Protecting our Pale Blue Dot — Plans for the Future

As we discover more about the brilliant scale and nature of the Universe, planet Earth's blue oceans, green forests and glistening city lights appear even more unique, and even more fragile.

Earthrise seen from Apollo 11 **Id** 225302

Many hazards have been identified originating in space, which although unlikely, continue to pose real dangers to our way of life, and in the worst cases to human health and safety.

Only in the past decades have we had the opportunity to understand the potential perils of our position in our Solar System, and as technologies continue to advance we are entering a period in which we can actually act.

However, as technologies advance, so too does our dependence on them, making us more vulnerable to both human-made and natural threats to this critical space infrastructure.

Space Safety & Security

ESA's Space Safety & Security activities aim at mitigating and preventing the impact from hazards from space, protecting our Pale Blue Dot, its inhabitants, and the vital infrastructures on which we have become so dependent.

Living so close to an active star, in a Solar System filled with ancient and fast-moving space rocks, on a planet that is becoming increasingly surrounded by discarded satellites and their debris, comes with a plethora of possibilities for something to go wrong.

On Earth, we also continue to face challenges from a changing world, be it climate, population changes and technological development.

ESA is in a unique position, with the cooperation and support of 22 member states, to coordinate the data and information needed to understand, and respond to threats originating in space and on Earth.

Space weather
ESA's space weather vision:

By 2030, Europe should be able to protect vital infrastructure in space and on the ground from extreme space weather events, ensuring societies are resilient to threats from our Sun

- ESA will develop a European space weather monitoring system, which will include
  - **The Lagrange mission**: A dedicated space weather monitoring spacecraft, located at the fifth Lagrange, obtaining an excellent 'side view' of the Sun
  - Small satellites in orbit around Earth with space weather monitoring payloads
  - Space weather 'piggyback' missions – monitoring instruments will be flown as 'hosted payloads' on European telecom, Earth observation and other missions
  - Robust networks of space weather sensors on ground
- The European **Space Weather Service Network** will process space weather data and provide analysis of the severity of space weather events

- Enhance ESA's **Space Weather Coordination Centre**'s ability to provide warnings, alerts and tailored space-weather information to European users such as industry
- Continue improving, developing and validating space-weather models and capabilities to provide 'nowcasts' and 'forecasts'
- Continue analysing the sensitivity of **European infrastructure** to space-weather effects
- Develop and test **emergency protocols** with European civil authorities to improve resiliency to space weather events
- Increase space weather hazard awareness in Europe

Risky asteroids

ESA's vision of planetary defence:

By 2030, Europe will be a fundamental contributor of a global planetary defence system, capable of providing early warning of dangerous asteroids larger than 40 m in size, about three weeks in advance, and able to deflect asteroids smaller than 1 km if known more than two years in advance:

- ESA's planned **Hera mission** will be humankind's first probe to rendezvous with a binary asteroid system – a little understood class making up around 15% of all known asteroids. As part of the international double-spacecraft mission called AIDA, NASA will first crash its DART spacecraft into the smaller of the two bodies, modifying its orbit around the primary asteroid, 'Didymos', by a tiny amount. Hera will then follow-up with a detailed post-impact survey that will turn this grand-scale experiment into a well-understood and repeatable planetary defence technique.
- Every night, ESA's planned network of **Flyeye telescopes** would scan the skies for rogue rocks, automatically flagging any that could pose an impact risk and bringing them to the attention of human researchers. Similar to the technique exploited by a fly's compound eye, these bug-eyed telescopes split each image into 16 smaller subimages, increasing the total amount of sky that can be observed and expanding the 'field of view'.
- ESA's **Near-Earth Object Coordination Centre** will continue to be the central access point to a network of European asteroid data sources and information providers.
- Deploy a new in-space satellite to detect asteroids coming from the direction of the Sun, the *daytime* side of Earth, which cannot be seen from the ground, e.g. the Chelyabinsk object of 2013

Space debris

ESA's response to space debris:

By 2030, Europe, in a global effort with partners worldwide, will have a vibrant fleet of spacecraft in orbit around Earth, resilient to the hazards of space debris. We will be capable of monitoring and safely managing the traffic in our 'sky-ways', capable of removing and avoiding debris, understanding and assessing risks, and able to applying end-of-life measures for sustainable use of space in an economically-viable way:

