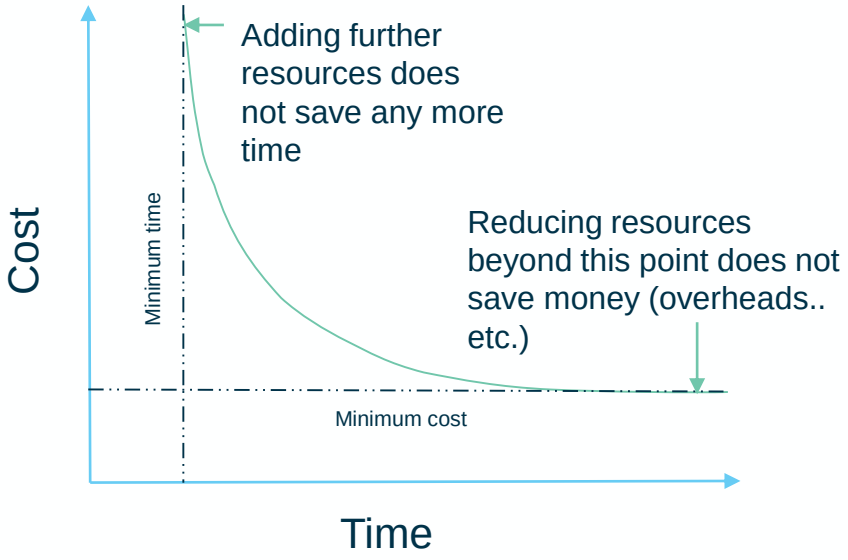
Definition: Project Management is about documenting, monitoring and controlling:

- The Project Manger cannot improve the 4 parameters at the same time, but try to can keep them in balance
- Implementing good management practice and procedures will help all your company and all your projects.



Increase functionality/ performance: either cost will increase directly or time will increase…….

In any case, cost increases



Space Project Management [M-Branch]

ECSS-M-ST-10C Rev.1 – Project planning and implementation

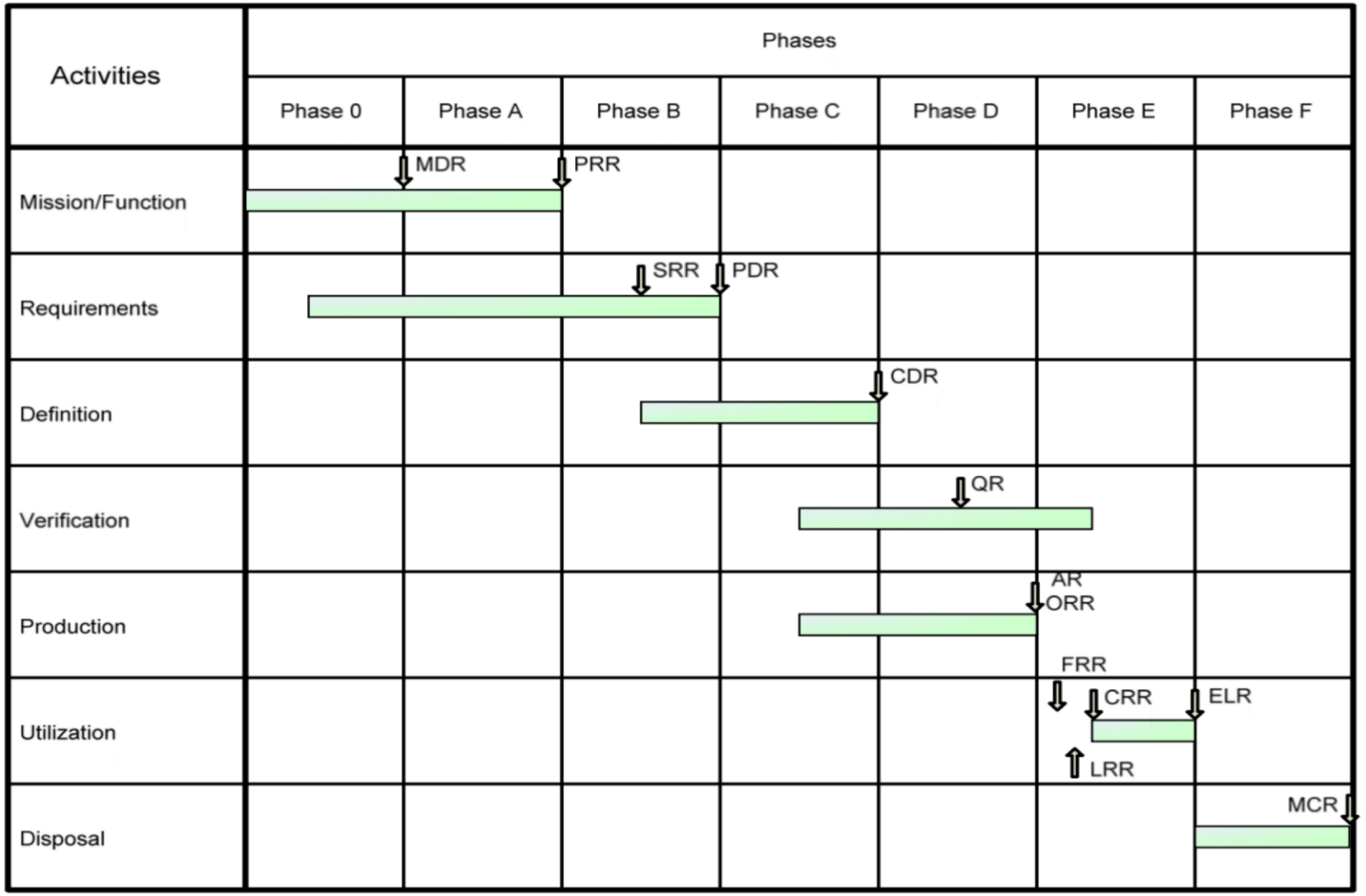
→ Set of processes / requirements for minimizing technical, scheduling and economic risks of the project

In particular this is done by:

- introducing phases and formal milestones
- defining project breakdown structures, used as unique reference system for the project to:
    - identifying the tasks and responsibilities of each actor
    - ensuring the coherence between all activities of the whole project
    - performing scheduling and costing activities
- setting up a project organization to implement a structured and complete approach to perform all necessary activities on the project

Space Project Management [M-Branch]

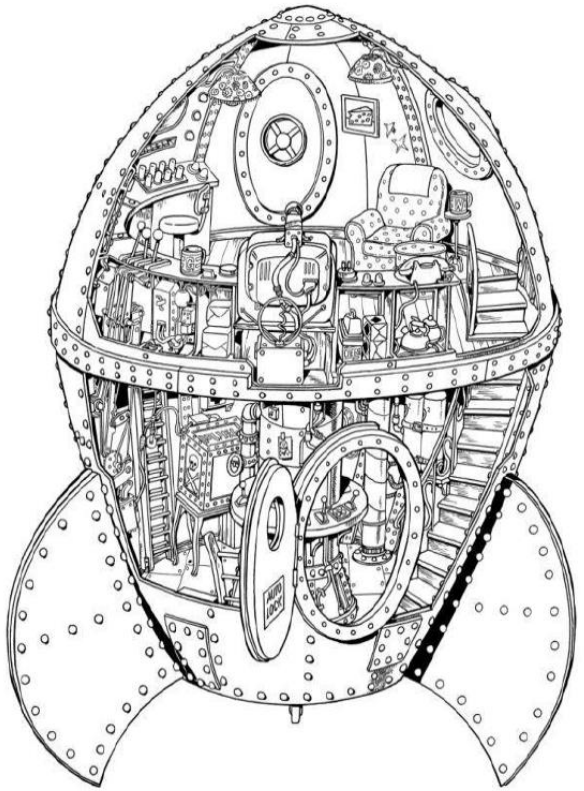
Typical space project lifecycle

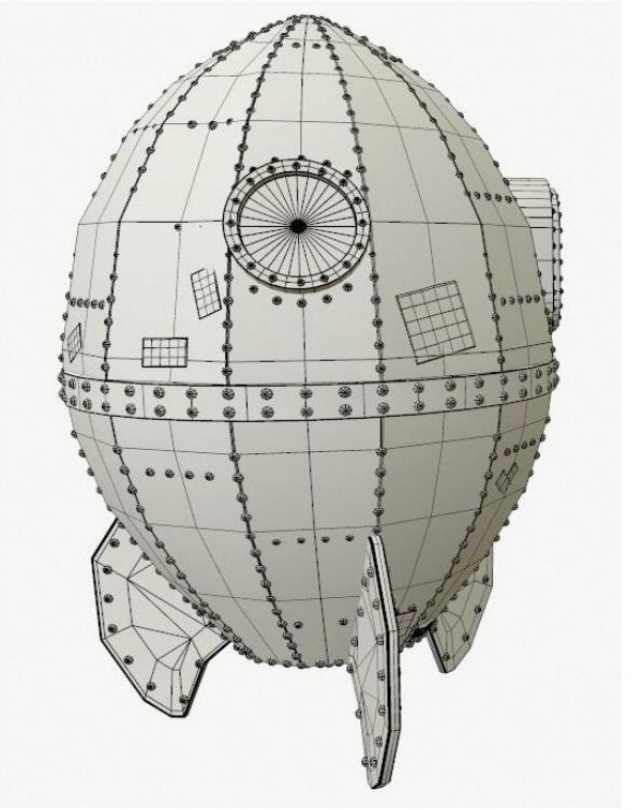


REVIEWS

MDR=Mission Definition
PRR=Preliminary req.
SRR=System req.
PDR=Preliminary design
CDR=Critical design
QR=Qualification
AR=Acceptance
ORR=Operational readiness
FRR=Flight readiness
LRR=Launch readiness
CRR=Commissioning result
ELR=End-of-life
MCR=Mission close-out

Space Project Management [M-Branch]





