PRODUCT ASSURANCE AND QUALITY ASSURANCE IN ECSS STANDARDS

ECSS-Q-ST-10 and ECSS-Q-ST-20 Disciplines

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The presenter

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Product Assurance and Safety Engineer – 20 years in Aerospace and Defense

- **Analysis, Design and Validation** of digital and RF telecom payloads //Industry
- **Testing and Validation** of SARs, EGSE specifications and validation, EuroFighter antennas qualification, AIT activities //Industry
- **ECSS Engineering Branch** Secretariat //ESA
- Currently **PA&S Manager for NGGM (Next Generation Gravity Mission) and AOS**
- Responsible for **coordinating & harmonising PA&S Support to Technology Development Activities** [ARTES, GSTP, InCubed…]
- **ESA TRL Calculator** responsible

Outline of the presentation

Part 1 - Quality management system vs Product/Quality Assurance

Quality management system vs Product/Quality Assurance

Scope of Product Assurance

Part 2- Product Assurance Management requirements (ECSS-Q-ST-10)

PA/QA Plan

Critical Item Control

Nonconformance Control

Part 3 – Quality Assurance (ECSS-Q-ST-20C)

Quality Assurance

Quality and safety assurance of space test centers

Storage, handling and transportation of spacecraft hardware

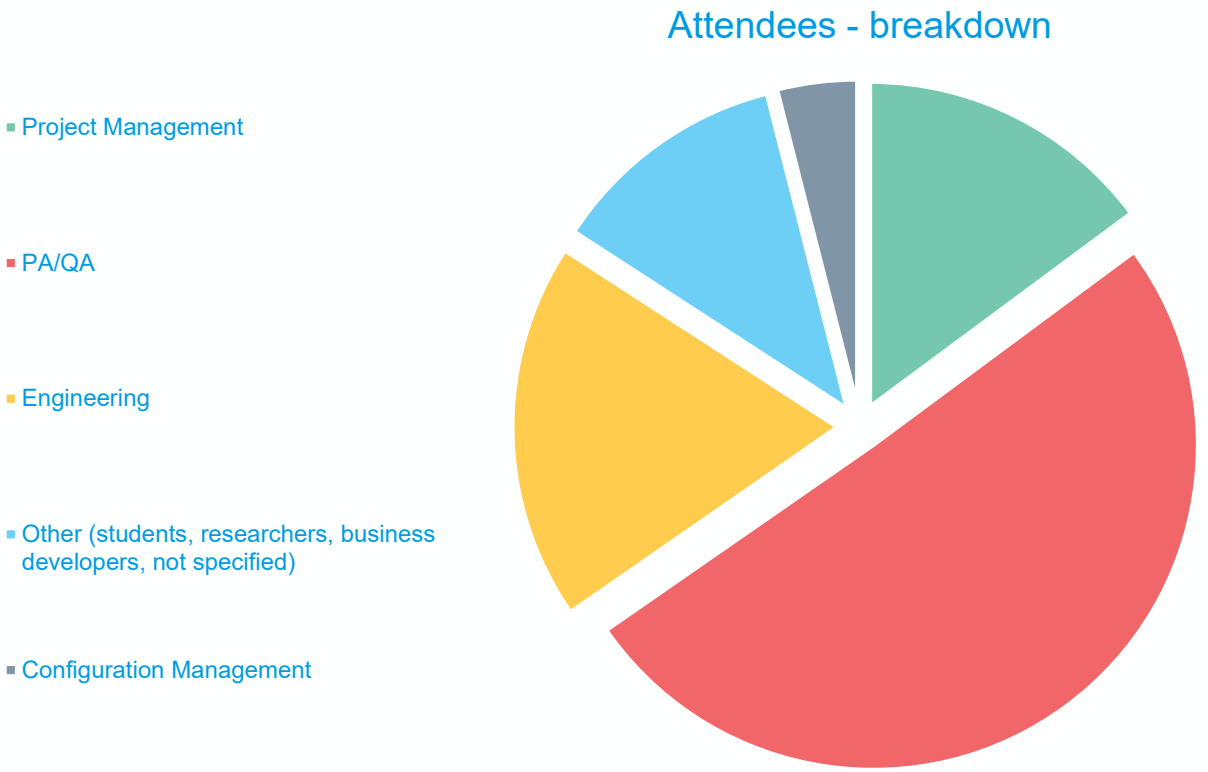
Off-The-Shelf items

Part 4 Implementation in project phases

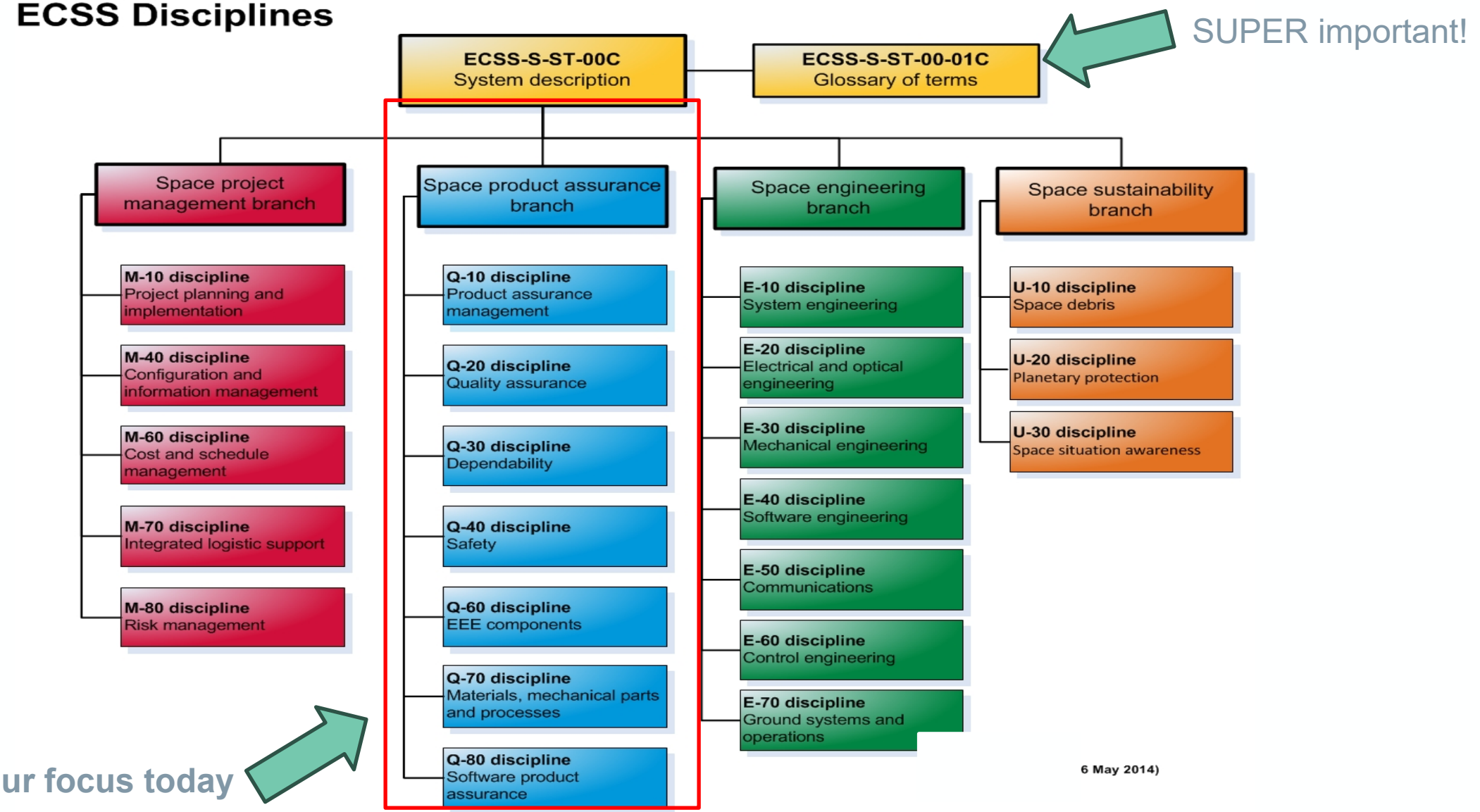
PA activities from project planning to launch

Composition of present audience

101 people enrolled as of 13th September 2023.

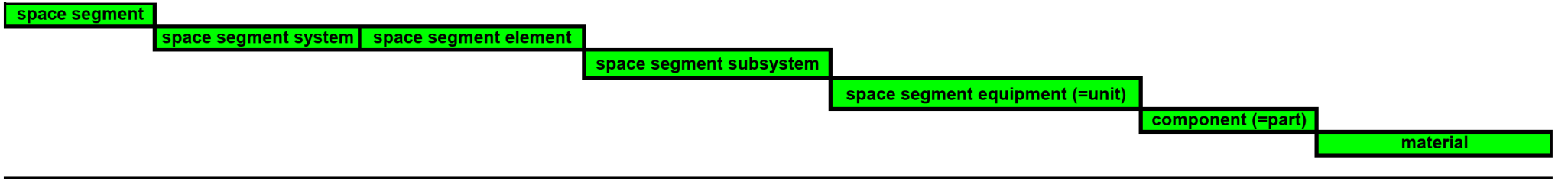


ECSS branches/disciplines



Space Segment tree – basic terminology with examples

B.1 Space segment



product or item					
examples					
Data Relay Satellite System	spacecraft (physical view)	power	electronic unit (e.g. DHU, PCSU, PDU, ICU)	ASIC	Alumiunium
Navigation Satellite System	satellite (physical view)	propulsion	thruster	hybrid	to be taken from Q60 & Q70
spacecraft (functional view)	payload	data handling	valve	integrated circuit	
satellite (functional view)	platform	thermal	battery	heat-pipe	
	instrument	structure	reflector	MLI	
	orbiter	AOCS	mechanism (when fully assembled)	structural panel	
	lander	Tm&Tc	vessel/tank	optical array	
	bay	optical	mirror/lenses/filters (assembly)	pyro components	
	module	RF	solar array (assembly)	PCB	
		communication	antenna (assembly)	mirror	
			focal plane assembly	solar cell	
			telescope (assembly)	insert	
			solar panel (equipped)	resistor	
			pressure vessels	diode	
			optical bench	transistor	
			RF filters	capacitor	
			LNA	thermistor	
			IMUX/OMUX	heater	
			OMT	propulsion fluidic	
			feeds		

Scope of QA vs Quality Management

ISO 9000:2015 Quality management systems — Fundamentals and vocabulary

- ***Management*** *- coordinated activities to direct and control an organization*
- ***Quality management -*** *management with regard to quality*

Quality management is one of the systems to manage the organization

Quality Management is broader than Product/Quality Assurance and encompasses the entire organization

What is Quality Assurance?

ISO 9000:2015 Quality management systems — Fundamentals and vocabulary

Quality *- degree to which a set of inherent characteristics of an object fulfils requirements*

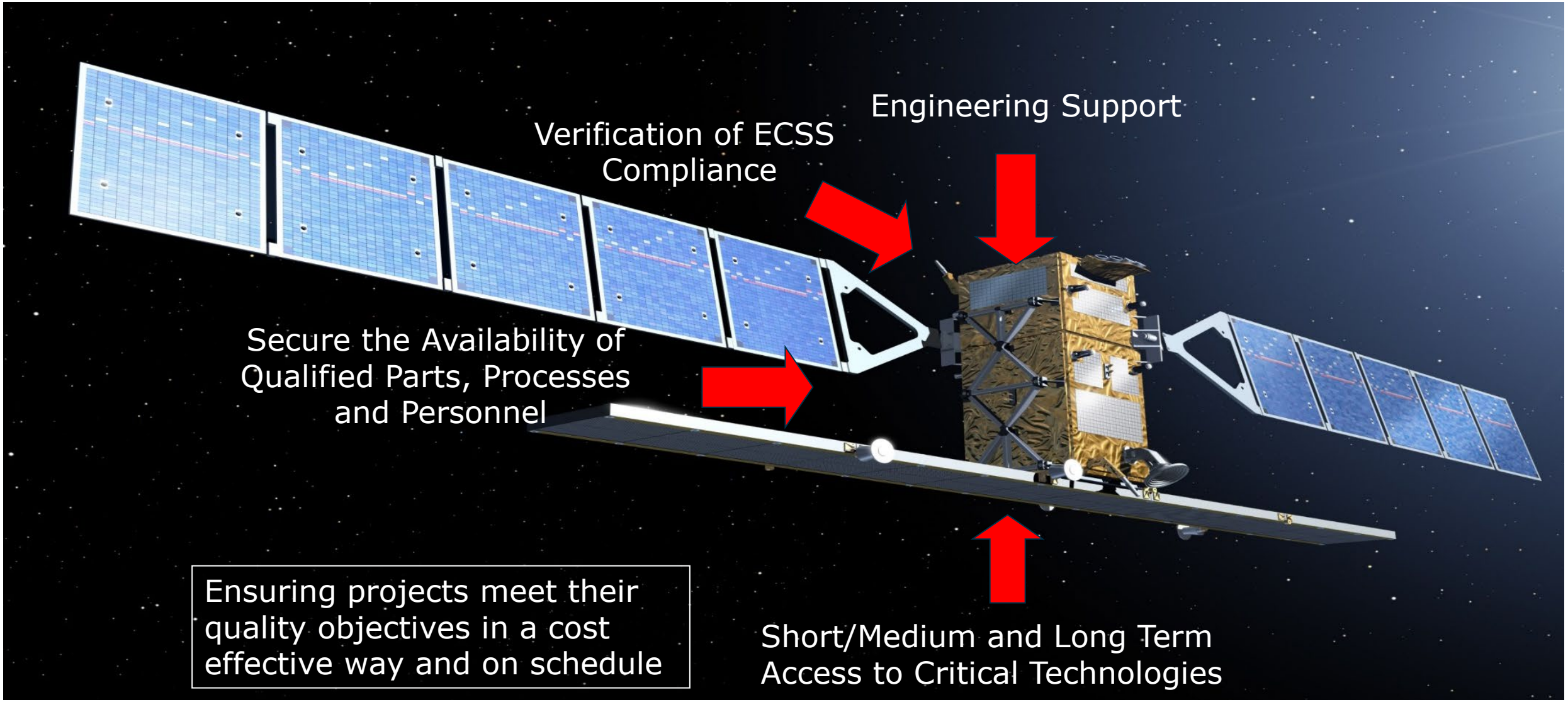
Quality assurance (QA) *- part of quality management focused on* ***providing confidence*** *that quality requirements will be fulfilled*

Quality control (QC) *- part of quality management focused on fulfilling quality requirements*

QA is about providing confidence that quality is achieved

Note: Reliability is "quality over time" after manufacturing. More accurately, it is "the ability of an item to perform a required function under given conditions for a given time interval".

