Paris, 22 May 2024

EUROPEAN SPACE AGENCY

Status Report on Space Safety

1. Introduction

The Space Safety Programme (S2P) has as its general objective to contribute to the protection of our planet, humanity and assets in space and on Earth from hazards originating in Space and to contribute to Europe, by providing safety from such hazards, as a service to its society.

The programme was created at the Space19+ and expanded at the CM22 ministerial conferences building on the success of the existing Space Situational Awareness (SSA) programme and expanding its activities to include a number of cornerstone missions and adding to the well-established monitoring dimension, the much-needed mitigation and remediation dimensions, as well as support to industry's competitiveness and commercialisation activities.

S2P covers activities and cornerstone missions in Space Weather (including the Vigil operational mission to Lagrange point L5, the small Aurora mission and several nanosat missions), Planetary Defence (including the Hera mission for the acquisition of asteroid deflection capabilities, the NEOMIR and Apophis reconnaissance missions and the augmentation of ESA's NEO survey system), Space Debris and Clean Space (including the Clearspace-1 mission for active debris removal in space, In-Orbit Servicing Missions RISE and ENCORE, the VISDOMS and DRACO small missions, and the development of laser and collision avoidance automation technologies).

Maximising synergies among space safety initiatives in Europe and globally is an important pillar of the programme, avoiding duplications, to develop opportunities for cooperation among ESA, Member States, the European Union and other partners, without prejudice to the independence of ESA as an organisation and recognising that the content of ESA programmes is determined by its Member States.

To this end, ESA has been entrusted by the EC with all tasks in the area of Space Weather and Planetary Defence from two programmes - the EU Space Programme and the EU Horizon Programme.

Space safety is at the core of Agenda 2025 as one of its 5 priorities, and it provides the technical and programmatic foundation for the PROTECT

accelerator. It is also an integral part of ESA's vision for the European space sector by 2040.

This document provides a summary of the status and main achievements of the Space Safety Programme Period 1 and 2 in the 2023 and a look forward into 2024.

2. Status and Achievements

2.1. Contractual Status

For S2P Period 1 and 2, more than 120 work plan activities have been procured or are under procurement, with a total budget of 900 M€. This corresponds to 90% of the programme's industrial budget for Periods 1 and 2.

2.2. Core and COSMIC Activities

Space Weather

The Space Weather Services (SWE) Portal currently have more than 4400 registered users. It underwent a major upgrade in July 2023 to introduce more than 60 new and updated products and tools. Webinar based user training is ongoing to help them to utilize new Portal features and functionalities. The space weather service network continues to monitor and report on current activity as we approach the expected solar maximum later this year.

An example of the use of this network was the forecasting and monitoring of the biggest solar storm event in the last 20 years, that happened on a few weeks ago, on 10 May 2024, creating colourful Aurora Borealis shows across the whole world at fairly low latitudes. It did not cause disruptions to space nor ground infrastructures, but events like this highlight the importance of having operational Space Weather services, interconnected with the relevant emergency services.

The 19th European Space Weather Week 2024 was organized in Toulouse on 20-24 November. ESA space weather activities were highly visible in this largest ever space weather week with over 700 participants on-site and over 100 additionally online.

Concerning hosted payloads, the radiation monitor data from the NGRM hosted on Sentinel-6 is processed in ESA Payload Data Centre and made available to the users through the Space Weather Service Portal in near-real time. Moreover, the ICARE-NG unit for the ERSA payload on the Lunar Gateway is currently under integration.

The CDF study for the SWORD space weather mission to monitor the radiation belts from a GTO orbit was successfully performed in November/December

and it produced a mission baseline for the Phase 0/A study to be launched in 2024.

An important application development project for ground based critical power infrastructure (EuroGIC) was started in February, to produce a web-based application for European power grid operators providing near real-time modelling of geomagnetically induced currents flowing in power grids and offline analysis of potential impacts.

The Aurora-D mission consolidation and Phase B1 have started. The development of the key instruments RadMag and the Auroral far UV Imager have also started.

The three parallel studies consolidating the Space Weather Nanosat Mission were completed with all consortia, allowing to proceed with the procurement of the service implementation and delivery.

The development of the new ESA Space Weather Payload Data Centre (PDC) was initiated in 2023, including a first step towards a unified ground processor. It will be synchronised with the Vigil mission development and aligned with the Vigil mission operations concept and includes the development of a payload mission planning capability for Vigil.