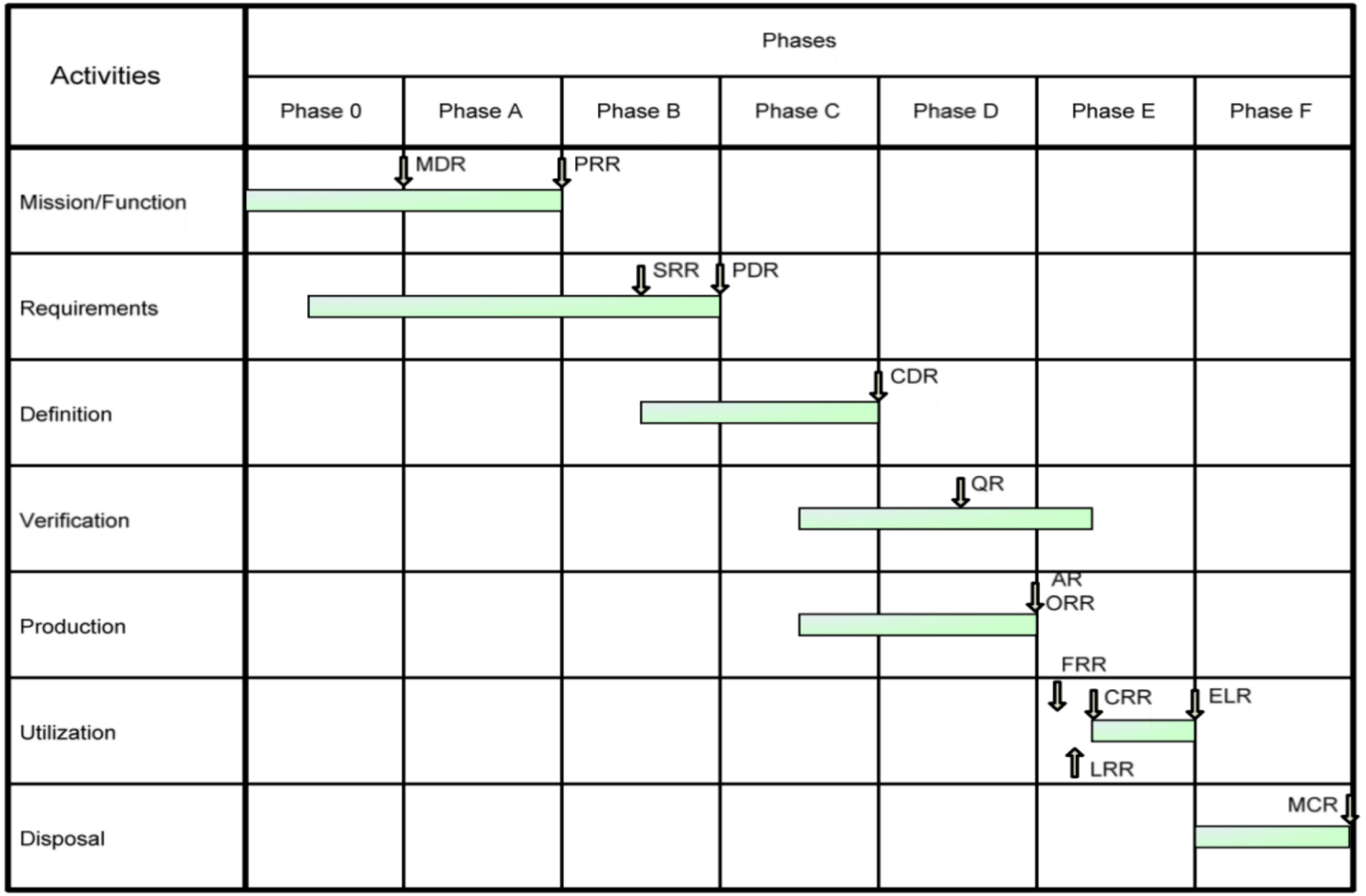
Phase A

Phase B

Phase C

Space Project Management [M-Branch]

Typical space project lifecycle



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ECSS-M-ST-10-01C - Organization and conduct of reviews

→ The objective of project review is to provide management with assurance throughout the project, that at the time of each specific review:

- the feasibility of meeting the mission objectives has been established;
- requirements are adequately defined so that by their fulfilment the mission objectives are satisfied;
- the design definition (including hardware, software, and operational approach) satisfies specified requirements for all parts of the system, including standardization where applicable;
- all configuration items conform with their design, configuration and performance requirements;
- verification of all specified requirements, from component to system level, has been demonstrated;
- no potentially serious risk has been overlooked which could affect safety, mission success or which could have major schedule or cost impact on the programme.

Types of reviews

Using the typical project life-cycle described in ECSS-M-10, reviews generally fall into the following categories:

Review	Purpose
System requirements reviews	examine the requirements derived to achieve the objectives
Preliminary design reviews	review the conceptual design derived to meet the requirements
Critical design reviews	has the detailed implementation met the requirements?
Qualification reviews	process by which a group of configuration items comprising a system is verified to have met specific contractual performance requirements
Acceptance reviews	examine and verify the criteria that a system or component must satisfy in order to be accepted by a user or customer

These reviews are usually carried out at any product level.

ECSS-M-ST-80C Risk management

Risk management discipline

- identifies all risks (including new opportunities)
- keeps these risks within defined and accepted boundaries that are defined in the risk policy of the project

Risk management encompasses all aspects of the programme including:

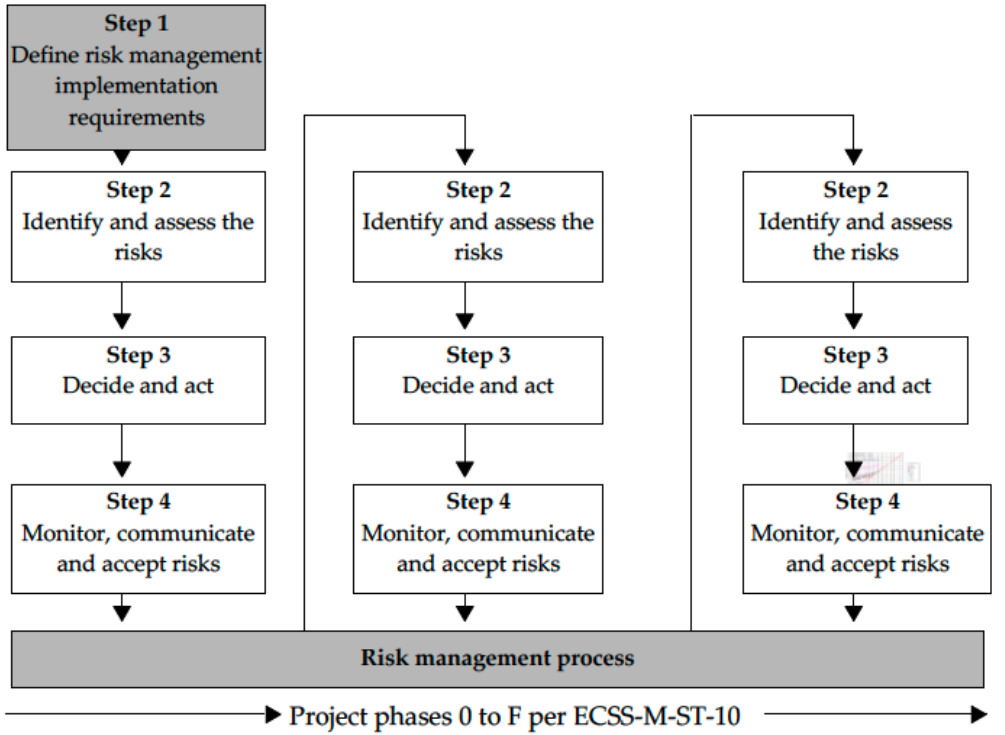
- Technical and Quality performance
- Programmatic (e.g. funding, political environment)
- Cost (e.g. contract type, project cost)
- Schedule and Operation (e.g. logistic support, security)

Score	Severity	Severity of consequence: impact on (for example) cost
5	Catastrophic	Leads to termination of the project
4	Critical	Project cost increase > tbd %
3	Major	Project cost increase > tbd %
2	Significant	Project cost increase < tbd %
1	Negligible	Minimal or no impact

Figure 5-3: Example of a severity–of–consequence scoring scheme

Score	Likelihood	Likelihood of occurrence
E	Maximum	Certain to occur, will occur one or more times per project
D	High	Will occur **frequently**, about 1 in 10 projects
C	Medium	Will occur **sometimes**, about 1 in 100 projects
B	Low	Will **seldom** occur, about 1 in 1000 projects
A	Minimum	Will **almost never** occur, 1 of 10 000 or more projects

Figure 5-4: Example of a likelihood scoring scheme



ECSS-M-ST-80C Risk management

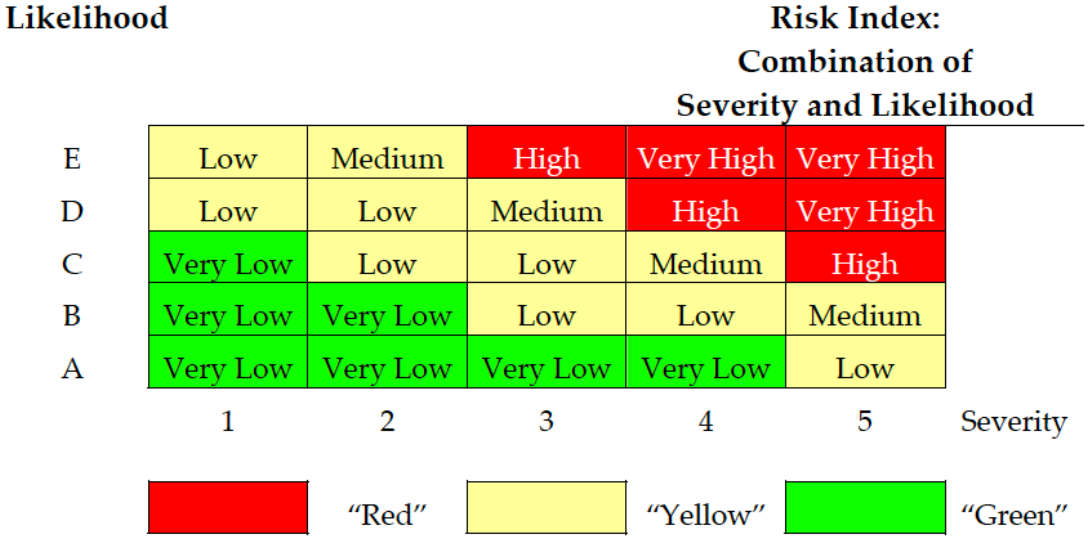
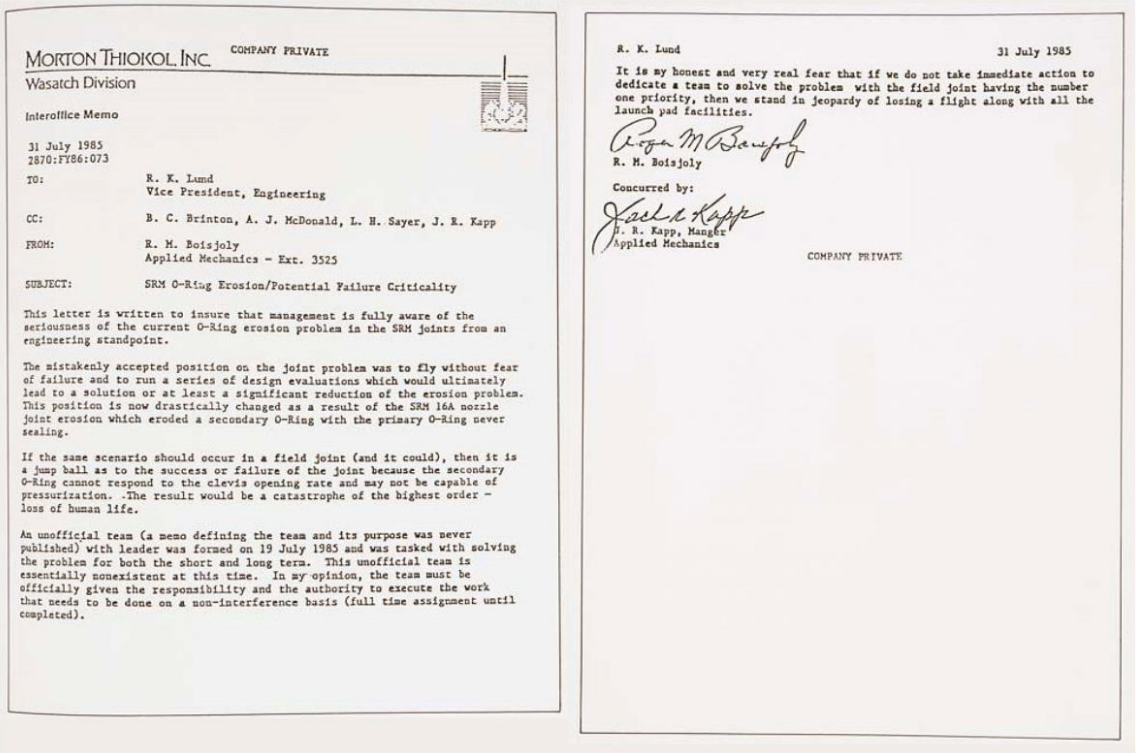


Figure 5-5: Example of risk index and magnitude scheme

Risk index	Risk magnitude	Proposed actions
E4, E5, D5	Very High risk	Unacceptable risk: implement new team process or change baseline – seek project management attention at appropriate high management level as defined in the risk management plan.
E3, D4, C5	High risk	Unacceptable risk: see above.
E2, D3, C4, B5	Medium risk	Unacceptable risk: aggressively manage, consider alternative team process or baseline – seek attention at appropriate management level as defined in the risk management plan.
E1, D1, D2, C2, C3, B3, B4, A5	Low risk	Acceptable risk: control, monitor – seek responsible work package management attention.
C1, B1, A1, B2, A2, A3, A4	Very Low risk	Acceptable risk: see above.

