

ESA Space Safety Programme

Protecting our Planet, Humanity and Assets from Space Hazards

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Space Safety: A concern for society



Solar flares in May 2024 revealed Earth's vulnerability to space weather

by **Debra Werner** February 12, 2025















SpaceX rocket debris crashes into Poland

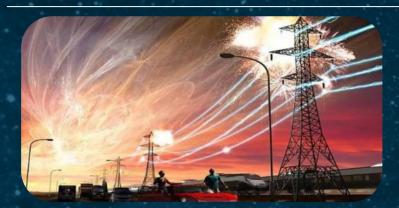


Eve Webster

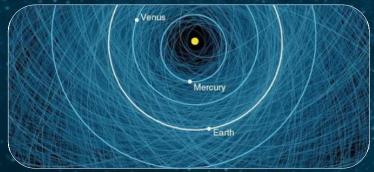
BBC News

S2P: Programmatic goals (2030)





- Providing timely, accurate, and actionable space weather alerts through a preoperational monitoring system
- Cooperating with with a Space Weather governing entity



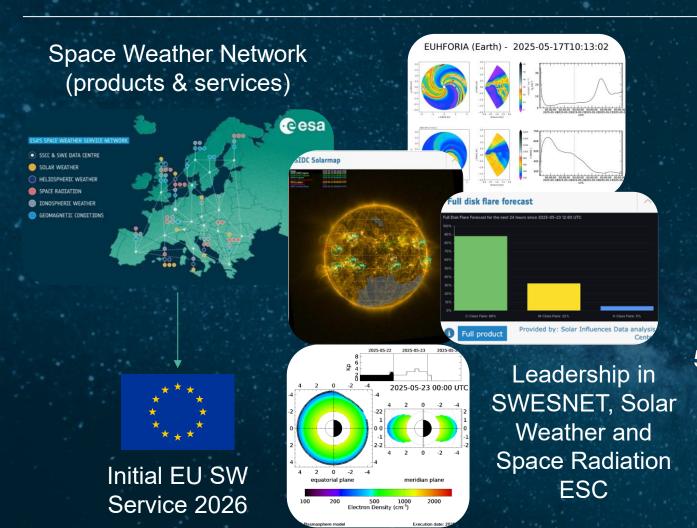
- Establishing a comprehensive detection and early warning network for asteroids larger than 40 m, providing alerts at least three weeks before impact.
- Deflecting asteroids smaller than 0.5 km.



- Developing technologies for a Zero Debris approach and assessing risks from small-sized debris
- Demonstrating in-orbit servicing technologies to advance the space circular economy
- Enhancing capabilities to evaluate environmental impacts on Earth