Why Product Assurance and Safety



Scope of QA vs Product Assurance (1/2)

ECSS Glossary - ECSS-S-ST-00-01C

➢***Product Assurance (PA)*** *- 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.***

(cl. 2.3.158 of ECSS-S-ST-00-01C, ECSS System – Glossary of Terms)

➢In practice, PA pursues a **safe & successful mission, looking at all components of the system** (Hardware, Software, Human) **and their interfaces**

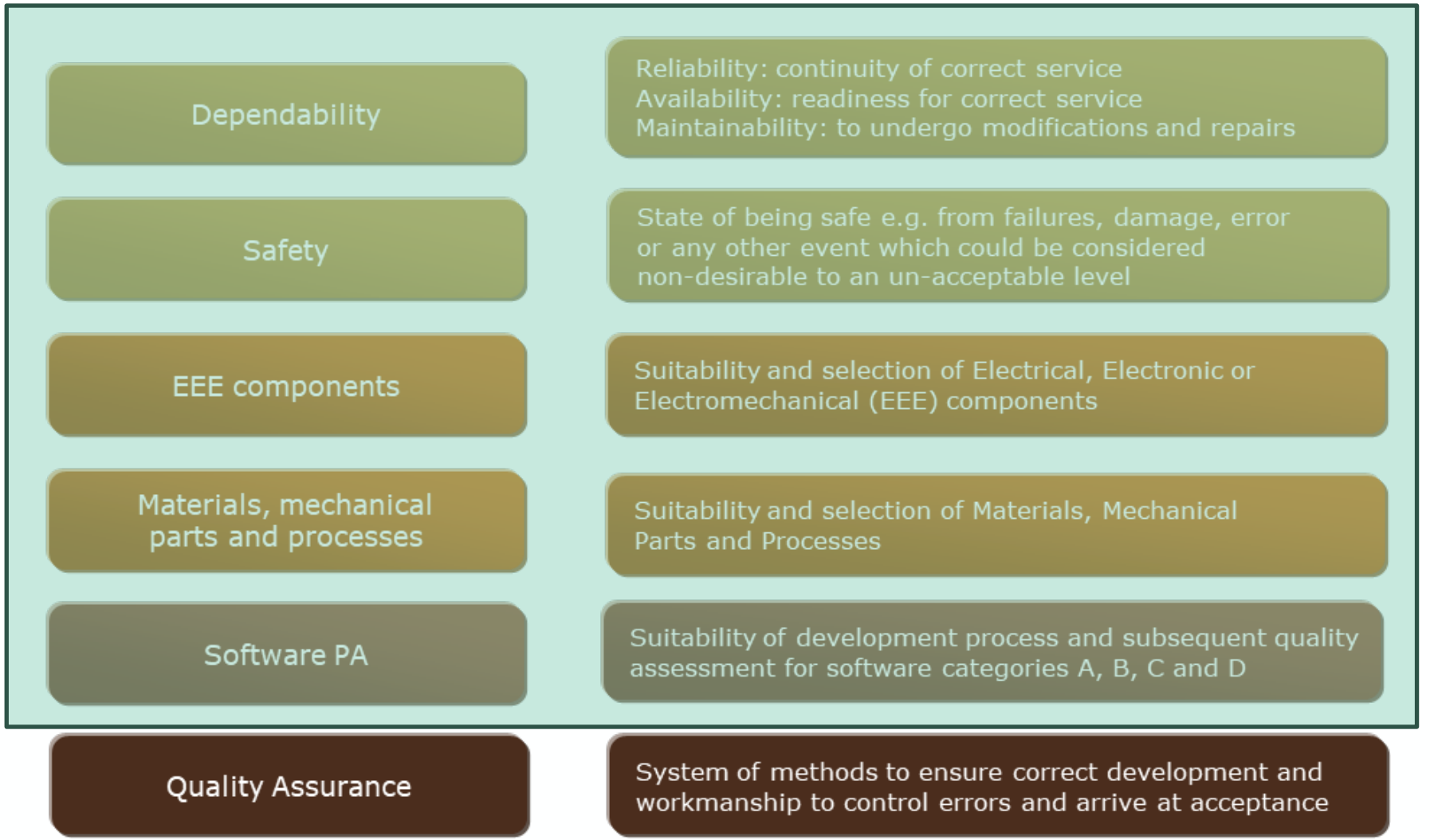
➢For this reason, in NASA and JAXA is named as **Safety and Mission Assurance (S&MA)**

For a PA engineer, main focus is on product quality and overall performance. Money and Time are a Project Manager's issue. A PA engineer is INDEPENDENT from the Project he/she provides support to.

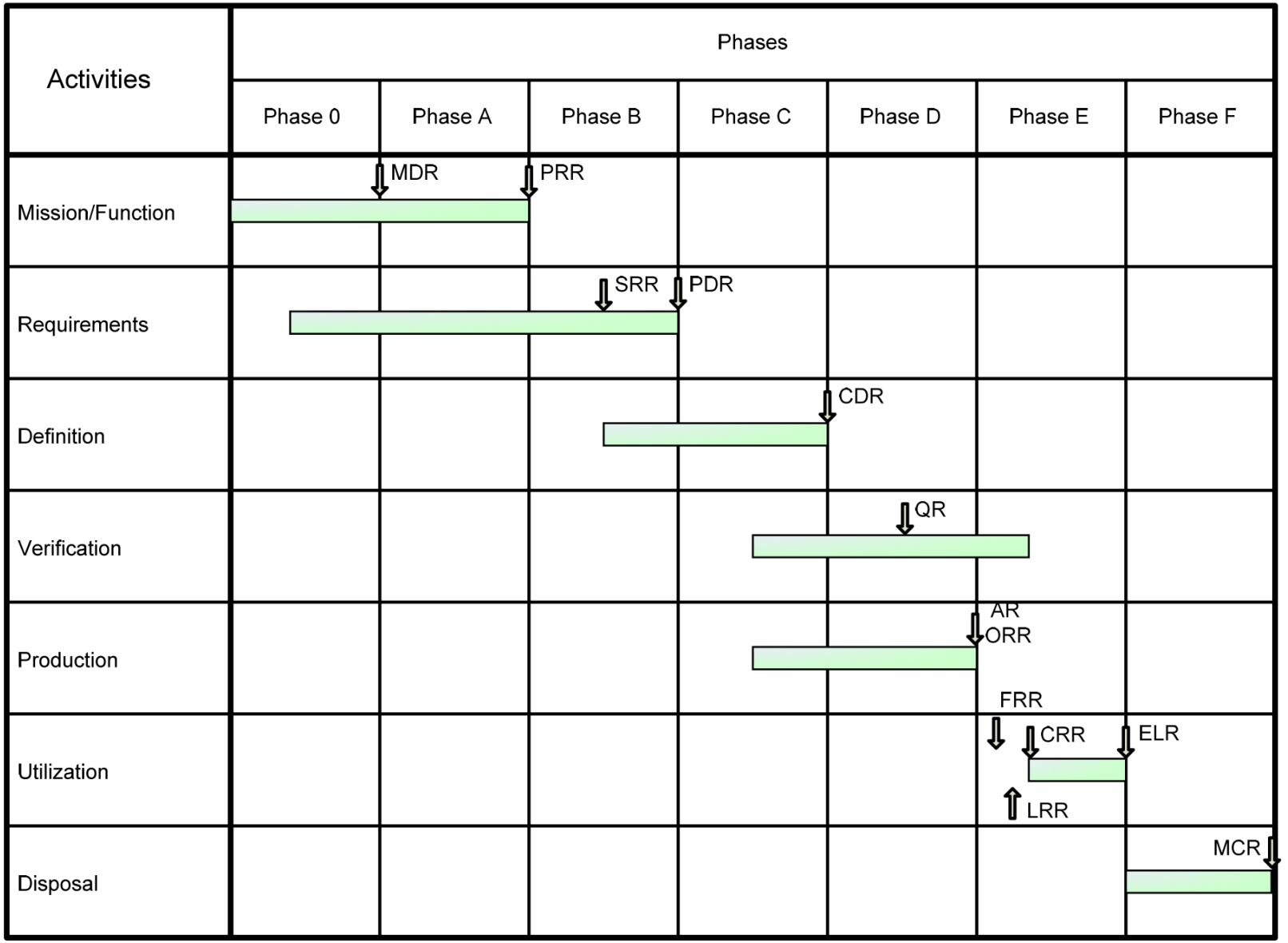
A PA cannot ignore cost and schedule; but it's not his main priority.

PA DISCIPLINES

QA is a discipline of Product Assurance



PA in Reviews – a dive into Project Phases



Who Are Product Assurance Engineers?

Cost of quality (1/3)

Internal failure costs: those incurred to remove defects from the products before shipping them to customers. Examples:

- Cost of scrap
- Rework labor and overhead
- Re-inspection of reworked products
- Disposal of defective products
- Down time caused by quality problems

External failure costs: those derived from shipping defective products to customers. Examples:

- Warranties
- Replacements
- Liabilities arising from the use of defective products
- Lost sales

Cost of quality (2/3)

Prevention costs: the costs incurred to avoid or minimize the number of defects at first place.

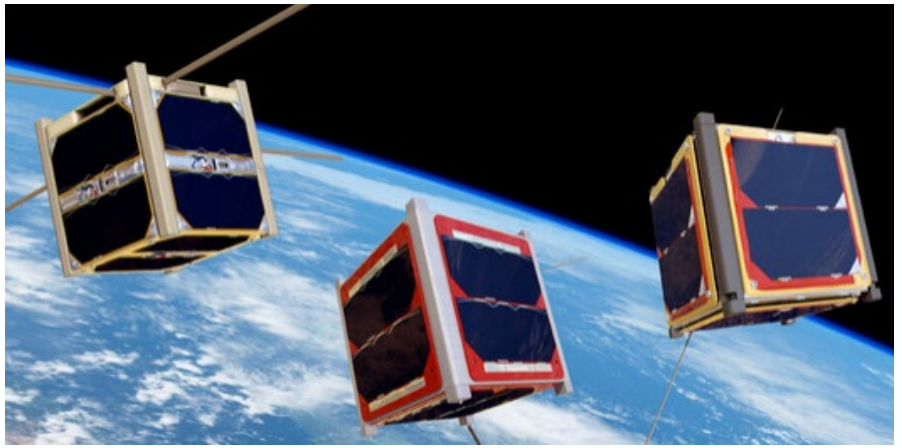
Examples:

- Improvement of processes
- Training
- Statistical process control
- Quality data reporting and analysis

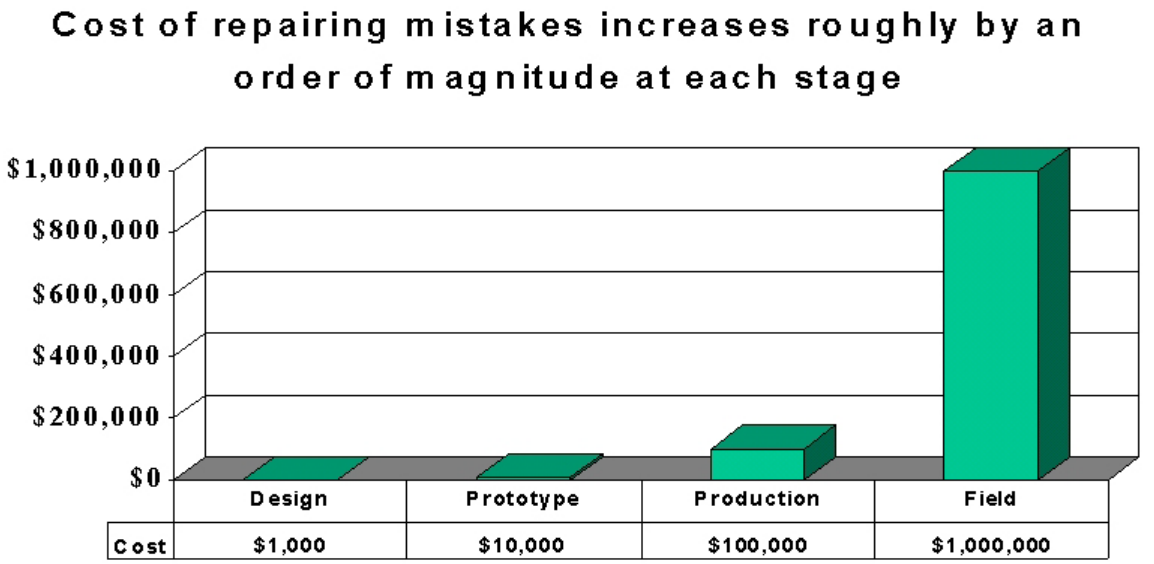
Appraisal costs (also named **inspection costs**): those incurred to identify defective products before they are shipped to customers.

Examples:

- Control of incoming materials
- Final product testing and inspection
- Supervision of testing and inspecting activities
- Inspection and test equipment



Cost of quality (2/3)



Courtesy of Harvard Business School ("Business Week" Magazine)

- Space missions are subject to many different types of risks, which makes space projects quite unique. Namely, space environment (thermal, radiation); technology and manufacturing readiness; launch constraints
- Many failures are not induced only by the environment, but by poor implementation of process control, workmanship, materials and quality of components used in the manufacturing of space products
- PA&S is contributing in failure investigations, focussing on root cause analysis and corrective/preventive measures

You recognize the lack of quality at once…..

The Cost of Quality after launch

Product Assurance adds cost but this is weighed against risks:

- Loss of life, astronauts and general population
- Programmatic losses since replacement time can be long and costly
- Loss of national capabilities and prestige
- Environmental impacts
- Sustainability (space debris)

SCOPE OF PRODUCT ASSURANCE

Scope of PA for different types of projects (1/2)

Manned Space Projects

- Driven by safety: for instance hazardous materials elimination, avoid accumulation of energy
- Independent safety review
- Human factors to be considered

Unmanned Space Projects

- Driven by reliability and/or availability. Maintainability is limited, and most of times are public or commercial services

Scope of PA for different types of projects (2/2)

Ground based projects

- Lower reliability requirements – availability achieved by maintenance
- Significant use of off-the-shelf components

Technology development projects

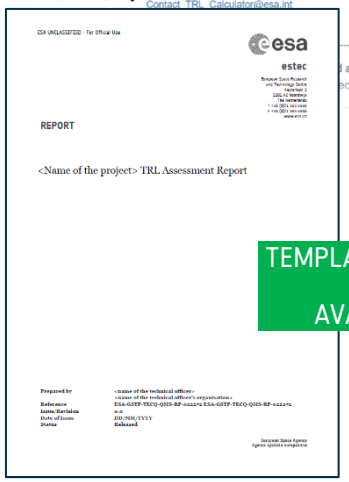
- The PA involvement is tailored to the nature of the final product
- TRL - Technology Readiness Level - is the key metric

Technology Readiness Level

TRL	Model	Performances	Environm.	Comments
TRL 1	Scientific papers	N/A	N/A	Preliminary scientific studies. No specific application envisaged.
TRL 2	Scientific papers	N/A	N/A	Basic research. Some applications are defined and discussed.
TRL 3	Proof of concept	Functions defined	Lab	Applied research. Applications identified.
TRL 4	Breadboard [BB]	Functions defined and prel. performance defined	Lab	HW available. Applied research continues to investigate for feasibility.
TRL 5	Breadboard [BB]	Critical functions identified	Relevant Environment	BB closer to EM but subject to scaling effects. Full experimental development.
TRL 6	EM/STM/ThM/ DM/EFM	Critical functions verified and performances identified	Relevant Environment	Form/Fit/Function (FFF) representative. Reliability not an issue.
TRL 7	QM	Full performance verification (QR)	Operation. Environment	Design verified against margins.
TRL 8	FM	Design change is over Element accepted (AR)	Actual Operational Environment	No latent defects and element integrated into sytem. Product Lifecycle starts.
TRL 9	Flight proven	Actual operational environment	Actual Operational Environment	Heritage data available (EQSR for OTS equipment).

