# ESA facing Cyber security issues


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# ESA facing Cyber security issues

- What is the European Space Agency?
  - ESA Purpose and Functioning
- ESA programmes and activities
- ESA and Cyber security
  - What is cyber security?
  - Examples of space related cyber attacks
  - How does ESA implement cyber security?
  - Data protection
- Security and safety – risks from space: the Space Situational Awareness Programme

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# ESA Purpose and Functioning

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## Facts and figures

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- Over 50 years of experience
- 22 Member States
- Eight sites/facilities in Europe, about 2300 staff
- 5.75 billion Euro budget (2017)
- Over 80 satellites designed, tested and operated in flight


# Purpose of ESA


“To provide for and promote, for exclusively peaceful purposes, cooperation among European states in space research and technology and their space applications.”

Article 2 of ESA Convention

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# ESA Member States

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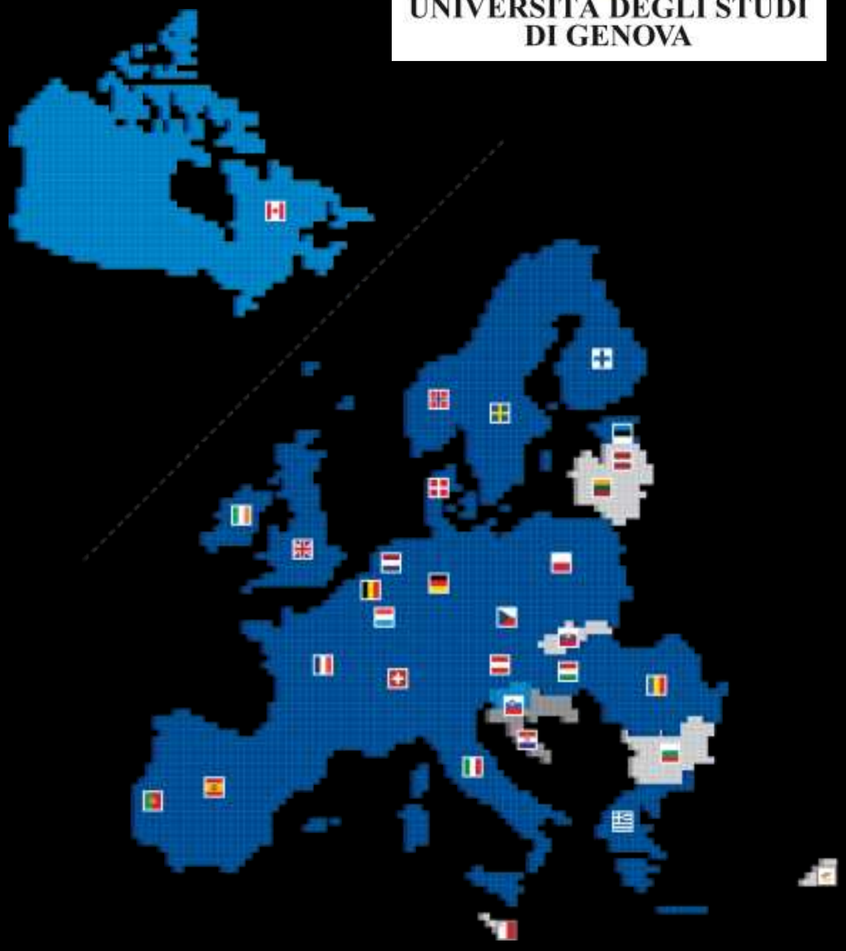
ESA has 22 Member States: 20 states of the EU (AT, BE, CZ, DE, DK, EE, ES, FI, FR, IT, GR, HU, IE, LU, NL, PT, PL, RO, SE, UK) plus Norway and Switzerland.



Six other EU states have Cooperation Agreements with ESA: Bulgaria, Cyprus, Latvia, Lithuania, Malta and Slovakia. Discussions are ongoing with Croatia.

Slovenia is an Associate Member.

Canada takes part in some programmes under a long-standing Cooperation Agreement.

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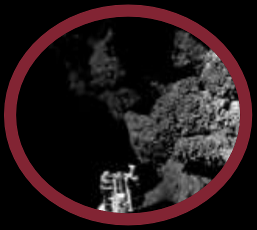
# Activities

ESA is one of the few space agencies in the world to combine responsibility in nearly all areas of space activity.