Achievements: Space Weather



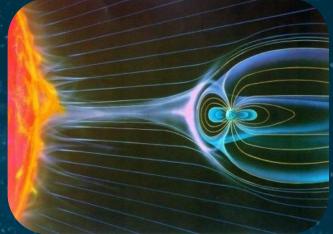




5 hosted payloads operational



Vigil contract signed



SWING Space Weather Nanosat

Achievements: Planetary Defence





Hera launched



RAMSES signed



9th pre-impact detection



FlyEye #1 in Matera

Achievements: Space Debris & Clean Space





Space debris laser operational DIGOS' ESA Rising Star



All large platforms under zero-debris maturation contract



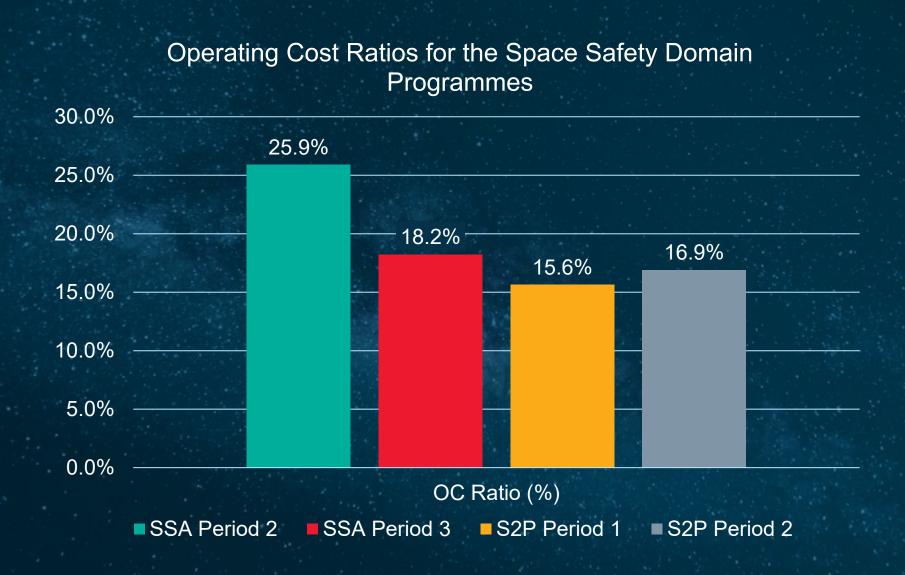
Rise IOS Mission signed



DRACO re-entry experiment kicked-off

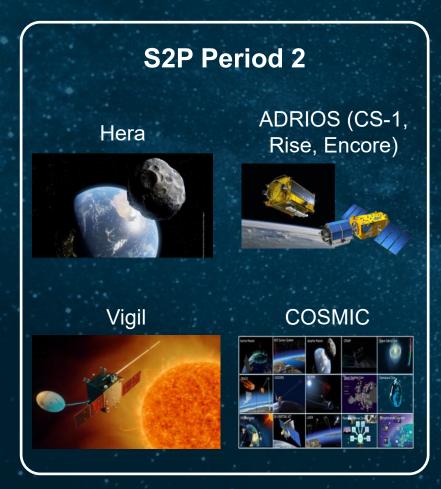
Evolution of programme overhead





S2P Period 3 Proposal: High-level structure





Reorganised 75% Continuation 25% New





S2P Period 3

ADRIOS Cornerstone

(CS-1, Rise, Encore)

