ESA Technology CubeSats:
IOD Cubesat Missions overview / LEO and Beyond

R2E ANNUAL MEETING 2022

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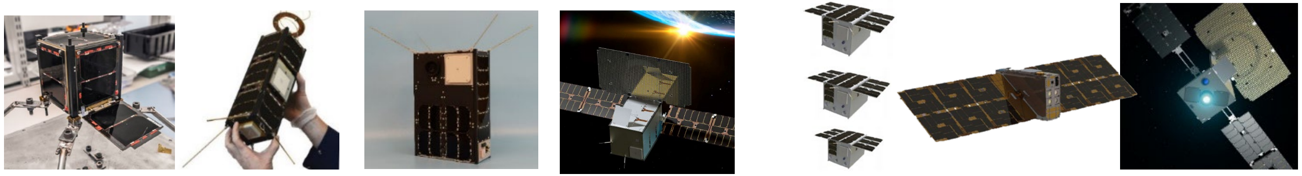
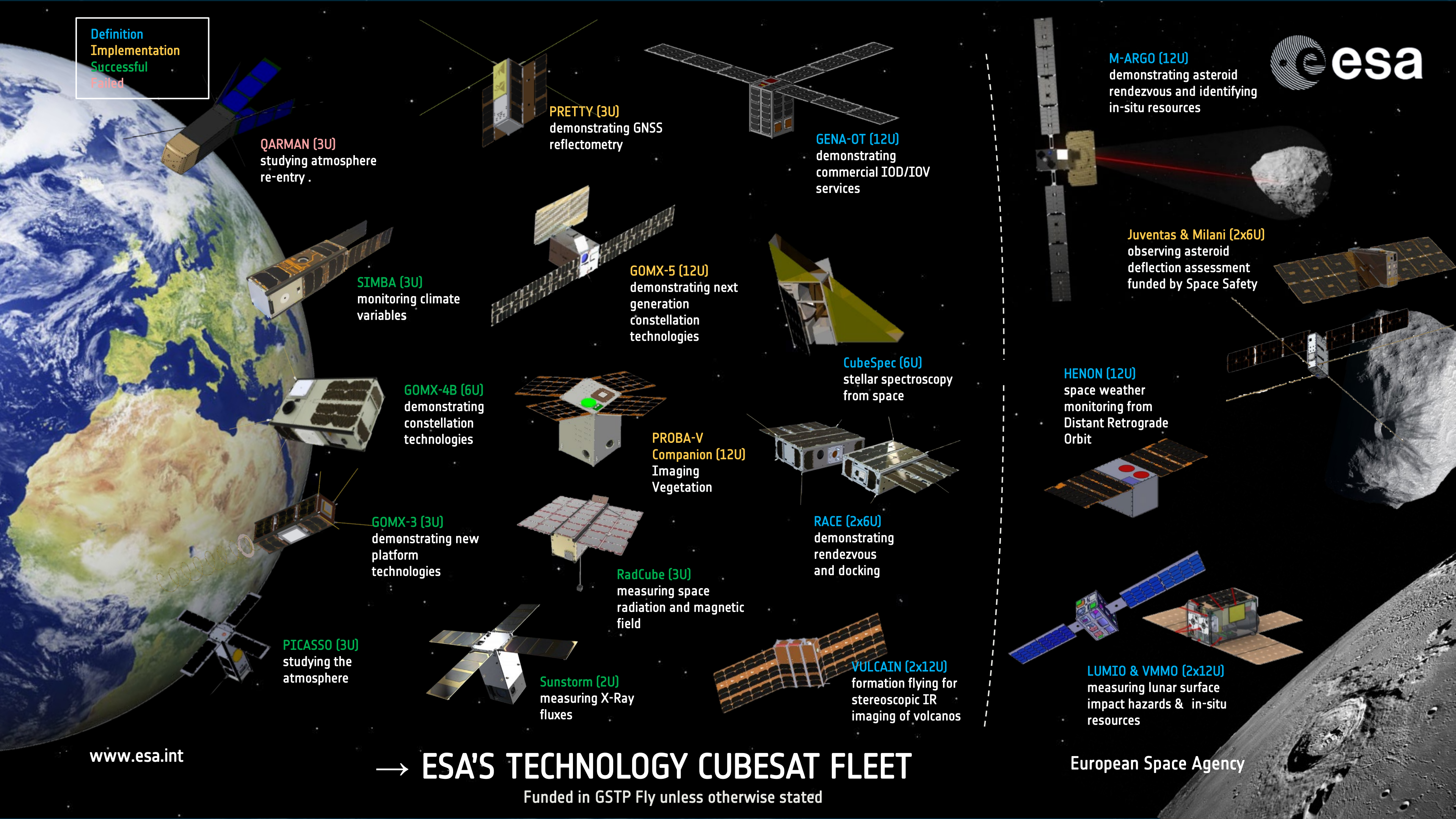
The Evolution of CubeSats at ESA



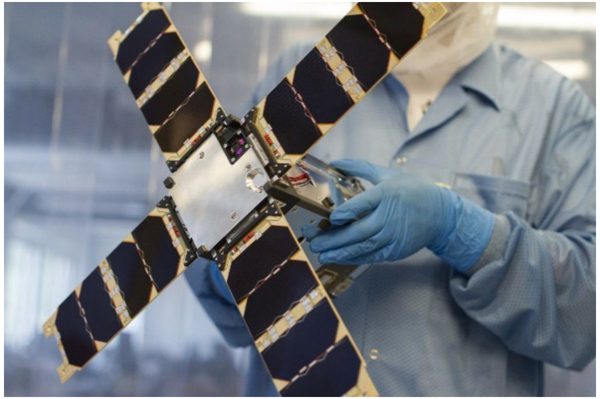
Size	1U	3U	6U	12U	3 x 12U	6U	12U
Mission	**Vega Maiden 1U Cubesats**	**GOMX-3**	**GOMX-4B**	**GOMX-5**	**SCOUT-1**	**HERA MILANI**	**M-ARGO**
GOAL	EDUCATION	IOD	IOD	IOD + Science	Earth Observation Constellation	DeepSpace Tec Demo + Science	DeepSpace Tec Demo + Science
Power (max)	2 W	6 W	12 W	100 W	30 W	60 W	130W
Pointing acc.	No Attitude control	2 deg (3-axis)	1 deg (3-axis)	< 0.1 deg	<< 0.1 deg	<0.1 deg	0.1 deg (3-axis)
RF Link	UHF (9 kbps)	3000 kbps (LEO X-band)	8 kbps @ 4500km (ISL) with second Satelllite	DL = 225 Mbps X-Band (K-SAT)	10 Mbps	Inter Satellite Link (460 kbps)	8 kbps @ 1 AU (X-band)
Delta-V	0 m/s	0 m/s	10 m/s (CP)	200 m/s (EP)	213 m/s (EP)	10 m/s (CP)	3000 m/s (electric)
Launch	2012	2015	2018	H1-2023	H2-2023	October 2024	2024-2025