ESA TRL Calculator

ESA TRL Calculator is available to Industry (https://trlcalculator.esa.int). It embeds path-to-flight approach for Design, AIV/AIT, PA, M&P, EEE, SW, RAMS, Management

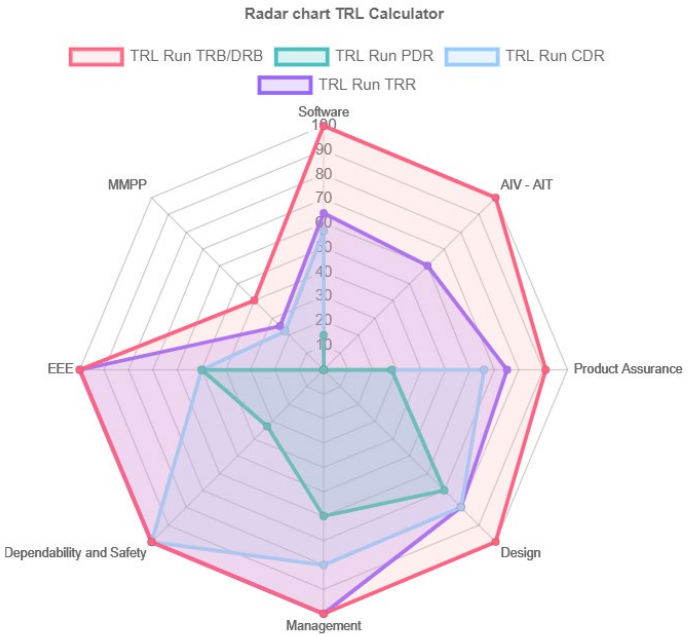


TEMPLATES EASILY AVAILABLE

ID	Question	Mandatory	Category	Subcategory	Answer
1	Are the critical functions identified?	True	Design		Yes
2	Is the relevant environment identified?	True	Design		Yes
3	Is there a breadboard available?	True	AIV - AIT		Yes
	ented in breadboard ICDs?	True	Design		Yes
	analytical models to predict g scaling)?	True	Design		Yes
	having different maturity levels were lyses and test reports show evidence work together as expected?	True	AIV - AIT		N/A
	Is failure propagation addressed in the design for safety				

In case sub-elements have different TRL maturities, the verification at BB level aims to verify that the overall TRL 5 is achieved. The different maturity levels should be documented in the DDV plan or equivalent. This question becomes crucial for complex instruments that are assembled from parts that are coming from different suppliers who have different visions on assessing the technology maturity.

CHECKLIST AVAILABLE FOR EACH TRL



SPIDER CHART FOR EACH AREA AND FOR DIFFERENT MILESTONES

https://trlcalculator.esa.int

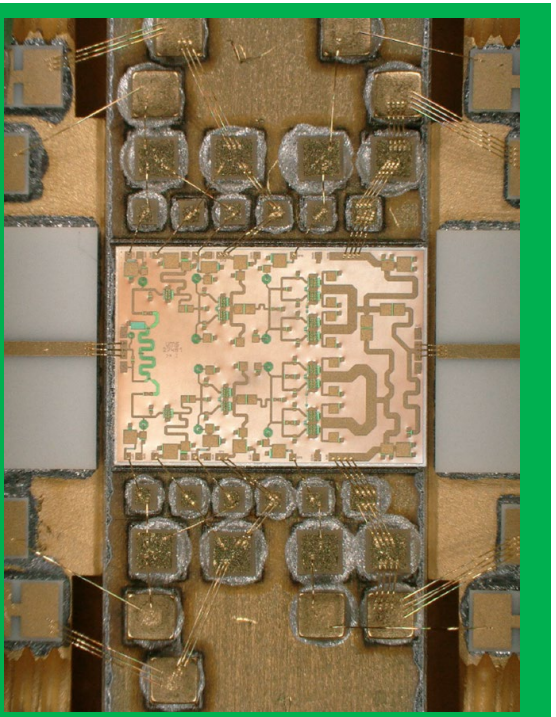
ECSS-Q-ST-10C Rev1

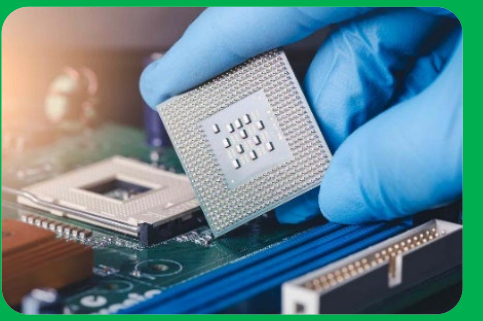
Product Assurance Management

Product/Quality Assurance plans contents (1/3)

PA PLAN (ECSS-Q-ST-10 Annex A)

- PA organization, responsibilities and authority, resources, PA interfaces & processes
- PA implementation procedures, including:
  - PA & risk management and reporting
  - PA audits
  - **Critical items**
  - Document & data control
  - **Quality records**
  - PA contribution to CC
  - **NCRs & Alerts management**
- **QA processes & procedures** including training and certification
- Design and verification QA activities and processes Procurement QA activities and processes
- Manufacturing, assembly, integration (MAI) and testing QA activities,
- QA specific activities, including:
  - **Critical items, NCRs & Alerts**
  - Authority media, Traceability, **Records**
  - Metrology and calibration
  - Handling and storage
  - Statistical quality control





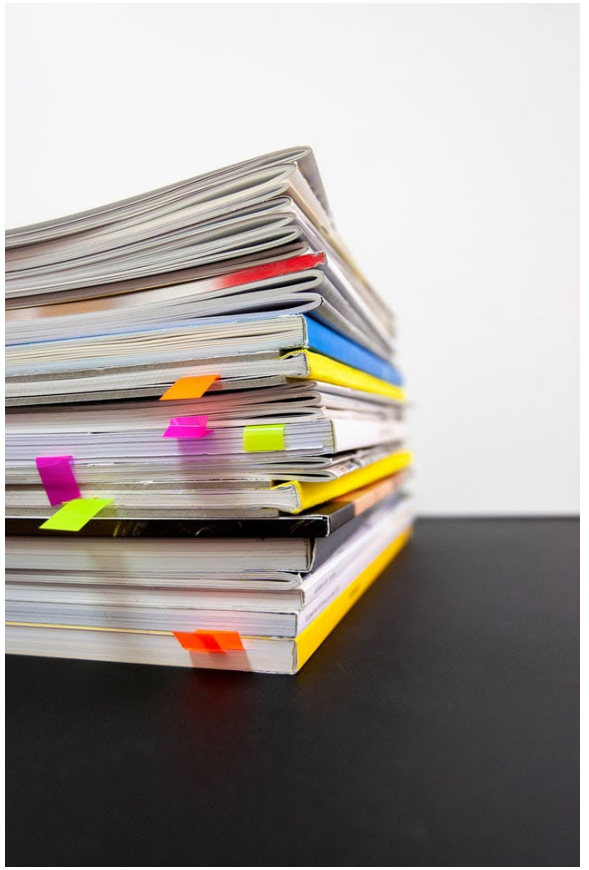
PA/QA plans contents (2/3)

PA/QA Plan shows how the quality will be managed/fulfilled, some examples:

- Lines of **responsibilities**, reporting, decision processes
- **Procurement control**, critical items control, quality records, audits
- **Training** of personnel, calibrated tools and machines
- **Workmanship** requirements and checks
- **Traceability** of work and parts (in both directions), storage
- Handling of **non-conforming parts** (containment, traceability, corrective actions, preventive actions), alerts management
- Overall **compliance status** and lists of exclusions

PA/QA plans contents (3/3)

- To the maximum possible extent, it should be based in existing company manuals and procedures, provided they are compliant to project requirements
- It has to be an **operational document**, that should be endorsed and applied by the organization
- Should identify all these aspects that are unique to the product: for instance, optics should address cleanliness and contamination prevention, electronics should address ESD protection, mechanism should address humidity effects to lubricants, SW should address coding standards & language etc…



ECSS-Q-ST-10

Product assurance management

ECSS-Q-ST-10C Rev.1	Product assurance management
ECSS-Q-ST-10-04C	Critical-item control
ECSS-Q-ST-10-09C Rev.1	Nonconformance control system

ECSS-Q-ST-10C pre-tailoring matrix in chapter 6

Table 6-1: Pre-Tailoring matrix for ECSS-Q-ST-10C Rev.1

ECSS req. number	Space product types									
	Space system	Space segment element and sub-system	Space segment equipment	Launch segment element and sub-system	Launch segment equipment	Ground segment element and sub-system	Ground segment equipment	Ground support equipment	Software	Comments
5.1.1.1a	A	A	A	A	A	A	A	NA	NA	For Software, covered by clause 5.1.4 of ECSS-Q-ST-80
5.1.1.1b	A	A	A	A	A	A	A	NA	NA	For Software, covered by clause 5.1.4 of ECSS-Q-ST-80
5.1.1.1c	A	A	A	A	A	A	A	NA	NA	For Software, covered by clause 5.1.4 of ECSS-Q-ST-80
5.1.1.1d	A	A	A	A	A	A	A	NA	A	

Project PA Audits ECSS-Q-ST-10C rev1

- Establish and maintain audit plan for both internal and external audits
- Audit plan include current status and schedule for auditing
- General contents of project audits are detailed in ECSS-M-ST-10, clause 5.2.3
- In case of consistent poor quality or other problems extra audits can be planned

PA Audits (both external and internal)

- Preparation, questionnaire
- Execution
- Follow-up actions closure

ECSS-Q-ST-10-04C

Critical Item Control

Critical Item Control ECSS-Q-ST-10-04C (1/2)

Critical items are **potential** threats to the performance, quality, dependability or safety of a system that are controlled by a specific action plan in order to mitigate emanating risks and to prevent undesirable consequences.

Annex C of ECSS-Q-ST-10-04 provide for a checklist; examples include:

- Single point failures with major loss of function
- Unqualified technology or units whose performance cannot be tested
- Items with life-limited parts, contamination sensitive parts etc.

The method of assessing and tracking critical items, in a critical items list (CIL) is fully described in a dedicated standard ECSS-Q-ST-10-04.

Critical Item Control ECSS-Q-ST-10-04C (2/2)

The items shall be kept in the CIL which lists the mitigation actions and criticality of the item. Refer to ECSS-Q-ST-10-04 § 5.1

The identification of critical items is done by the supplier as soon as a preliminary design emerges, first issue of CIL at Preliminary Design Review.

The CIL shall be reviewed during the design reviews and all listed critical items shall be closed by the acceptance review

ECSS-Q-ST-10-09C Rev1

Nonconformance control system

Nonconformance (1/2)

Major NCR has an impact on the **customer's requirements** on:

- safety of people or equipment,
- operational, functional or any technical requirements imposed by the business agreement (BA),
- reliability, maintainability, availability, lifetime,
- functional or dimensional interchangeability,
- interfaces with hardware or software regulated by different BA,
- changes to or deviations from approved qualification/acceptance test procedures,
- project specific items which are proposed to be scrapped.

Nonconformance (2/2)

Minor NCRs

- Nonconformances which by definition cannot be classified as major.

For instance, if the form, fit or function are not affected.

- If in doubt raise major NCR

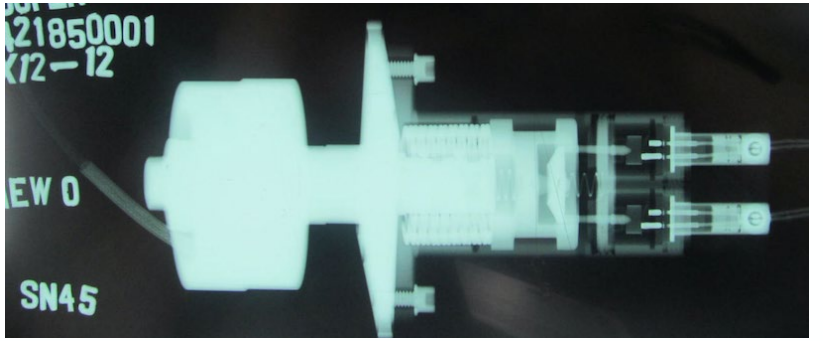
Project PA Activities – NCR Process

When non-conformance is identified, a Non Conformance Report (NCR) is raised. An example report in Annex C in ECSS-Q-ST-10-09C Rev1.

Assessment of NCR is performed in a Non Conformance Review Board (NRB), mandatory participants PA and representative engineering.

Key aspects to cover:

- Which item/model is affected
- Criticality identification (Major/Minor)
- Root cause evaluation, Corrective/preventive actions
- Determine whether to return to supplier/use-as-is/rework/repair/scrap



Nonconformance review board (NRB) (1/2)

Internal NRB tasks

- Investigate the causes and consequences of the NCR and classifies the nonconformance either as minor or major
- For minor NCR disposes as follows:
  - **Return to supplier**: This disposition only applies to nonconforming procured items.
  - **Use "as is"**: The item is found to be usable without eliminating the nonconformance.
  - **Rework**: The item is recoverable to conform completely to all specified requirements. Additional work is performed to prepare the item for the rework (e.g. removal of faulty work and cleaning). In no case should the result of earlier applied processes or the precondition for other processes to be applied later on, be affected. In other terms, the reworked item still conforms to the originally specified requirements.
  - **Scrap**: The item is not recoverable by rework or repair, for technical or economic reasons.
  - **Repair**: The item is recoverable such that it fulfils the intended usage requirements although it does not conform to the originally specified requirements.

Note: The repair procedure is either a. Qualified or standard repair procedure or b. Specific repair procedure.

Nonconformance review board (NRB) (2/2)

Customer NRB – Major NCR

The customer NRB follows the same process as the internal NRB.

An assessment whether requirements of higher level customers are impacted is performed. If so, these higher level customers are involved in ensuing NRBs. The need for a request for waiver is also identified and recommended by this NRB.

Request for Deviation/Waiver ECSS-M-ST-40C rev1

Request for Deviation

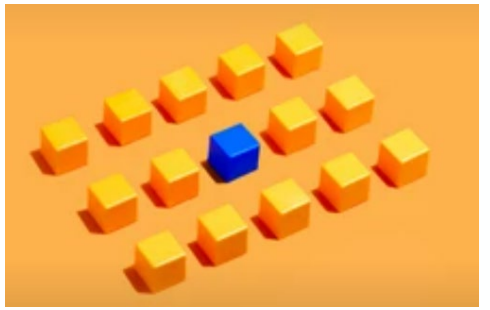
Planned departures from requirements or design, describing why the product concerned cannot meet requirements of the baselined configuration documentation.

Translation: this affects the requirement in the design phase already, PRIOR to manufacturing.

Request for Waiver

Unplanned departures from requirements or design. Translation: your MANUFACTURED items does not conform to requirements. So, you need to trigger this by means of an NC.

Example form and requested content in ECSS-M-ST-40C Rev1.



ECSS-Q-ST-20C rev2

Quality Assurance

Quality Assurance general requirements

Quality Assurance plan can be combined with Product Assurance Plan

The previous slides already introduced Critical Items Control and NCR management

In addition the QA general requirements (chapter 5.2) include:

- Management of Alerts
- Traceability
- Acceptance authority media
- Statistical quality control and analysis
- Metrology and calibration
- Handling, storage, transportation and analysis

Pre tailoring matrix can be found on chapter 6 of the standard.

Ariane 501 failure. Since this failure ESA has put a number of measures in place for development, verification and validation of flight and ground software such as ISVV and Spice4Space

ECSS-Q-ST-20

Quality assurance	
ECSS-Q-ST-20C Rev.2	Quality assurance
ECSS-Q-ST-20-07C	Quality and safety assurance for space test centres
ECSS-Q-ST-20-08C	Storage, handling and transportation of spacecraft hardware
ECSS-Q-ST-20-10C	Off-the-shelf items utilization in space systems

Table 6-2: Pre-tailoring matrix per "Space product types"

	Space product									
ECSS req. number	Space system	Space segment element and sub-system	Space segment equipment	Launch segment element and sub-system	Launch segment equipment	Ground segment element and sub-system	Ground segment equipment	Ground support equipment	Software	Comments
5.1.1a	X	X	X	//	//	X[1]	X[1]	-	-	[1] except for suppliers of catalogue OFF-THE-SHELF items such as standard laboratory equipment, work stations,.. , from whom a dedicated QA plan is not required.
5.1.1b	X	X	X	//	//	X	X	-	-	

Alert Management

Alerts are formal notification from a supplier or agency of a problem that can affect more than one user. Some sources

- GIDEP (US **G**overnment **I**ndustry **D**ata **E**xchange **P**rogram)
- NASA Parts advisory
- ESA Alerts (https://alerts.esa.int/)
- CNES Alerts
- JAXA Alerts

Industry also issue alerts, sometimes under different names

- Letter or notice
- Warning Notice (e.g. Airbus Defence and Space)

Alert Management

Alerts need to be assessed to determine whether a particular risk exists in the project (i.e. if item is within perimeter of the alert)

If product is affected then alerts usually provide recommendations that depend on the state of development.

Alerts can have major cost and schedule impacts. An example is to replace a EEE component after a unit has been completed.

