esa mission classification

ESA Mission Classification

Andrew Brown
Senior Product Assurance & Safety Engineer
TEC-QPM
ESA/ESTEC, Noordwijk, The Netherlands

ESA-TECQP-HO-2025-000848

WHY an ESA Mission Classification?

The ESA Mission Classification initiative started in 2020 with a focus on:

- **Alignment**: Change from individual **requirements** to requirements per Mission Class
- **Structure**: defined **use of** Commercial Off The Shelf (**COTS**) per mission class

The concept was enlarged with additional objectives:

- **Structured framework** to manage **acceptable risks** to stakeholders
- **Pre-tailored requirements** to reduce effort
- **Support ESA suppliers** by simplified flow-down of requirements

BACKGROUND

- **ESA Mission Classification** with associated tailoring rules defined according to ESA's stakeholders **expectation of mission success** traded against mission **implementation costs**
- **Based on application of 4 criteria** (was 5 in 2020), mission class assigned at project level
- **Based on 4 classes of missions** (Original Classification (2020-2023) was for 5 classes I to V)
- **Establish the pre-tailoring of (ECSS) requirements** for each class of mission
- **Establish the acceptable risk level**, for the mission as early as possible in the process. This may be done by means of a formal iterative process (i.e. Project Risk Assessment) and will be very much dependent on the type of mission, eg human space flight mission, small robotic mission etc.

Current Status

In January 2024, ESA's Board of Directors decided:

To reduce the number of mission classes from 5 to the following 4

- **Alpha (α):** => Meeting performances whatever it takes α
- **Beta (β):** => Finding the best compromise between acceptable risk and cost
- **Gamma (Γ):** => Affordability, designing the mission vs hard time and cost limit
- **Delta (Δ):** => Almost full delegation to Industry

That the Mission Class for all ESA Missions has to be identified:

- during Phase A
- to be re-confirmed at Integrated Project Review (IPRev)

Endorsed the pre-tailoring of the ECSS Q-Branch

Approved the Product Assurance Requirement Document (PARD) templates per Mission Class.

ALPHA Missions

Definition

- Flagship mission
- Extremely critical and strategic for ESA
- Budget > 400 M€
- Lifetime > 7 years
- High number of requirements
- Low Risk