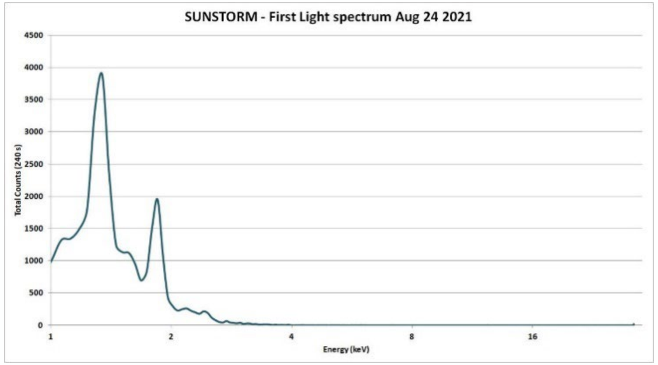
- Factor 10 reduction in entry-level cost
- Fast to develop (1-3 years)
- Driver for miniaturisation
- **Ideal for technology in-orbit demonstration (IOD)**
- Opening access to space for new players (New Member States, SMEs, research institutes, universities)
- Enabling for highly distributed autonomous systems
- Unique applications in constellations, swarms & fleets


Definition
Implementation
Successful
Failed
QARMAN (3U)
studying atmosphere re-entry .
PRETTY (3U)
demonstrating GNSS reflectometry
GENA-OT (12U)
demonstrating commercial IOD/IOV services
M-ARGO (12U)
demonstrating asteroid rendezvous and identifying in-situ resources
esa
SIMBA (3U)
monitoring climate variables
GOMX-5 (12U)
demonstrating next generation constellation technologies
Juventas & Milani (2x6U)
observing asteroid deflection assessment funded by Space Safety
CubeSpec (6U)
stellar spectroscopy from space
GOMX-4B (6U)
demonstrating constellation technologies
PROBA-V Companion (12U)
Imaging Vegetation
HENON (12U)
space weather monitoring from Distant Retrograde Orbit
GOMX-3 (3U)
demonstrating new platform technologies
RACE (2x6U)
demonstrating rendezvous and docking
RadCube (3U)
measuring space radiation and magnetic field
PICASSO (3U)
studying the atmosphere
Sunstorm (2U)
measuring X-Ray fluxes
VULCAIN (2x12U)
formation flying for stereoscopic IR imaging of volcanos
LUMIO & VMMO (2x12U)
measuring lunar surface impact hazards & in-situ resources
www.esa.int
→ ESA'S TECHNOLOGY CUBESAT FLEET
Funded in GSTP Fly unless otherwise stated
European Space Agency

SunStorm Overview – Space weather

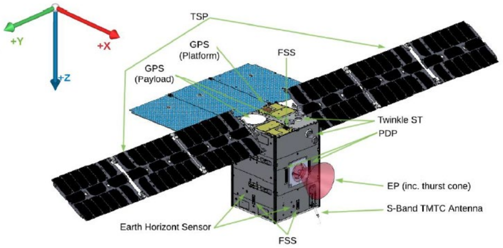
- Project: SunStorm
- Contractor: KUVA Space (ex. Reaktor Space Labs) (FI)
- Platform: 2U CubeSat (KUVA) with 3-axis pointing
- Mission:
  - Monitoring of X-rays emitted by the Sun in the energy range 1.5–25 keV to 1% accuracy at 1 minute intervals
- Payloads:
  - Solar X-ray flux Monitor (XFM) by Isaware (FI), ASRO (FI), Oxford Instruments (UK), Talvioja Consulting (FI)
  - Candidate to be flown on the Lagrange space weather mission to Sun-Earth L5 Lagrange point
- Launch: 16/08/2021 on Vega VV-19 to 550 km SSO
- Status: LEOP & commissioning successful, Solar X-ray spectrum acquired with XFM-CS payload 7 days after launch, nominal ops on going

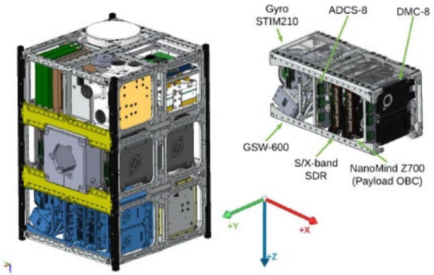




Next Gen. Constellation Technology Demonstration

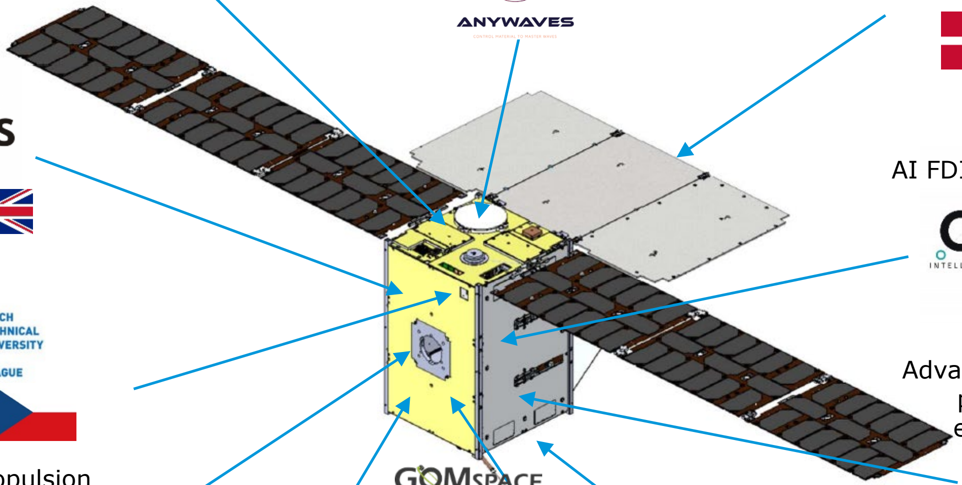
- Project: GOMX-5 (GomSpace DK)
- IOD Mission:
  - Large orbit transfers using electric propulsion (delta-V >280 m/s)
  - **Radiation Monitor MIRAM** Instrument:
    - Based on the new generation Medipix ASIC chips (Timepix), provides high resolution and wide range characterization of mix radiation field environment
      - Particle fluxes, rate meter: 100 -107 (#/cm2/sec)
      - Particle dose meter: 10-2 -104 (uGy/min)
      - Angular fluxes for energetic charged particles
      - Particle type resolving power
    - Institute of Experimental and Applied Physics Czech Technical University in Prague
    - **RADMON** instrument (CERN)
- **Operations:** EP apogee raise >800 km, perigee lower <450 km
- Status: CDR September 2021 (On-going)





Commissioning	IOD Payloads Experiments LEO	Orbit Raising Manoeuvering (Perigee < 480 km, Apogee: 800-1000 km)	Platform OPS at High LEO (800-1000 Km apogee)	Orbit Lowering Manoeuvering (Perigee<250 km)	Disposal
2 Months	6 Months	4.6 Months	24 Months	35 Days	1 Day