Contractors are to maintain a listing of all alerts and the responses – this is reviewed periodically and is recommended to be part of the project progress reporting

ESA Alert System

It covers failures in:

- EEE parts, mechanical parts
- pyrotechnic devices
- materials
- software
- Equipment

Problems affecting:

- safety
- manufacturing processes
- handling procedures
- standard test methods
- standard operational procedures
- software development & test methods and tools
- continuity of production of an item

Criteria to issue an Alert

The observed problem may apply to **more than one project** or organisation

The problem was observed while the item was applied **within its specified limits**

A preliminary investigation has provided **sufficient evidence of the cause of the problem**

The problem is confirmed **not to be of a random nature**

The **complete and unambiguous traceability** of all the affected items to the impacted users **is not possible**.

ESA Alert EA-2012-PYR-4-A (1/4)

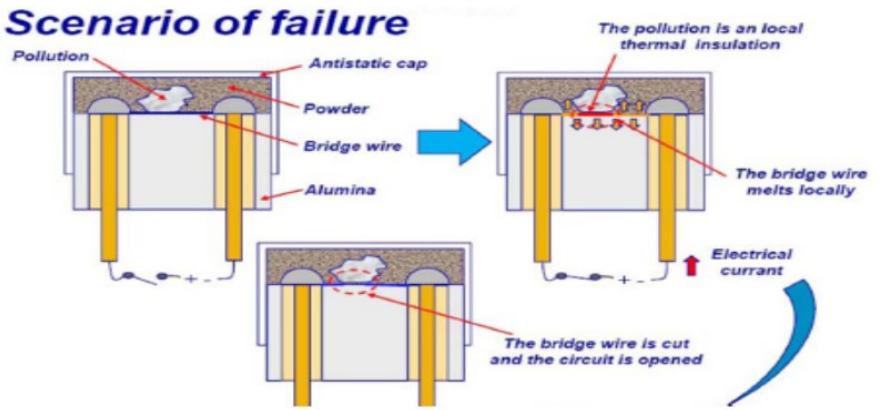
- **Missed firing of one initiator** (S/N48), during Acceptance Test of Pyro-Initiators 1TAPWH40S batch 29 (delivered for Ariane 5 Vulcain Igniter applications)

- An initiator is a component containing a small quantity of energetic material, located upstream of an explosive train. In the initiator a transformation of energy occurs, and the effect produced is a combustion, deflagration or detonation (see ECSS-E-ST-33-11C Rev. 1, 2017)

- **Pyro-Initiators** are used in almost all ESA Projects also in Safety critical applications (solid motors igniters, fairing separation, solar array release)

ESA Alert EA-2012-PYR-4-A (2/4)

- **Cause of the misfiring**: Contamination
- The **failure investigation** performed identified the presence of a **polyamide particle** from the **antistatic cap**, in contact with the **bridge wire** inside the powder (AW1)
- The particle modified the thermal exchange between bridge wire and AW1 (thermal barrier) leading to the **local melting of the bridge wire** itself **without the ignition** of the AW1 powder.
- **Cause of the contamination**: The particle was likely generated by polyamide chip-outs coming from **manufacturing line**, which was used also for other products.



ESA Alert EA-2012-PYR-4-A (3/4)

Perimeter of the Alert

Number of initiators with antistatic caps batch #543255 involved in the observed failure: **5000 units since 2009**

Since the supplier stated that there had not been any changes in the manufacturing process for the antistatic caps, also earlier batches were considered suspect ➔ **total of 45000 units**

ESA Alert EA-2012-PYR-4-A (4/4)

Actions on / by manufacturer

- **Audit** with several recommendations to ensure defect-free manufacturing
- Certification of a **CT-Scan inspection** to detect any defect on existing caps

Actions by users

- Preferred: **replace** suspect initiators, or perform **CT-Scan**
- **If not possible: use-as-is**, based on reliability evaluation performed by ESA

Traceability (1/3)

Traceability covers many type of activities

- Requirements/verification traceability
- Materials and parts traceability (procurement)
- Machine/operator/metrology traceability

Traceability (2/3)

Focusing on the production aspects

- Decision early in the design to determine what mechanical parts, assemblies or units to serialize
- Proper storage management, handling during AIT (bag/tag control)
- EEE and critical materials traced through date-codes or lot identification
- Shop travellers to contain information on machines, operators
- Quality records must be able to provide ***traceability in both directions*** – the source of a material/part and where it is eventually used/installed.

Traceability (3/3)

Traceability is vital information

- Assessing whether a system is within the perimeter of an alert
- Investigating a non-compliance
- Data collection for routine monitoring of quality (correlation)
- Containment and segregation of unsuitable materials or parts

Traceability documentation is found throughout

- As-built configuration list (ABCL) → in EIDP
- As-built declared component lists (DCL)
- Shop travellers or as-run procedures
- Inventory lists

Acceptance Authority

Acceptance Authority (formerly stamp control) is used to trace completion of operations and QA approval or inspections.

- Source or incoming inspection
- Process inspection, tests and final inspections, e.g. KIP/M
- Storage and shipment preparations

This traceability also improves integrity and commitments to quality since the responsibility is documented and link to individuals

Statistical Data Analysis (1/2)

Effective quality management requires objective data to be collected and analysed to support decisions, for example:

- Inspection, sampling, screening of parts → accept/reject parts
- Material properties → accept into production chain
- Process repeatability and accuracy → are processes stable?
- Performance (accuracy, resolution, and repeatability)→ accept/reject
- Failures → correlation, reasons, containment, correct and improve

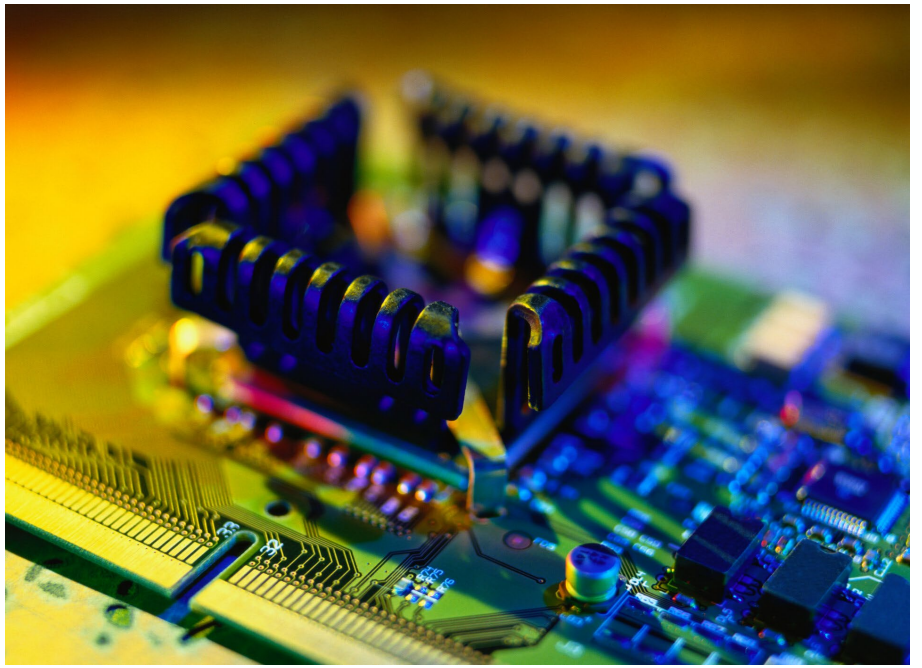
General requirements for statistical methods are detailed in ECSS-Q-ST-20C Rev2, 5.2.8.

This is also an important area of development for data analytics and use of AI for preventive maintenance.

Statistical Data Analysis (2/2)

For companies producing many parts, statistical quality checks by sampling is permitted (e.g. EEE components)

- Requirements in § 5.2.8 of Q-20
- Lot definition, lot sampling approach and allowable failures to be justified
- Statistical methods must be approved by customer



Metrology and calibration

The emphasis in the ECSS-ST-Q-20C is the completeness of the calibration of any items used for metrology.

- Calibration is up-to-date and traceable to calibration standards
- Traceability of machine/operator and training
- Validation, especially for use of software
- ensure that the means are adequate for the purpose of measurements (accuracy, resolution and precision)

→ Do not forget the national safety requirements for equipment involved with testing

ECSS-Q-ST-20-07C

Quality and safety assurance for space test centers

Test Facilities (1/2)

- All technical and programmatic risks associated with testing must be identified and managed
- Subject to ECSS-Q-ST-20-07C Quality and safety assurance for space test center's
  - QMS compliant with EN9100
  - Description of facilities, configuration control
  - Risk assessment, planning and documentation of test process
  - Personnel competence, awareness and training
  - Environmental control: temperature, RH, differential pressure, cleanliness
  - Safety programme for personnel, including the customer and visitors, the test specimen, the test facilities and its associated infrastructure
  - Site security and access control

Test Facilities (2/2)

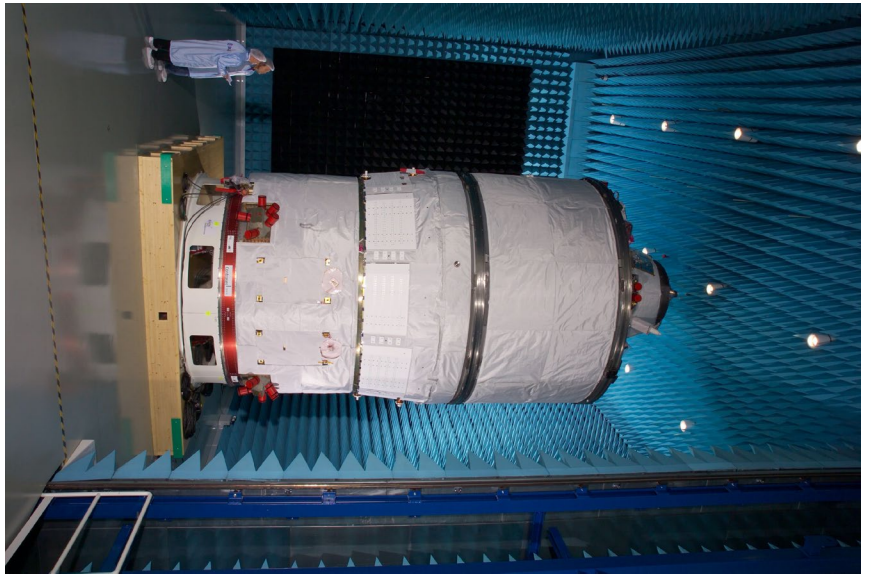
The questionnaire on the use of hazardous items and operations can be found Annex A of the ECSS-Q-ST-20-07

The questionnaire is in three parts:

- Part 1: knowledge on safety hazards coming from the test specimen (i.e. radioactive sources and generations, explosive devices, mechanical energy…)
- Part 2: sensitivity of test specimen (i.e. sound levels with spectral distribution, humidity, chemicals, contamination…)
- Part 3: detailed description (i.e. hazards to which personnel are exposed during the operation…)

Annex B: Typical test process sequence (EN 9100:2009 + ECSS-Q-ST-20-07)

NOTE: Please consider a MAJOR ECSS standard to define test sequences, test-as-you-fly methods, control gates etc is the ECSS-E-ST-10-03C



ECSS-Q-ST-20-08C

Storage, handling and transportation of spacecraft hardware

Handling and Storage (1/2)

- Despite the obvious need for safe handling, accidents do occur during handling and transportation. The QA approach is to assess the risks, ensure personnel are trained and procedures are complete

- Storage in clean room or not?

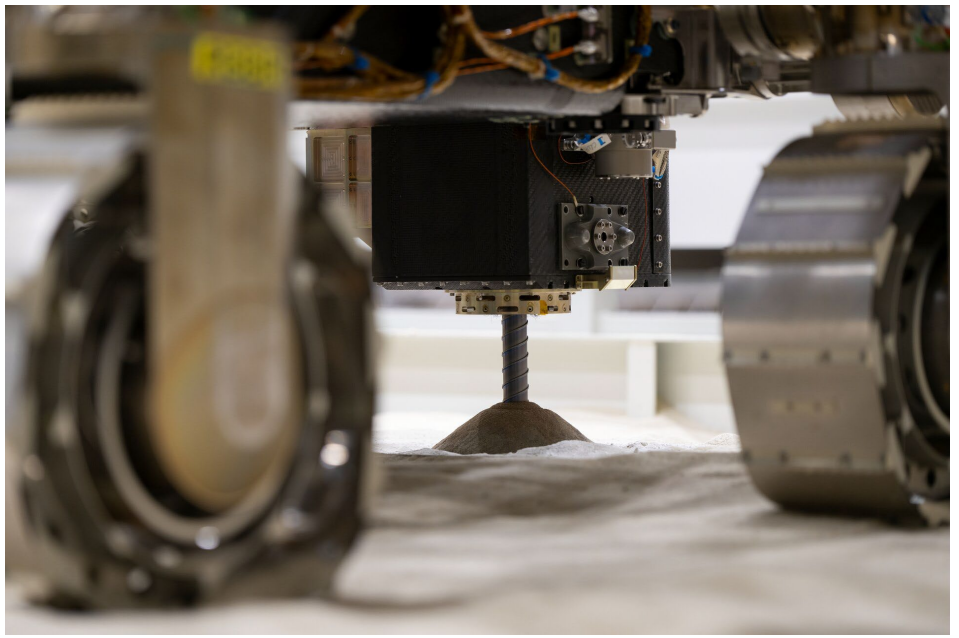
Handling and Storage (2/2)

- Some of the handling risks to guard against
  - Unwanted contact, scratches to sensitive surfaces – consider handling devices, tooling protections, tethers, covers, captive screws
  - Cleanliness – training of personnel, facilities, monitoring
  - Access constraints – to be tackled during design phase
  - ESD – personnel training, grounding
  - GSE design – ensure complete validation before acceptance
  - Untested procedures – to be tackled during development using BB, EQM

Lesson learned from handling accidents: most common causes (1/2)

Physical

- Interfaces handling tools – item non error-proof
- Improper tools
- Inadequate barriers
- Insufficient or misleading marking



Procedures

- Insufficient detail
- Ambiguity, interpretation

Lesson learned from handling accidents: most common causes (2/2)

Human factors

- Training
- Lack of communication
- Stress
- Schedule pressure, improvisation

Error-proof design, reduce likelihood and impacts of human error!

Delivery: shipping, transportation

Shipping control

- Items to be shipped must be inspected before release, for
  - Completeness
  - Adequate preservation and packaging
  - Correct marking
  - Presence of all required documents
  - Documentation shall include
  - EIDP
  - Handling and packing or unpacking procedure
  - Any relevant safety procedures

Unloading the second Swarm satellite in Plesetsk (ESA/M. Shafiq)

Transportation - All necessary measures shall be taken to prevent damage to items during transportation

An example of transportation accident

http://www.bournemouthecho.co.uk/news/1633688.**investigation_into_space_cargo_chaos/**

21 August 2007

"It is designed to survive the rigours of terrestrial travel, but the multi-million pound satellite that became wedged in to the frame of Poole lifting bridge, may have been nobbled at its first hurdle.

The company, …, **has launched an investigation** in to how the lorry transporting several million pounds worth of satellite components to Poole ferry terminal, failed to make the 4.6 meter clearance height. …"

ECSS-Q-ST-20-10C

Off-the-shelf items utilization in space systems

Scope of OTS items

Off-the-Shelf (OTS) Items in THIS standard are those that, even if not necessarily developed for space applications, can be procured from the market and utilized in a space system.

Bear in mind, though, that sometimes OTS is referred to as being designed and manufactured according to aerospace standards. The purely commercial counterpart is referred to as being Commercial OTS, or COTS.