Figure 5-6: Example of risk magnitude designations and proposed actions for individual risks

Importance of Risk Management



MORTON THIOKOL, INC. COMPANY PRIVATE
Wasatch Division

Interoffice Memo

31 July 1985
2870:FY86:073

TO: R. K. Lund
Vice President, Engineering

CC: B. C. Brinton, A. J. McDonald, L. H. Sayer, J. R. Kapp

FROM: R. M. Boisjoly
Applied Mechanics - Ext. 3525

SUBJECT: SRM O-Ring Erosion/Potential Failure Criticality

This letter is written to insure that management is fully aware of the seriousness of the current O-Ring erosion problem in the SRM joints from an engineering standpoint.

The mistakenly accepted position on the joint problem was to fly without fear of failure and to run a series of design evaluations which would ultimately lead to a solution or at least a significant reduction of the erosion problem. This position is now drastically changed as a result of the SRM 16A nozzle joint erosion which eroded a secondary O-Ring with the primary O-Ring never sealing.

If the same scenario should occur in a field joint (and it could), then it is a jump ball as to the success or failure of the joint because the secondary O-Ring cannot respond to the clevis opening rate and may not be capable of pressurization. The result would be a catastrophe of the highest order - loss of human life.

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Concurred by:

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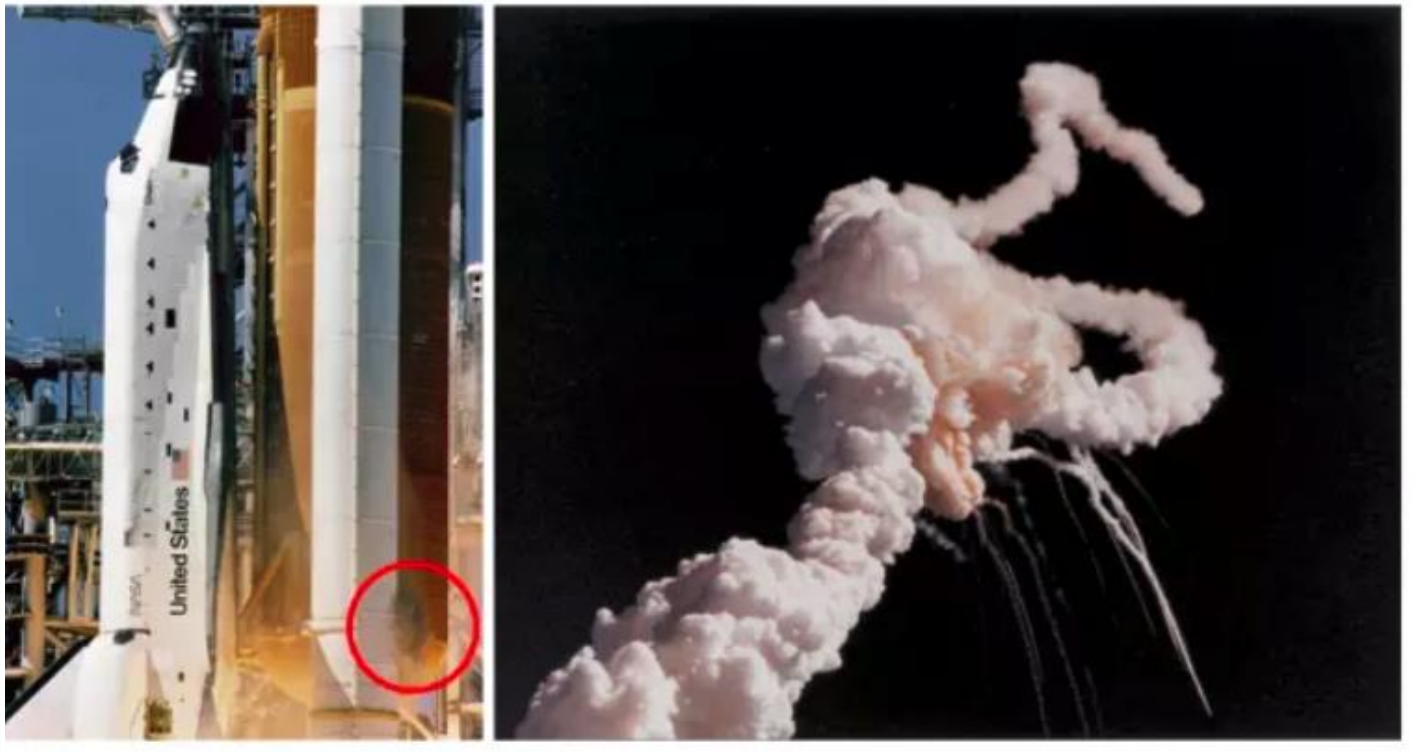
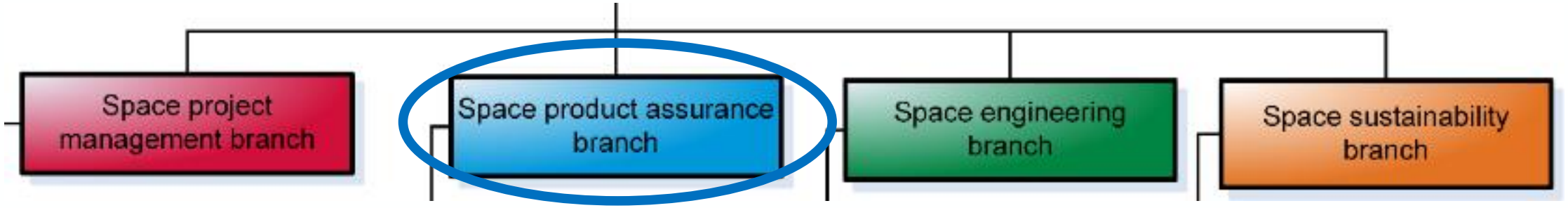
COMPANY PRIVATE



Letter from employee to the company's vice president, highlighting the issue and anticipating the disaster in July 1985.

Space Shuttle Challenger before and shortly after explosion, January 1986

Space Product Assurance Branch [Q-Branch]



The **Q Branch** addresses all aspects of Product Assurance needed for a project (dependability, safety, material and processes, software and audits).

Space Product Assurance Branch [Q-Branch]

The Discipline	What it addresses
Product Assurance Management	Defines the Product Assurance management requirements for space projects
Quality Assurance	System of methods to ensure correct development and workmanship to control errors and arrive at acceptance
Dependability	Reliability: continuity of correct service Availability: readiness for correct service Maintainability: to undergo modifications and repairs
Safety	State of being safe e.g. from failures, damage, error or any other event which could be considered non-desirable to an unacceptable level
EEE components	Suitability and selection of Electrical, Electronic or Electromechanical (EEE) components
Materials, mechanical parts and processes	Suitability and selection of materials, mechanical parts and processes
Software PA	Suitability of development process and subsequent quality assessment for software categories A, B, C and D

Where to find it

Q-ST-10

Q-ST-20 ★

Q-ST-30

Q-ST-40

Q-ST-60

Q-ST-70 ★

Q-ST-80

★ *Recommend to start reading*

Space Product Assurance Branch [Q-Branch]

- **Product Assurance:** “Discipline devoted to the study, planning and implementation of activities intended to assure that the design, controls, methods and techniques in a project result in a satisfactory degree of quality in a product” (ECSS-S-ST-00-01C, Glossary of terms)

  → a **product-focused** management concept which verifies that to meet customer requirements (1) all critical activities are identified, (2) required resources are made available for each activity, (3) these resources are applied in a most efficient and effective manner.

SYSTEM
QMS = PA +QA

Mission Objectives / Requirements

PRODUCT
Mission accomplished / High customer satisfaction

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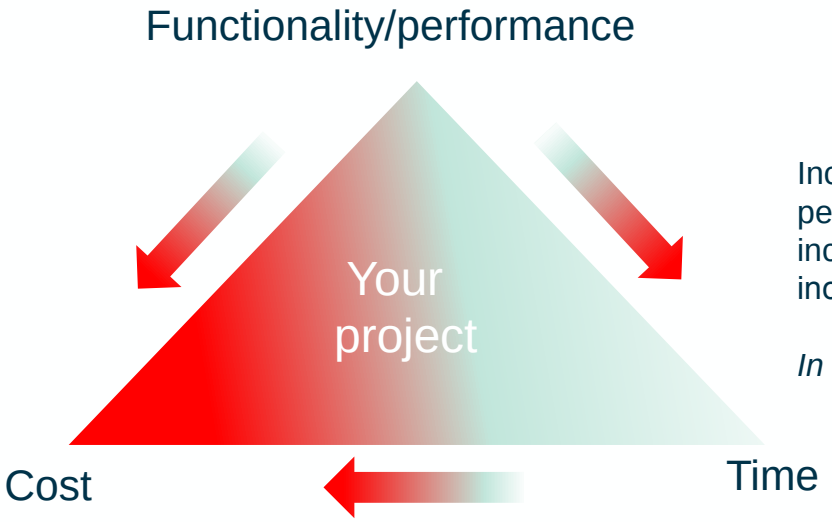
  → a **product-focused** management concept which verifies that to meet customer requirements (1) all critical activities are identified, (2) required resources are made available for each activity, (3) these resources are applied in a most efficient and effective manner.

- **Quality Assurance: “**Part of quality management focused on providing confidence that quality requirements will be fulfilled”. [ISO9000:2005]

  → a proactive, **process-focused** concept, where the processes are put in place to ensure the correct steps are done in a correct and repeatable way.

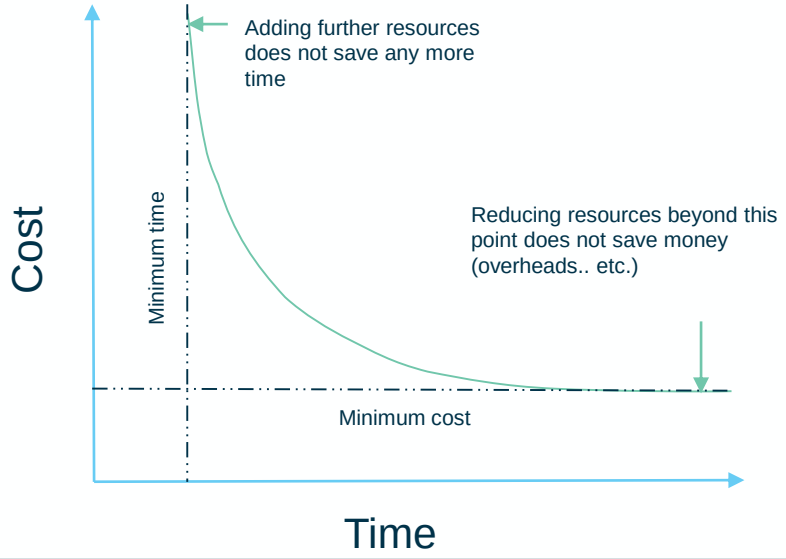
- **Quality Control: data-driven** with a focus on demonstration to identify quality issues and showing the quality requirements are met.