GOMX-5 IOD Payloads



GNSS PPP receiver – Syrlinks

Dual-band GNSS antenna – ANYWAVES

X-band Reflectarray antenna – TICRA

GNSS PPP receiver – deimos SPACE

CZECH TECHNICAL UNIVERSITY IN PRAGUE

AI FDIR experiment – aiko INTELLIGENT SPACE SYSTEMS

Advanced Rad-Hard processors experiment – COBHAM Cobham Gaisler AB, gmv

Electric propulsion – ThrustMe

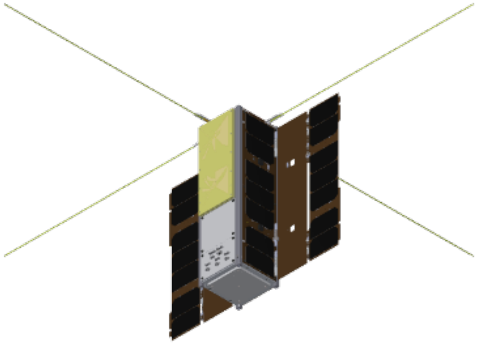
4x mini star trackers – arcsec

Radiation monitor – CERN

Multispectral imager – TARTU OBSERVATORY space research centre

GNSS Reflectometry Demonstration

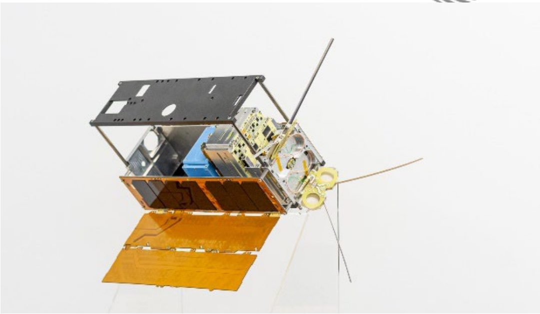
- Project: PRETTY (RUAG Austria, TU Graz, **Seibersdorf Labs**)
- Platform: 3U CubeSat (TU Graz) with 3-axis pointing
- Payloads:
  - Software-defined GNSS-Reflectometry receiver & L-band multi-patch antenna (RUAG, TU Graz)
  - Radiation dosimeter (**Seibersdorf Labs**)
- Mission:
  - exploit GNSS-R grazing altimetry technique to measure sea state, ice and ocean currents at high precision
  - Characterization of radiation dose environment and radiation dose rate at three geographic regions of interest with elevated radiation levels:
    - Longitude: 90°W to 40°E, Latitude: 50°S to 0° (South Atlantic Anomaly)
    - Longitude: 180°W - 180°E; Latitude: >45°N (North Pole)
    - Longitude: 180°W - 180°E; Latitude: >45°S (South Pole)
  - Provide a technology demonstration of a reference dosimeter system based on a FGDOS and RADFET radiation sensor on-board CubeSat in shielded and un-shielded configuration
- Status: On-going AIV

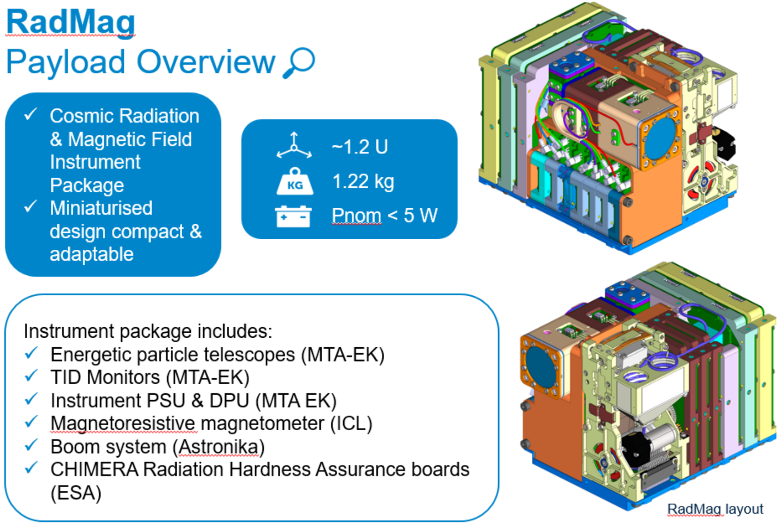


Credit: TU Graz

In-Situ Space Weather Demonstration

- Project: RadCube
- Contractor: C3S (HU), MTA EK (HU), ICL (UK), Astronika (PL)
- Platform: 3U CubeSat (C3S) with 3-axis pointing
- Payloads:
    - RadMag including electron/proton/cosmic ray particle detector (MTA EK), magnetometer (Imperial) on boom (Astronika)
    - Radiation Hardness Assurance board (ESA) Characterisation of Radiation effects on EEE components
- Mission:
    - In-situ Radiation environment & Magnetic field monitoring for future space weather services (data provision to ESA SWS)
- Status: Launched (August 2021) Commissioning completed. Nominal science operations on-going





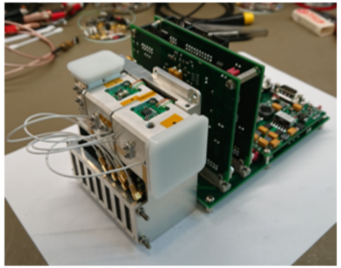
RADMAG Instrument + Chimera Board

Imperial College London mtaEK Astronika

4th ESA CubeSat Industry Days, 5th June 2019, ESTEC

RADTEL
Detectors specifications

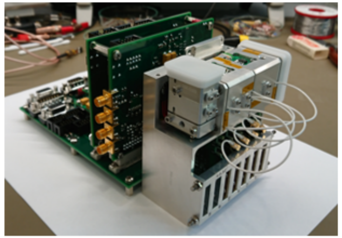
RADTEL1:
4-detector system
From 1st to 4th detector, lower to higher energy deposition spectrum → adsorbed dose can be determined up to heavy ions



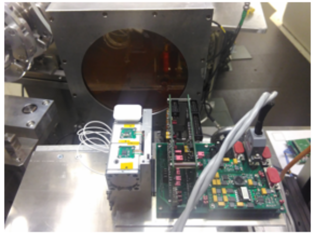
EBB model RADTEL1 view

Parameter	Value, range
Particle types	Electrons, Protons, Heavy Ions
Electron energy	Minimum: 100 KeV Range: 0.1 – 8 MeV
Proton energy	Minimum: 1 MeV Range: 1 MeV- 1 GeV
Heavy ion	Types: He, C, N, O, Fe Range: 100 MeV/n – 1 GeV/n
Orthogonal directions	≥ 2

RADTEL2:
3-detector system, lower resolution, measures electrons and protons energy