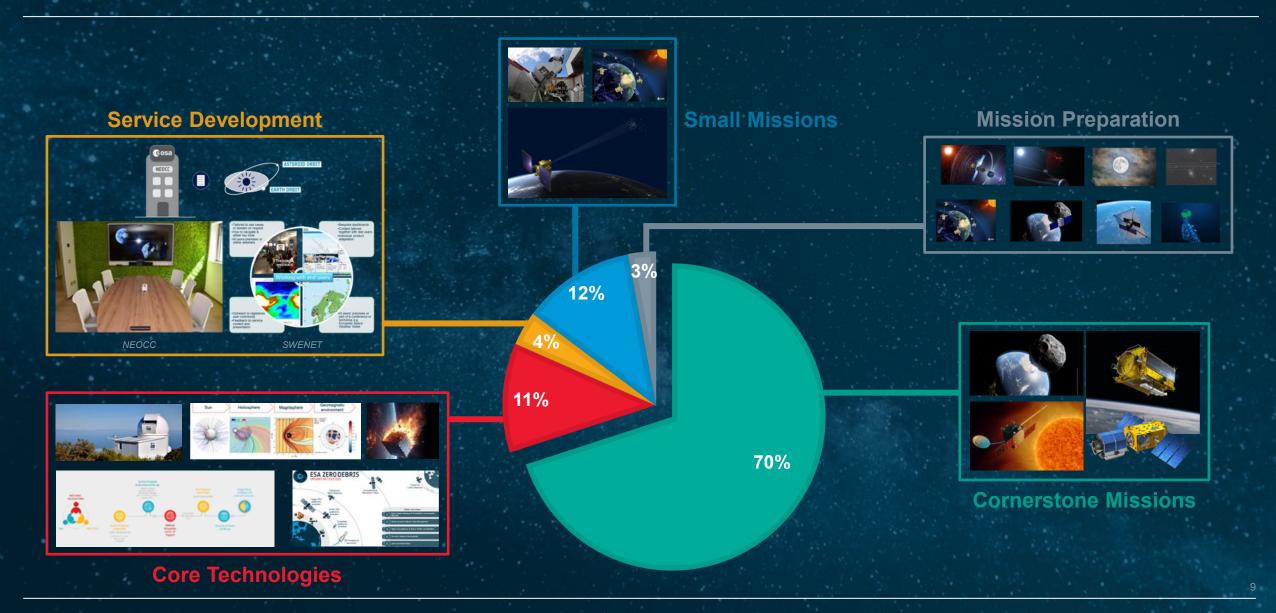


COSMIC



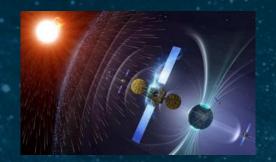
Classification of programme content





Mission Studies





SWORD: Dedicated mission to provide nowcasts of the radiation belts



NEOMIR: Operational Infrared NEO
Observatory at L1



LEMO-TD: Monitoring of cis-lunar space traffic



VISDOMS-S Space-based Optical Mission



PAN Asteroid Ion Beam Shepherding



Space Weather Nanosat #3



SATIS: Small Asteroid Inspector



SAILOR: Debris Impact Measurements



ECOSTARS IOD of green platforms



Circular Economy Missions

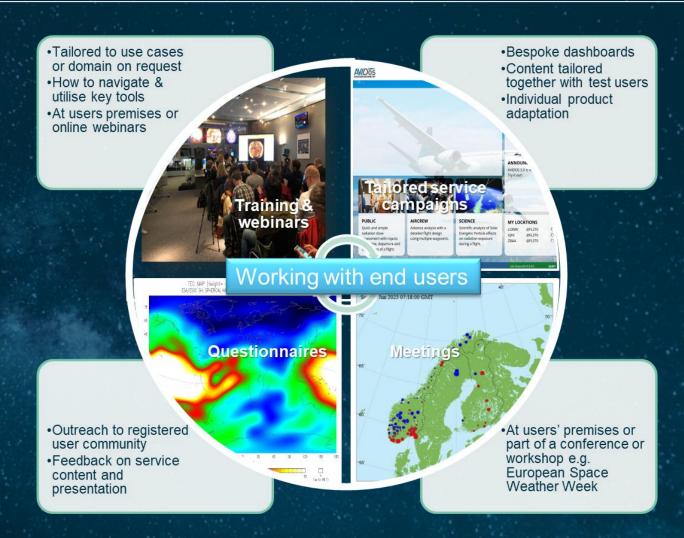
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(Pre-Operational) Services Development