This Standard considers “complex” OTS items, as for example: motherboards, cards, data storage units/items, optical equipment, photo cameras and video units, LANs, mechanical/electrical and electromechanical devices, batteries, sensors, monitoring support units, medical equipment and items, laptops

This Standard does not cover

SW OTS, re-use of OTS items already qualified for space applications, pieces, parts and materials e.g. EEE parts, thermocouples, rivets, fasteners, connectors, fittings, adhesives, insulation, wiring and plumbing.

How Do we manage OTS in a Project?

Answer: For units, via **Equipment Qualification Status Review**

The EQSR is held normally in an early design phase, when

a make/buy decision is to be made and we need

To gain insights as to whether the OTS unit is fit for

Use in the S/C environment.

The PA manager has a key role to evaluate whether

The PA requirements are properly covered:

For ex: materials, processes, EEE components, SW

The EQSR is a complex review and is organised

Per areas of intervention:

- Performance comparison
- Interfaces comparison
- Flight history, etc

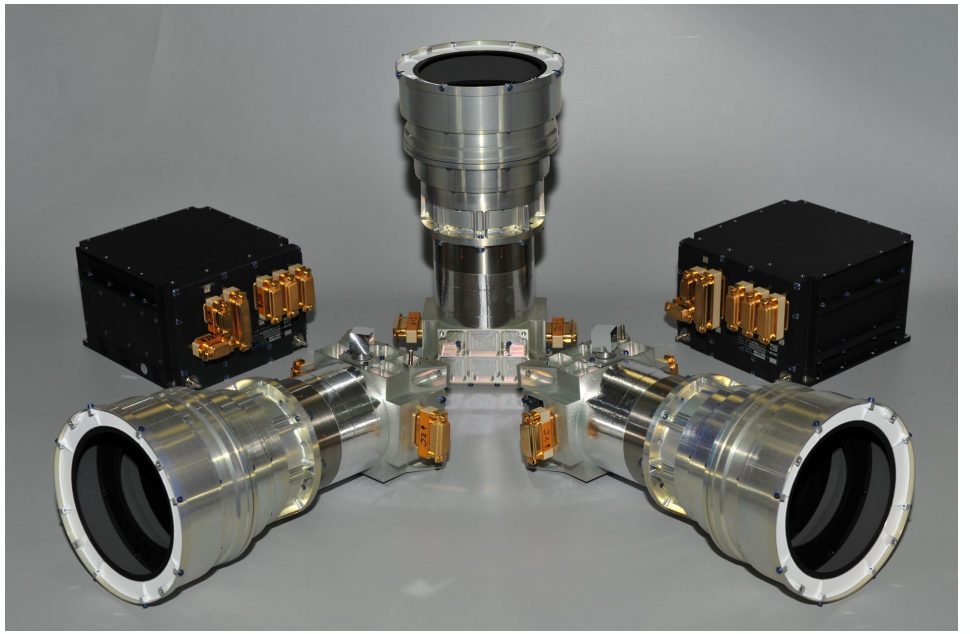
Table 5-1: Product categories according to heritage

Category	Description	Qualification programme
A	Off-the-shelf product without modifications and • subjected to a qualification test programme at least as severe as that imposed by the actual project specifications including environment and • produced by the same manufacturer or supplier and using the same tools and manufacturing processes and procedures	None
B	Off-the-shelf product without modifications. However: It has been subjected to a qualification test programme less severe or different to that imposed by the actual project specifications (including environment).	Delta qualification programme, decided on a case by case basis.
C	Off-the-shelf product with modifications. Modification includes changes to design, parts, materials, tools, processes, procedures, supplier, or manufacturer.	Delta or full qualification programme (including testing), decided on a case by case basis depending on the impact of the modification.
D	Newly designed and developed product.	Full qualification programme.

Documentation Requirements for OTS

The KEY information to be provided by a supplier for the usage of an OTS instead of an item specifically developed for the intended application, is the evidence that the item can be used in its new operational environment. In case of equipment, the evidence is shown at the time of the EQSR, or Equipment Qualification Status Review.

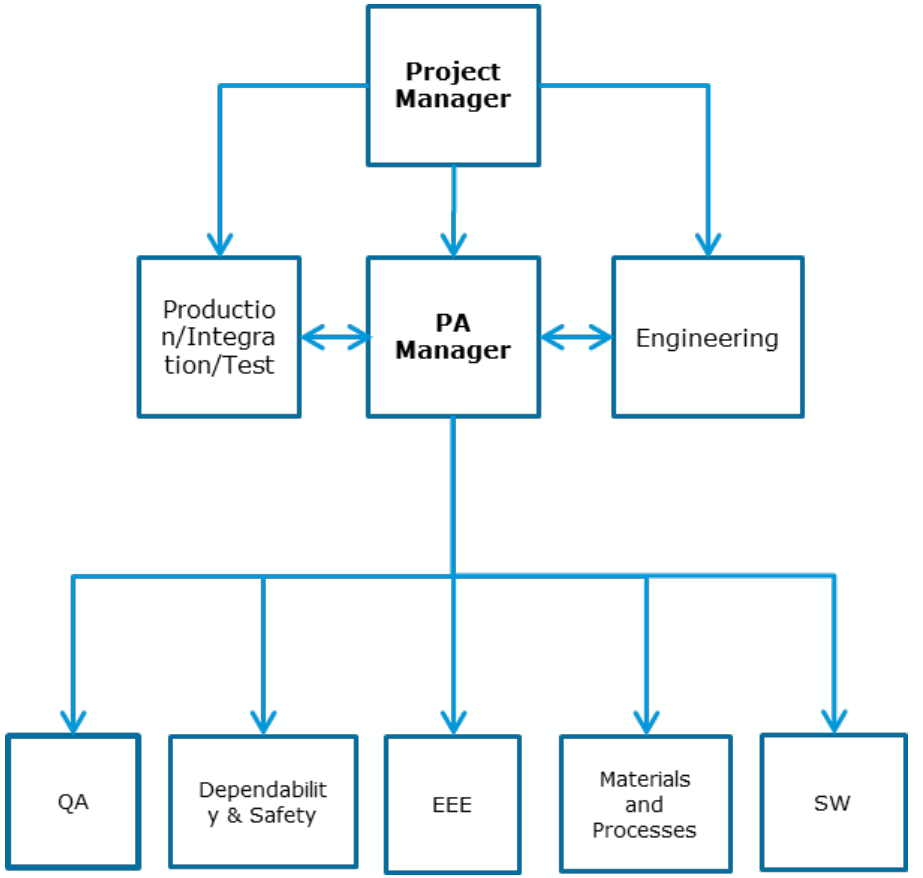
- A dedicated OTS Plan (Annex A of ECSS-Q-ST-20-10C)
- Equipment specification
- OTS item evaluation dossier (Annex B of ECSS-Q-ST-20-10C)
- OTS item criticality
- Data collection (designed for aerospace or military application preferred)
- PA evaluation (dependability, safety, EEE parts, MMP)
- Engineering evaluation (structural, thermal, electrical
- Procurement and qualification



Product Assurance in ESA project

Product Assurance in a Project

- Management Support
  - Risk assessment
  - Configuration control
  - Procurement (requirements)
- Engineering
  - Design review process
  - Verification completeness
  - Qualification and Acceptance
- Production/AIT
  - Inspection
  - Training
  - Facilities/machines/testing



PA is 'independent' from engineering, cost control, schedule and production

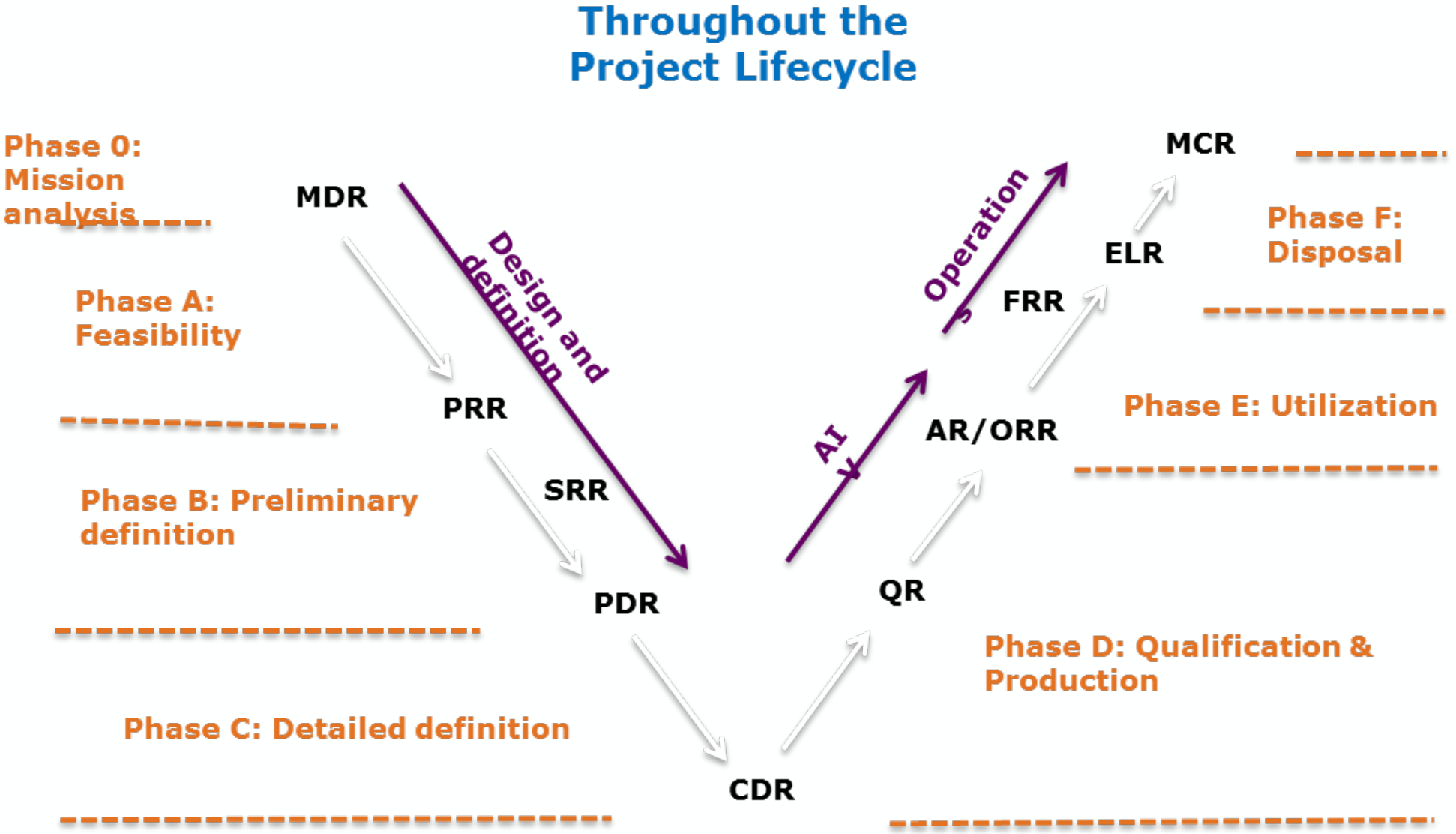
Roles of ESA PA

- Responsible for overall System PA activities
- Deal with inter segment issues
- Interface to Prime contractor(s)
- Monitoring is the main activity
- Responsible for generation of top level PA requirements for the project
- Reviewing the key review documentation for project milestones/reviews
- Providing expertise for PA activities to industry
- Participation to Anomaly meetings and project meetings

Roles of Industry PA

- Responsible for single element (Segment or Unit)
- Interface with ESA and lower tier contractors
- Definition of the PA Plan in response to the PA Requirements from the customer
- Definition, implementation and verification of the Quality processes in-house and at lower tier suppliers
- Day to day responsibility for project PA activities
- Direct compliance and configuration control activities
- Anomaly handling
- Control of MPCB process
- Control of PCB process
- Incoming inspection control of parts/materials

When is Product Assurance Needed?



PA Activities During Phase A/B

Identification of high level availability requirements and apportionment to subsystems

Identification of system Failure modes and mitigations

Ensure that failure mitigation requirements are in place

Concurrent Design Facility

PA Activities During Invitation To Tender

Preparation of Customer Product Assurance and Safety Requirements

Preparation of Customer EEE Requirements

Preparation of Customer Radiation Hardness Assurance Requirements

Identification of applicable Standards Baseline

PA Activities During Bid Preparation

Preparation of Statement of Compliance against the Tender documents

Tailoring of standards to the project (cubsesat vs satellite vs manned flight)

Preparation of a Product/Quality Assurance and Safety Plan

Identification of Requirements to flow down to sub contractors

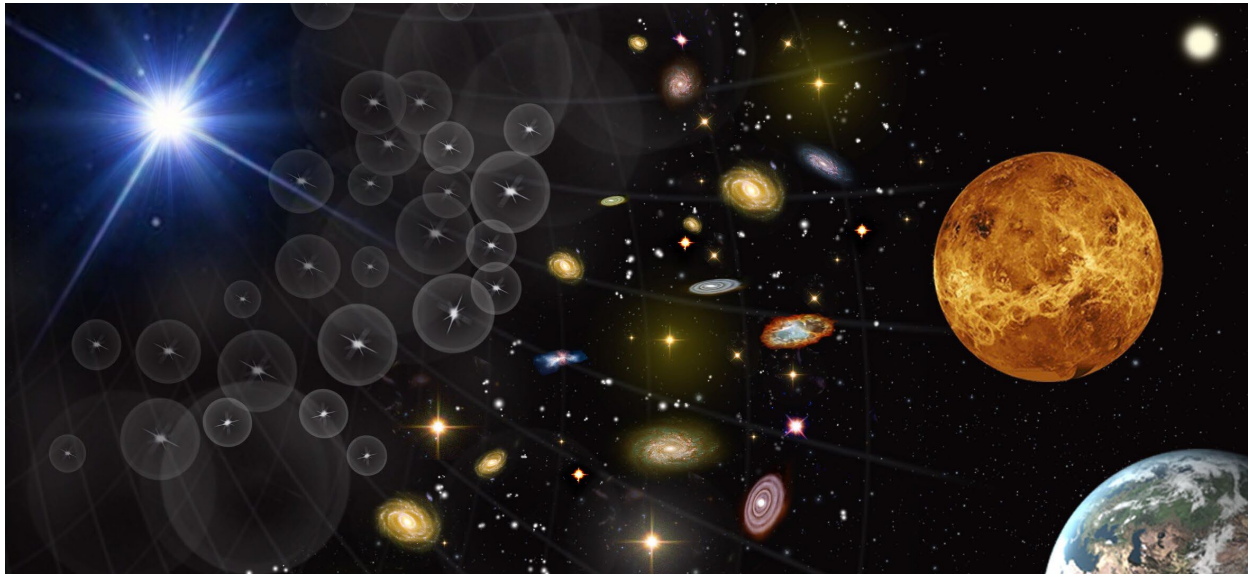
PA Activities During Bid Evaluation (and SRR)

Verification of Statement of Compliance and evaluation of any non compliances

Evaluation of effectiveness of Product Assurance and Safety Plan

Evaluation of qualification efforts

Evaluation of requirements flow down to lower tier contractors

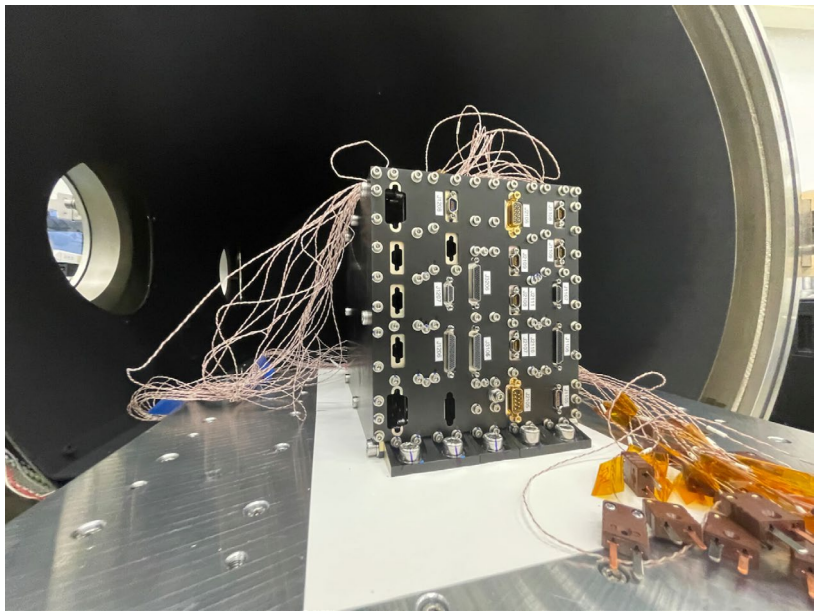


Qualification Status

The qualification status of the product, re-use file for SW, and its constituents should be stated and justified in qualification status list.