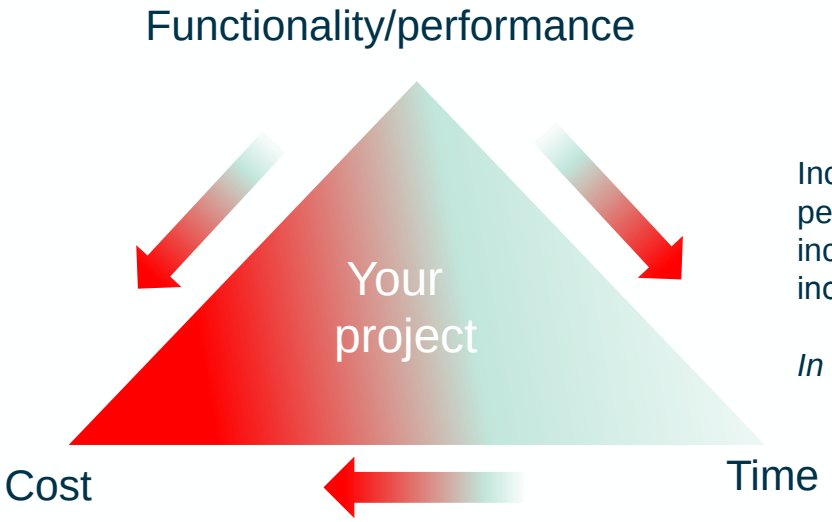
- A **Quality management system (QMS)** is a formal way to documents processes, procedures, and responsibilities and ensure they are followed. The goal of the quality system should be to prevent errors rather than to find them and correct them.



Increase functionality/ performance: either cost will increase directly or time will increase…….

In any case, cost increases





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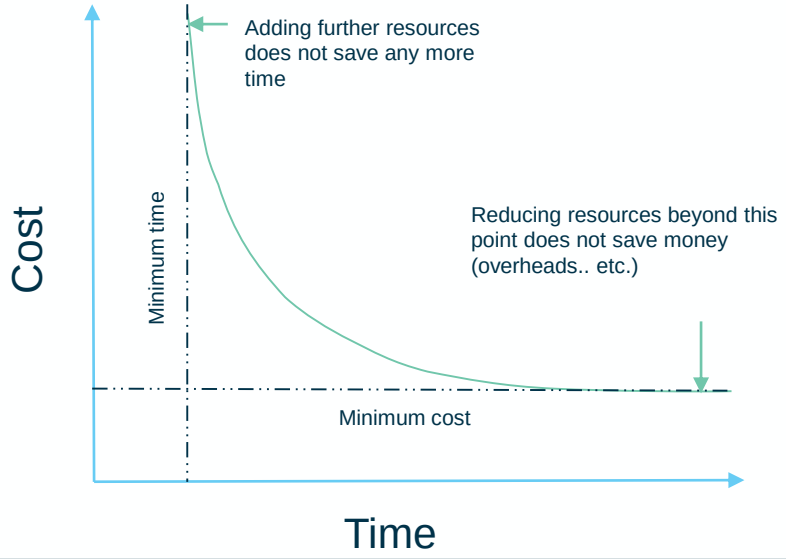

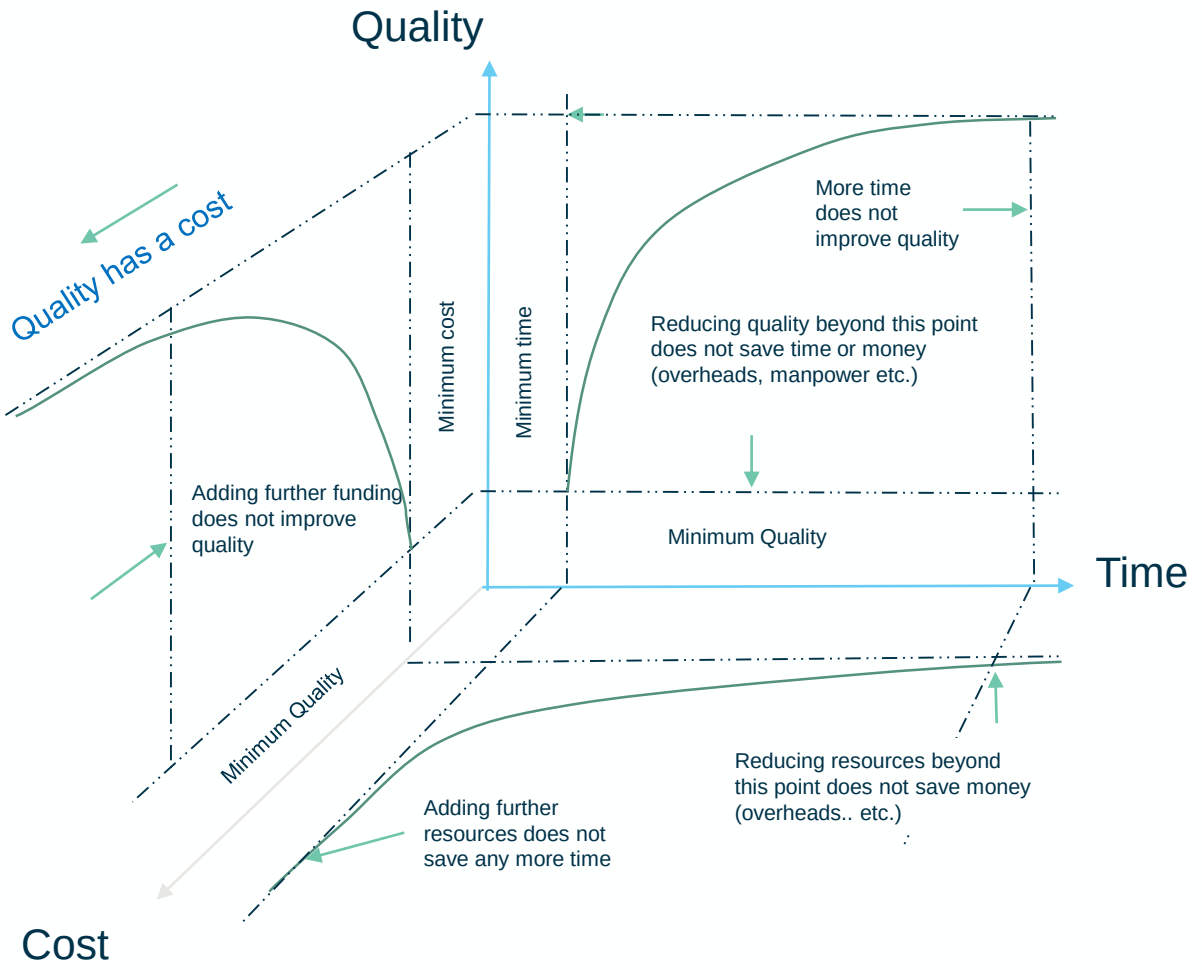

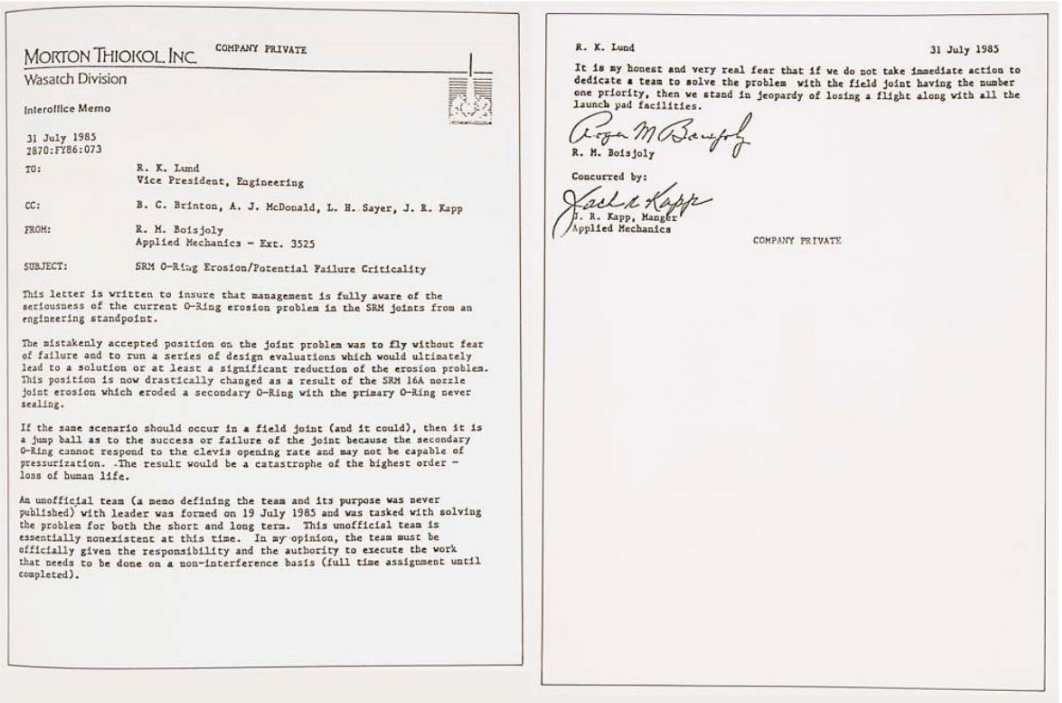

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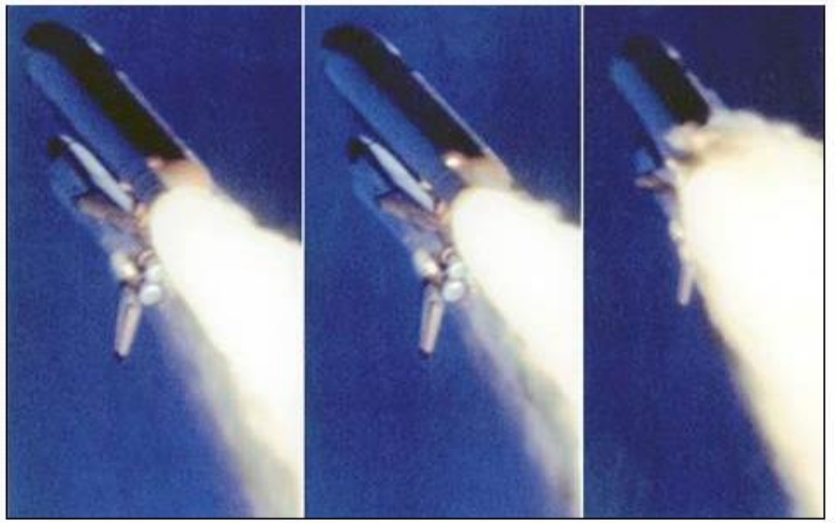
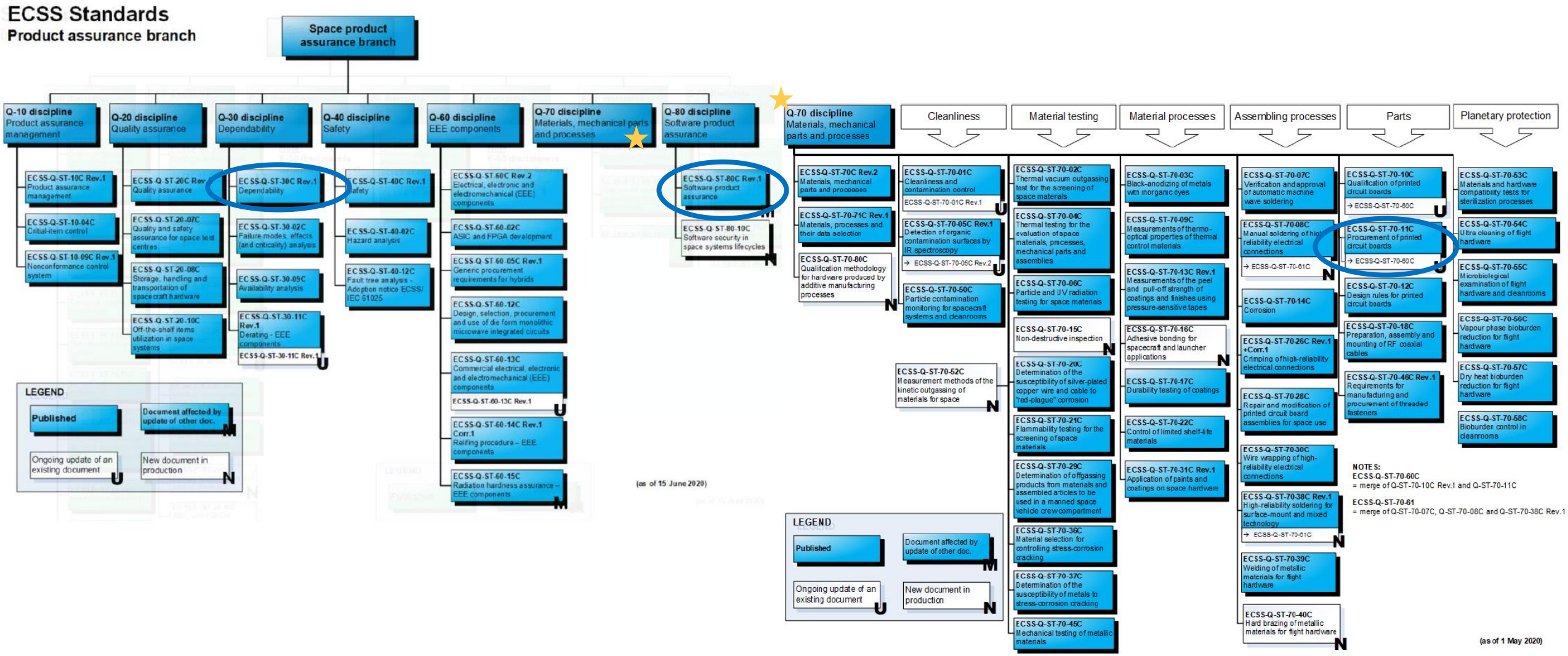