Examples

- EarthCARE
- Metop-SG
- MTG
- ARGONAUT
- …

ARGONAUT

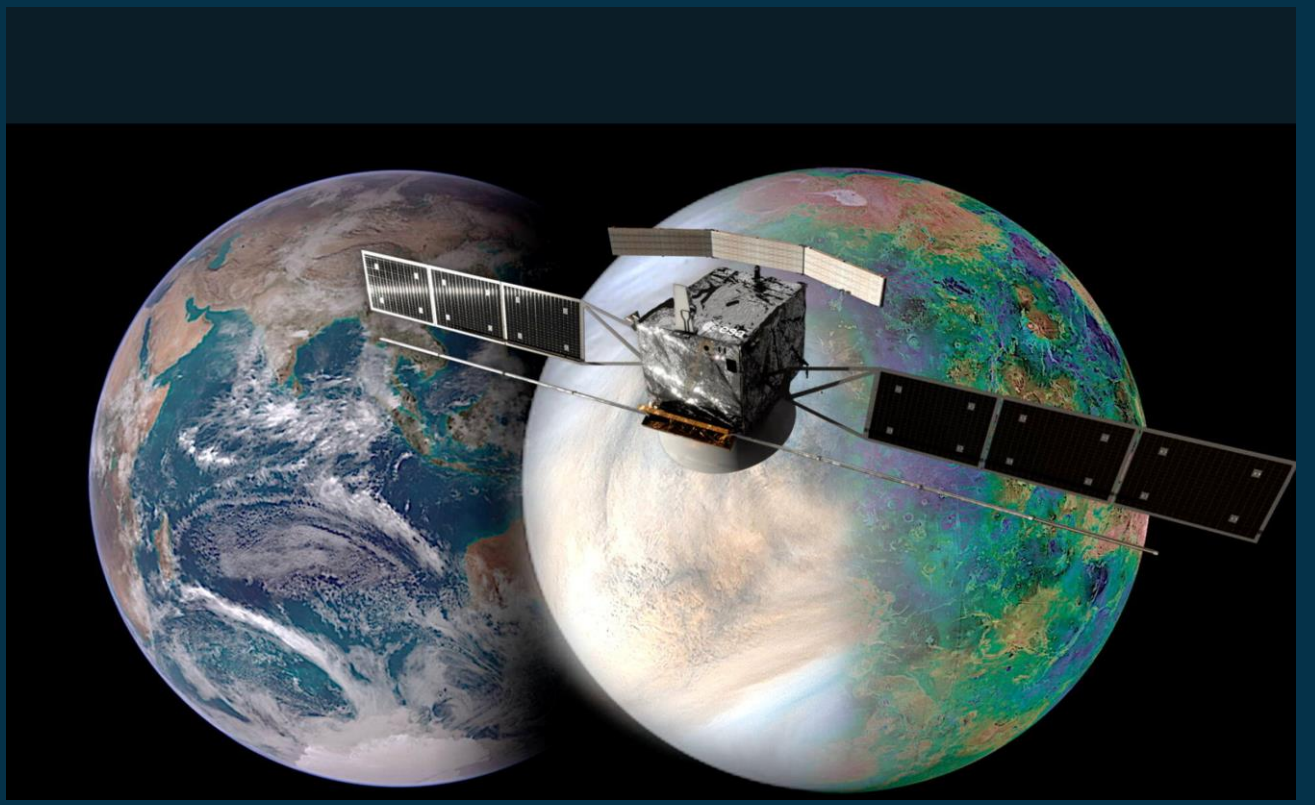
BETA Missions

Definition

- Top mission
- Highly critical and strategic for ESA
- Budget 200 to 400 M€
- Lifetime 5 to 7 years
- Substantial number of requirements
- Increased risk in comparison to ALPHA