EBB model RADTEL2 view

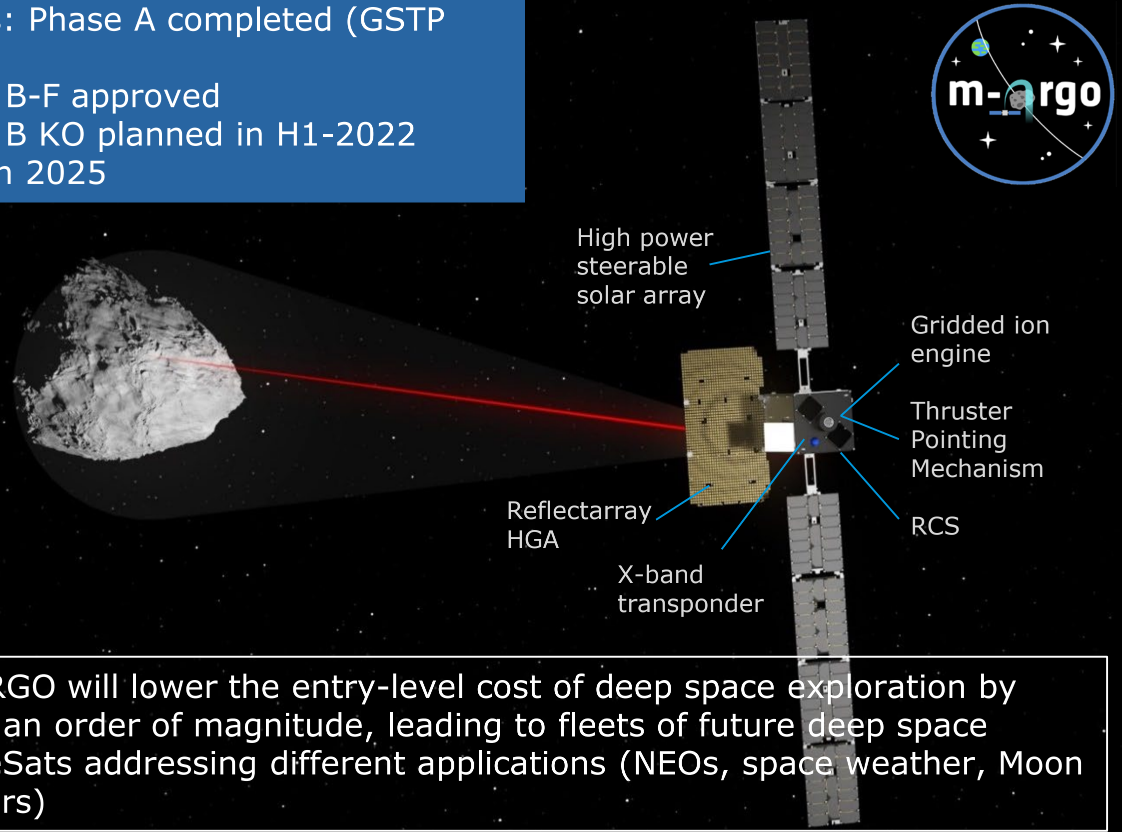


EBB model during test at PSI

Credit: Chiara Palla, Space and Atmospheric Physics, The Blackett Laboratory, *Imperial College London*

MARGO - Miniaturised Asteroid Remote Geophysical Observer

Status: Phase A completed (GSTP Fly)
Phase B-F approved
Phase B KO planned in H1-2022
Launch 2025



M-ARGO will lower the entry-level cost of deep space exploration by over an order of magnitude, leading to fleets of future deep space CubeSats addressing different applications (NEOs, space weather, Moon & Mars)

Objectives:

- Demonstrate critical technologies & operations for stand-alone deep space CubeSats in the relevant environment
- Rendezvous with a Near Earth Object
- NEO physical characterisation for in-situ resource exploration purposes
- Test autonomous GNC techniques

Mission concept:

- 12U XL CubeSat
- piggyback launch to Sun-Earth L2 transfer or Earth escape
- 1-3 year low-thrust interplanetary transfer (ΔV 2-3 km/s)
- 6-month close proximity ops at NEO
- 120 different NEO targets accessible

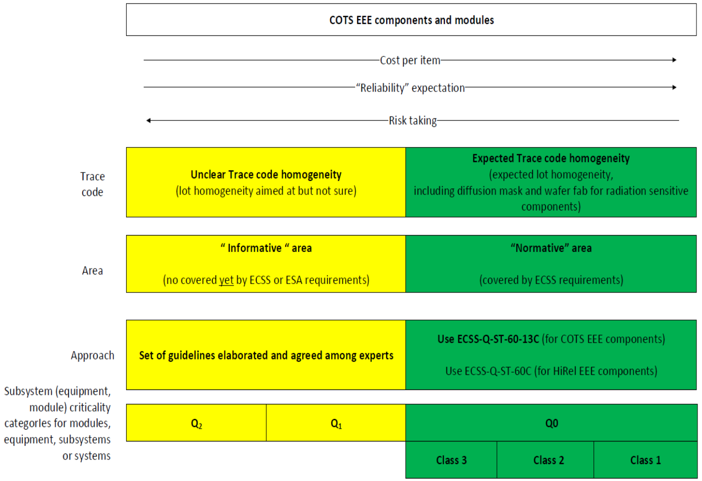
ESA Cubesat Radiation Requirements and Guidelines

ESA Missions requirements

- Can the RHA requirements be the same for all Mission?
- Part selection- ECSS-Q-ST-60/60-13 RadHard, RadTol, COTS
- Radiation mitigation by design: H/W, S/W
- In-flight flexibility: e.g. power cycles, resets, observability
- Radiation testing : TID/TIND/SEE@Part/Board

ESA COTS guideline a new ESA Handbook

- **New: criticality categories for COTS**
- **It is a set of guidelines and not requirements**
- It contains a very reasoned and balanced approach among all impacted engineering aspects, according to a progressive scheme from higher to lower risk taking
- It addresses the issue of **small procurement lots** and relevant **lot homogeneity issues**
- Addressing the application of COTS parts in modules, equipment or subsystems of **different criticality categories for ESA institutional missions**
- It goes beyond a simple and not realistic tailoring of ECSS requirements to address COTS applications for institutional space applications
- Introduces how commercial standards might be used to allow an effective use of COTS components and modules with a controlled risk posture



Expand the possibility to use and fly promising COTS component and modules with limited budget and time impacts. Allows a minimum risk taking thanks to the "do not harm" (recommendations) contained

RHA Approach to Mission Classification

- **5** Classes, **4 different sets of requirements tailored from ECSS-Q-ST-60-15 and guidelines**
- Class V: Suggested to have a separate standard- Perhaps only PARD

Class V

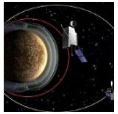
- < 3 M
- No TID test
- NO SEE test **except for MOSFET VDS > 200V**
- **Proton Test recommended (component or board level)**

Class IV

- 3M-2y
- No TID test if TIDL<5Krad
- **SEE** HI test **recommended**
- **Proton** test **required**

Class III

- 2y -5 y
- No TID if TIDL<5Krad
- HI at part and board level
- Proton at part and board level