Space Shuttle Challenge Disaster

O-ring Seals

Space Product Assurance Branch [Q-Branch]



ECSS-Q-ST-30C Rev.1 – Dependability

The dependability discipline addresses all aspects to ensure that the dependability performance (availability performance and its influencing factors reliability performance, maintainability performance and maintenance support performance) is met for the space product including system functions implemented in software and the interaction between hardware and software.

In particular it includes:

- Design rules (e.g. derating, end of life parameter drifts), and
- Dependability analyses (e.g. worst case circuit performance, failure mode and effects, criticality).

More details, descriptions and requirements are given in ECSS-Q-ST-30.

ECSS-Q-ST-30-11C Rev.2 – Derating of EEE parts

Example

The objective of this Standard is to ensure a guaranteed performance and reliability up to end-of-life.

To this end, the following are specified:

- Load ratios or limits to reduce stress applied to components;
- Application rules and recommendations.

Awareness level knowledge: p.17 and 18 <- **Start just with this** ☐

Example

Key information: (TRL 1-4) ☐

- The derating requirements shall be taken into account at the beginning of the design cycle of an equipment
- The main parameters to be derated: junction or case temperature; power (rating, dissipation); voltage; current.
- The parameters to be derated depend on component type.
- The remainder of the document are the tables giving the derating to be applied to each type of component.
- Clearly only the components you use are applicable.

Advanced use: (TRL >4) ☐

- Exceptions and unusual conditions
- Documentation templates
- Doing a compliance matrix

Example: Bipolar transistors:

Parameter	Load ratio / limit
Collector – Emitter Voltage	75%
Collector – Base Voltage	75%
Emitter – Base Voltage	75%
Base current	75%
Power	65% of max
Junction Temperature	110C of T_{max}-40C (whichever is lower)

ECSS-Q-ST-60C – Electrical, electronic and electromechanical (EEE) components

This standard defines the requirements for selection, control, procurement and usage of EEE components for space projects.

1. Capacitors
2. Connectors
3. Crystals
4. Discrete semiconductors (including diodes, transistors)
5. Filters
6. Fuses
7. Magnetic components (e.g. inductors, transformers)
8. Monolithic Microcircuits (including MMICs)
9. Hybrid circuits
10. Relays
11. Resistors, heaters
12. Surface acoustic wave devices
13. Switches (mechanical, thermal)
14. Thermistors
15. Wires and Cables
16. Optoelectronic Devices
17. Passive Microwave

ECSS-Q-ST-70C - Materials, mechanical parts and processes

This Standard specifies the requirements applicable to materials, mechanical parts (*) and processes (**) and their data selection to satisfy the mission performance requirements.

** piece of hardware which is not electrical, electronic or electromechanical, and which performs a simple elementary function.*

*** set of interrelated resources and activities which transforms a material or semifinished product into a semifinished or final product*

ECSS-Q-ST-70-11A – Procurement of PCBs

Example

This Standard defines the requirements for PCB procurement.

This Standard is applicable for the following type of boards:

- Rigid PCBs (single-sided, double-sided, multilayer, sequential multilayer and PCBs with metal core)
- Flexible PCBs (single-sided and double-sided)
- Rigid-flex PCBs (multilayer and sequential multilayer)
- High frequency PCBs
- Special PCBs.

PCB Procurement

ECSS-Q-ST-70-11A – Procurement of PCBs

Example

This Standard defines the requirements for PCB procurement.

This Standard covers:

- Procurement of PCBs: General requirements
- Base materials: Restrictions on base layers and metal layers
- Delivery: What is needed for delivery
- Packaging: How they need to be packed and handled
- Acceptance: What you have to do to inspect and store the PCBs

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Key requirement summary for rigid single / double sided boards:

- Base material: FR4 or glass-reinforced polyimide resin
- Max thickness 3.2mm
- The layout and the build should be as symmetrical as possible. A minimum of two prepregs, between layers. The number of electrical layers shall be an even number.
- Electrical layers should be:
  - External: basic copper size: 70µm, 35µm, 17,5µm and 9µm
  - Internal: basic copper size: 70µm, 35µm and 17,5 µm
- The amount of copper in the boards shall be evenly distributed.
- Hot air solder levelling and infrared reflow shall not be used.
- Before mounting of components or soldering operations a baking shall be performed

Example

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Low TRL developments: Design restriction awareness for electrical designer

Example

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High TRL: Compliance to packaging and acceptance for PA/QA and MAIT personnel

Example

ECSS-Q-ST-80C – Software product assurance

This Standard defines a set of software product assurance requirements to be used for the development and maintenance of software for space systems.

This Standard also applies to the development or reuse of non deliverable software which could affect the quality of the deliverable product or service provided by a space system, if the service is implemented by software.

Always use in combination with ECSS-E-ST-40C!

Structure of the Standard

Software product assurance programme implementation	
5.1 Organization and responsibility	5.5 Procurement
5.2 Software product assurance programme management	5.6 Tools and supporting environment
5.3 Risk management and critical item control	5.7 Assessment and improvement process
5.4 Supplier selection and control	

Software process assurance
6.1 Software development life cycle
6.2 Requirements applicable to all software engineering processes
6.3 Requirements applicable to individual software engineering processes or activities

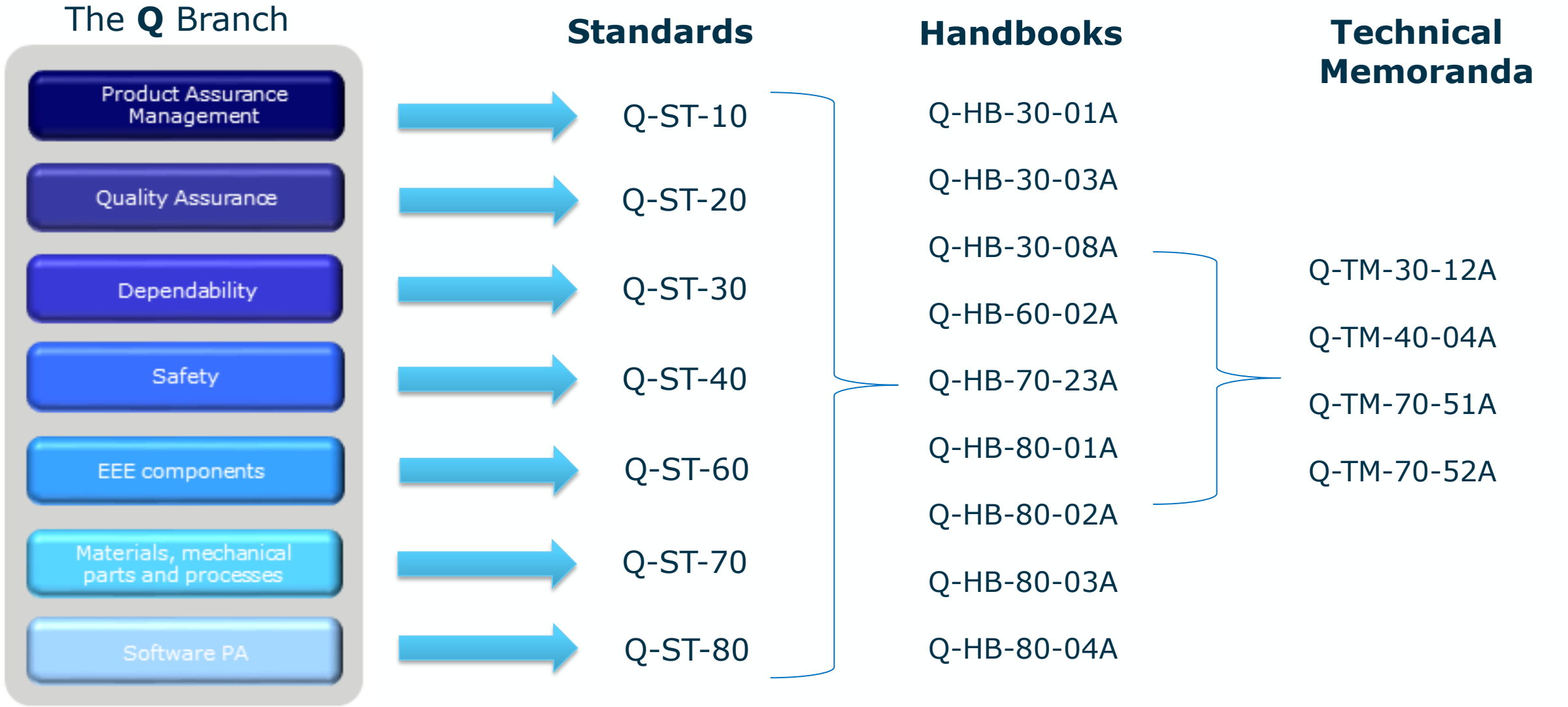
Software product quality assurance
7.1 Product quality objectives and metrication
7.2 Product quality requirements
7.3 Software intended for reuse
7.4 Standard ground hardware and services for operational system
7.5 Firmware

Space Product Assurance Branch [Q-Branch]

Liftoff of Ariane 5 L501, 4 June 1996. (ESA)

Explosion of Ariane 5 L501, 4 June 1996 (ESA)

Space Product Assurance Branch [Q-Branch]



Space Product Assurance Branch [Q-Branch]

Company level

- ECSS-Q-ST-10C Rev.1 – Product assurance management
- ECSS-Q-ST-20C Rev.2 – Quality assurance
- ECSS-Q-ST-10-04C – Critical-item control
- ECSS-Q-ST-10-09C Rev.1 – Nonconformance control system
- ECSS-Q-ST-70-01C – Cleanliness and contamination control
- ECSS-Q-ST-20-08C – Storage, handling and transportation of spacecraft hardware
- ECSS-Q-ST-70-22C – Control of limited shelf-life materials
- ECSS-Q-ST-70-50C – Particles contamination monitoring for spacecraft systems and cleanrooms

Analyses

- ECSS-Q-ST-40-12C – Fault tree analysis
- ECSS-Q-ST-30-02C – Failure modes, effects (and criticality) analysis (FMEA/FMECA)
- ECSS-Q-ST-30-09C – Availability analysis
- ECSS-Q-ST-30C Rev.1 – Dependability
- ECSS-Q-ST-40-02C – Hazard analysis
- ECSS-Q-ST-40C Rev.1 – Safety