SWENET: Space Weather Network

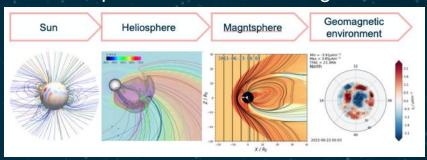
Core Technology Elements



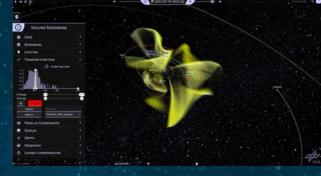




Virtual Space Weather Modelling Centre

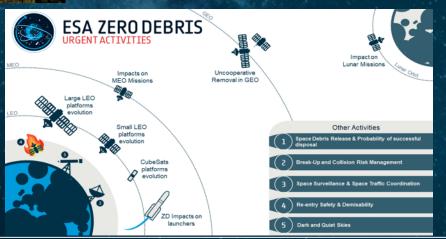


Advanced Space Weather Visualisation



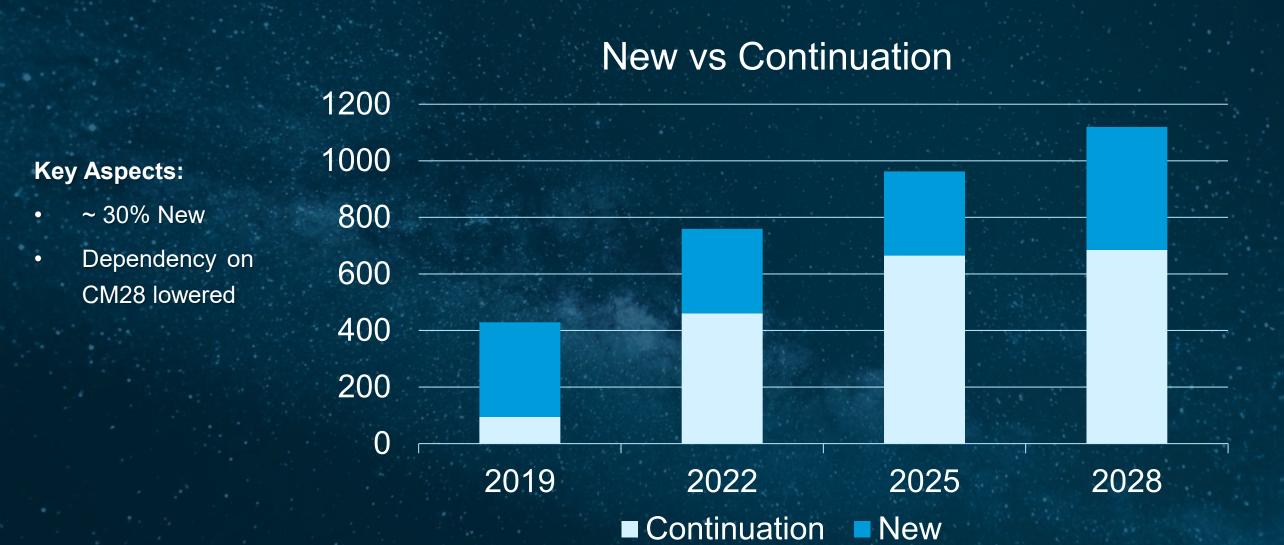
Competitiveness





New vs continuation







Space Weather Cornerstone



Vigil



Operational mission at L5 providing the capability to monitor and predict space weather activity and provide a timely warning of extreme solar events.

- Space weather events disrupt GNSS, comms, and radar
- Forecast horizon: up to 4–5 days vs. today's 12–18 hours
- Impact timing: cut prediction error from 6–12 hours
- Operational service: agreed availability and low latency to maximize warning time
- Ongoing collaboration with NASA/NOAA
- In complement to an emerging very strategic cooperation with EC
- Satellite PDR planned for Q1 2026





Planetary Defence Cornerstone



RAMSES



Rendezvous mission with Apophis to monitor the close encounter with Earth and to characterise its interaction with Earth's gravity with high-resolution before and after the encounter

- Once-in-7,500-year Apophis event → global spotlight
- Most credible approach to reach Apophis
- Mature plan: PDR passed (Jan 2025); CDR Q4 2025;
 launch Apr 2028
- Strong international partnership: JAXA, NASA
- Exceptional value: JAXA launcher + high-heritage design
- Budget-efficient: request <€20M
 - with H3 <€15M for a large industrial package
- High visibility and key role for Belgium



RAMSES



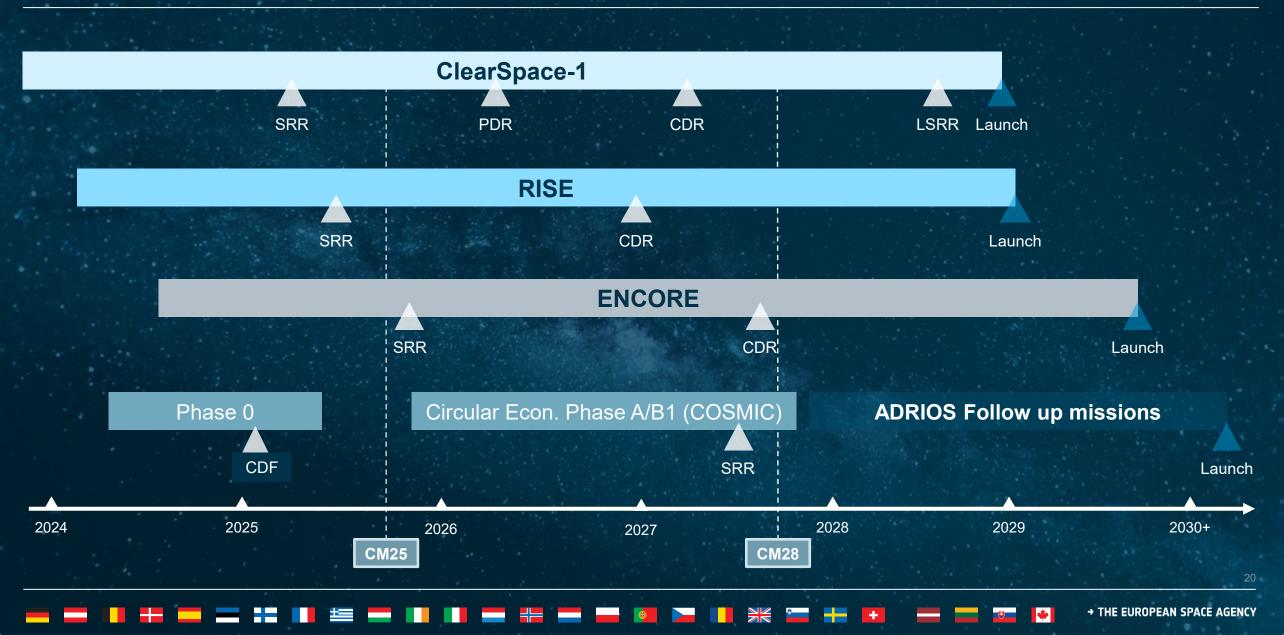
Belgium is one of RAMSES' largest contributors with several key technologies and equipment for the mission being developed in Belgium