A qualification plan (could be part of the development plan) needs to be submitted

Category	Description	Qualification programme
A	Off-the-shelf product without modifications and • subjected to a qualification test programme at least as severe as that imposed by the actual project specifications including environment and • produced by the same manufacturer or supplier and using the same tools and manufacturing processes and procedures	None
B	Off-the-shelf product without modifications. However: It has been subjected to a qualification test programme less severe or different to that imposed by the actual project specifications (including environment).	Delta qualification programme, decided on a case by case basis.
C	Off-the-shelf product with modifications. Modification includes changes to design, parts, materials, tools, processes, procedures, supplier, or manufacturer.	Delta or full qualification programme (including testing), decided on a case by case basis depending on the impact of the modification.
D	Newly designed and developed product.	Full qualification programme.



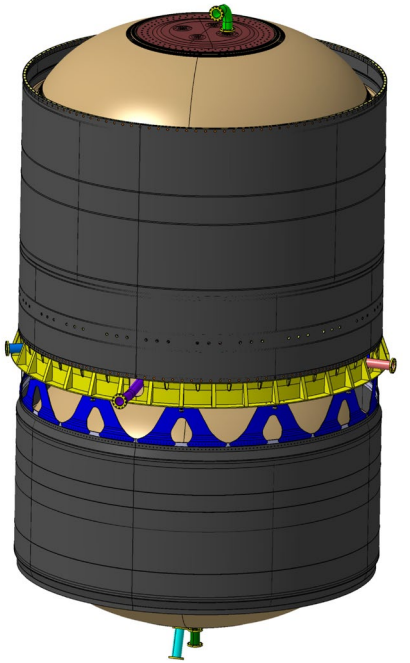
PA Activities at Equipment Qualification Status Review

EQSR: Equipment Qualification Status Review (ESSB-M-ST-002)

- Determine Qualification Status (CAT A, B, C or D)
- Identify changes to unit functionality
- Identify flight Heritage
- Identify Obsolescence
- Identify changes in manufacturing processes
- Compliances to PA and development standards

Conduction of Design Reviews: ECSS-M-ST-10-01C

A dedicated procedure is established to define:



- Objectives and criteria for success of the review
- Contents of the documentation to be provided
- Assign responsibilities (reviewers, panels, board)
- Establish a schedule
- Normally handled by means of RIDs (Review Item Discrepancy), settled down at a collocation
- Action items are assigned if depart from normal work

Documentation integrity: technical & physical

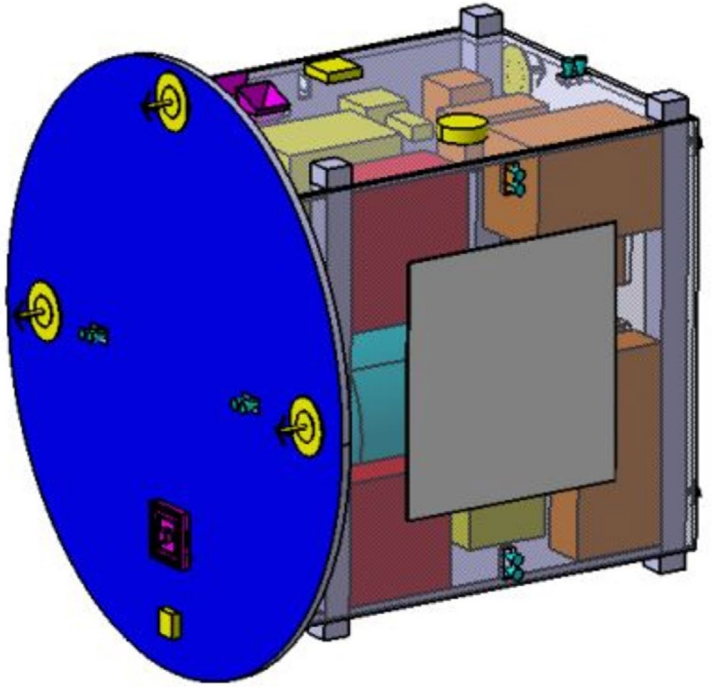
- Documents must be released and modified through formal procedures (Configuration Control Plan ECSS-M-ST-40C rev1)
- A “Configured Item Document List” must be continually updated/maintained and made available to document users
- Obsolete documents must be promptly removed from all point of use, or clearly identified (e.g. “OBSOLETE” red ink stamp)
- Document users must be forbidden to alter or deface released documents (by adding personal notes, work instructions, etc.)

Preliminary Design Review

PA Activities at Preliminary Design Review

Preliminary Design Review (PDR)

- Verification of the preliminary design of the selected concept and technical solutions against project and system requirements (including reliability/redundancy, FDIR concept, safety),
- Release of Declared Parts, Materials and Processes lists,
- Release of final management, engineering, product assurance and DDV plans, work breakdown structure and lower level specifications.
- Updated compliance matrixes.
- Release of CIDL and product tree.
- Identification of critical items and impact of alerts



PA after Preliminary Design Review

Follow up of activities, taking also into account that the procurement of lower items is going on

- Participation in the PDR of lower level items
- Part and Materials Evaluation (start of PCB, MPCB, ERCB, REACH)
- Critical Items and Alerts follow up
- Start of configuration control from the PDR baseline
- Possibly, growing pains: non-compliances produced along the manufacturing of EM's

PA Activities after Preliminary Design Review

Parts Control Board (PCB)

- Part Approval Document (PAD) ECSS-Q-ST-60C rev2 Annex D
- Radiation control board/radiation harness control board

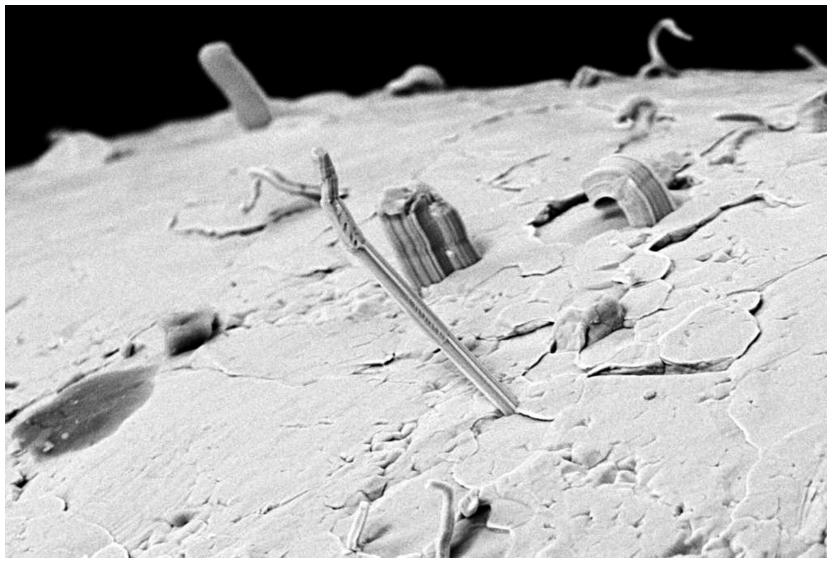
Materials and Processes Control Board (MPCB)

RFA part 1

- Describes the materials/processes to be qualified
- Qualification Plan approval

RFA part 2

- Qualification reports
- NCRs/RFDs/RFWs



Registration, Evaluation, Authorisation and Restriction of Chemicals (1/3)

REACH is a European Union regulation concerning the Registration, Evaluation, Authorization and restriction of chemicals. It came to force 1st June 2007.

REACH aim:

- to improve the protection of human health and the environment from the risks that can be posed by chemicals, while enhancing the competitiveness of the EU chemicals industry.
- It also promotes alternative methods for the hazard assessment of substances in order to reduce the number of tests on animals.

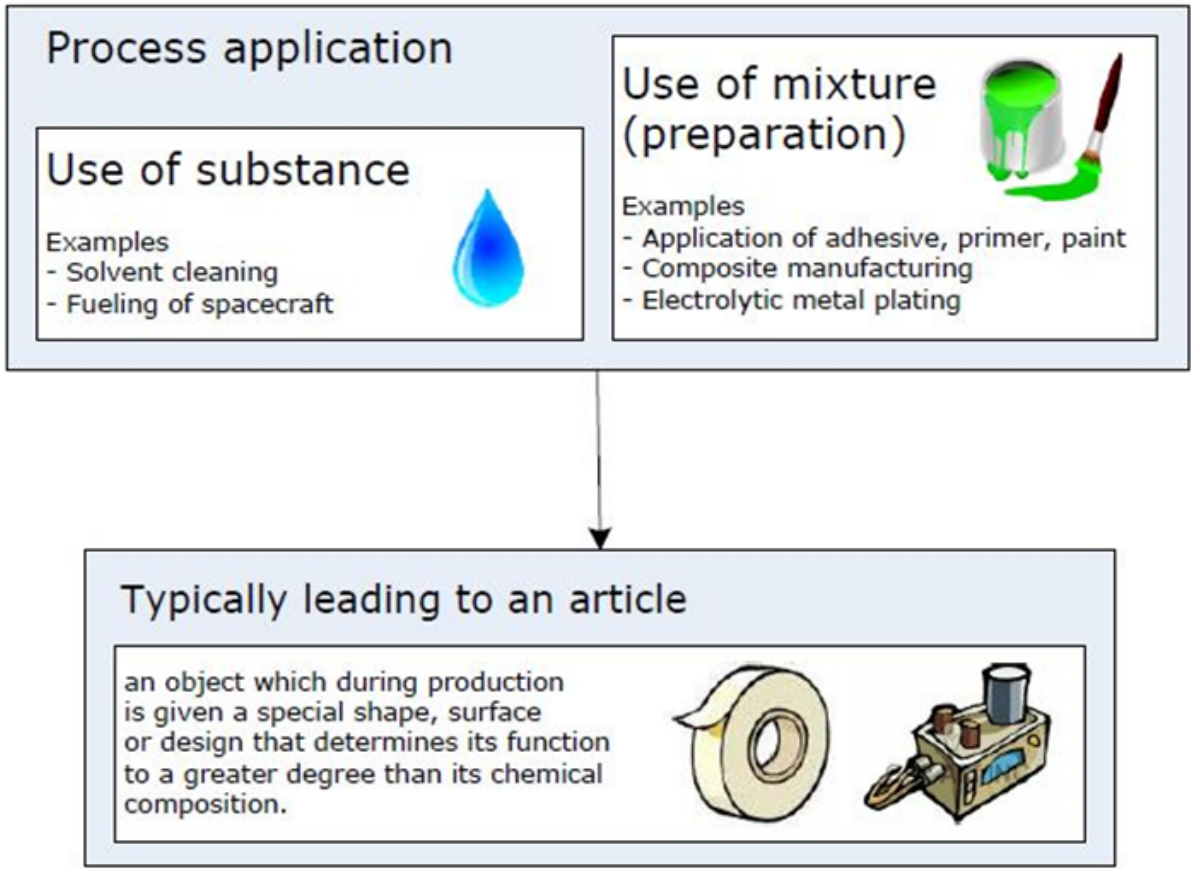
Registration, Evaluation, Authorisation and Restriction of Chemicals (2/3)

REACH for space:

REACH is affecting European space industry as a whole (obsolescence).

The Materials & Process Technology Board (MPTB) is a European platform that includes industrial partners and national space agencies including members from Airbus DS, Airbus SafranLaunchers, ASI, Avio, CNES, DLR, ESA, MAP, OHB, REACHLaw, RUAG, TESAT, and TAS.

Registration, Evaluation, Authorization and restriction of Chemicals (3/3)



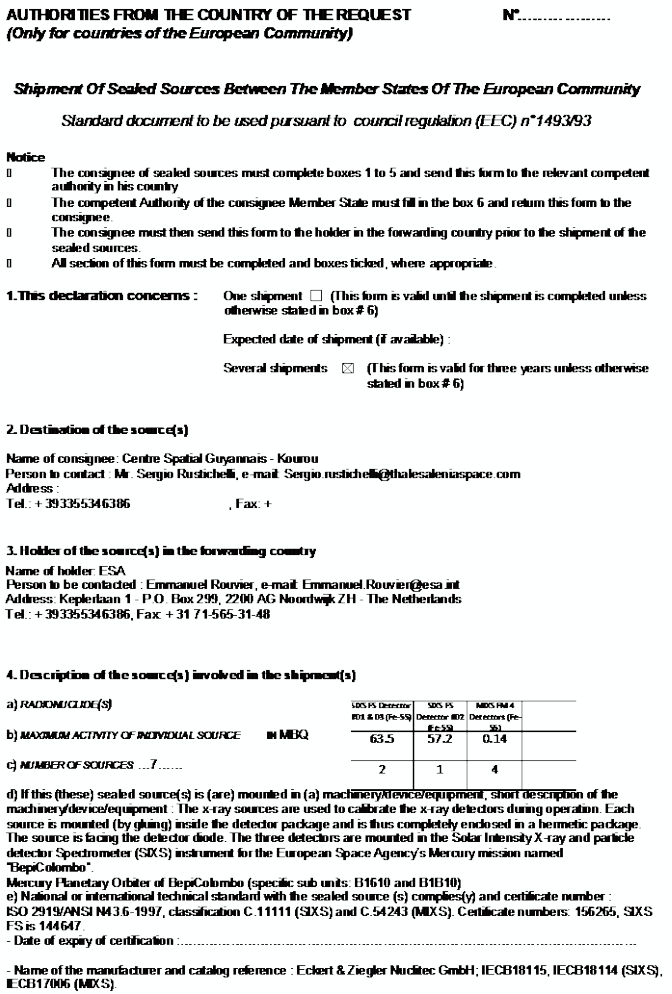
REACH obligations if a substance is classified a Substance of Very High Concern (SVHC) or mixture contains SVHC above threshold SVHC > 0.1%.

Trend of REACH:
Current estimates indicate ~ 8 % of our materials are probably affected in mid-term and 20% are possibly affected in long-term

Transportation of radioactive materials

Transportation of H/W item containing ionizing radiation sources

- Submission of EURATOM Forms required to authorize the transportation of radioactive materials.
- EURATOM forms and documentation to be processed enough in advance



AUTHORITIES FROM THE COUNTRY OF THE REQUEST N°.....
(Only for countries of the European Community)

Shipment Of Sealed Sources Between The Member States Of The European Community

Standard document to be used pursuant to council regulation (EEC) n°1493/93

Notice
- The consignee of sealed sources must complete boxes 1 to 5 and send this form to the relevant competent authority in his country
- The competent Authority of the consignee Member State must fill in the box 6 and return this form to the consignee
- The consignee must then send this form to the holder in the forwarding country prior to the shipment of the sealed sources.
- All section of this form must be completed and boxes ticked, where appropriate

1. This declaration concerns : One shipment ☐ (This form is valid until the shipment is completed unless otherwise stated in box # 6)

Expected date of shipment (if available) :

Several shipments ☒ (This form is valid for three years unless otherwise stated in box # 6)

2. Destination of the source(s)

Name of consignee: Centre Spatial Guyannais - Kourou
Person to contact : Mr. Sergio Rustichelli, e-mail: Sergio.rustichelli@thalesalenia space.com
Address :
Tel.: + 393355346386 , Fax: +

3. Holder of the source(s) in the forwarding country

Name of holder: ESA
Person to be contacted : Emmanuel Rouvier, e-mail: Emmanuel.Rouvier@esa.int
Address: Keplerlaan 1 - P.O. Box 299, 2200 AG Noordwijk ZH - The Netherlands
Tel.: + 393355346386, Fax: + 31 71-565-31-48

4. Description of the source(s) involved in the shipment(s)

a) *RADIONUCLIDE(S)*

b) *MAXIMUM ACTIVITY OF INDIVIDUAL SOURCE* IN MBQ

c) *NUMBER OF SOURCES* ....7.....