Legend:

- General awareness
- TRL 1-4
- TRL > 4

Indication on when you may really need them

Electrical

- ECSS-Q-ST-60C Rev.2 – Electrical, electronic and electromechanical (EEE) components
- ECSS-Q-ST-60-13C – Commercial electrical, electronic and electromechanical components
- ECSS-Q-ST-30-11C Rev.2: Derating – EEE components
- ECSS-Q-ST-60-15C – Radiation hardness assurance – EEE components
- ECSS-Q-ST-70-12C – Design rules for printed circuit boards
- ECSS-Q-ST-70-60C Qualification and procurement of printed circuit boards
- ECSS-Q-ST-70-28C – Repair and modification of printed circuit board assemblies
- ECSS-Q-ST-70-26C Rev.1 – Crimping of high-reliability electrical connections
- ECSS-Q-ST-70-30C – Wire wrapping of high-reliability electrical connections
- ECSS-Q-ST-60-14C Rev.1 - Relifing procedure – EEE components
- ECSS-Q-ST-70-61C – High reliability assembly for surface mount and through hole

Materials and processes

- ECSS-Q-ST-70C Rev.2 – Materials, mechanical parts and processes
- ECSS-Q-ST-70-71C Rev.1 – Materials, processes and their data selection
- ECSS-Q-ST-70-31C Rev.1 – Application of paints on space hardware
- ECSS-Q-ST-70-03C – Black-anodizing of metals with inorganic dyes
- ECSS-Q-ST-70-36C – Material selection for controlling stress-corrosion cracking
- ECSS-Q-ST-70-46C Rev.1 – Requirements for manufacturing and procurement of threaded fasteners

ECSS-Q-ST-10-09C Rev.1 – Nonconformance control system

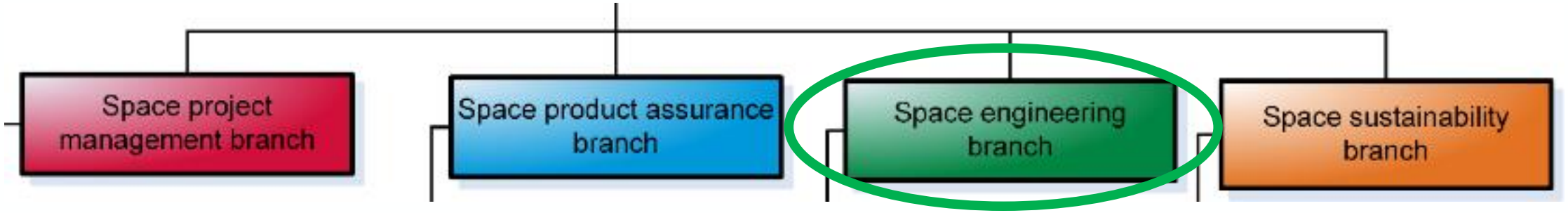
- According to ECSS-S-ST-00-01C:

  nonconformance: non-fulfilment of a requirement
  anomaly: any deviation from the expected situation. An anomaly justifies an investigation that might lead to the discovery of a nonconformance or a defect.

This Standard defines the requirements for the control of nonconformances and describes the approach to the identification and processing of nonconforming items, which can be performed at each customer/supplier level.
The Standard applies to all deliverable products and supplies, at all the levels, which fail to conform to project requirements.

This Standard is applicable throughout the whole project lifecycle as defined in ECSS-M-ST-10.

Space Engineering Branch [E-Branch]



The **E Branch** covers all engineering aspects of space systems and products, including:

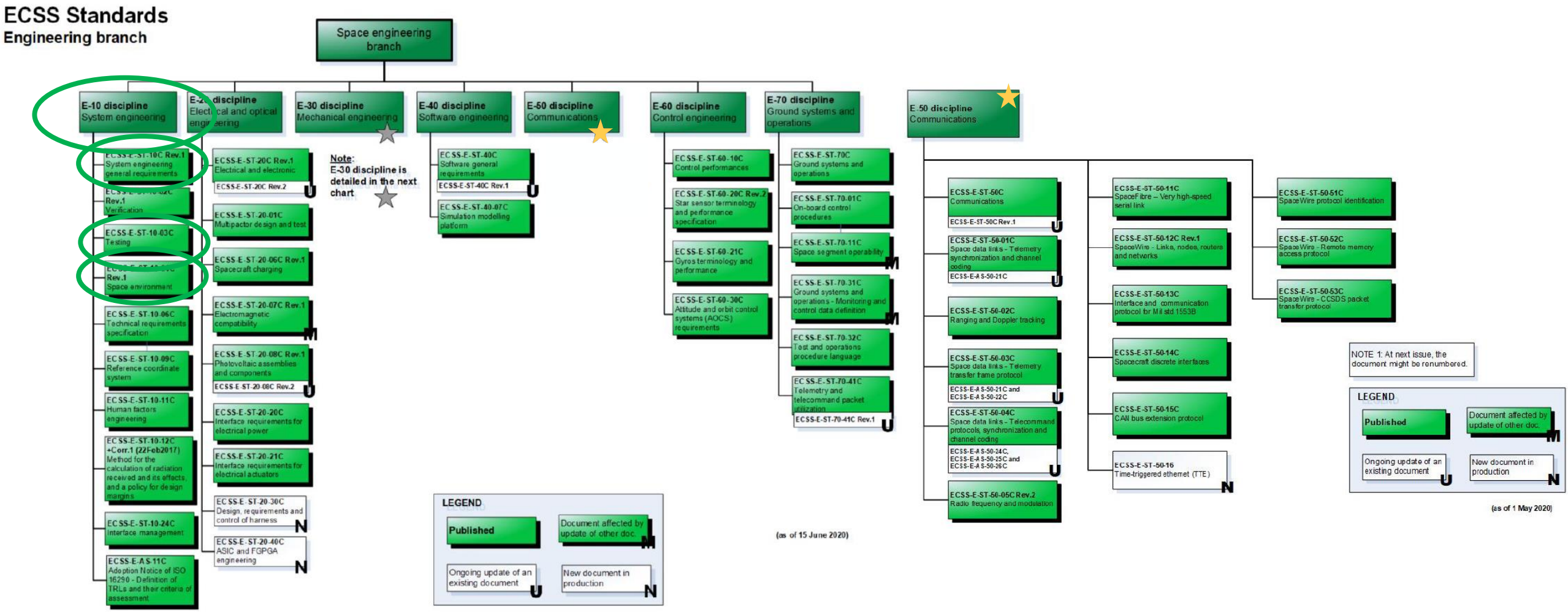
- the engineering process as applied to space systems and their elements or functions, and
- technical aspects of products used to accomplish, or associated with, space missions.

Space Engineering Branch [E-Branch]

The Discipline	What it addresses	Where to find it
System engineering	The system engineering implementation requirements for space systems and space products development	**E-ST-10** ★
Electric, electronics & optics	The electrical, electronic, electromagnetic, microwave and optical engineering processes of space projects	E-ST-20
Mechanical	The mechanical engineering requirements for materials, encompassing the effects of the natural and induced environments, materials will be subjected to	E-ST-30
Software engineering	All aspects of space S/W engineering including requirements, definition, design, production, verification, validation, operation and maintenance	E-ST-40
Communications	End-to-end data communications systems for spacecraft including the ground networks necessary to support it	E-ST-50
Control engineering	Space control engineering including requirements definition, analysis, design, production, verification and validation, transfer, operations and maintenance.	E-ST-60
Ground systems and operations	Basic rules, principles & requirements applied to the engineering of the ground segment & mission operations	E-ST-70

★ *Recommend to start reading*

Space Engineering Branch [E-Branch]



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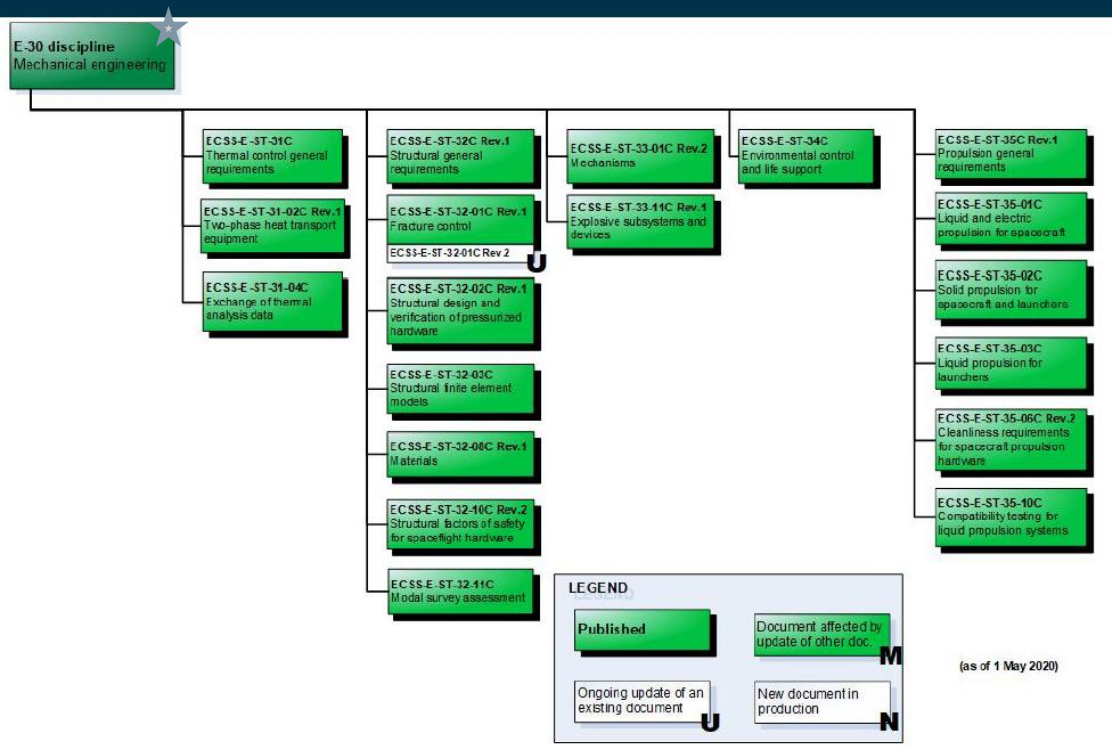
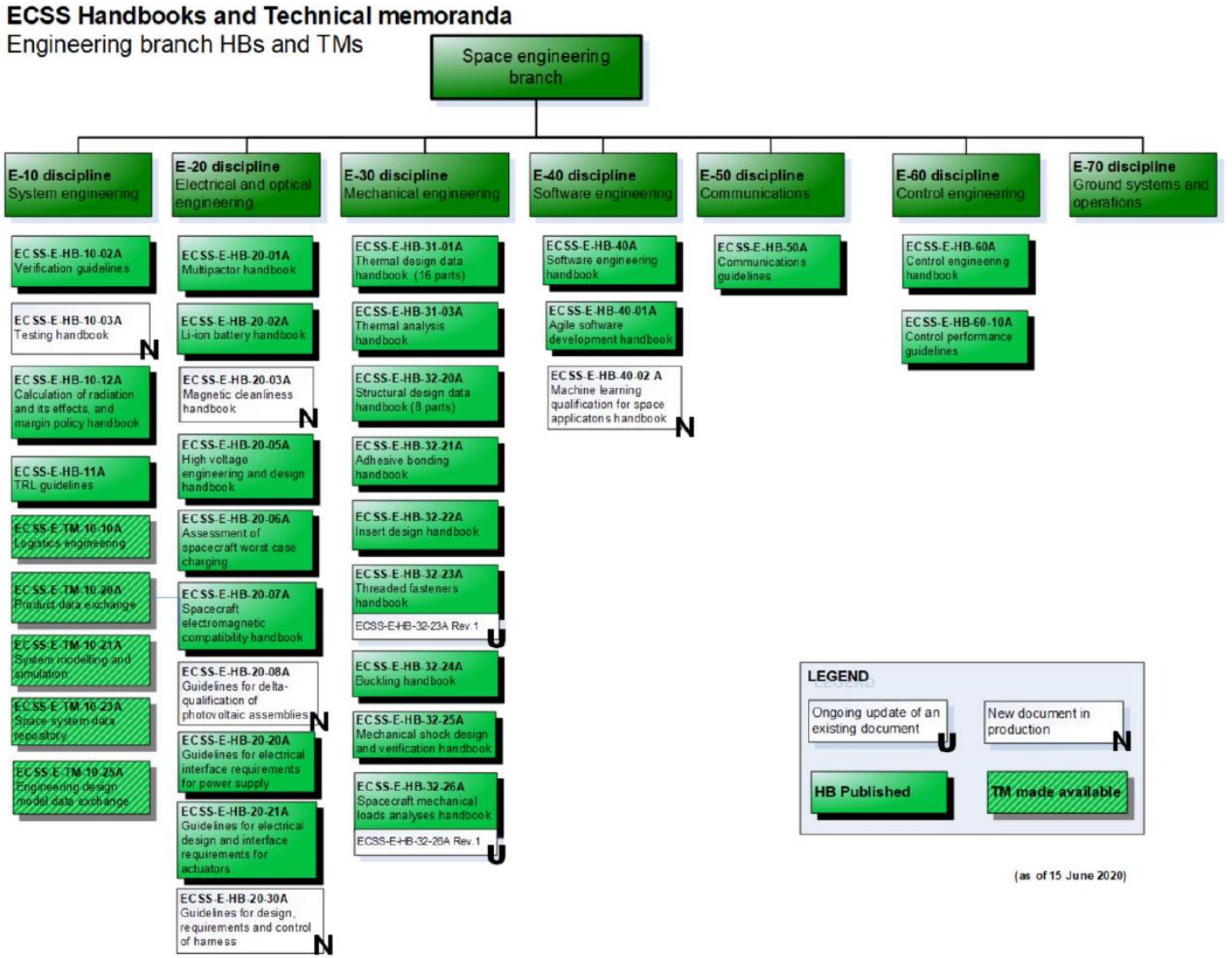