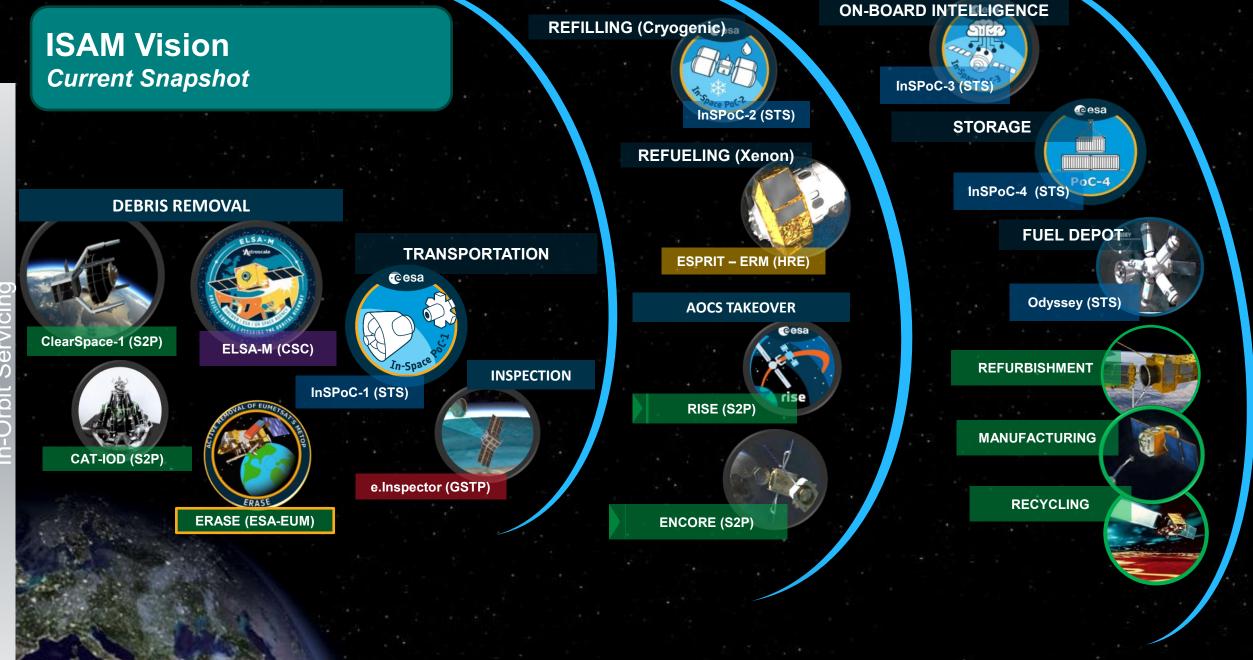




ADRIOS: Timeline







RISE



RISE aims to bring together a service provider and a customer for the verification of life extension of a satellite through Attitude and Orbital Control Takeover (AOCS Takeover) in geosynchronous graveyard orbit (GGO)