Examples

- Sentinels
- Harmony
- EnVision
- FLEX
- …



EnVision

GAMMA Missions

esa mission classification

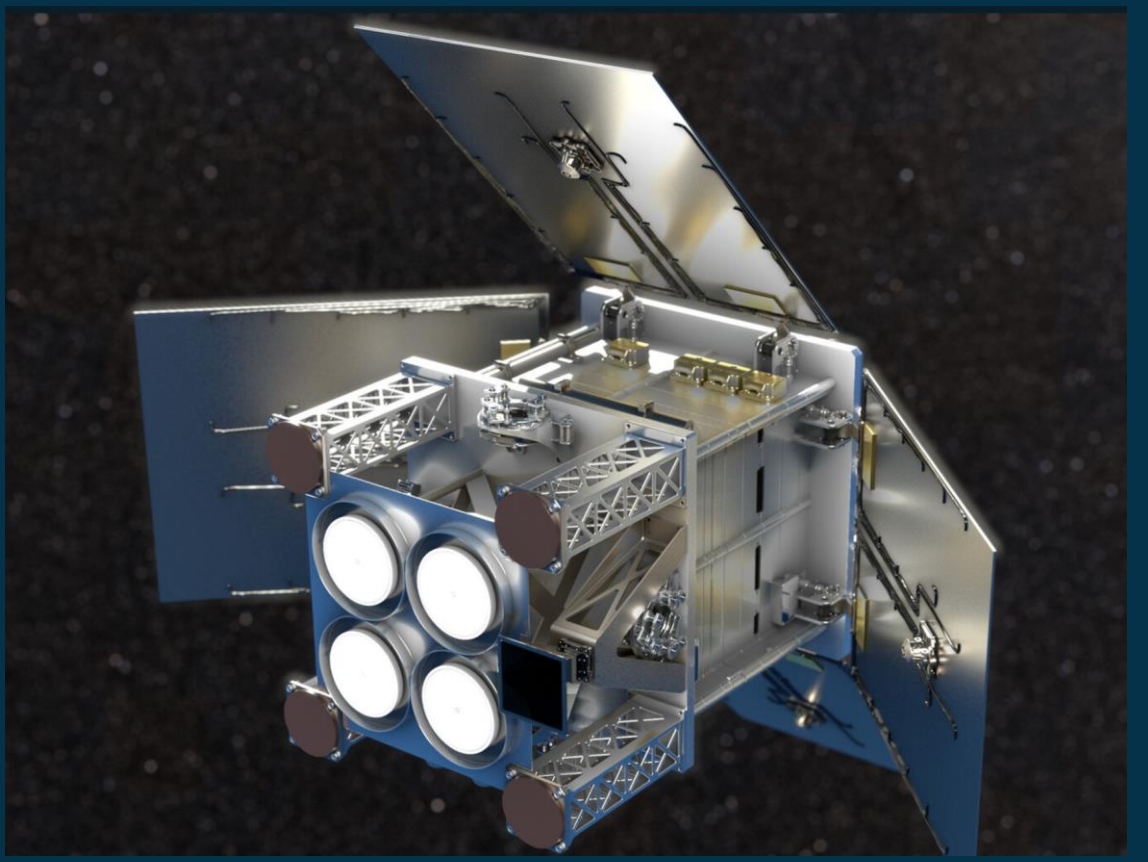
esa

Definition

- Medium class mission
- *“New Space” approach*
- Budget 25 to 200M€
- Lifetime 2 to 5 years
- Moderate requirements
- Non-negligible risk

Examples

- Camilla
- SCOUT Missions
- Harmony
- RAMSES
- WISDOMS
- …



SCOUT HydroGNSS mission

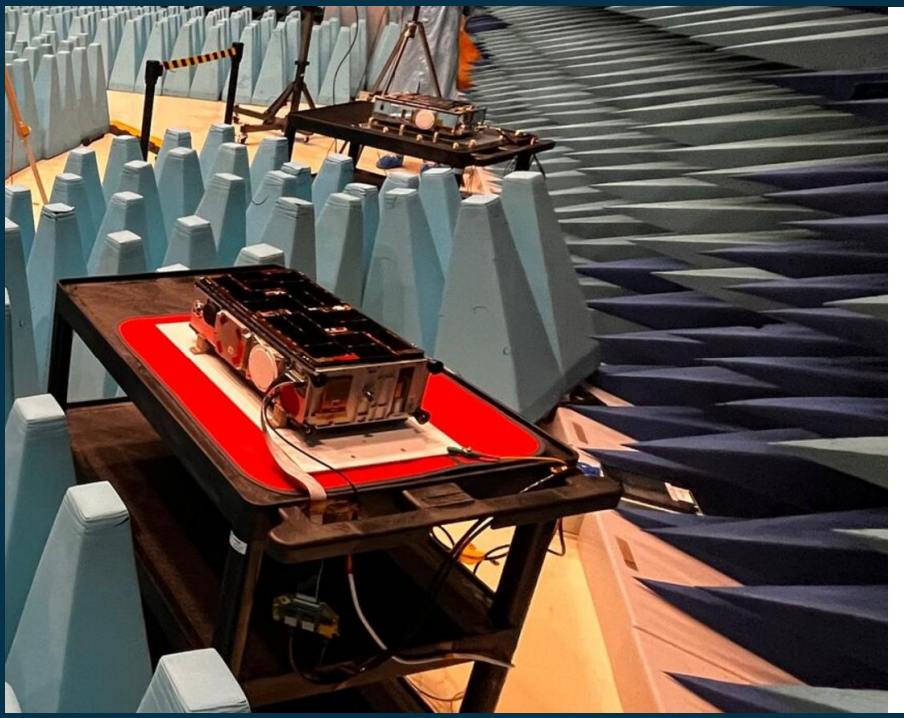
DELTA Missions

Definition

- Low class mission
- Criticality is low and strategic importance is limited
- Budget < 25 M€
- Lifetime < 2 years
- Very limited requirements (“do not harm”)
- Significant risk

Examples

- YPSAT
- Milani
- Juventus
- …



HERA Cubesats

ESA Mission Classification: Criteria

A set of 4 **criteria** was defined to allow the classification of ESA missions, see next slides for details.

Criticality to Agency Objectives, Strategy and Image *Flagship mission, international co-operation, impact on strategic ESA goals and image*	Extremely Critical	Highly Critical	Medium Criticality	Low Criticality
Cost *Cost at completion inc. Phase E1*	> 400 M€	200 – 400 M€	25 – 200 M€	< 25 M€
Mission Lifetime *Nominal mission life duration*	> 7 years	5 – 7 years	2 – 5 years	< 2 years
Mission complexity *Design interfaces, unique payloads, new technology development*	Extremely Complex	Highly Complex	Medium Complexity	Low Complexity

Validated by the ESA internal Steering Committee co-chaired by D-TEC and DG-I with participation of Project H/Departments from D-NAV, D-EOP, D-HRE and D-SCI

Criteria (1/2)

1. Criticality to Agency strategy, including ESA image:

Extremely critical - Fulfilment of all mission objectives is extremely high priority. European-led flagship missions or highly strategic international cooperation mission involving very high public visibility and having extreme impact on ESA image.