Class I & II

- > 5 y
- ECSS-Q-ST-60-15 + ESSB-Q-008
- TID
- SEE

Mission Class IV: ECSS-Q-ST-60-15+ ESSB-Q-008+ tailoring

- **TID**
  - **TIDL < 5 Krad** (including a 2*RDM if 3D shielding analysis) : **testing is recommended, not required**
  - **TIDL > 5 Krad** (including a 2*RDM if 3D shielding analysis): testing at part (RDM=2 as per Class I and II) or **board level (RDM=3) is required**
- **TNID**
  - **Test of optoelectronics is required (No DD testing on Bipolars)**
- **SEE**
  - Heavy ion test data are **recommended**. Proton testing **required** (at component **or board level)**
    - **LETth > 38 MeVcm2/mg no analysis required**
    - **15 MeVcm2/mg < LETth < 38 MeVcm2/mg Heavy ion SEE analysis required**
    - LET < 15 MeVcm2/mg Heavy ion and proton SEE analysis required
    - **No SEE destructive events allowed**. **Mitigation techniques or testing to be implemented**

Radiation analysis is required

No radiation drift to be considered in WCA

Radiation & Design mitigation reviews required by PDR and CDR

Work in Progress

Mission Class V: ECSS-Q-ST-60-15 + tailoring = recommendation + minimum requirements

- **TID**
  - **TIDL < 5 Krad** (including a 2*RDM if 3D shielding analysis) : **No testing required**
  - **TIDL > 5 Krad** (including a 2*RDM if 3D shielding analysis): Testing at part or **board level is recommended**
- **TNID**
  - **Test of optoelectronics is recommended, for proton rich environments**
- **SEE**
  - **No heavy ion test data are required except for MOSFET > 200V**
  - **Proton Test is recommended** (component or **board level**)
  - **Derating of power MOSFET at 30% of Vds max rating (no negative Vgs for N channel, no positive Vgs for P channel)**
  - **No SEE destructive events allowed**. **Mitigation techniques or testing to be implemented**

Radiation analysis is required

No radiation drift to be considered in WCA

No Radiation & Design mitigation reviews

Work in Progress

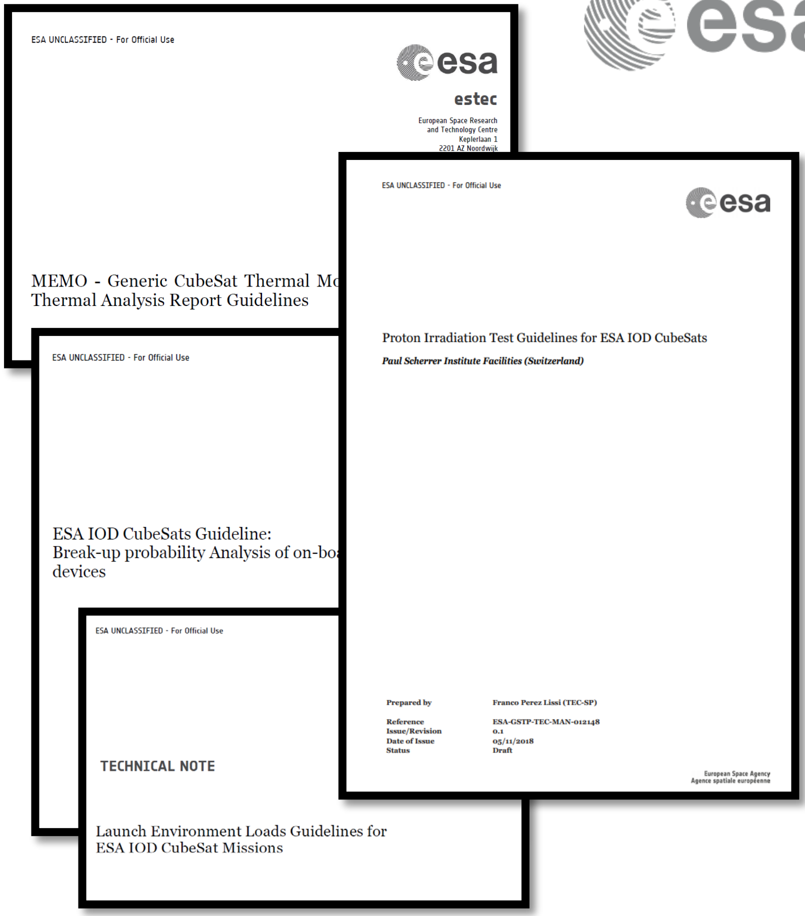
Current ESA Cubesat Approach (Pre-release of Guidelines)

	ESA Cubesat LEO IOD Mission	ESA Cubesat - Deep Space IOD Mission
TID	• TIDL < 5 Krad (including a 1.5*RDM if 3D shielding analysis) : testing is recommended, not required • TIDL > 5 Krad (including a 1.5*RDM if 3D shielding analysis): board level testing is required • Testing Recommend up to 20 krad (board level)	Board level testing is required Testing Recommend up to 20 krad (board level) or maximum predicted TID
TNID	Test of optoelectronics is recommended, for proton rich environments	Test of optoelectronics is recommended, for proton rich environments
SEE	• No heavy ion test data are required • Proton Test is mandatory on new electronic developments. Destructive latch-up screening is performed with High Energy Protons • Maximum beam intensity at 230 MeV: 2 nA (at 74.5 MeV ca. 5 nA effectively) • Maximum flux at 230 MeV for the focused beam: ~ 2*109 protons/sec/cm2 • No SEE destructive events allowed. Mitigation techniques or testing to be implemented	• No analysis is required for components with LETth > 60 MeV.cm²/mg regarding destructive effects. b. Component sensitive to destructive effects (other than SEL) with LETth < 60 MeV.cm²/mg: - shall demonstrate a failure rate at least 10 times lower than the intrinsic - System failure rate shall be submitted for approval to ESA. c. Component with SEL LETth > 40 MeV.cm²/mg shall implement mitigations to recover from loss of functionality. d. Component with SEL LETth < 40 MeV.cm²/mg (not preferred): - Shall demonstrate that no other SEL free option is available within the context of the project. - Shall be SEE tested in-the-loop with the implemented mitigation. - Shall demonstrate no loss of functionality after a large number of occurrences. - Shall not severely impact the mission in terms of availability. - Shall be submitted for approval to ESA • Proton Test for pre-screening is mandatory on all avionics . Destructive latch-up screening is performed with High Energy Protons • Maximum beam intensity at 230 MeV: 2 nA (at 74.5 MeV ca. 5 nA effectively) • Maximum flux at 230 MeV for the focused beam: ~ 2*109 protons/sec/cm2
Radiation Analysis	Mandatory . Sectorial Analysis Recommended, otherwise SPENVIS	Mandatory, Sectorial Analysis
Radiation Review	Space Environment Document at PRR,PDR,CDR Test results before CDR	Space Environment Document at PRR,PDR,CDR Test Results before CDR

ESA IOD Cubesat Guidelines

New guidelines for:

- Environmental Loads and Mechanical Testing
- Thermal Vacuum Cycling Testing
- Thermal Modelling
- Reduced Thermal Models Creations
- In-orbit break up probability analysis
- **High Energy Proton Testing Radiation**
- TRR Checklist Template



Radiation Testing Approach on ESA Cubesats for LEO Missions

Radiation Approach - ESA IOD Cubesat Missions

If **EEE COTS components** are expected to be used in a unit design, the contractor shall define a **process to de-risk the use of these parts**, complementing the normal qualification / acceptance process for this unit.