A delegate Workshop on potential options and recommendations for the operational governance in Europe and the Future Development of the ESA Space Weather Service took place in February 2024

The first space weather contract in the tasks entrusted to ESA by the European Commission (EC) was started in November. This Socio-economic Impact Analysis of a European Space Weather Service will provide results that support the prioritization of those services from the socio-economic benefit perspective.

Planetary defence

Detection of a number of sizeable Near Earth Objects (NEO) took place in this period, stressing the relevance of a coordinated early warning system. Both the International Asteroid Warning Network (IAWN) and the Space Mission Planning Advisory Group (SMPAG) celebrated their 10-year anniversaries in February 2024.

A 700m diameter NEO briefly rose in September to the top of ESA's risk list with a potential impact in 2032, but follow-up observations allowed to exclude any impact probability for the next 100 years.

In early morning of 21 January, small asteroid 2024 BX1 entered Earth's atmosphere near Berlin, causing a bright but harmless fireball. It was the 8th asteroid detected prior to an impact with our planet. This marks a new record level in terms of coordination among astronomers, fireball observers and space agencies (in particular, ESA and NASA) in the area of imminent impactors. A wealth of data has been collected through numerous observations and by the retrieval of over 30 meteorite fragments on ground.

Just a few days ago, a huge and fast-moving fireball, most likely a piece of a comet, re-entered the Earth atmosphere over Spain and Portugal on May 19, 00:46 CEST, and it was widely observed and filmed. The NEO finally fell to the Atlantic Ocean.

The EU-ESA Workshop for the increase of Emergency Response Agencies awareness for Asteroid impact threats was held at ESOC in November 2023. In particular, the German Civil Protection Office (BBK) and the German SSA Centre visited ESOC for a Workshop on an even more efficient notification chain and a roadmap to an end-to-end inclusion into the national warning systems has been established. The goal is to have the notification chain operational before the end of the year.

Construction activities at the Matera site of the first FlyEye-1 Telescope, designated to host the telescope during the latter part of the factory acceptance and science validation phase, are progressing as planned site readiness is foreseen to be reached in Q2 2024. Regarding the final site at Monte Mufara, a first-stone ceremony is planned for 24 June, including the presence of ESA DG, ASI President, and Italian National and local authorities.

For the FlyEye-2, the kick-off of the telescope Critical Design Phase took place in February 2024. The selection of the hosting site remains open, with a science-case been submitted to the European Southern Observatory (ESO), proposing its installation at La Silla (Chile).

The two parallel Phase 0/A studies for the NEOMIR mission (funded from the Preparatory Element) studies have successfully concluded, and procurement of the remaining Phase A is proceeding.

Concerning a mission to the Apophis asteroid, which will have a close encounter with the Earth in April 2029, a PB-SSA workshop was held in December 2023 and further discussions in April 2024. The programmatic approach for the activity, the motivation and expected benefits for planetary defence and the associated scientific applicability was presented to delegates. Following the feedback from the Programme board, both mission options (RAMSES, a mission based on the Hera / Comet-I platform, and SATIS, based on a nanosatellite equipped with electric propulsion) will be studied further to provide the Member States with a choice of the final concept for implementation at the CM25.

Space Debris

The uncontrolled re-entry of ERS-2 received wide media coverage. ERS-2 was subject to end-of-life actions including lowering the orbit to 570km already in 2011. The safe uncontrolled re-entry occurred at 17:17UTC on 21 Feb 2024 between Alaska and Hawaii. No reports of fragments were received. The event was subject of IADC re-entry test campaign. Imaging from Fraunhofer's TIRA radar indicated half of the solar array getting loose already from ~200km altitude, which may stipulate further research in re-entry risk assessments.

An important activity for space sustainability was concluded in early 2024, to design, develop, and deploy of software infrastructure to assess the impact of a space mission on the space environment, addressing a debris risk metric to measure the potential contribution of a mission to the space debris issue. Similarly, an activity a material and component database for high-risk objects was developed that can support automation and standardisation for regulators.

Two activities under the preparatory element have started that could lead to new small missions in S2P (a CREAM demo platform and a space-based verification of laser momentum transfer), and a full CDF study to address monitoring of objects in the cislunar space is currently ongoing.

For the VISDOMS debris monitoring mission with a space-based component, the procurement of the mission Phase B and Instrument Phase C/D/E development is under way. An update of the design is underway, and several risk mitigation activities are being discussed.

For the DRACO design-for-demise mission, the procurement of the mission Phase B/C development is being concluded, and the instrument breadboard review was successful.