* Space science is a Mandatory programme, all Member States contribute to it according to GNP. All other programmes are Optional, funded ‘a la carte’ by Participating States.


space science


human spaceflight


exploration


earth observation


space transportation


navigation


operations


technology


telecommunications

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# ESA locations

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- ESA sites
- Offices
- ESA Ground Station
- ESA Ground Station + Offices
- ESA sites + ESA Ground Station

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# ESA budget for 2017: 5.75 B€

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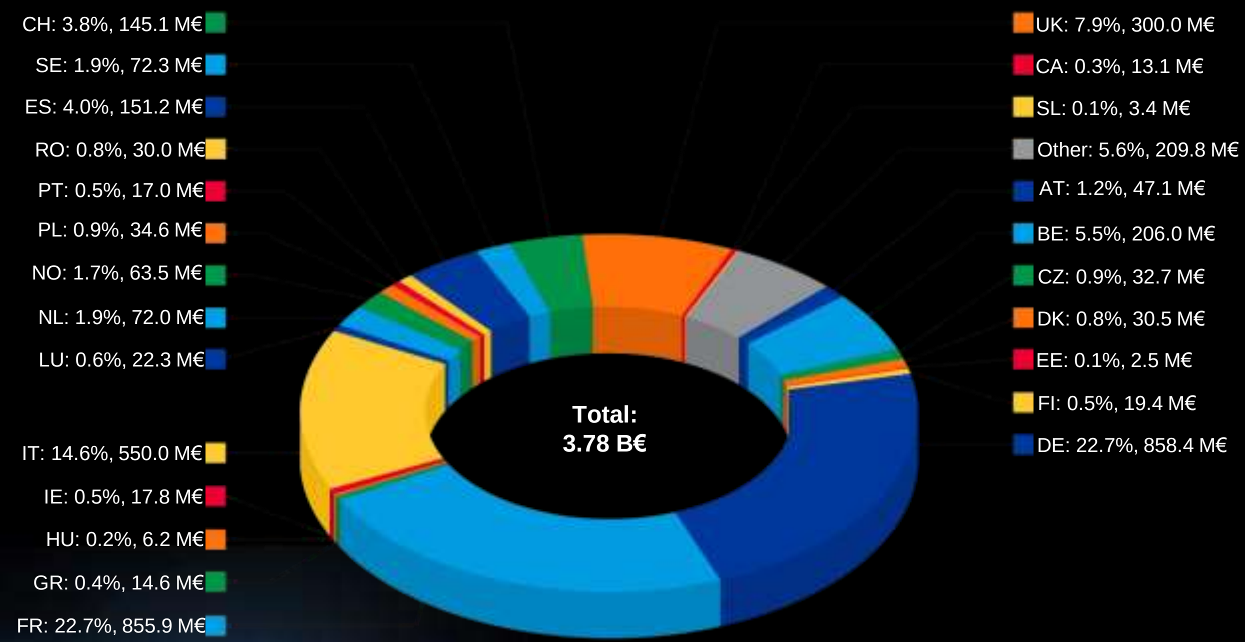
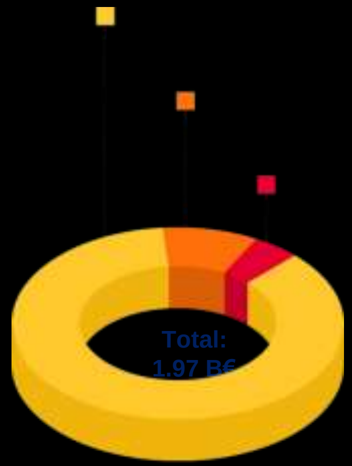
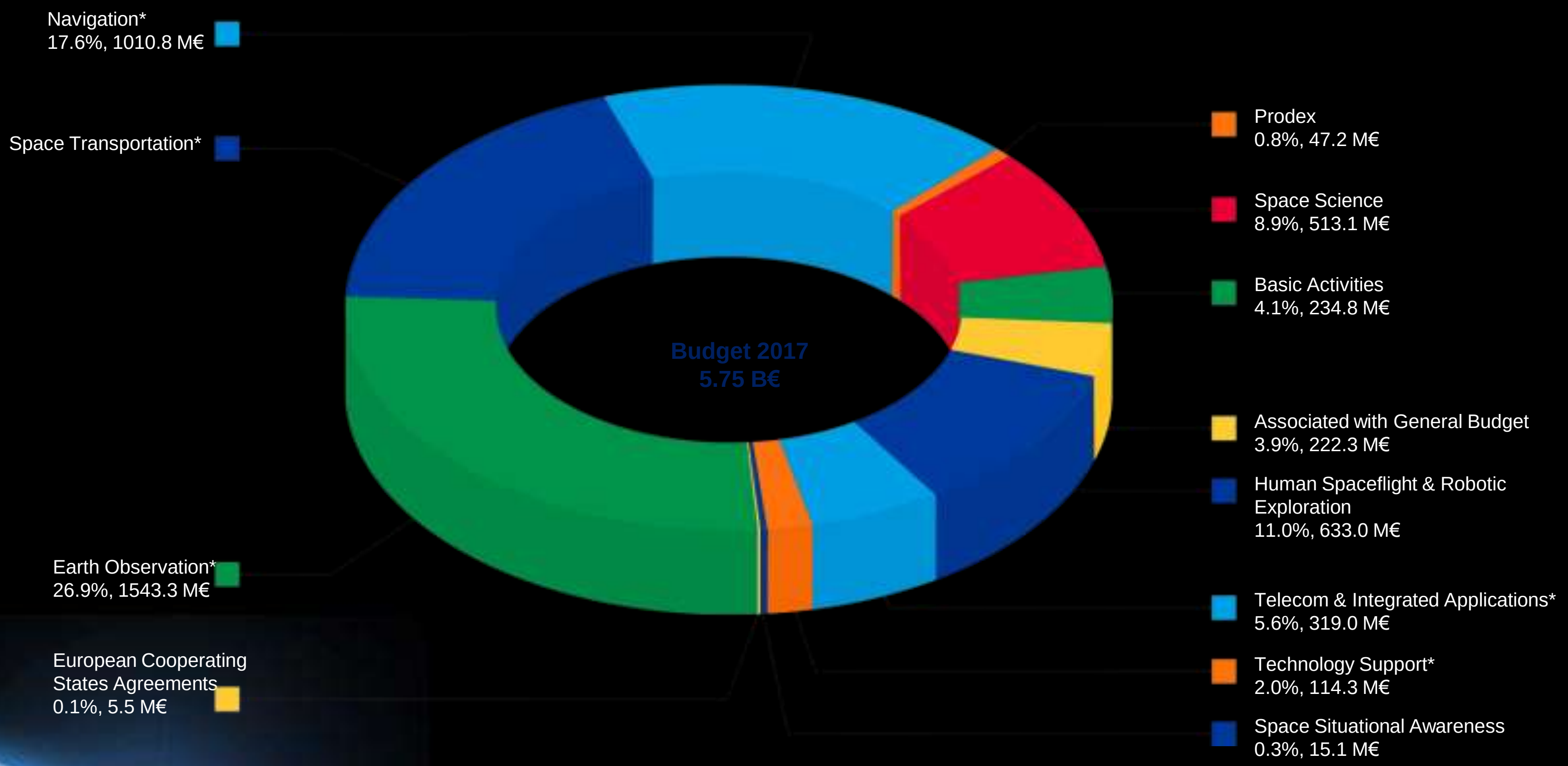