The (6) steps to be followed for the de-risk activity are the following:

1. **Environment and Effects**: Space environment assessment for the target orbit (PRR), and understanding of the potential radiation effects.
2. **Identify applicable requirements**
3. **Radiation analysis** of the SC on the target orbits (PDR), assess compliance to Mission and System Requirements
4. **Critical units Identification:** Identify all EEE parts, and new avionics to be embarked (PDR). Selection of critical subsystems
5. **Radiation Testing:** Execute HEP Radiation Test Campaign at Board Level (Post PDR), or HI part level (deep space)
6. **Re-design (if needed):** Feed the design with test results (CDR) and consolidate design

1- Space environment assessment for the target orbit

GOMX-5

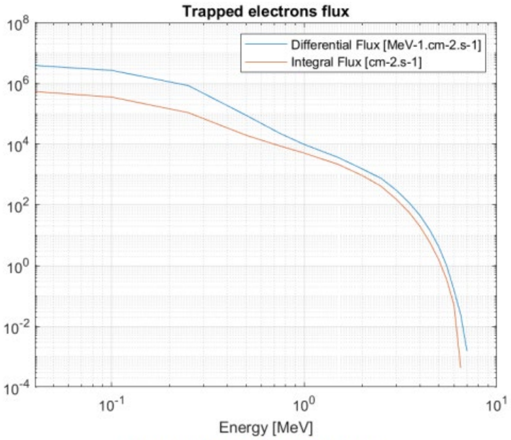


Figure 4-2: Trapped Electrons for the GOMX-5 mission

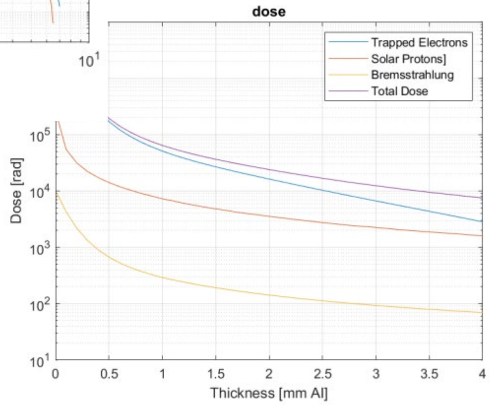


Figure 4-8: Dose-depth curve for the GOMX-5 mission

HERA

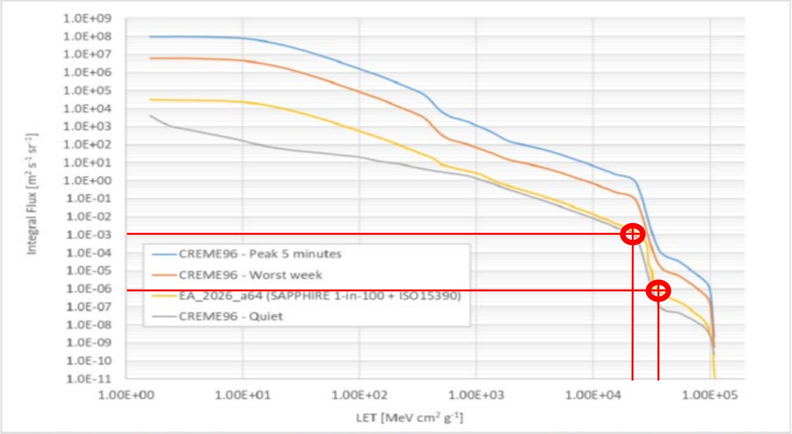


Figure 6-4: Integral particle fluxes as a function of LET for a component shielded by 1 g.cm-2 Al shielding (spherical configuration); peak 5-minute (worst case peak), worst week (worst case SPE), quiet (GCR) and the cumulative values expressed as the mission average flux per second.

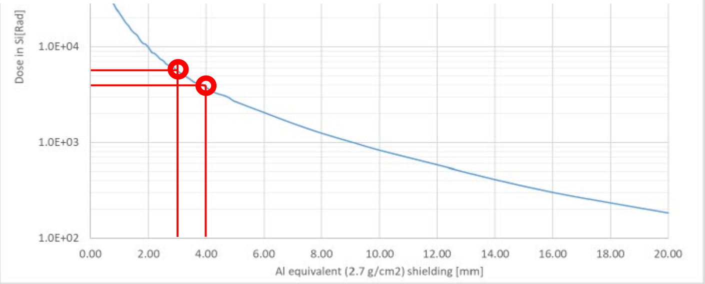


Figure 6-5 Total mission dose in Silicon as a function of spherical Aluminium shielding for Hera.

2 - Applicable Requirements

	ESA Cubesat LEO IOD Mission	ESA Cubesat - Deep Space IOD Mission
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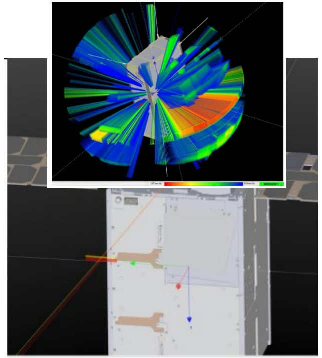
Radiation Review	Space Environment Document at PRR,PDR,CDR Test results before CDR	Space Environment Document at PRR,PDR,CDR Test Results before CDR

3- Radiation Analysis (LET/TID/TNID)

Sectorial Analysis GOMX-5

Name	Mean Dose (krad)	Sigma Absolute (krad)	Dose with Uncertainties (krad)	Qualification Level (krad)	RDM
NanoTorque GSW-600-4P (15)	2.0	2.5	11.6	20.0	1.7
	2.0	3.0	13.2	20.0	1.5
	1.4	1.8	8.3	20.0	2.4
	1.4	1.9	8.6	20.0	2.3
	1.3	1.8	7.9	20.0	2.5
	1.2	1.6	7.3	20.0	2.8
	1.2	1.6	7.1	20.0	2.8
	1.2	1.6	7.1	20.0	2.8
	1.2	1.5	6.9	20.0	2.9
	1.2	2.0	8.4	20.0	2.4
	1.2	2.7	11.1	20.0	1.8
	1.1	1.9	8.2	20.0	2.5
	1.1	1.8	7.8	20.0	2.6
	1.1	1.5	6.8	20.0	3.0
	1.1	1.5	6.7	20.0	3.0
	1.0	1.4	6.4	20.0	3.1
	1.0	1.4	6.3	20.0	3.2
	1.0	1.4	6.3	20.0	3.2
	0.7	1.0	4.3	20.0	4.7