- Industry led mission by D-Orbit-IT industry defining the mission and system requirements
- End-to-end contract signed in Q3 2024 covering Phase A to E
- Currently in Phase B1, with SRR in Q2 2025
- Through RISE D-Orbit aims to develop a recurrent commercial service
 - On board computer
 - Propulsion equipment
 - Software

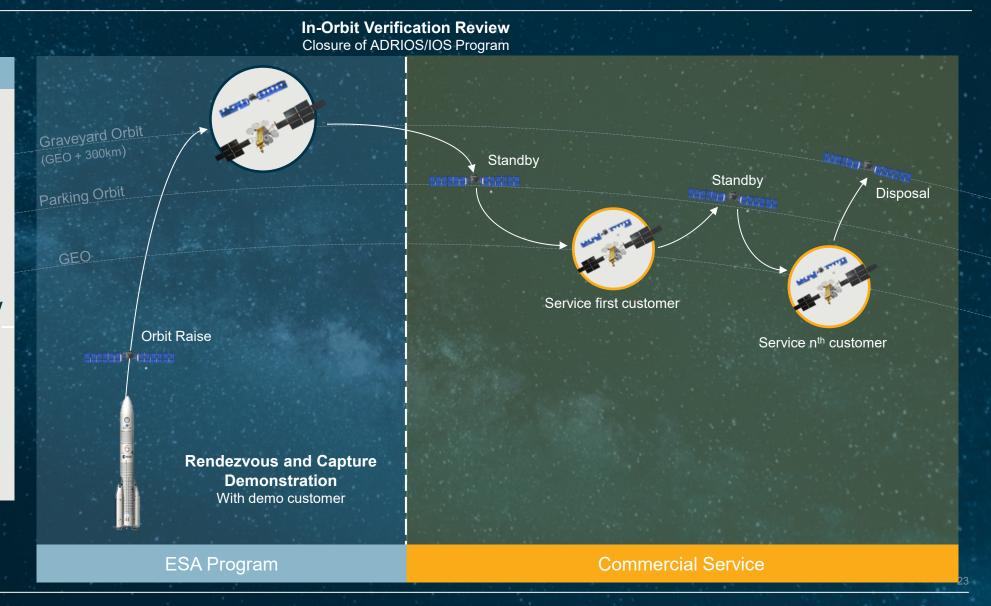


Rise: Mission architecture



Mission Overview

- Launch injection into Geostationary Transfer Orbit
- 2. Orbit Raise from GTO to GEO Graveyard Orbit
- 3. Rendezvous and Capture Demonstration in GGO with demo customer
- 4. In Orbit Verification Review
- 5. Standby in parking orbit until start of servicing
- 6. Servicing of first commercial customer
- Disposal in GEO Graveyard Orbit



Capture Payload Bay (CAT)



The Capture Payload Bay (CAT) removal system, utilizing ESA's standardized D4R removal interfaces, requires in-orbit demonstrations (IOD) to establish these interfaces as a trusted and standard solution for future commercial and institutional missions

- To be flown with LUR-1 mission (Spanish regional mission) in 2029
- Most relevant milestones:
 - Phase A kick-off in January 2025
 - o Phase 1 kick-off, IPRev Light in May 2025
 - Participants workshop held in July 2025
 - Ground Segment
 - Platform