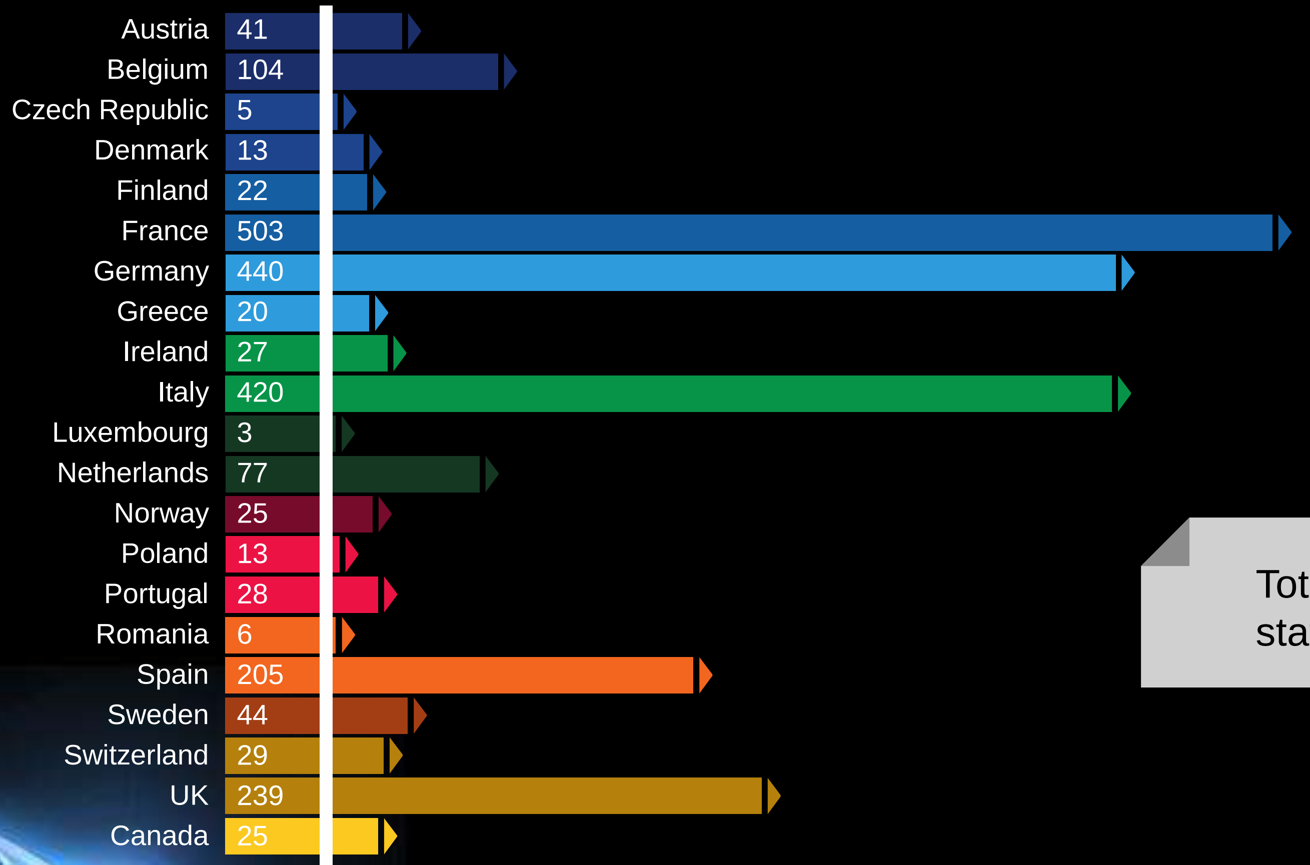

B€: Billion Euro M€: Million Euro

# ESA budget for 2017: by domain





# Staff by nationality in 2016




Total international staff: 2289

# ESA and the European space sector

ESA Member States finance 50% of the total public space spending in Europe. Because of the cooperation between ESA, EC and the national space agencies:

- The European space industry sustains around 35 000 jobs;
- Europe is successful in the commercial arena, with a market share of telecom and launch services higher than the fraction of Europe’s public spending worldwide;
- European scientific communities are world-class and attract international cooperation;
- Research and innovation centres are recognised worldwide;
- European space operators (Arianespace, Eumetsat, Eutelsat, SES Global, etc.) are the most successful in the world.

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# ESA’s industrial policy

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**About 85% of ESA’s budget is spent on contracts with European industry.**

ESA’s industrial policy:

- Ensures that Member States get a fair return on their investment;
- Improves competitiveness of European industry;
- Maintains and develops space technology;
- Exploits the advantages of free competitive bidding, except where incompatible with objectives of the industrial policy.

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# Birth of commercial operators

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ESA 'catalyst' role

ESA is responsible for R&D of space projects. On completion of qualification, they are handed to outside entities for production and exploitation. Most of these entities emanated from ESA.

Meteorology: Eumetsat

Launch services: Arianespace

Telecoms: Eutelsat and Inmarsat

# ESA Council

The Council is the governing body of ESA.

It provides the basic policy guidelines for ESA's activities. Each Member State is represented on the Council and has one vote.

Every two to three years, Council meets at ministerial level ('Ministerial Council') to take key decisions on new and continuing
programmes and financial commitment.

The ESA Council at ministerial level also meets together with the EU Council to form the European 'Space Council'.

# Ministerial Council 2016
# Lucerne

Ministers declared support for the ESA Director General’s vision for Europe in space and the role and development of ESA

Four Resolutions were adopted:

- Towards Space 4.0 for a ‘United Space in Europe’;
- Level of Resources for the Agency’s Mandatory Activities 2017–21;
- Guiana Space Centre, 2017–21;
- ESA Programmes.

# Space 4.0

## represents the evolution of the space sector into a new space era

- from being the preserve of the governments of a few spacefaring nations, to an increased number of diverse space actors around the world;
- with the emergence of private companies, participation with academia, industry and citizens, digitalisation and global interaction;
- analogous to, and is intertwined with, Industry 4.0, which is considered as the unfolding fourth industrial revolution of manufacturing and services.

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# ESA PROGRAMMES

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## SCIENCE

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# ESA's pioneers of space science (1)

- Hipparcos (1989–93) first comprehensive star-mapper
- IUE (1978–96) longest-lived orbital ultraviolet observatory
- Giotto (1986) first close flyby of a comet nucleus
- Ulysses (1990–2008) first spacecraft to fly over Sun's poles
- ISO (1995–8) first European infrared observatory
- SMART-1 (2003–6) first European mission to the Moon

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# ESA's pioneers of space science (2)

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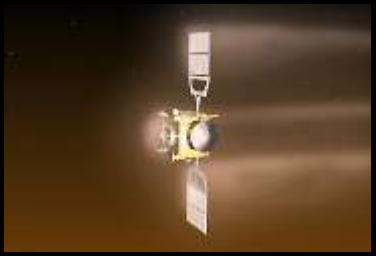
- Planck (2009–13) detecting first light of Universe and looking back to the dawn of time
- Herschel (2009–13) unlocking the secrets of starbirth and galaxy formation and evolution
- Venus Express (2005–15) first global investigation of dynamic atmosphere of Venus
- Rosetta (2004–16) first long-term mission to study and land on a comet