Highly critical – Fulfilment of all mission objectives with high priority. Typically, ESA-led or carried out with international partners, fully in line with ESA strategic goals, having high public visibility.

Medium Criticality - Fulfilment of all mission objectives has a medium priority (typical IOD). Member State agencies play a leading role in such missions, having medium public visibility and medium impact to ESA strategic objectives.

Low Criticality - Fulfilment of all mission objectives has low priority in terms of ESA goals with medium/low public visibility. Usually developed for IOD or educational purposes, following a “do no-harm” principle..

2. Cost:

Refers to Cost at Completion established at the beginning of a project (per individual satellite). Combination of Spacecraft and Ground Segment.

Criteria (2/2)

3. Mission lifetime

Missions with a longer lifetime need to more strictly adhere to PA requirements than short-lived programs/projects.

4. Mission complexity

Extremely Complex: New development is **usually between 50% and 70%** of total number of units/instruments. Need of developing a large number of technologies or delta qualification for off-the-shelf equipment in a different operational environment.

High Complexity: New development is **usually between 20% and 50%** of total number of units/instruments. The risk associated is that some technology development activities are disposed of because they are unsuccessful.

Medium Complexity: Well known interfaces, and partnerships are of low risk. New development less than 20% of total number of units/instruments. High degree of confidence that the performances will be achieved without significant impact on cost budget.

Low Complexity: Simple systems with well known interfaces, included also CubeSats, Educational and IOD type missions.

Final matrix…

Acceptable Risk *Risk of not fulfilling some or all of the mission objectives*		LOW ACCETTABLE RISK HIGH Alpha	Beta	Gamma	Delta	Input Score (1 to 4)	Weighted Score
Criticality to Agency Objectives, Strategy and Image *Flagship mission, international co-operation, impact on strategic ESA goals and image*		**Extremely Critical**	**Highly Critical**	**Medium Criticality**	**Low Criticality**		
Weight (10/25/30%):	25		X			2	0,50
Cost *Cost at completion inc. Phase E1*		**> 400 M€**	**200 – 400 M€**	**25 – 200 M€**	**< 25 M€**		
Weight (10/25/30%):	25		X			2	0,50
Mission Lifetime *Nominal mission life duration*		**> 7 years**	**5 – 7 years**	**2 – 5 years**	**< 2 years**		
Weight (10/25/30%):	25			X		3	0,75
Mission complexity *Design interfaces, unique payloads, new technology development*		**Extremely Complex**	**Highly Complex**	**Medium Complexity**	**Low Complexity**		
Weight (10/25/30%):	25		X			2	0,50
Total % (must be 100):	100					**Total (*):**	**2,25**

Grading System

1 <= Total <= 1,75 = **Alpha**

1,75 < Total <= 2,5 = **Beta**

2,5 < Total <= 3,25 = **Gamma**

3,25 < Total <= 4,0 = **Delta**

Pre-tailoring: ECSS Q Branch

ECSS-Q / Q-Branch:

- Space Product Assurance ECSS-Q: covering product/Quality assurance, dependability & safety, materials & processes, SW product assurance. Pre-tailoring completed.
- Pre-tailored PARD templates for each class of mission.
- Simplified PARD approval process flow for classified ESA missions and pre-tailored PARD.

- In 2024, a 1st set of ESA projects were piloted for ECSS Q-Branch:
  - Class Beta: NGGM, HARMONY (EOP), EnVision (SCI), MicroGeo (CSC)
  - Class Gamma: VISDOMS (OPS), RAMSES (HRE), SCOUT (EOP)….

Summary

- The ESA mission classification is an ESA scheme encompassing one-off missions (man, non-manned missions), recurring operational spacecraft, IOD/IOV, CubeSats, satellite constellations and launchers.
- A mission classification and respective weighting criteria are proposed by the project itself and confirmed by ESA management.
- A specific mission class can contain units/payloads with different classes, potentially on-board the same S/C, for example by application of the “ESA COTS Guidelines” or the Space Debris Mitigation.
- More flexibility is given to industry as a function of the class of the mission, for example:
  - greater reliance on contractor’s internal processes,
  - more simplification of the documentation (combine documents) and required reporting
  - delegation of responsibility and risk to industry
- Security and safety (including space debris) are not subject to tailoring – do no harm principle

What's next?