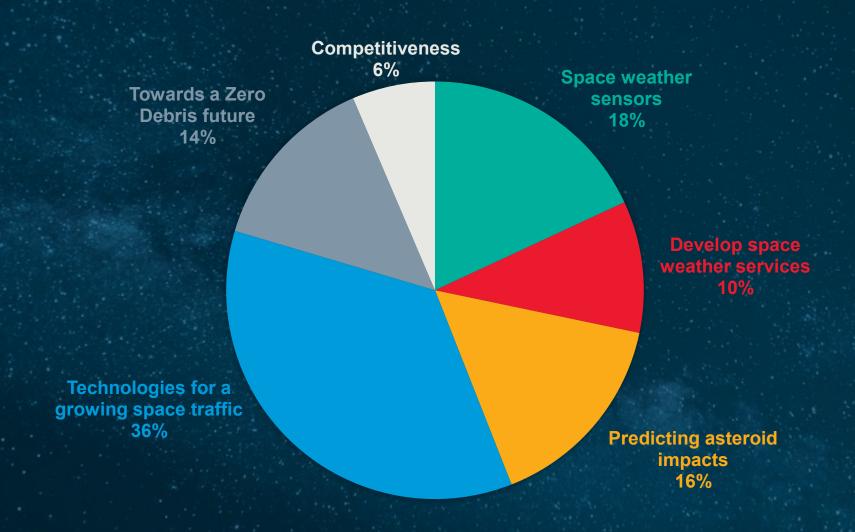
- Initialize CAT Mission (Phase B1) (parallel contract) and CAT-EM (Phase 2). KO in Q1 2026
- Mission prime selection and full mission implementation for B2/C/D in Q4 2026





Cosmic Segments Breakdown





Space Weather Sensors



Distributed Space Weather Sensor System (D3S) aims to monitor "Earth space" environment and provide near-real-time data for operational applications

- Dedicated deep space missions, e.g. Vigil, to facilitate improved space weather nowcasting and forecasting
- Ground based observations systems



Aurora

Keeps an eye on auroras and other parts of Earth's protective layers to protect ground infrastructure



Nanosatellites

Cost-effective missions that support the commercialisation of space weather monitoring



SWORD

Enables 'nowcasting' the space radiation environment, essential for spacecraft operators



Hosted payloads

Aurora



Aurora-D demonstration mission will explore the potential of far UV and optical imaging to monitor continuously the Auroral Oval, in preparation of constellation Aurora-C

- Phase B1 underway with OHB Sweden as mission prime,
 Project internal SRR conducted in Q1 2025
- RFQ for Phase B2/C/D to be released immediately after corporate SRR in Q4 2025, Phase E to be initiated later
- Preparation of Aurora-C potentially by EUMETSAT

AUI Instrument prime



SWORD



SWORD mission will provide data on Earth's radiation belts allowing a nowcast of the overall belt status

- ESA internal CDF performed end 2023
- Currently two parallel pre-Phase A studies ongoing,
 primed by 1) Redwire (BE) and 2) Airbus DS SAU (ES)

Mission Prime and platform



Develop Space Weather Services

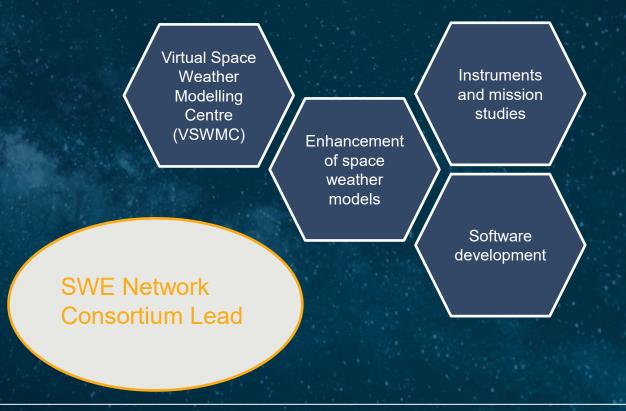


ESA Space Weather Service Network builds and matures the **monitoring services** needed for a dependable European space weather system

Core Space Weather focus on **basic developments** that improve European capability

=> R2O(2R) framework for space weather





Belgium at the heart of Europe's SWE network

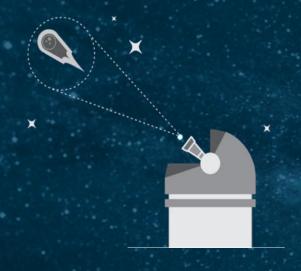


- The SSA Space Weather Coordination Centre (SSCC) is located at the Space Pole (Belgium)
- First European Space-Weather Helpdesk
- Solar and space radiation expert service centre leadership
- Service assurance → day-to-day monitoring of continuity and quality for services including federated products
- User impact: tailored bulletins for priority users, professional training programme, active promotion to the SWE community
- Strategic value for Belgium: reinforces Belgium's role as a hub for SWE information and expertise, supporting increased resilience for affected users