Procurement of Laser Momentum Transfer and experiment support for the IZN-1 (Tenerife, Spain) testbed activities is progressing. Preparation for activities on Space Debris Laser Ranging has been started.

Deorbiting Kit Activities are progressing with the Preliminary Design Review (PDR) in Q2 2024. The second phase of the Deorbiting Kit project, which covers phases C/D/E, was approved and procurement was started in Q1 2024.

<u>Clean Space and Zero Debris approach</u>

Work is progressing swiftly in the development of clean space technologies enabling a zero debris future and a more sustainable use of space.

Procurement of the “Large LEO platforms evolution for Zero Debris Policy Implementation Phase 1” activity, co-funded between EOP and OPS, is proceeding and the KO of the activity is foreseen in June 2024.

The Zero Debris technology roadmap highlights critical technology to ease the implementation of the new requirements in upcoming ESA missions, and to support industry in the verification of compliance with new ESA Space Debris Mitigation (SDM) Standard, guaranteeing a levelled competitive playfield. A cross cutting action across the different ESA directorates took place during Q1 2024 to implement this urgent Roadmap supporting a swift transversal preparation of the different industrial segments to the compliance with the new standard.

The co-development process of the Zero Debris Technical Booklet was kicked off in January 2024, where participating organizations were invited to provide feedback on a draft 0. ESA is collecting and integrating all feedback received

in an update of the draft on time for the Space Debris Week which will take place from June 25th to June 28th at ESOC. The finalisation of the first version of the booklet is planned for November, following a 2nd co-development workshop planned to take place during in October 2024.

The version 2.0 of the Design For Removal (D4R) Interface Requirement Document is now applicable to all satellite types in Low Earth Orbit (LEO), expanding from its previous focus on larger satellites. The updated version includes requirements and objectives for satellites performing both controlled and uncontrolled re-entries.

Following the publication of the Space Circular Economy White Paper in December 2023 “Enabling a Space Circular Economy by 2050”, ESA initiated a SysNova call to invite academic and industrial institutions across ESA Member States to join forces and propose solutions to these pressing challenges in paving the way for a space circular economy.

The ESA internal working group on ‘Eco-design and Life Cycle Thinking implementation at ESA’ has kicked-off in March 2024. Its aims is to define and develop a consistent implementation approach of Eco-design and life cycle thinking towards CM25 and beyond. It will be run in parallel with the update of the ESA Space Systems LCA Guidelines and the industrial WG on Eco-design.

A workshop on “Understanding the Atmospheric Effects of Spacecraft Re-entry took place in January 2024, at ESTEC. The event gathered atmospheric chemists and physicists, material experts, the space industry, and international space research related organizations to address the impact of spacecraft re-entry on the atmosphere. Strategies for mitigating and regulating these effects were proposed.

CREAM

Continuing increase of close approaches between ESA's satellites and other operational satellites was affected by missing information and delayed availability of the other operators. This situation showcases the current gaps and the pressing need for automation of effective collision avoidance coordination among actors as supported via technology developments in the programme.

CREAM activities intended to advance technologies are ongoing in the area of automated avoidance manoeuvre decisions, late commanding paths and operations concepts, and coordination of operators and catalogue providers, together with the development of a prototype of a space traffic coordination monitor.

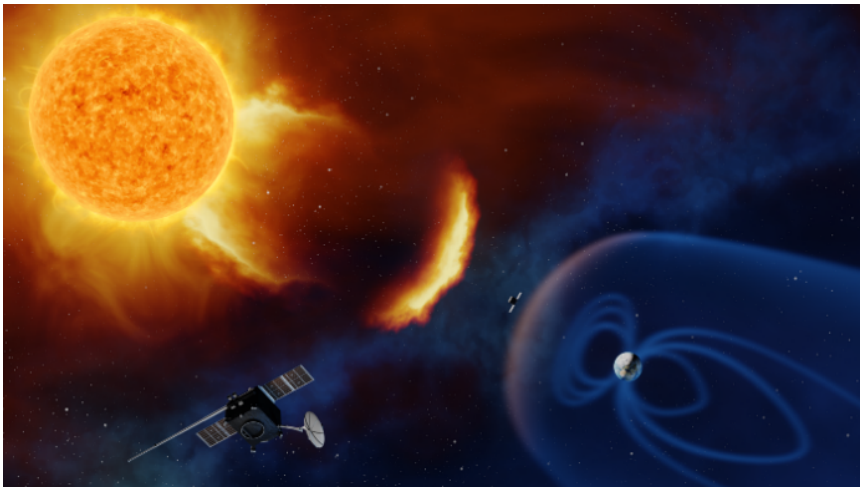
Competitiveness Segment

The competitiveness segment in ESA's Space Safety Programme aims at developing the space safety market and at exploiting commercialisation dimensions. The segment uses a two-staged industry-driven procurement