SIXS PS Detector #01 & 03 (Fe-55)	SIXS PS Detector #02 (Fe-55)	MIXS Hall 4 Detectors (Fe-55)	
63.5	57.2	0.14	
2	1	4	

d) If this (these) sealed source(s) is (are) mounted in (a) machinery/device/equipment, short description of the machinery/device/equipment : The x-ray sources are used to calibrate the x-ray detectors during operation. Each source is mounted (by gluing) inside the detector package and is thus completely enclosed in a hermetic package. The source is facing the detector diode. The three detectors are mounted in the Solar Intensity X-ray and particle detector Spectrometer (SIXS) instrument for the European Space Agency's Mercury mission named "BepiColombo".
Mercury Planetary Orbiter of BepiColombo (specific sub units: B1610 and B1B10)
e) National or international technical standard with the sealed source (s) complies(y) and certificate number : ISO 2919/ANSI N43.6-1997, classification C.11111 (SIXS) and C.54243 (MIXS). Certificate numbers: 156265, SIXS FS is 144647
- Date of expiry of certification :.....

- Name of the manufacturer and catalog reference : Eckert & Ziegler Nuclitec GmbH; IECB18115, IECB18114 (SIXS), IECB17006 (MIXS).

Transportation of radioactive materials

Example - BepiColombo:

Fe-55 radioactive material in one Instrument (SIXS, from Finland), as calibration source for X-ray measurements

- Instrument transportation from Finland institute to ESTEC
- Interfaces for transport to CSG (transportation from Institute to ESTEC, from ESTEC to CSG):
  - CSG CNES PCR (Person Competent for Radioprotection)
  - ESA Project focal point, identified as PCR for ESA
  - Support from ESTEC Health, Safety and Security Section (**HIF-ETH**)

Critical Design Review

PA Activities at Critical Design Review

Critical Design Review (CDR)

- Assess the qualification and validation status of the critical processes and their readiness for deployment for phase D.
- Confirm compatibility with external interfaces.
- Release the final design.
- Release assembly, integration and test planning.
- Release flight hardware/software manufacturing, assembly and testing.
- Release of user manual.

Critical Design Review

Expected outcome

- Final issue of reliability and safety analysis
- Final statement of compliance
- Parts, materials and processes approved
- All plans approved
- Supporting tests on Engineering models should be completed
- Actions from previous reviews completed as required

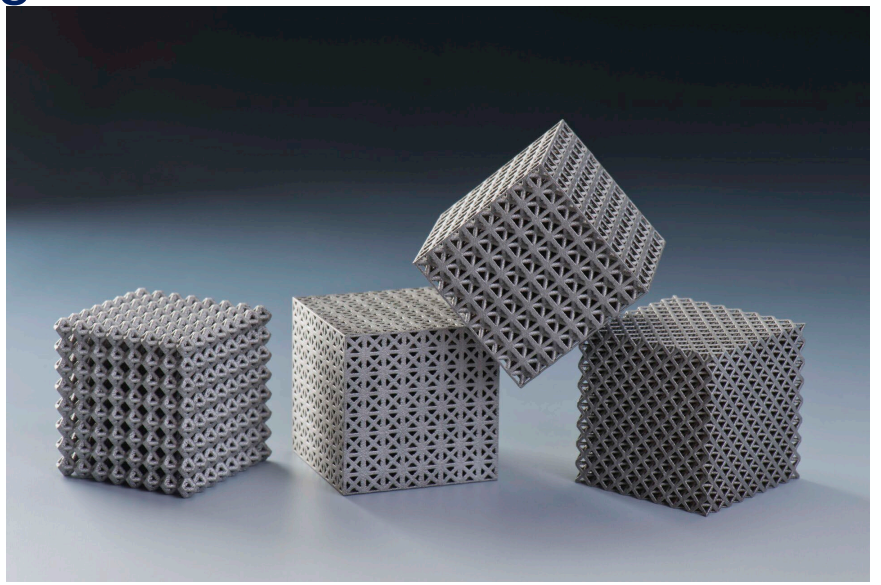
If everything regarding the design is approved, then it is time to start the production

Manufacturing Readiness Review and Integration Readiness Review

PA Activities

Manufacturing Readiness Review and Integration Readiness Review

- Manufacturing Plant and/or Clean room check (entry, clothing, cleaning, environmental monitoring, ESD, training)
- Materials (Self life/dangerous items)
- Materials and processes qualification status
- Shop traveler, step-by-step instructions
- Training



Cleanrooms and Contamination Control - terminology

3.2.9 cleanroom

room in which the concentration of airborne particles is controlled, and which is constructed and used in a manner to minimize the introduction, generation and retention of particles inside the room, and in which other relevant parameters, e.g. temperature, humidity and pressure, are controlled as necessary

[ISO 14644-6]

3.2.27 particle

unit of matter with observable length, width and thickness

3.2.29 particle size

apparent maximum linear dimension of a particle in the plane of observation as observed with an optical microscope, or the equivalent diameter of a particle detected by automatic instrumentation

NOTE The equivalent diameter is the diameter of a reference sphere having known properties and producing the same response in the sensing instrument as the particle being measured.

3.2.6 cleanliness (contamination) control

any organized action to control the level of contamination

3.2.7 cleanliness level

quantitative level of contamination

Table 5-4: Selected airborne particulate cleanliness classes for cleanrooms and other controlled environment

ISO classification number (*N*)	Maximum concentration limits (particles/m³ of air) for particles equal to and larger than the considered sizes shown below (concentration limits are calculated in accordance with equation (1) in 3.2)					
	0,1 µm	0,2 µm	0,3 µm	0,5 µm	1 µm	5 µm
ISO Class 1	10	2				
ISO Class 2	100	24	10	4		
ISO Class 3	1 000	237	102	35	8	
ISO Class 4	10 000	2 370	1 020	352	83	
ISO Class 5	100 000	23 700	10 200	3 520	832	29
ISO Class 6	1 000 000	237 000	102 000	35 200	8 320	293
ISO Class 7				352 000	83 200	2 930
ISO Class 8				3 520 000	832 000	29 300
ISO Class 9				35 200 000	8 320 000	293 000
NOTE Uncertainties related to the measurement process require that concentration data with no more than three significant figures be used in determining the classification level						

3.2.18 HEPA particle filter

throwaway, extended-medium, dry type filter in a rigid frame that has a minimum particle-collection efficiency of 99,97 % (that is a maximum particle penetration of 0,03 %) for 0,3 µm thermally generated DOP or specified alternative aerosol

Clean room rules –Example (1/2)

Pass clean room **training**

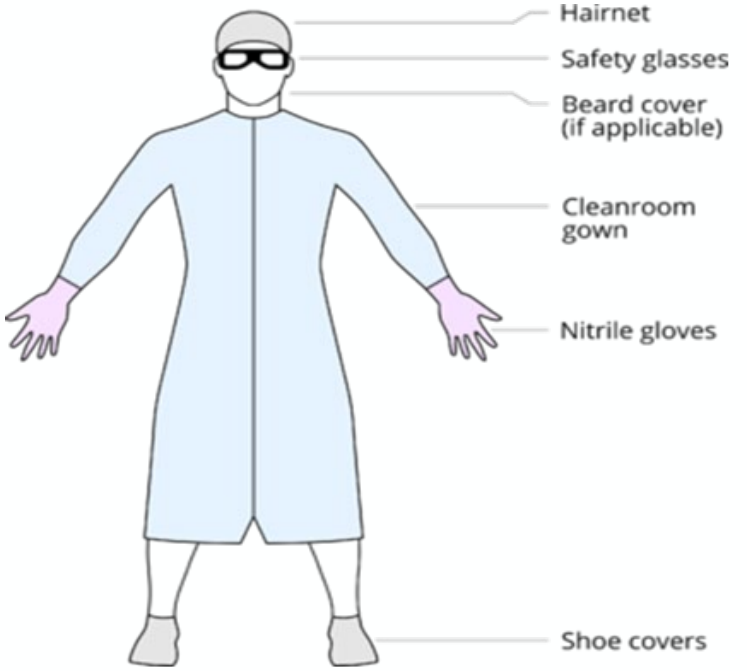
Undergo **controlled access**

Follow **entrance airlock** discipline

Wear **clean garments,** depending on class

Dress from head to toes, undress toes to head

Remember: human activities do contaminate!



PEOPLE ACTIVITY	PARTICLES/MINUTE (0.3 micr
Motionless (Standing or Seated)	100,000
Walking about 2 mph	5,000,000
Walking about 3.5 mph	7,000,000
Walking about 5 mph	10,000,000
Horseplay	100,000,000

Clean room rules –Example (2/2)

Personal actions typically **prohibited**

- Eating, drinking, smoking, wearing make up
- Fast motions
- Wearing torn or soiled garments
- Wearing clean room garments outside the clean room

Clean any items to be entered

Do not enter any substances, objects, materials or devices **that might compromise general cleanliness** (Flaking materials e.g. pencils)

Keep Paper at a bare minimum

Only approved tools and equipment

Clean room monitoring

Temperature control: 22° ± 3° C, to be monitored continuously

Relative Humidity control: 55 ± 10% , to be monitored continuously

Pressure control: A positive pressure differential shall be maintained between the cleanroom and the outside

Cleanroom and surrounding area: min 1,2 mm H2O (12 Pa)

Clean room and entrance lock: min 0,5 mm H2O (5 Pa)

Contamination monitoring and control

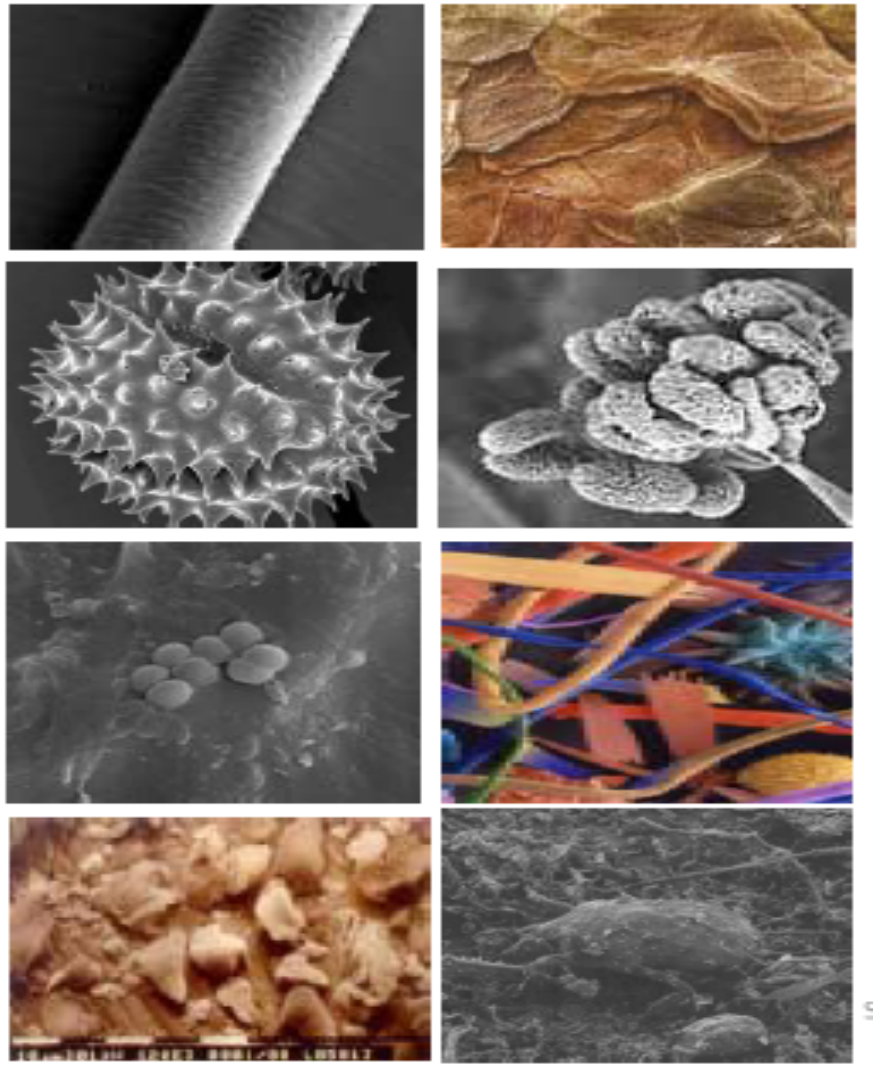
Common cleanroom contaminants and their size

Contaminant Type	Size (∝m)
Human hair	70-100
Human skin flakes	0.4-10
Pollen	5-100
Mold	2-20
Smoke	0.01-1
House dust	0.05-100
Bacteria	0.25-10

Sizes of a number of common cleanroom contaminants

Activity	Rate (> 03∝m/min)
Motionless/Sitting/Standing	100,000
Head/Arm/Neck/Leg motion	500,000
All above with foot motion	1,000,000
Standing to Sitting Position	2,500,000
Walking (2 mph)	5,000,000
Walking (3.5 mph)	7,500,000
Walking (5 mph)	10,000,000

Particle generation rates for a number of human activities



Clean room monitoring

Particle Fall Out (PFO) Provides level of deposited particulate on a surface.
Test methods:

- Particle Fall Out plates (Obscuration factor)
- Tape lift (Particle counting, mostly manual)
- Si-wafer (Particle counting, automated counting, optical microscopy or Scanning Electron Microscopes-Energy Dispersive X-ray)

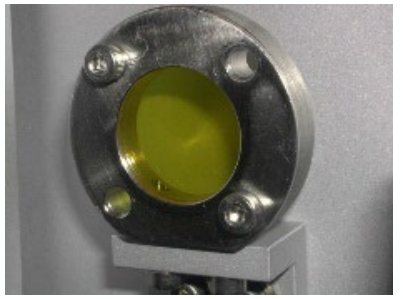
Clean room monitoring (Cont')

Airborne particulate monitoring

- Portable, mobile & fixed counting systems, mostly based on laser scattering techniques

Molecular Contamination

- Collector Plate (MOC's), periodically analysed by FTIR [Fourier transform infrared spectroscopy] or Chromatography for presence of carbon and silicon-based compounds

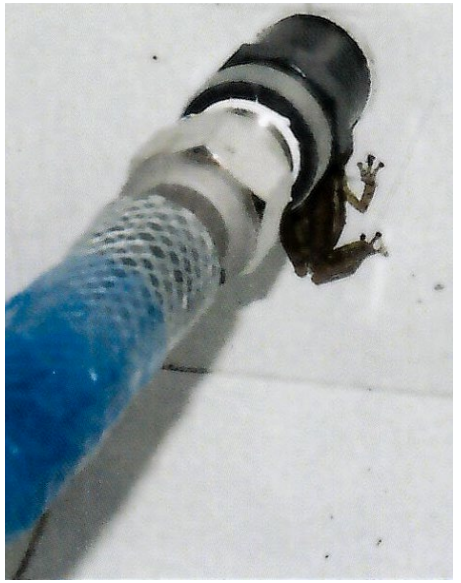


Clean room monitoring (Cont')

At the launch site: S/C preparation in EPCU facility (CSG – Kourou)

- Some clean-room facilities generally very good vs. level of typical contaminants (e.g. hydrocarbons, silicones, particle depositions, etc.)
  - for example: EPCU S5, clean-room S5C, S5B (for fuelling)