Predict Asteroid Impact





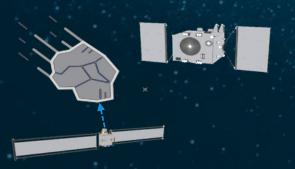
Observation

Neo Survey System

- FlyEye Telescopes
- Telescope Array

Near-Earth Object Mission in the Infra-Red (NEOMIR)

Satis (Asteroid Inspector)



Mitigation

Precise Asteroid Nudging (PAN)

Ion-Beam deflection method



Assessment

Near-Earth Object Coordination Centre (NEOCC)

- Aegis: Orbit determination and impact monitoring system
- Meerkat: Quick warning system evaluating imminent impact threats

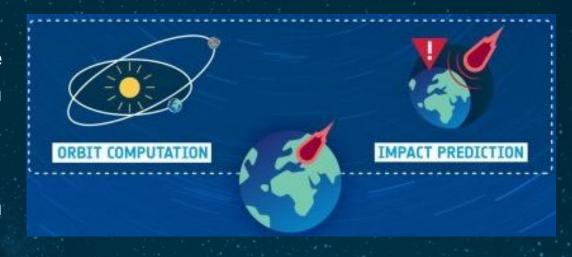
Near-Earth Object Coordination Centre (NEOCC)



Based at ESA's ESRIN site (Frascati, Italy), the NEOCC is the central access point to an entire network of European near-Earth object data sources and information providers

- Contribute to and coordinate observations of small bodies in the Solar System – such as asteroids and comets
- Provide orbital information, impact monitoring, data provision, risk analysis and propose mitigation measures if needed







Technologies for a growing space traffic



Laser Tracking of Space Debris

On-demand ephemeris provision

Core Technologies

Risk management (re-entries and fragmentation)
Observation – focus on <1 cm pieces of debris
Capacity monitoring
Support understanding of debris consequences



Destructive Reentry Assessment Container Object (DRACO)

Understanding re-entry and demisability



Sail Array for Impact Logging in Orbit (SAILOR)

Improve space environment knowledge on least observed size range (sub-mm to cm)



Lunar Environment MOnitoring – Technical Demonstrator (LEMO-TD)

Monitor space debris in cislunar space

DRACO



DRACO (Destructive Re-entry Assessment Container Object) mission will **study in-situ the destructive break-up of spacecraft during atmospheric re-entry** and provide crucial validation data for engineering, scientific, and risk models

- Platform prime DEIMOS (ES), and re-entry capsule leads
 FGE (UK) and VKI (BE)
- End-to-end funded under Period 2
- Scheduled for launch Q1 2027

- Capsule final integration and testing
- Data exploitation



Toward a clean and zero debris future



By 2030, ESA's ambitious **Zero Debris approach** aims to **stop creating new debris**, and **Green Agenda** aims to **reduce its projects on-ground carbon footprint by 28%**

Zero Debris

- Zero-Debris satellites, from CubeSats to large platforms
- De-orbiting Kit
- Design for Demise
- Design for Removal

Ecodesign

EcoStars missions

Circular economy

In-Orbit Servicing, Assembly and Manufacturing (ISAM) acceleration platform



Zero Debris Platforms evolution



Coordinated work of integrators and supply chains for evolution of European product lines to align with Zero Debris vision **PDR** RR MTR SRR Platform design and development by the integrators Maturation and adaptation of key technologies Simplify End of Subcontractors' involvement: RFI, RFQ, TDA Life RR SRR PDR Platform design and development by the integrators **Understand &** Maturation and adaptation of key technologies avoid failure Subcontractors' involvement: RFI, RFQ, TDA **SysNova IOD Phase A IOD Mission (Phase A - F)** studies If failure, reduce risk 2024 2025 2026 2027 Large LEO platforms **Small platforms** CleanCube

Competitiveness



The competitiveness segment aims at developing the space safety market and at exploiting commercialisation dimensions → industry-driven ideas of higher TRL to seed markets!