Planck

Herschel

Venus Express



Rosetta

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# Cassini-Huygens

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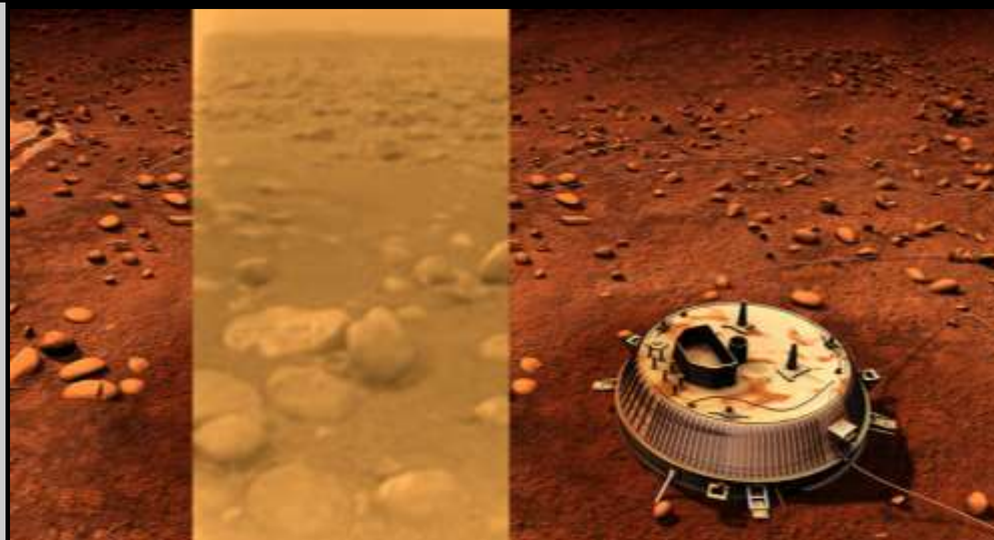
First landing on a world in the outer Solar System

On 14 January 2005, ESA's Huygens probe made the most distant landing ever, on Titan, the largest moon of Saturn (about 1427 million km from the Sun).



# Rosetta

First rendezvous, orbit and soft-landing on a comet

On 6 August 2014, ESA's Rosetta became the first spacecraft to rendezvous with a comet and, on 12 November, its Philae probe made the first soft-landing on a comet and returned data from the surface.

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# Today's Science missions (1)

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- **Hubble** (1990– ) orbiting observatory for ultraviolet, visible and infrared astronomy (with NASA)
- **SOHO** (1995– ) studying our Sun and its environment (with NASA)
- **XMM-Newton** (1999– ) solving mysteries of the X-ray Universe
- **Cluster** (2000– ) studying interaction between Sun and Earth's magnetosphere
- **Integral** (2002– ) observing objects simultaneously in gamma rays, X-rays and visible light

Hubble

SOHO

Cluster

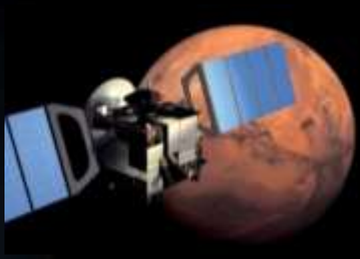
Integral

XMM-Newton

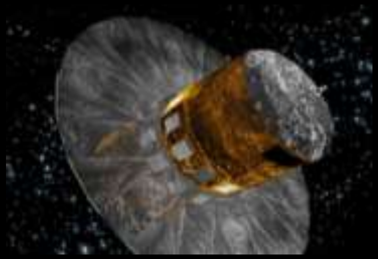
# Today’s Science missions (2)

- **Mars Express** (2003– ) studying Mars, its moons and atmosphere from orbit
- **Gaia** (2013– ) mapping a thousand million stars in our galaxy
- **LISA Pathfinder** (2015– ) testing technologies to detect gravitational waves

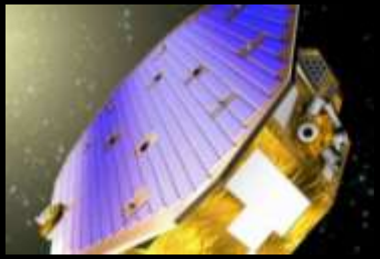
Mars Express



Gaia



LISA Pathfinder



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# Upcoming missions (1)

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- **BepiColombo** (2018) a satellite duo exploring Mercury (with JAXA)

BepiColombo Cheops Solar Orbiter James Webb Space Telescope

- **Cheops** (2018) studying exoplanets around nearby bright stars
- **Solar Orbiter** (2018) studying the Sun from close range
- **James Webb Space Telescope** (2018) studying the very distant Universe (with NASA/CSA)


BepiColombo


Cheops


Solar Orbiter

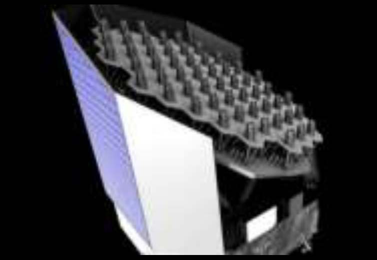

James Webb Space Telescope

# Upcoming missions (2)

- **Euclid** (2020) probing ‘dark matter’, ‘dark energy’ and the expanding Universe
- **JUICE** (2022) studying the ocean-bearing moons around Jupiter
- **Plato** (2024) searching for planets around nearby stars
- **Athena** (2028) space telescope for studying the energetic Universe
- **Gravitational wave observatory** (2034) studying ripples in spacetime caused by massive objects in the Universe


Euclid


JUICE


Plato


Athena

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# Science operations

ESAC (near Madrid, Spain) is ESA's centre for science operations.