ECSS-E-ST-10C Rev.1 – System engineering general requirements

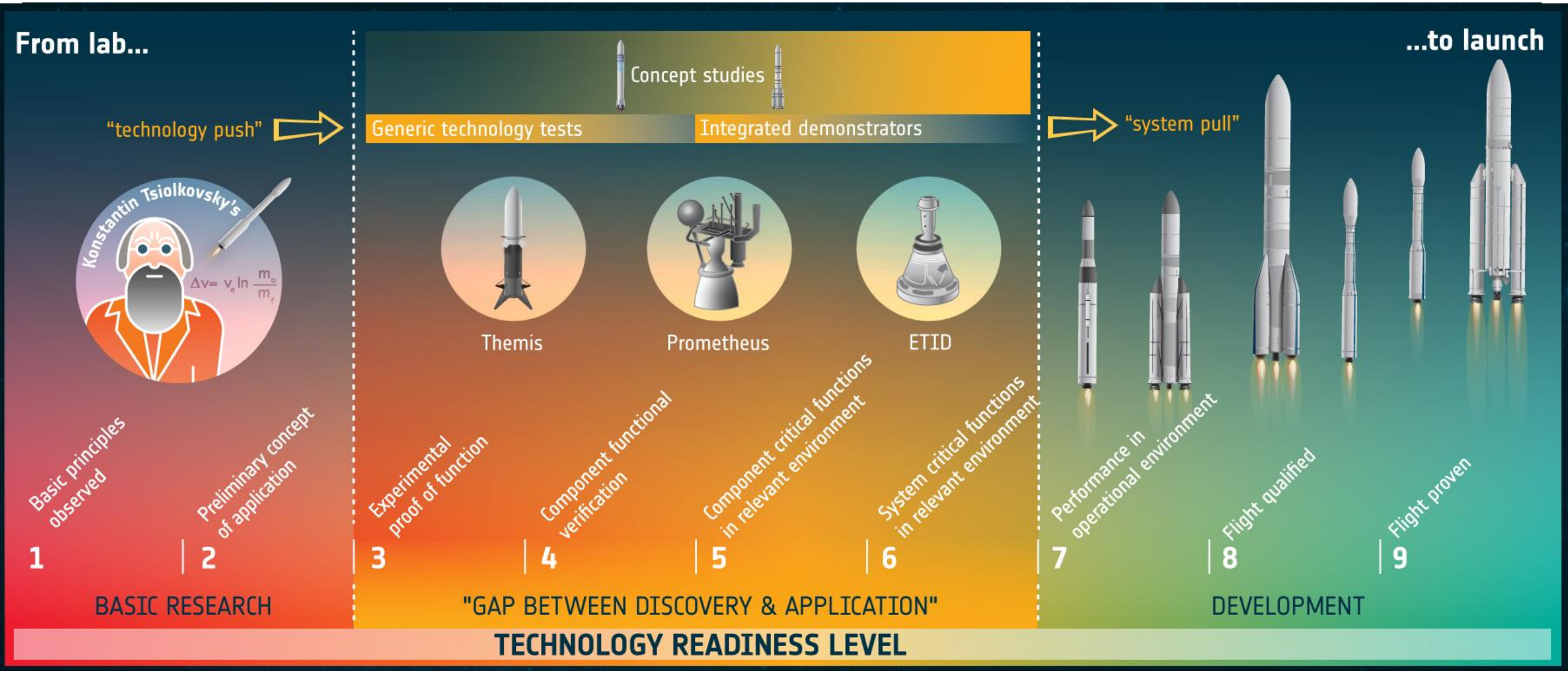
This standard specifies the system engineering implementation requirements for space systems and space products development.

Specific objectives of this standard are:

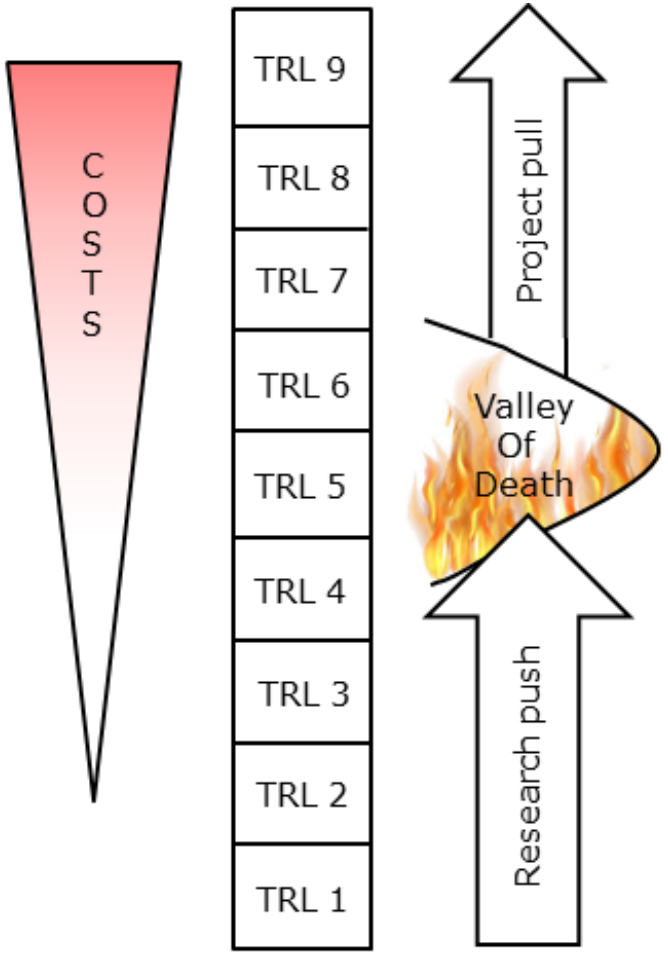
- to implement the system engineering requirements to establish a firm technical basis and to minimize technical risk and cost for space systems and space products development;
- to specify the essential system engineering tasks, their objectives and outputs;
- to implement integration and control of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

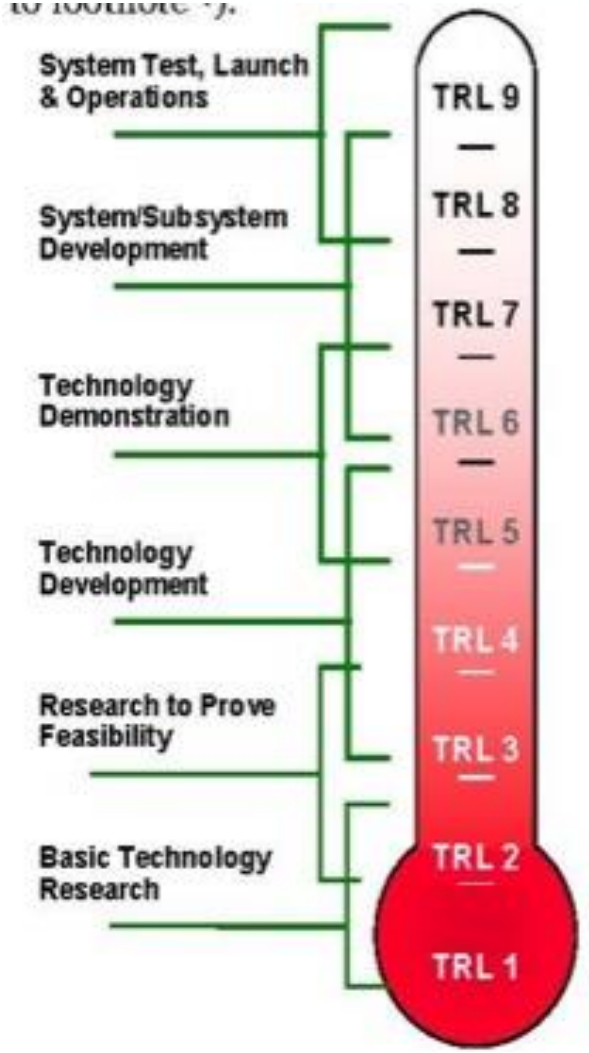
Space Engineering Branch [E-Branch]

ECSS-E-HB-11A – Technology readiness level (TRL) guidelines



ECSS-E-HB-11A – Technology readiness level (TRL) guidelines





Technology Readiness Levels	
9	Actual system "flight proven" through successful mission operations
8	Actual system completed and accepted for flight ("flight qualified")
7	Model demonstrating the element performance for the operational environment
6	Model demonstrating the critical functions of the element in a relevant environment
5	Component and/or breadboard critical function verification in relevant environment
4	Component and/or breadboard functional verification in laboratory environment
3	Analytical and experimental critical function and/or characteristic proof-of-concept
2	Technology concept and/or application formulated
1	Basic principles observed and reported

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

★ *Recommend to start reading*

This standard applies to all product types which exist or operate in space and defines the natural environment for all space regimes. It also defines general models and rules for determining the local induced environment.

Large radiation-induced cracks in the outer layer of multilayer insulation after 6.8 years of space exposure (Townsend et al., 1999).

Severe degradation to the aluminized-Teflon® outer layer of multilayer insulation after 19 years of space exposure (Yang and de Groh, 2010).

Space-exposure damage to Hubble Space Telescope multilayer insulation.

ECSS-E-ST-10-04C – Space environment

This standard applies to all product types which exist or operate in space and defines the natural environment for all space regimes. It also defines general models and rules for determining the local induced environment.