process via a permanently open Call for Proposals (CfP) on ESA's Open Space Innovation Platform (OSIP). Industry-driven outline proposals for innovative ideas are submitted and are then immediately iterated with the Executive. Once the idea meets the criteria of the CfP, and the budget is supported by the delegation, a full proposal is requested and negotiated in direct negotiation. With this approach a high maturity of the proposals can be ensured and still a fast time from idea to contract is achieved (currently average is 5 months).

As of Spring 2024, when the CfP has been open for 9 months, a total of 11 outline proposals has been received and covers a very diverse set of business ideas. The rolling approach to place contracts is reflected in the current status that sees three running activities, three under negotiation, two under full proposal tendering, and the others under discussion at outline stage. Under Period 2 of the programme a total of 8.4M€ has been allocated.

2.3. Cornerstone 1: Vigil Mission



The Vigil project has successfully completed the negotiation of the financial/contractual aspects of the completed the Vigil satellite contract and a kick-off meeting was held in early April. The contract signature ceremony took place at the occasion of the Space Council in Brussels on 22 May.

This was followed by the kick-off meetings of the Prime-Procured Instruments (PPI), namely Heliospheric Imager (HI), Plasma Analyser (PLA) and Magnetometer (MAG). Initial preparation work towards the first review (Satellite System Requirement Review) is already underway.

The PMI instrument development is proceeding well. Now that the satellite prime is under contract, ADS-UK has ramped up technical support as part of their Customer Procured Instrument responsibilities.

2.4. Cornerstone 2: Hera Mission

The Hera mission successfully completed the thermal-vacuum test qualifying the spacecraft to the space environment. All payloads have been successfully integrated on the spacecraft asteroid deck.

The two CubeSats have completed their respected environmental test campaigns and delivered to ESA. The mission patch of the Milani CubeSat was selected following a public design contest.

And end-to-end functional test between ESOC-Hera-CubeSats was successfully performed along with mechanical deployment tests confirming the functional performance of the deep-space deployers. Additional Integrated Ground System Tests have been performed between ESOC and Hera, supporting the testing of the flight software.

The LEOP simulation campaign has been organized by the operations team, starting in mid-June 2024. The launch campaign planning has been initiated and iterated between ESA, industry and the launch authority.

The Hera project is on track with respect to the planned launch slot in October 2024, maintaining adequate contingency margins.

2.5. Cornerstone 3: ADRIOS Missions

ESA's Space Safety cornerstone ADRIOS, Active Debris Removal (ADR) and In-Orbit Servicing (IOS), is ESA's commitment to leading the way in space sustainability. With the primary goals of demonstrating and consolidating European leadership in ADR and IOS, ADRIOS contributes to unlock the development of a sustainable ADR and IOS market in Earth orbit and advance towards a circular economy in space.

ClearSpace-1 Mission

The mission has been subject to the re-baselining of the project to maintain the Cost at Completion within the approved funding level in CM22. The mission will target the ESA-owned PROBA-1 spacecraft, which orbits below 550 km, with a dedicated launch and direct injection into the target orbit by mid-2028. ClearSpace-1 will inspect the target spacecraft, synchronise its motion and capture the non-cooperative target using a claw-based caging approach. ClearSpace-1 will then lower its orbit to 350 km with the goal of an uncontrolled stack re-entry by 2030.

In-Orbit Servicing Missions

Procurement of the RISE mission phases A/B/C/D/E started in 2023. RISE is set for launch in early 2029, will demonstrate AOCS takeover of a geostationary satellite. The activity is a continuation of ESA's In-Orbit Servicing Maturation Phase activities, including consolidation of the mission concept, preliminary design, procurement of critical equipment, development activities, launch and operations up to completion of the In-Orbit Verification Review (IOVR). A Milestone will be held in Q2/Q3 2025 where the consolidated industrial consortium will be presented, and the overall affordability of the mission will be assessed in the time for the ESA Ministerial Council CM25.

Procurement of the Mission Definition for the ENCORE IOS Mission started in 2023.

6. Conclusion

Space safety activities in Europe have a strong foundation in the S2P programme, which has made an important progress in Period 1 and has started Period 2 at full speed. It is now the moment to act with urgency, in synergy with all relevant stakeholders, and supporting European industry in this emerging and fast-growing market.