This is not the end of the story!!!

- Additional pre-tailoring for ECSS-E and ECSS-M Branches is planned once industry (ECSS Next Generation WG) has completed their work.
- ESA Mission Classification decision paper, summarising the progress made so far and including further risk definition is under preparation
- An ESA Mission Classification implementation plan is being consolidate for, In medium term, step by step, and where applicable – trying to adapt the entire Mission Development Process, as for example:
  - Procurement: Adapting size & activities for review (TEB) of Industrial proposals
  - Project Corporate Reviews (same as above) and Project Management (MARD?) approach
  - Mission development and verification processes
  - Project Core and Functional Teams sizing … etc…

Take away

- Reduced budget and time to launch of some missions imply A**cceptable Risk**

- **ESA Mission Classification launched internally in January 2025!!!**
  - Info Note presented to the Industrial Policy Committee Technology Harmonisation Working Group (IPC TA-WG) on 12/12/2025
  - based on Q Branch pre-tailoring

ESA Director General Josef Aschbacher introducing the ESA Mission Classification to ESA Member States during the Council Meeting in June 2024 (ESA HQ, Paris)

ESA Mission Classification

Thank you!

Questions?

BACK-UP SLIDES

Initial Mission Classification (5 classes)

esa mission classification

esa

Class type	I	II	III	IV	V
Mission Criteria and Marking					
Criticality to Agency strategy (flagship mission, international 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 – 700 M€	50 – 200 M€	50 – 1 M€	< 1 M€
Marking					
Mission lifetime (nominal mission life duration)	>10 years	5-10 years	2-5 years	2 years-3 months	< 3 months
Marking					
Mission complexity (design interfaces, unique payloads, new technology development)	High	High to Medium	Medium to Low	High (IOD/IOV) Low (commercially driven)	Low
Marking					

D-TEC Expectation on Mission Classification

Class	Alpha	Beta	Gamma	Delta
Typical mission in class	*JUICE*	*Harmony*	*Cheops New Space*	*EDU/ Nano IOD/IOV/ CubeSats*
Success Prob	max	95%	80%	40%
Nominated saving	0%	15%	40%	90%
Schedule Savings	0%	20%	50%	80%
Requirements (Q+E Branch)				
ESA Mgmt involvement (M-Branch**)**				
ESA Team Risk Mindset				

Figures are only indicative

Current Status

Outcome of the WG for 5 classes found hardly any difference between the Cat. I and Cat. II requirements.

- CAT. I & II => ALPHA (removed Mission Class II)
- CAT. III => BETA
- CAT. IV => GAMMA
- CAT. V => DELTA

- Mainly in line with the original WG templates other than for EEE

  Alpha => Class 1 (same)

  Beta => Class 2 (was class 3)

  Gamma => Class 3 (was Class 3 - tailored)

  Delta => Class 3 – Tailored (was no class)

Working Group

Establish the Pre-tailoring of (ECSS-Q) requirements for each class of mission via a dedicated Working Group supported by TEC Experts in technical sub-WGs

Current focus was on ECSS Q-branch (and to some extent the M-branch), its agreed that ECSS E-branch needs to be addressed in a later phase.

ESA Mission Classification WG => Project Managers, TEC HoDiv +HoS, Heads of PA&S Offices supported by several expert Sub-WGs.

- **Sub-WG Software: COTS SW/SW Validation and Verification/Agile etc.**
- **Sub-WG System Engineering & RAMS: Design Redundancy, Single Point Failure, Probabilty of failure.**
- **Sub-WG EEE + Radiation Hardness: COTS, Automotive parts, plastic components, Radiation tolerant vs Radiation Hard, Radiation Board level testing**
- **Sub-WG Manufacturing, Materials and Processes: Commercial PCBs, Advanced Manufacturing, Cleaningless and Contamination**
- **Sub-WG Product Assurance: Project Reviews, MIPs, KIPs, Spacecraft Operation etc…**

Outcome of the WG was a set of pre-tailored Product Assurance Requirements Documents (PARD) templates that could be applied to each mission class.