- But for instance, intrusion of wild life in clean room is not uncommon at CSG
  - for BepiColombo: lizard, spider and frog found in EPCU S5C



PA Activities during manufacturing

Inspections (Mandatory Inspection Point (**MIP**)/Key Inspection Point (KIP**)**

- MIP: Customer **must** be invited
- KIP: Customer participation is **optional**

Non conformance (NCR) handling

Criticality identification and **Root cause** Analysis

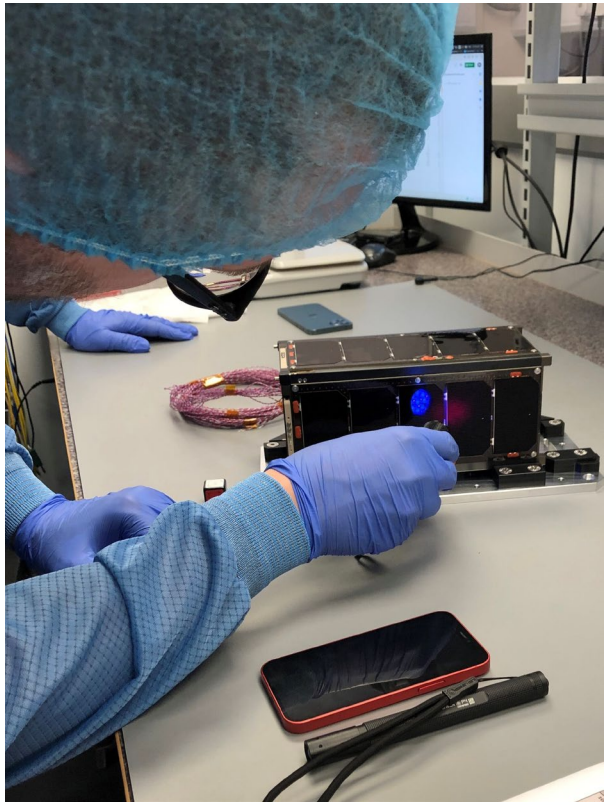
Waivers and Deviations

Coverage and Handling

PA Activities – Inspections (MIPs/KIPs)

Inspections that give maximum visibility and consist of

- Physical Item inspection
- Review of documentation related to the item
  - Expected configuration (as-built vs as-designed)
  - Log Books including Mate/Demate records, presence of anomalies
  - Calibration documents
  - Test reports
  - Open Items and non conformances status
  - Red/Green tag items lists

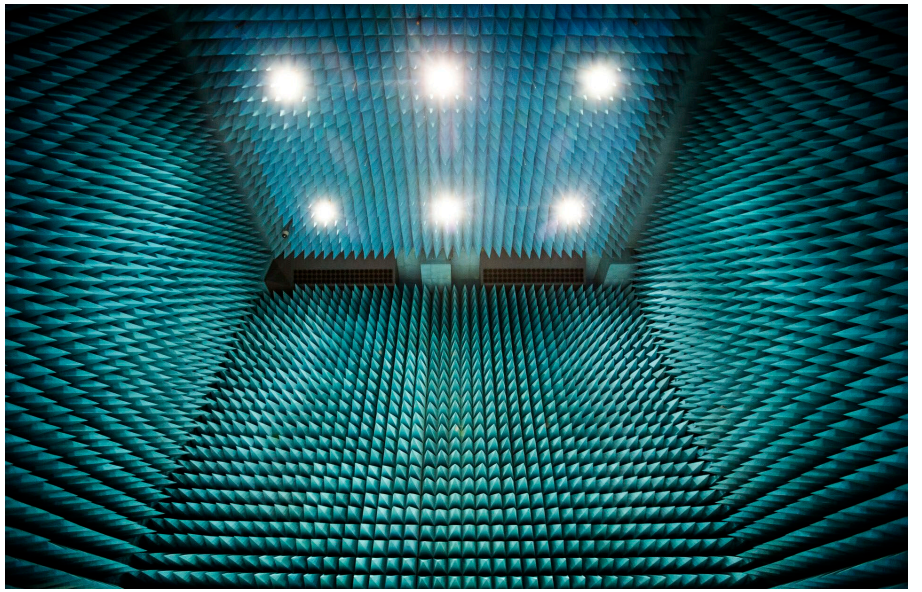


PA tasks at Tests

PA Activities at Test Readiness Review

Test Readiness Review (TRR)

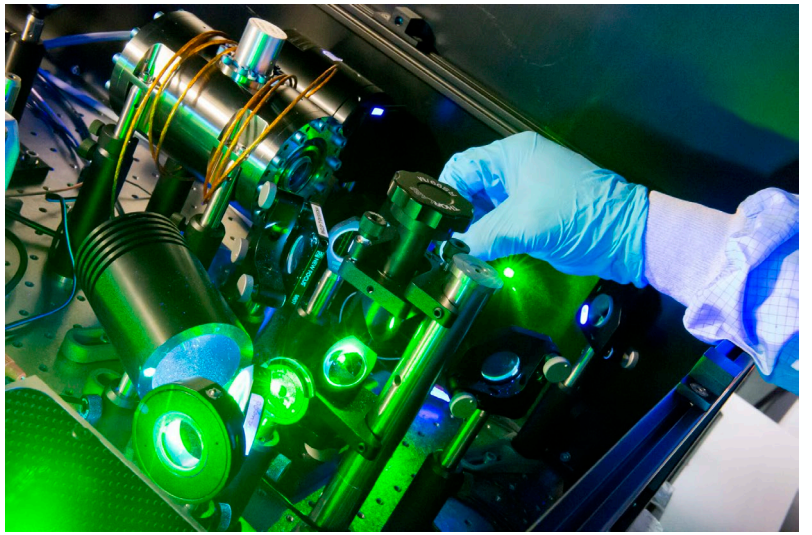
- Does the test facilities meet the test requirements (ex: FRR)?
- Are test procedures ready and formally released?
- Is the unit under test configuration complete, including SW?
- Is all test equipment calibrated?
- Have all open anomalies been processed?
- Are all open work items in correct state?



PA Activities – Post Test Review

Post Test Review (PTR)

- Is the as-run complete and is test data available?
- Have all variations been red-marked/recorded in process variation sheet?
- Are all NCRs and anomalies formally tracked?
- Have test objectives been met?
- **Can the test configuration be broken?**



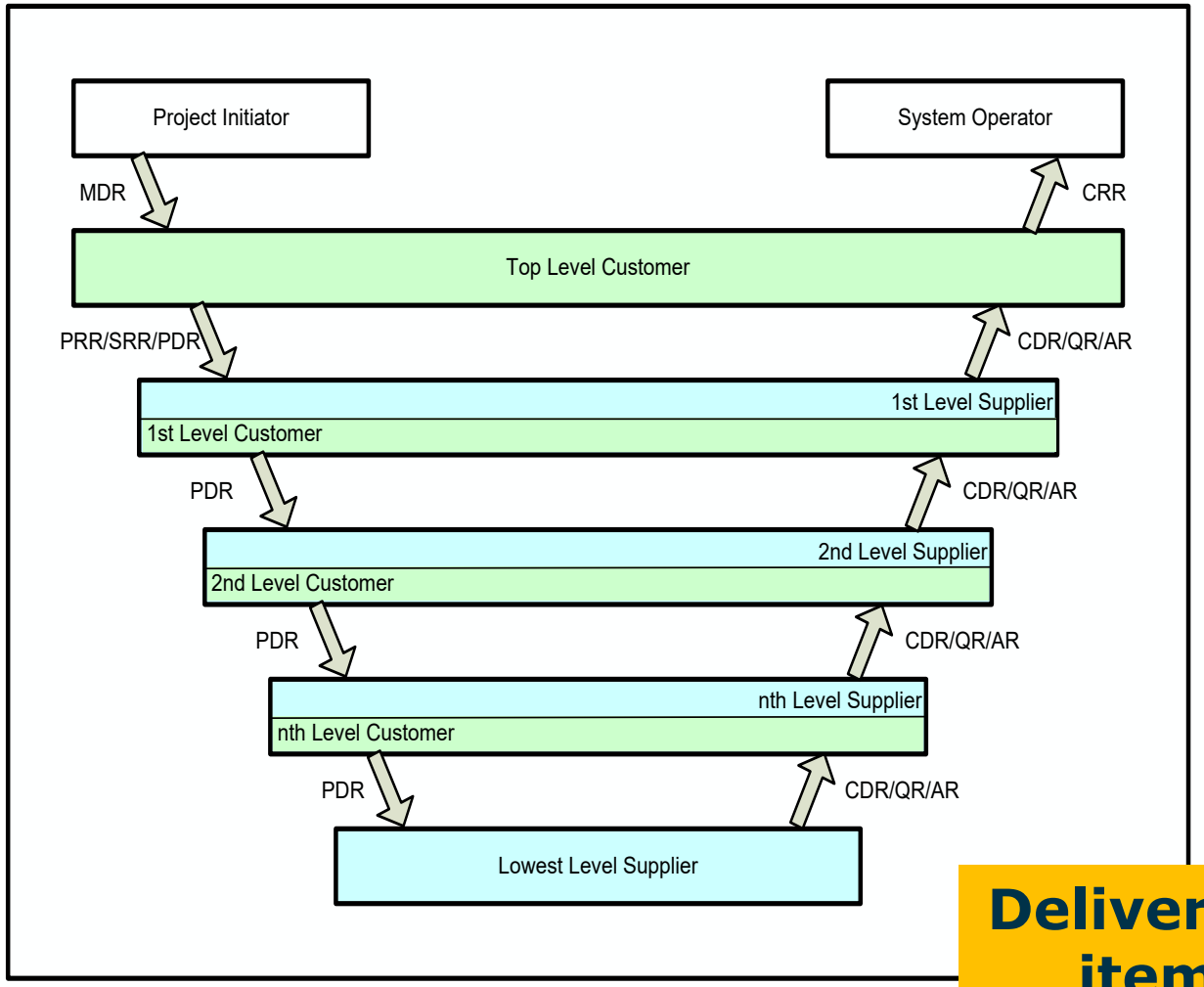
PA Activities at Qualification/Acceptance Review and Delivery

PA Activities at Qualification/Acceptance Review and Delivery

Qualification/Acceptance Review (QAR)/Delivery

- Have all qualification and acceptance tests been completed?
- Are all NCRs tracked and appropriate waivers/Deviations raised and approved?
- Is the Item Configuration properly documented?
- Is the End Item Data Package (EIDP) complete?

Acceptance and delivery process



- Complex customer-supplier chains are the norm for space projects
- Therefore, a **formal acceptance process for all deliverable items is required**
  - Acceptance Procedures, Acceptance Reviews …
  - At any contractual level
  - To ensure that conformity of the items to be delivered is fully assessed and documented

End Item Data Package (EIDP) (1/2)

- To be provided by the supplier for each deliverable item

- Basis for **formal acceptance reviews**

- To be maintained and integrated into higher level EIDPs during subsystem or system integration and testing

End Item Data Package (EIDP) (2/2)

EIDP Main contents

- **Certificate of Conformity** of the item (CoC)
- **As Built** Configuration List (ABCL)
- NCR list (and copies of major NCRs)
- Summary and status of RFDs and RFWs
- Logbook of the item
- Documents to be used for further integration, testing and operation in higher level assemblies
- Procedures to be used for the proper handling of the product after its final delivery
- Copies of the product **test reports** (or how to find them)
- List of the loose items and not installed items

Delivery Review Board (1/2)

The DRB **authorizes the shipment and the transfer of ownership of the items under acceptance**, certifying that:

- the items **conform to contractual requirements** and approved configuration
- the items are **free from material and workmanship deficiencies**
- all **non-conformances are closed-out**, or corresponding plans are accepted
- the **EIDP** is complete and accurate

Delivery Review Board (2/2)

DRB includes **representatives** from

- the receiving organization (chairing)
- the submitting supplier
- higher level customer(s)

Delivery shall only be authorized by the **unanimous agreement** of the DRB members

Preparation for Delivery

- Packaging materials, methods, procedures and instructions to provide for protection of item
  - while at the supplier's plant
  - during transportation
  - after their arrival at destination

- Appropriate marking and labelling for packaging, storage, transportation and shipping of items must be implemented

PA Activities at Launch

PA activities preparation to launch

- Each S/C launch requires specific precautions and trainings
- Hazardous activities on the launcher (fueling)
- Think and plan in advance how to prepare for critical functions and how to protect the sensitive instruments (i.e. contact launch site well in advance about contamination sensitive instruments and launch site preparation steps)
- GREEN/RED tag operations preparation and inspections
- Define GO/NOGO criteria
- Agree ESA/Industry roles and responsibilities
- Define launch success criteria

PA activities after launch

In case of anomaly be ready to start investigation

In case no anomaly, follow up the operations

Questions?

Backup Slides – New Space, Cubesats and Mission Classification

ESA New Space Approach for Cubesats

- **New Space** for a good part is a concept based on a different **PROCUREMENT** approach w.r.t to the past. It goes into the direction of widening the access to Space to private companies or academia which might not have a long history of space programs. A few typical definitions for New Space applicable to Cubesats are provided below, along with some of the consequences:

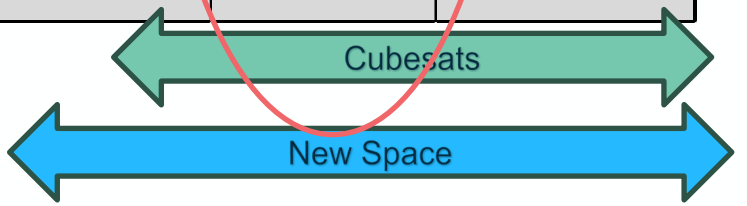
- **Accessibility** to smaller investors, lower mission cost, faster turnover is a MUST
- The reliability can be **spread across** a larger number of small and cheaper spacecrafts rather than a big, expensive spacecraft
- The mission is generally of short duration (1- 2 years max for LEO), so **reliability** goal is easier to achieve
- It normally relies usage of **COTS**, especially for EEE components
- There is an important trade-off between use of COTS and optimization of the system design
- The design might be not fully verified and validated on-ground, in order to have a **shorter time to market and so short-term ROI**
- The development (BB/EM/QM) and the flight production activities are often **parallelized**
- It often involves **knowledge transfer** from ESA to NMS companies, to leverage the technology risks
- ECSS or other standards are often used as a **reference only**

Note: the risk attitude of a company is of paramount importance as to how to define the development and validation strategy of a cubesat project ("risk appetite")

PA Approach – ESA Mission Classification

- In ESA Mission Classification Scheme 5 different mission classes have been identified
- More flexibility is given to industry as a function of class of the mission (highest flexibility and associated risk for class V), but also more reliance of ESA on contractor's internal processes, more simplification of the documentation and required reporting, at the cost of the less visibility given to ESA and more delegation of responsibility and of risk is given to industry

Class type	I	II	III	IV	V
Mission Criteria and Marking					
Criticality to Agency strategy (Flagship mission, Internationnal cooperation, Impact on ESA strategic goals, and image)	Extremely high Criticality	High Criticality	Medium Criticality	Low Criticality	Educational purposes
Marking					
Mission Objectives (Directorate priority and purpose, e.g in orbit demonstration, educational)	Extremely high Priority	High Priority	Medium Priority	Low Priority	Educational purposes
Marking					
Cost (Cost at Completion, Including Phase E1)	>700 M€	200 - 700M€	50 - 200M€	1- 50M€	< 1M€
Marking					
Mission Lifetime (Nominal mission life duration)	> 10 years	5-10 years	2-5 years	1-2 years	1 year
Marking					
Mission Complexity (Design interfaces unique payloads, New technology development)	High	High to Medium	Medium	Medium to Low	Low
Marking					



I. Critical strategy/safety (e.g. manned missions)

II. Performances should be met whatever it takes

III. Finding the best compromise between risk and cost to deliver the mission

IV. Mission is designed according to a hard cost limit (affordability approach)

V. Almost full delegation to industry