This standard covers:

- Gravitation
- Geomagnetic fields
- Solar and Earth electromagnetic radiation
- Neutral Earth atmosphere
- Plasmas
- Energetic particle radiation
- Particulates
- Contamination
- *Annexes: Models for each of the above*

ECSS-E-ST-10-04C – Space environment

This standard applies to all product types which exist or operate in space and defines the natural environment for all space regimes. It also defines general models and rules for determining the local induced environment.

This standard covers:

- Gravitation –GNC and mission planners (gravity model / Newton's law)
- Geomagnetic fields - AOCS and mission planners
- Solar and Earth electromagnetic radiation - AOCS, power (solar arrays) and payloads (solar constant, Albedo)
- Neutral Earth atmosphere - GNC (propulsion, drag), mission planners and external surfaces (atomic oxygen)
- Plasmas - external surfaces and mission planners (solar wind, ionosphere and magnetosphere, charging and communications blockage)
- Energetic particle radiation - electrical, optical and system engineers
- Particulates - external surfaces and optics (micrometeorites, space debris and their assessment)
- Contamination - optics, solar arrays and thermal surfaces (outgassing and thruster plumes)
- *Annexes: Models for each of the above*

ECSS-E-ST-10-04C – Space environment

Radiation Effect Key Parameter Overview

- Electronic component degradation: Total ionizing dose.
- Material degradation: Total ionizing dose and Non-Ionising Energy Loss (NIEL)
- CCD and sensor degradation: Non-Ionising Energy Loss (NIEL)
- Solar cell degradation: Non-Ionising Energy Loss (NIEL) and equivalent fluence.
- SEU and latch-up: LET spectra (ions), proton energy spectra, explicit SEU/SEL rate of devices.
- Internal electrostatic charging: Electron flux and fluence, dielectric E-field.

Example

ECSS-E-10-03A – Testing

This standard aims at a consistent application of on ground testing requirements to allow proper qualification and acceptance of space products.

The standard provides:

- Requirements for test programme and test management,
- Requirements for retesting,
- Requirements for redundancy testing,
- Requirements for environmental tests,
- General requirements for functional and performance tests,
- Requirements for qualification, acceptance, and protoflight testing including qualification, acceptance, and proto-fight models' test margins and duration,
- Requirements for test factors, test condition, test tolerances, and test accuracies,
- General requirements for development tests pertinent to the start of the qualification test programme,
- Content of the necessary documentation for testing activities (e.g. DRD).

ECSS-E-10-03A – Testing

Model and testing philosophy

Model	Representativeness
Breadboard (BBM)	Test model, cheap, partial models
Engineering (EM)	Close to the flight, cheaper parts, less functionality
Structural – Thermal (STM)	Same mass and power dissipation
Qualification (QM)	Identical to flight
Flight (FM)	Full functionality, qualified parts, materials and processes
Spare (FS)	Identical to flight / spares kit
Protoflight (PFM)	Full functionality, qualified parts, materials and processes
Engineering Qualification (EQM)	Close to flight, cheaper parts, full functionality

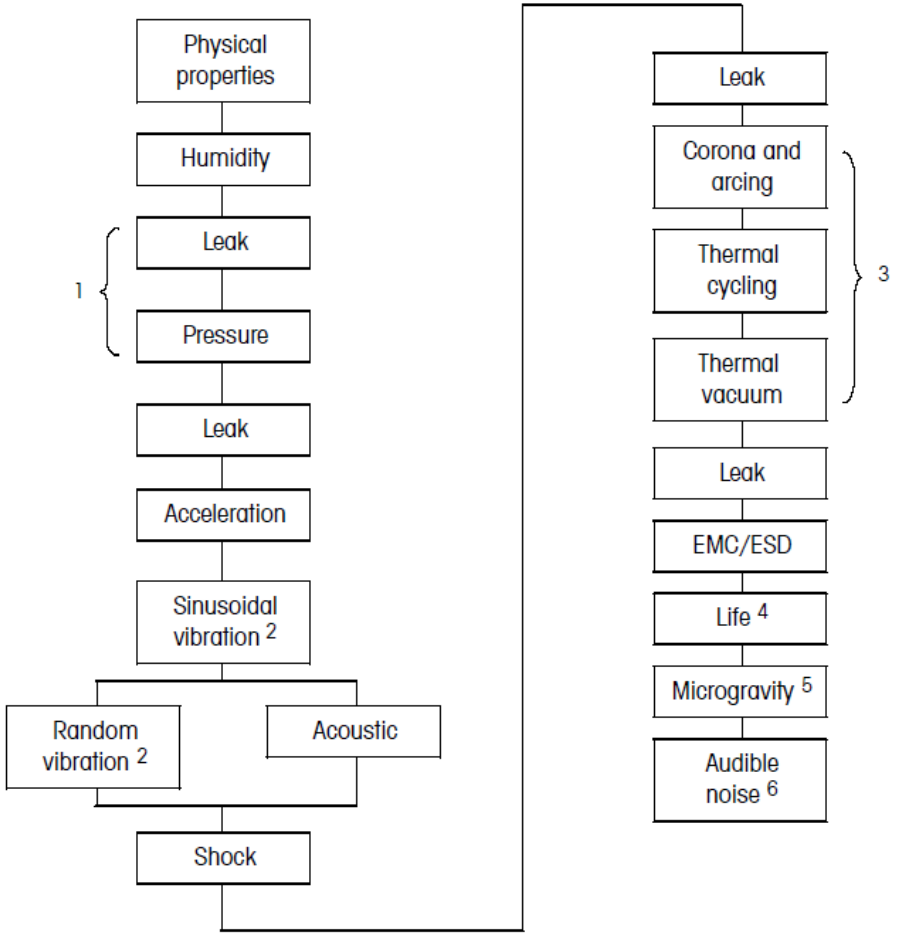
Main use	Qualification test levels	Acceptance test levels
Development testing	No	No
Test as much as you can	No	No
Confirm mechanical and thermal analysis	Yes	No
Check design survives	Yes	No
Go to space ☺	No	Yes
Reserve	No	Yes
Go to space with more risk	Qualification levels and acceptance durations (usually)	
Check design survives (cheaper and quicker)	Yes	No

ECSS-E-10-03A – Testing

Typical test programme

Physical	Structural	Thermal	Electrical
Visual inspection	Shock*	Thermal vacuum	Functional and performance
Dimensions check	Sine vibration	Thermal balance	Calibration
Physical properties	Random vibration		Grounding, bonding and isolation
Deployment			EMC
Strip-down inspection			ESD*
			Magnetic cleanliness

* Can be destructive



ECSS-E-10-03A – Testing

Test	Reference subclause	Recommended sequence	Category/type of equipment											
			a	b	c	d	e	f	g	h	i	j	k	l
Physical properties	6.1.4	1	R	R	R	R	R	R	R	R	R	R	R	R
Functional and performance	6.1.5	2[1]	R	R	R	R	R	R	R	R	R	-	R	R
Humidity	6.1.6	3	O	O	O	O	O	O	O	O	O	O	O	O
Leak	6.1.7	4,6,11,14[7]	R[2]	-	R[2]	R	R	R	O	O	-	-	-	-
Pressure	6.1.8	5[7]	R[2]	-	R[2]	R	R	R	R	-	-	-	-	-
Acceleration	6.1.9	7	O	R[10]	O	O	-	O	-	-	R[10]	-	-	O
Sinusoidal vibration	6.1.10	8	R	R	R	R	R	R	R	R	R	R	R	-
Random vibration	6.1.11	9	R	R[3]	R	R	R	R	R	R	R	R	R	-
Acoustic	6.1.12	9	-	R[3]	-	O	-	-	-	-	-	O	O	R
Shock	6.1.13	10	R[10]	O	O	O	O	-	O	O	O	-	-	O
Corona and arcing	6.1.14	12	R[5]	R[5]	O	O	O	-	-	-	-	-	-	-
Thermal vacuum[9]	6.1.15	13[6]	R	R	R	R	R	O	R	R	R	O	R	R
Thermal cycling[11]	6.1.16	13[6]	R	R	R	R	R	O	R	R	R	O	R	O
EMC/ESD	6.1.17	16	R	O	-	R	O	-	O	-	-	-	-	-
Life	6.1.18	16	O	O	O	O	O	O	O	O	O	O	O	O
Microgravity[4]	6.1.19	17	R	R	-	R	R	-	R	-	R	R	R	-
Audible noise[8]	6.1.20	18	R	R	-	R	R	-	R	-	-	R	R	-

Categories / Types of Equipment

a = Electronic and electrical equipment
b = Antennas
c = Batteries
d = Valves
e = Fluid or propulsion equipment
f = Pressure vessels
g = Thrusters
h = thermal equipment
i = Optical equipment
j = Mechanical equipment
k = Mechanical moving assemblies
l = Solar arrays

Space Engineering Branch [E-Branch]

Standards	Handbooks	Technical Memoranda
E-ST-10	E-HB-10-02A	
E-ST-20	E-HB-10-12A	E-TM-10-10A
E-ST-30	E-HB-11A	E-TM-10-20A
E-ST-40	E-HB-20-01A	E-TM-10-21A
E-ST-60	E-HB-20-02A	E-TM-10-23A
E-ST-70	E-HB-20-05A	E-TM-10-25A
E-ST-80	E-HB-20-06A	E-TM-40-07A
	E-HB-20-07A	
	E-HB-20-02A	

Space Engineering Branch [E-Branch]

General standards (e.g. for your system engineer)

- ECSS-E-AS-11C –Definition of the Technology Readiness Levels (TRLs)
- ECSS-E-ST-10-02C Rev.1 – Verification (1 February 2018)
- ECSS-E-ST-10-03C – Testing (1 June 2012)
- ECSS-E-ST-10-04C Rev.1 – Space environment (15 June 2020)
- ECSS-E-ST-10-06C – Technical requirements specification (6 March 2009)
- ECSS-E-ST-10-09C – Reference coordinate system (31 July 2008)
- ECSS-E-ST-32-08C Rev.1 – Space engineering – Materials (15 October 2014)

For your mechanical engineer

- ECSS-E-ST-32C Rev.1 – Structural general requirements (15 November 2008)
- ECSS-E-ST-32-10C Rev.2 Corr.1 – Structural factors of safety for spaceflight hardware (1 August 2019)
- ECSS-E-ST-32-03C – Structural finite element models (31 July 2008)
- ECSS-E-ST-32-11C – Modal survey assessment (31 July 2008)
- ECSS-E-ST-32-01C Rev.2 – Fracture control (30 July 2021)

For your electrical engineer

- ECSS-E-ST-20C Rev.2 – Electrical and electronic (8 April 2022)
- ECSS-E-ST-10-12C – Methods for the calculation of radiation received and its effects
- ECSS-E-ST-10-24C – Interface management (1 June 2015)
- ECSS-E-ST-20-07C Rev.2 – Electromagnetic compatibility (3 January 2022)
- ECSS-E-ST-50-15C – CANbus extension protocol (1 May 2015)

Legend:

General awareness

TRL 1-4

TRL > 4

Indication on when you may really need them

For your thermal engineer

- ECSS-E-ST-31C – Thermal control (15 November 2008)
- ECSS-E-ST-31-04C – Exchange of thermal analysis data (1 February 2018)

- *Focus first on the standards having a direct technical impact to your design at that TRL.*
- *Understand and apply key principles first*
- *Get documentation and compliance matrices ready for later/ higher TRLs*
- *Stepwise approach*

ECSS Training

ECSS Training sessions on several individual ECSS subjects are held within ESA on a bi-annual basis.

The dates for the next sessions planned in 2022 are not known yet – so keep consulting the ECSS website.

NOTE: Recordings of the Training sessions and the Training material are all available for download.

Questions about ECSS Training can be sent to the ECSS Secretariat.

Thank you for your attention!