ESAC hosts ESA's Science Operation Centre (SOC) for ESA astronomy and Solar System missions.

Science operations include the interface with scientific users, mission planning, payload operations and data acquisition, processing, distribution and archiving.

The scientific archives for the majority of ESA's science missions are kept here so that researchers have a single 'entry point' for accessing the wealth of scientific data.

# EARTH OBSERVATION

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# Pioneers in Earth observation

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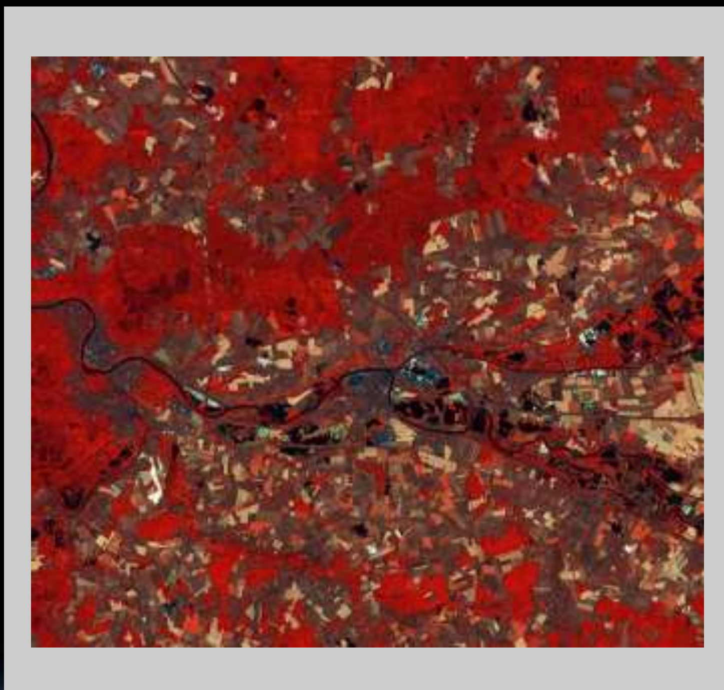

ESA has been dedicated to observing Earth from space ever since the launch of its first meteorological mission, Meteosat-1 in 1977.

ERS-1 (1991–2000) and ERS-2 (1995–2011) providing a wealth of invaluable data about Earth, its climate and changing environment.

Envisat (2002–12) the largest satellite ever built to monitor the environment, it provided continuous observation of Earth’s surface, atmosphere, oceans and ice caps.

# ESA's eye on Earth

ESRIN, in Frascati, Italy, is ESA's centre for Earth Observation where operations and exploitation of Earth Observation satellites are managed.

The world's largest database of environmental data for both Europe and Africa is managed from ESRIN.

# Earth Explorers

These missions address critical and specific issues raised by the science community, while demonstrating the latest observing techniques.

- GOCE (2009–13) studying Earth's gravity field
- SMOS (2009– ) studying Earth's water cycle
- CryoSat-2 (2010– ) studying Earth's ice cover
- Swarm (2013– ) three satellites studying Earth's magnetic field
- ADM-Aeolus (2017) studying global winds
- EarthCARE (2018) studying Earth's clouds, aerosols and radiation (ESA/JAXA)
- Biomass (2021) studying Earth's carbon cycle

# Meteorological missions

Developed in cooperation with ESA's partner, Eumetsat, as Europe's contribution to the World Meteorological Organization's space-based Global Observing System:

Meteosat Second Generation (2002, 2005, 2012, 2015–) series of four satellites providing images of Earth from geostationary orbit.

MTG

Meteosat Third Generation (2021– ) series of six geostationary satellites providing images (four satellites) and atmospheric sounding (two satellites).

MetOp (2006, 2012, 2018) – series of three satellites providing operational meteorological observations from polar orbit.

MetOp-SG

MetOp Second Generation (2021– ) two series of polar-orbiters, three satellites in each series, continuing and enhancing meteorological, oceanographic and climate monitoring observations from the first MetOp series.

# Global monitoring for a safer world



Copernicus: an Earth observation programme for global monitoring for environment and security.