- ESA will enable the safe operation of individual satellites and large constellations by developing and demonstrating an **Automated Collision Avoidance System**, free from causing damage.
- ESA will support the monitoring and safe **management of space traffic** and the application and verification of the necessary debris mitigation measures according to internationally agreed guidelines, standards and best practices
- ESA's **Space Debris Office** will continue to assessing, model and mitigate the risks due to debris and reentries
- Through development of **new sensor and monitoring technology** for radars, laser ranging and optical space surveillance, based in orbit and on ground, to include 'piggyback' hosted payload and smallsat options

Clean space

ESA's plans for a clean space:

Through its Clean Space initiative, ESA is pioneering an eco-friendly approach to space activities. On the ground, that means adopting greener industrial materials, processes and technologies. In space, it means preserving Earth's orbital environment as a safe zone, free of debris.

- **Active Debris Removal/In-Orbit Servicing**: ESA will develop a new 'Swiss Army knife' of a mission – an 'In Orbit Servicing Vehicle' (IOSV) that will perform a variety of roles in orbit, vitally including the ability to safely de-orbit satellites at the end of their lives. The new vehicle will also be able to refuel satellites, manoeuvre them and ultimately demonstrate the technologies needed to extend the lifespan of missions from space.
- With the In-Orbit Servicing Vehicle, ESA will spark off a valuable **new business model** for European industry that will go a long way toward mitigating new space debris and ensuring the long-term sustainability of spaceflight.
- ESA's **CleanSat** initiative is working to reduce the production of space debris – which includes reducing the amount of mass put into high density debris regions such as low-Earth orbit and geostationary orbit, developing technologies with consideration of the end of their lives in 'design for demise', and promoting end-of-life passivation – emptying the tanks and discharging the batteries of satellites to prevent debris producing explosions.
- ESA's **EcoDesign** initiative is designing to address environmental impacts and foster green technologies through the establishment of a common eco-design framework for the European space sector.

Secure space

How ESA plans to safeguard space infrastructure:

As of 2019, more than 1500 active satellites are in orbit around our planet, providing an enormous range of vital services, like navigation, telecommunication and internet access.

Because of the important role of space technologies now and in the future, ensuring their safety and security is critical for civil society. This includes not only protecting space infrastructure from space-based hazards, but also understanding the cybersecurity threats from Earth.

In recent examples, ground control systems for a number of NASA satellites were infiltrated and breached, while an ESA ground station experienced a so-called ‘Denial of Service’ attack aimed at rendering it unable to relay data. Fortunately no lasting damage was caused by these cyber-attacks, but these and other incidents highlight the importance of ensuring critical space systems do not fall victim to those with evil intent.

Safety & Security from space

How space technology can and will help in our response to terrestrial hazards:

Massive global changes are sweeping across the planet and these are expected to continue, from migration, demographic shifts and conflict to natural disaster, food shortages and climate change.
These challenges can be addressed, in part, in space. Reliable information, fast and up-to-date data, applications and secure communication services are of great importance to understanding and reacting to these calamitous shifts, ensuring international coordination and keeping emergency services, national and regional governments and other civil organisations informed, connected and secure.

Find out more about the cornerstones of ESA’s Space Safety & Security vision:

Hera
Lagrange
Active Debris Removal/In-Orbit Servicing

Satellite Collision Avoidance System

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Sandbox

Although unlikely, solar storms and asteroid strikes have happened before and we know, one day, will happen again. Fortunately, technological advances have meant we are able to detect and characterise these threats, putting us in a position where we can take active measures.

However our success in placing satellites into orbit has also come at a cost – in the form of space debris.

Here, space technology plays a vital role, through observation, data collection and dissemination, communication and regulatory frameworks. These capabilities are of great importance too in responding to hazards originating on Earth, such as natural disasters.

This means that efforts to defend our planet also rely on protecting our space infrastructure from marauding space debris, space rocks, and cyber-attacks.

Unpredictable and temperamental, the Sun has made life on the inner planets of the Solar System impossible due to the intense radiation combined with colossal amounts of energetic material that it blasts in every direction, creating the ever-changing conditions in space known as ‘space weather’.