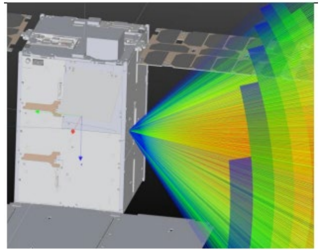


Table 11-2: Comparison between traditional and Monte Carlo analysis

Orbit Altitude	Spherical model (2 mm aluminium)	Monte Carlo simulation (worst case)	Monte Carlo simulation (mean)
800 km	20.7 KRAD	2.5 KRAD	1.2 KRAD
1500 km	121.1 KRAD	25.7 KRAD	15.3 KRAD

TID Analysis HERA Cubesat (Pre-assessment)

	Duration [days]	*Start date*	*TID [krad]*		*NIEL [TeV g(Si)$^{-1}$]*	
			Unmargined	**Margined**	**Unmargined**	**Margined**
Cruise (2024 nominal)	811	2024-10-08	3.66	5.49	62.38	93.57
Cruise (2025 backup)	1,913	2025-11-05	6.51	9.76	110.92	166.38
Cruise (2026 backup)	1,187	2026-11-06	4.70	7.05	80.10	120.14
ProxOps	180	2026-12-28	5.51	8.26	90.47	135.70
Cruise 2024 + ProxOps	991	2024-10-08	9.17	13.75	152.85	229.27
Cruise 2025 + ProxOps	2,093	2025-11-05	12.02	18.02	201.39	302.08
Cruise 2026 + ProxOps	1,367	2026-11-06	10.21	15.31	170.56	255.84

Pre-assessment of the total ionizing doses are computed with SPENVIS using the SHIELDOSE-2 model; the non-ionizing doses are computed using the JPL Si damage curve with a damage factor of 10-11 g(Si)/MeV. These doses are computed assuming the following shielding: a total of 3 mm during cruise (2 mm from Hera + 1 mm from Juventas) and a total of 1 mm during proximity operations (Conservative approach)

Sectorial Analysis inside HERA

Table 29 Properties of sandwich panels of HERA

Component	Thickness [mm]	Area from CAD [m²]	Core Thickness [mm]	FaceSkin
Panel_YP_Radiator	20	2.018	19	AL2024
	20	2.02	19	AL2024
	20	2.0	19.4	M55JPre-preg
	20	0.813	19.4	M55JPre-preg
	20	0.833	19.4	M55JPre-preg

4. Selection of Critical Parts/Units

Proton and TID Susceptibility (All Mission)

All units (without flight heritage) are proton tested, and destructive latch up screened.

This is applicable to all LEO Missions.

Usually, all SC avionics are tested, as a flatsat configuration. Either running unit by unit with the associated EGSE, or the full system running, while the beam is focused on a single Unit.

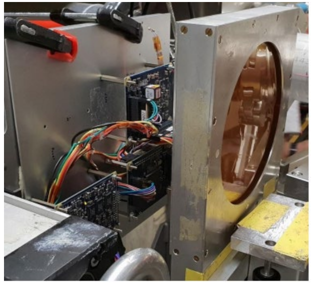
IOD Deep Space Mission - HI Susceptibility:

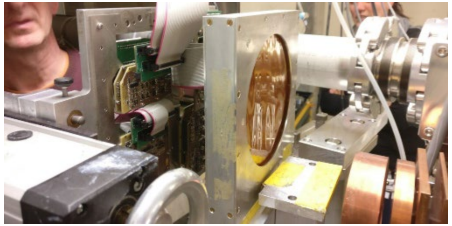
Usually, due to programmatic (budget/development schedule) constraints, and the extensive use of COTS, heavy Ion testing is not possible on every single part of the DCL for the full SC. Therefore, in order to balance risk for an IOD Mission:

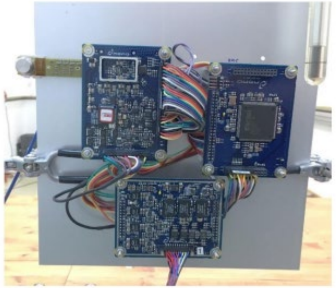
1. A criticality assessment on the main avionics is performed, selecting main targets for the campaign (e.g. DHS, PCDU, BAT, Propulsion Handler), this assessment is performed based on the availability requirements of the missions, and each spacecraft architecture.
2. Once the unit level is defined, DCL and unit schematics are assessed by Electrical experts and Radiation experts in order to create a list of candidates EEE parts for HIA Testing.
3. Once the list is finished, the expected beam time required to test the candidate parts is derived, and the test is started.
4. An assessment of the re-design impact for each part is performed (what does it mean to substitute a part for RAD-Tolerant version). This is performed in advanced to the test. Usually back-up parts are carried to the test, in order to avoid major delays during the campaign.
5. Test results are assessed. Re-design or acceptance of the risk is decided based on technical and programmatic constraints.

5- Radiation Testing

HEP (Destructive Latch-up screening GO/Non-go Test)







The irradiation test consists of high-energy proton irradiation and is primarily aimed at screening for destructive SEEs at board-level. In cases where latch-up protection has been implemented for these boards (either at board or system level), the effectiveness of such protection to detect and mitigate against destructive SEEs shall also be evaluated.

The secondary objective of the mission is to identify as many soft errors as possible and also investigate potential proton induced events (e.g. SEFI) considerably affecting the system and reducing spacecraft/instrument availability

The available high proton beam at PSI has the following features:

- Initial proton energies: 230, 200, 150, 100 and 74 MeV (can be modified if requested)
- Energies available using the PIF degrader: quasi continuously from 6 MeV up to 230 MeV
- Energy straggling for the initial beam energy of 74.3 MeV: e.g. FWHM=2.4 MeV at 42.0 MeV, FWHM=5.6 MeV at 13.3 MeV.
- Maximum beam intensity at 230 MeV: 2 nA (at 74.5 MeV ca. 5 nA effectively)
- Maximum flux at 230 MeV for the focused beam: ~ 2*109 protons/sec/cm2
- Beam profiles are of Gaussian-form with standard (typical):FWHM=10 cm
- Irradiations take place in air.
- The maximum diameter of the irradiated area: f 9 cm
- The accuracy of the flux/dose determination: 5%
- Neutron background: less than 10-4 neutrons/proton/cm2
- Irradiations, devices and sample positioning are supervised by the computer
- Sample mounting frame 25 x 25 cm2 (SEU and HIF facilities compatible) is attached to the XY table

- Example: Micro-controller high current consumption & anomalous behavior (bad check sum, SEFI) during destructive SEE no/no-go test at PSI (e.g. STM32L-152)