Led by the European Commission in partnership with ESA and the European Environment Agency, and responding to Europe’s need for geo-spatial information services, it will provide autonomous and independent access to information for policy-makers, particularly for environment and security issues. ESA is implementing the space component: developing the Sentinel satellite series, its ground segment and coordinating data access.

ESA has started a Climate Change Initiative, for storage, production and assessment of essential climate data.

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# Copernicus space component: the Sentinels

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- Sentinel-1 – land and ocean services. Sentinel-1A launched in 2014/Sentinel-1B in 2016.
- Sentinel-2 – land monitoring. Sentinel-2A launched in 2015/Sentinel-2B (2017).
- Sentinel-3 – ocean forecasting, environmental and climate monitoring. Sentinel-3A launched in 2016. Sentinel-3B (2017).
- Sentinel-4 – atmospheric monitoring payload (2019)
- Sentinel-5 – atmospheric monitoring payload (2021)
- Sentinel-5 Precursor – atmospheric monitoring (2017)
- Sentinel-6 – oceanography and climate studies (2020)

# TECHNOLOGY

# Space technology

The development of technology, along with access to space, is one of the enabling activities of ESA. ESA's technical heart is ESTEC (NL).

- Supporting competitiveness of European industry.
- Transferring technology from space to non-space applications ('spin-off'), and bringing innovations from outside the space sector to use in design of new space systems ('spin-in').
- Fostering innovation and enhancing European technological independence and the availability of European resources for critical technologies.
- Creating Space Incubators across Europe.

# ESA's technical heart

ESTEC is the incubator of the European space effort, where most ESA projects are born and where they are guided through the various phases of development.

This is home to the Directorate of Technology, Engineering and Quality, responsible for longer-term technology development for new ESA and European missions.

# MISSION OPERATIONS

# Mission operations




- ESOC, the European Space Operations Centre, is ESA’s centre for mission operations and ground systems engineering, where we: Study and develop mission concepts and technologies;
- Specify required ground facilities and functionality;
- Simulate mission scenarios and train multi-disciplinary mission teams;
- Perform end-to-end mission readiness testing;
- Plan and execute spacecraft and ground facilities operations during all mission phases.

# Ground segment engineering

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ESOC's ground systems engineering teams:

- Develop multi-mission infrastructure for mission control systems, ground stations, high-fidelity simulators, operational communication and computer systems and tailor them for specific missions;
- Perform studies, mission analysis, flight dynamics, high-precision navigation, space-debris monitoring and avoidance and CleanSpace studies;
- Develop new technologies and standards to support future missions.

# Space Situational Awareness

ESOC is home to the Space Situational Awareness Programme (SSA) an initiative aiming to provide European autonomy in civil systems and services needed to protect satellites and Earth.


Entering its third development period, it will consolidate European facilities and services for:

- Monitoring, cataloguing and tracking space debris;
- Monitoring space weather, and preparing for a future Lagrange mission;
- Identifying and tracking near Earth objects.

# TELECOMMUNICATIONS & INTEGRATED APPLICATIONS

## A pioneer in telecoms



1968 – Europe started to develop communications satellites. The Orbital Test Satellite (OTS) was launched 10 years later. OTS, and its follow-up ECS, was used for more than 13 years by ESA and Eutelsat.

Olympus (1989–93) an experimental satellite, at the time of launch it was the largest civilian telecommunications satellite in the world.

Artemis (2001– ) this multi-purpose telecommunications and technology demonstration satellite introduced a new range of telecommunication services to the world.

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# Ensuring competitive and innovative industry

ESA's Advanced Research in Telecommunications Systems (ARTES) programme stimulates innovation and promotes the development of products, services and applications in partnership with industry.

- Helping European industry to stay at the leading edge of the highly competitive global market for satellite communications and applications;
- Supporting R&D and pioneering technical, commercial and operational approaches to bring new systems and solutions close to the point of market readiness;
- Building partnerships capable of creating wealth, jobs and new services for the citizens of Europe;
- Improving our daily lives across almost every market sector, from health to transport and from civil protection to energy and environmental services.

# ARTES satellite platforms

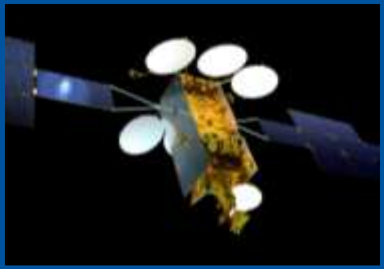


- SmallGEO – for the 3-tonne market, with OHB (first launch on Hispasat's H36W-1, 2017)
- Spacebus Neo and Eurostar Neo – for the 3- to 6-tonne market, with Thales Alenia Space/Airbus D&S (first launches in 2019)
- Electra – first fully electric propulsion OHB satellite, with SES (2021)