ESA Mission Classification: 4 Classes

esa mission classification

ALPHA	• Top class missions • Extremely critical and strategic for ESA. • Budget > 400 M€ • Lifetime > 7 Years. • Requirements are high, risk is very low.		✓ Critical strategy/safety (e.g. manned missions) ✓ High level of requirements and low risk. ✓ Performances should be met whatever it takes
BETA	• High class missions, • Highly critical and strategic for ESA • Budget 200 to 400M€, • Lifetime 5 to 7 Years, • Requirements are relatively high, and the risk is low.		✓ Finding the best compromise between risk and cost to deliver the mission
GAMMA	• Medium class missions, (e.g. hosting New Space type of mission) • Medium critical and strategic for ESA Budget 25 to 200M€ • Lifetime 2 to 5 Years, • Requirements are moderate with a non-negligible risk.		✓ Mission is designed according to a hard cost limit (affordability approach)
DELTA	• Low class mission, • Low critical and strategic for ESA • Budget < 25M€, • Lifetime <2 years • Requirements are very limited with a significant risk.		✓ Almost full delegation to industry (Minimum requirements but increased risk)

Examples of ESA Missions

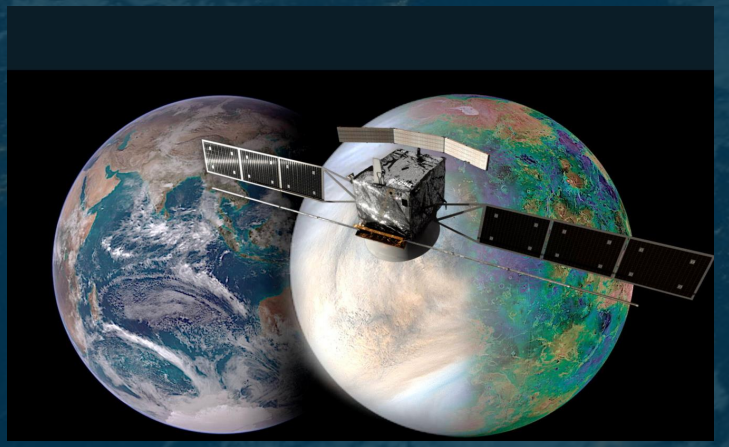
ALPHA Missions:

- Earthcare
- Metop-SG,
- MTG,
- ARGONAUT

ARGONAUT

BETA Missions:

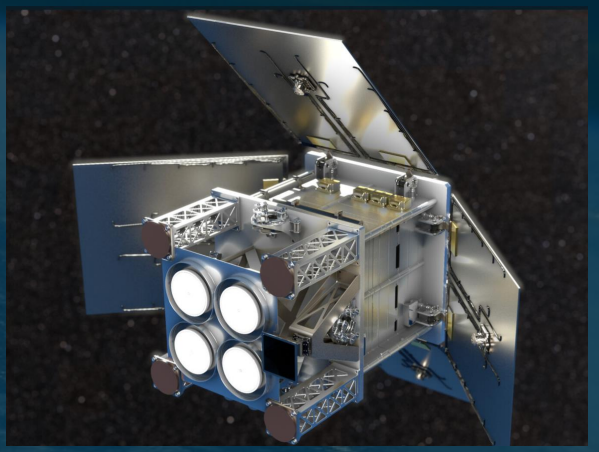
- Sentinels
- Harmony
- EnVision
- FLEX



EnVision

GAMMA Missions:

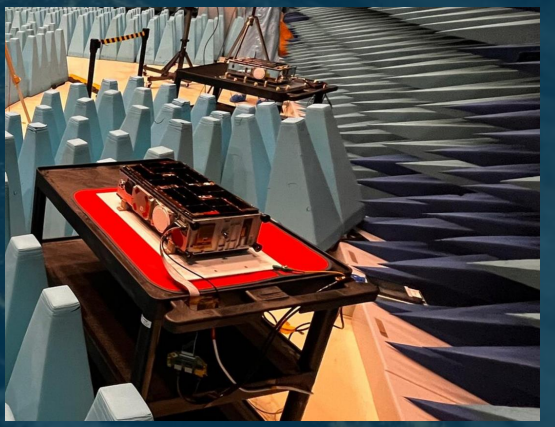
- Camilla
- SCOUT Missions
- Harmony
- RAMSES
- WISDOMS



SCOUT HydroGNSS

DELTA Missions:

- YPSAT
- Milani
- Juventus



HERA Cubesats