- Are the correct SEE mitigation measurements in place on your EPS, in order to recover from UPSETs. Are you able to autonomous power cycle the subsystem under failure? Can you derive the availability of your subsystems?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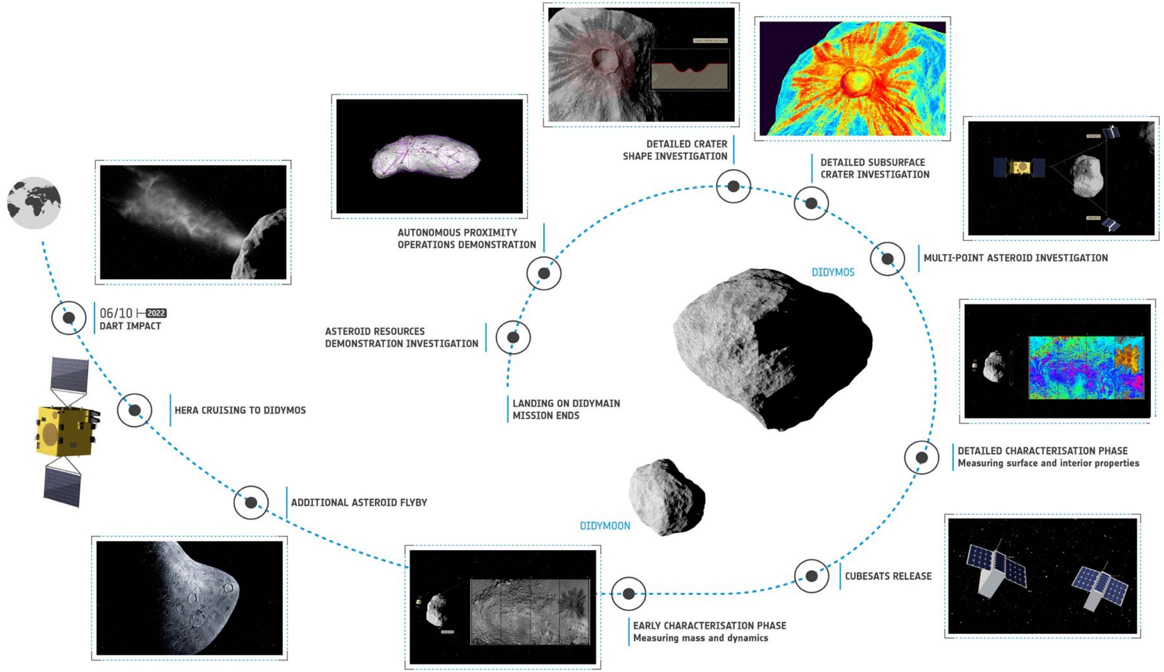
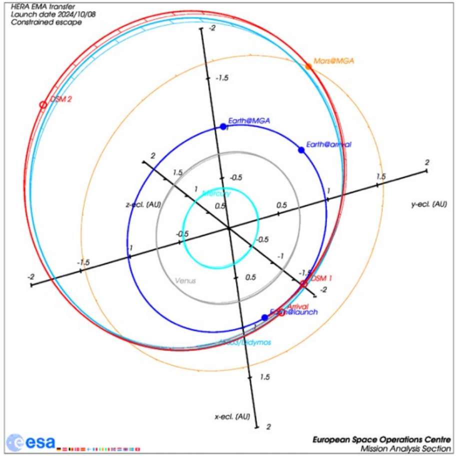
HERA Mission: JUVENTAS and MILANI Cubesats





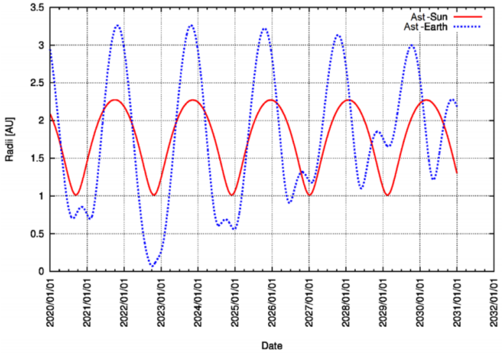
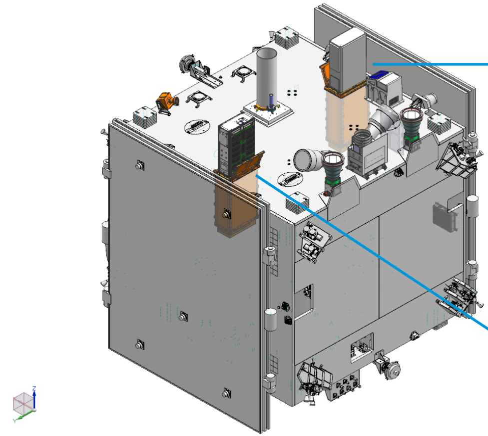


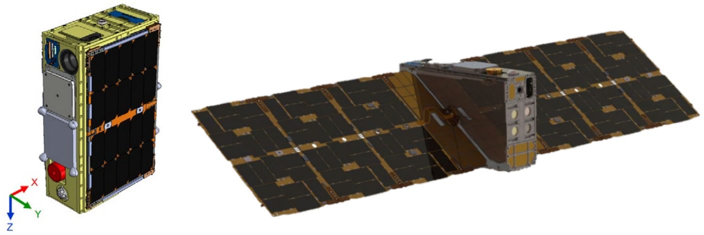
Figure 2-1: Asteroid-Sun and Earth Distance from 2020 to 2030

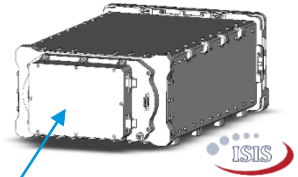
Cubesats on HERA: Milani and Juventas

Launch
October 2024



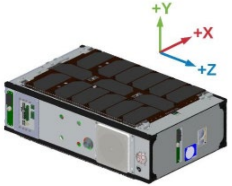
MILANI
DSD (Yn)

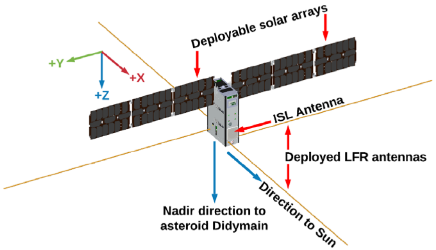


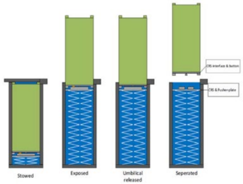


Life Support Interface Board

JUVENTAS
DSD (Yp)







Conclusions

1. All ESA IOD Cubesats shall perform a complete space environment assessment and electronics radiation analysis (sectorial and/or spherical shielding) before PDR.
2. All ESA IOD Cubesat Missions follow a set of guidelines and tailored specifications, setting the expected requirements based on the mission target space environment.
3. All ESA IOD Cubesat Missions are tested against HEP in order to perform a destructive latch-up screening, as go/no go test for the proposed avionics.
4. New IOD Deep Space Missions are following a hybrid approach in which, COTS (automotive-grade) and rad-tolerant parts are utilized. Radiation Testing on HI is performed on critical units and critical EEE parts, in order to assess mission susceptibility to SEE, and derive mission availability.
5. European Radiation facilities (e.g. PSI, UCL etc) are extensible used through external commercial agreements and internal ESA agreement for beam time.
6. In-orbit performance for IOD Cubesat missions in LEO, have shown very low reset rates. More results to be disclosed with the upcoming GX5,RADCUBE, SUNSTORM and PRETTY missions.

THANK YOU

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