Our magnetic field protects life beneath it from the solar wind — the constant stream of electrons, protons and heavier ions from the Sun — and from Coronal Mass Ejections (CMEs), the Sun’s occasional outbursts of billion-tonne clouds of solar plasma into space.

However the most extreme events, arrivals of fast CMEs or high-speed solar-wind streams, disturb our protective magnetic shield, creating geomagnetic storms at Earth with the potential to cause serious problems for modern technological systems.

These storms can disrupt or damage satellites in space and the multitude of services — like navigation and telecoms — that rely on them, blacking out power grids and radio communication and creating a radiation hazard for astronauts in space, even serving potentially harmful doses of radiation to astronauts on future missions to the Moon or Mars.

While these events can’t be stopped, advance warning of an oncoming solar storm would give operators of satellites, power grids and telecommunication systems time to take protective measures, and explorers time to reach safety.

The vision is a Europe that by 2030 in the frame of a global effort with its partners worldwide:
Has a vibrant and sustainable space traffic and is:

- capable of monitoring and safely managing its space-related traffic;
- equipped with (autonomous) systems free from causing damage;
- capable of removing and avoiding debris;
- understanding and assessing related risks;
- capable of applying end-of-life measures for sustainable use of space in an economically-viable way:
- European space traffic management;

Is a fundamental contributor of a global planetary defence system and is:

- capable of providing early warnings for asteroids larger than 40 m in size about three weeks in advance;
- able to deflect asteroids smaller than 1 km, if known more than two years in advance;

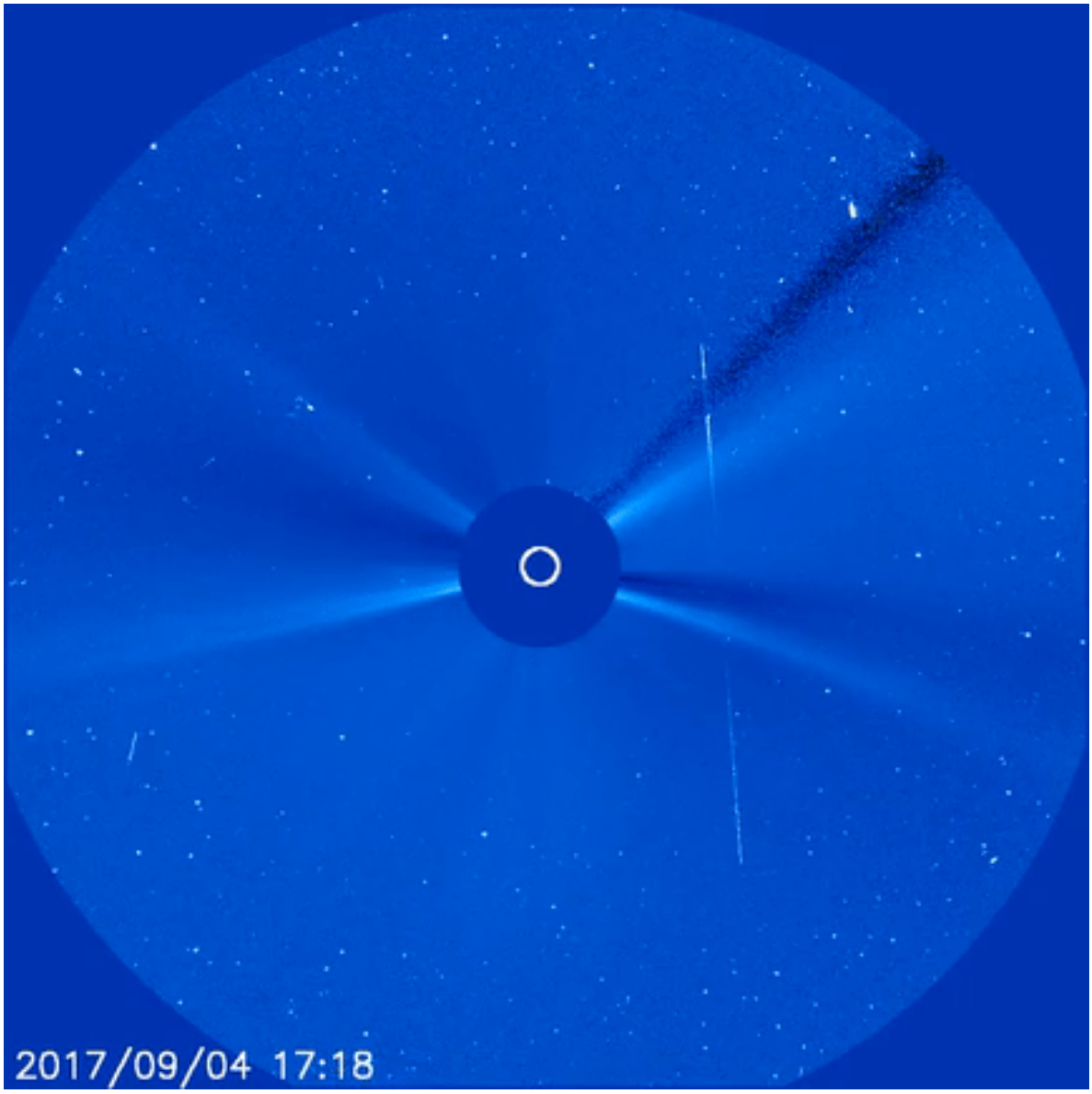
and where its society and space and ground infrastructure are resilient to space weather and is in possession of:

- operational space weather services tailored to European user needs providing timely, accurate and actionable information;
- tested and exercised early warning system enabling prompt responses based on actionable information;
- operational space weather monitoring system with longer term maintenance and enhancement plan;

To this vision ESA contributes by a comprehensive set of activities to advance priority technologies and ensures overall robustness and balance of the mission and activity roadmap in the fields of Debris and Clean Space, Planetary Defence and Space Weather.

The cornerstones are: Hera, Lagrange, Active Debris Removal/In-Orbit Servicing, and Satellite Collision Avoidance System.

Video: What is Space Weather?



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Space weather poses a real threat to infrastructure in space and on the ground. So, what is ESA doing about it?

Video: What is ESA doing about space weather?

ESA will monitor the Sun 24-hours a day, from a position in space that no spacecraft has gone to before.

Located at the fifth 'Lagrange point', ESA's solar observer will observe the Sun from the side. As our star rotates, the Lagrange satellite will see hazardous

events before they come into view of Earth, feeding this information quickly to antennas on the ground.

ESA's Space Weather Service Network (SWSN) will then distribute this data to governments, industry and academia.

The Chicxulub asteroid is probably the most famous space rock in the world. Although you may not know its name, its impact 66 million years ago is legendary – causing a mass extinction event that saw most non-flying dinosaurs and many other species wiped out.

Hera

Hera – named after the Greek goddess of marriage – is a planned ESA mission and humankind's first probe to rendezvous with a binary asteroid system, a little understood class making up around 15% of all known asteroids.

Hera is the European contribution to an international double-spacecraft mission called AIDA. NASA will first crash its DART spacecraft into the smaller of the two bodies, modifying its orbit around the primary asteroid, 'Didymos', by a tiny amount. Hera will then follow-up with a detailed post-impact survey that will turn this grand-scale experiment into a well-understood and repeatable planetary defence technique.

While doing so, Hera will gather crucial scientific data, helping scientists and future mission planners better understand asteroid compositions, structures and behaviours in response to a 'kinetic impact'.

Flyeye telescopes

Impacts from such large asteroids are immensely rare, but medium-sized rocks are far more common and can still do serious damage.

These asteroids sometimes reach the ground, but even those that disintegrate in Earth's atmosphere can create explosive airbursts upon impact, with resulting shockwaves that can shatter glass, damage buildings and injure anyone who happens to be nearby.

Every night, ESA’s planned network of Flyeye telescopes would scan the skies for rogue rocks, automatically flagging any that could pose an impact risk and bringing them to the attention of human researchers. Similar to the technique exploited by a fly’s compound eye, these bug-eyed telescopes split each image into 16 smaller subimages, increasing the total amount of sky that can be observed and expanding the ‘field of view’.