SmallGEO

Spacebus Neo

Eurostar Neo



Electra

# ARTES innovation and new technology


GlobeNet


Quantum

- EDRS – the European Data Relay System, or ‘SpaceDataHighway’, that with its GlobeNet extension will make data gathered anywhere on Earth available in quasi-real time, with Airbus D&S (first launch, 2016; second launch, 2017)
- ScyLight – optical communications capable of exchanging unprecedented amounts of data between satellites, aircraft and the ground (starting 2017)
- Quantum – in-orbit reprogrammable ‘chameleon’ satellite, with Eutelsat/Airbus D&S (2018)
- ICE – next-generation mobile satellite services, with Inmarsat (starting 2017)

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# ARTES ground segment

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- ECO – bringing affordable and reliable ‘wi-fi’ to low-income users in sub-Saharan Africa, with Avanti (2016–2021)
- Indigo – ground segment innovations, with Intelsat (2015–2018)
- AIDAN – ground segment for broadband and aviation, with ViaSat (starting 2017)

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# ARTES for new markets

SAT-AIS

Iris

- SAT-AIS – microsatellites will track seafaring vessels anywhere on Earth, with the European Maritime Safety Agency (first launch, 2017)
- Iris – a new satellite-based data communication system as part of the Single European Skies Air Traffic Management Research project, with Inmarsat (precursor service, 2018–28)
- ESA’s Govsatcom Precursor – secure and resilient European government communications, in coordination with the EC and EDA (service demonstration, 2017–20)
- Pioneer – helping new technologies and services obtain fast, low-cost in-orbit demonstration (starting 2017)

# ECSAT

- At Harwell, near Oxford (UK), the headquarters of ESA's Directorate of Telecommunications and Integrated applications;
- ESA teams also work on climate change, exploration and disruptive technologies;
- Leads ESA's promotion of commercial down-to-Earth applications;
- Cooperates with the Harwell Space Cluster and acts as a gateway between the UK space sector and the global space industry.

ECSAT: European Centre for Space Applications and Telecommunications

# NAVIGATION

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# Galileo: ‘made in Europe’

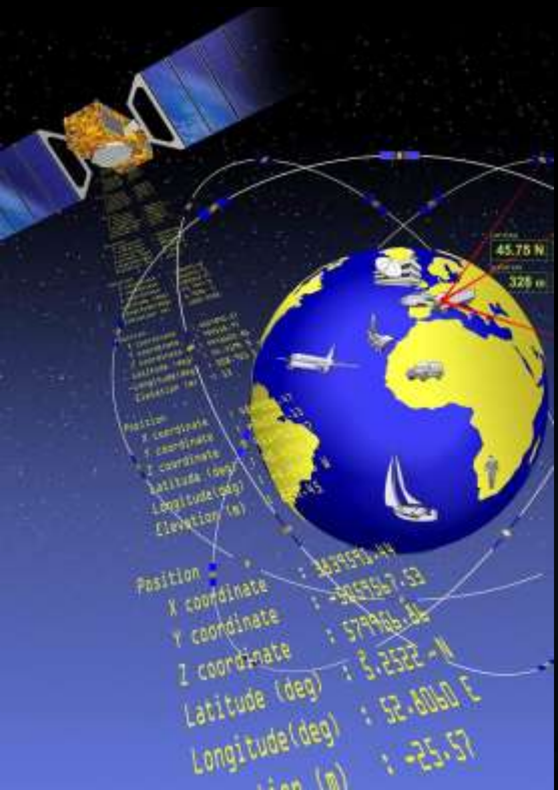
Putting Europe at the forefront of this strategically and economically important sector, Galileo will provide a highly accurate, guaranteed global positioning service under civilian control.

Full Operational Capability – 18 satellites now in orbit. Deployment of remaining ground/space infrastructure ongoing (full system – 24 satellites, plus orbital spares to prevent interruption in service).

ESA is the system architect for Galileo, managing its design, development, procurement, deployment and validation on behalf of the EU. ESA will maintain this role, providing technical support to the European GNSS Agency, designated by the EC to run the system and provide Galileo services.

Dec 2016 – start of Galileo Initial Services, the first step towards full operational capability.

# EGNOS, Galileo applications and NAVISP




- Since 2010, EGNOS has been improving accuracy and augmenting GPS, offering safety-critical applications for aviation users.
- Galileo is expected to spawn a wide range of applications, based on positioning and timing for transport by road, rail, air and sea, infrastructure and public works management, agricultural and livestock management and tracking, e-banking and e-commerce.
- It will be a key asset for public services, such as rescue operations and crisis management.
- With the new ESA Navigation Innovation and Support Programme (NAVISP), research will focus on integration of space and terrestrial navigation and new ways to improve GNSS.

# HUMAN SPACEFLIGHT

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# European Exploration Envelope (E3P)

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In response to the Resolution on Europe’s Space Exploration Strategy adopted in Luxembourg in December 2014, exploration activities are being consolidated in a single European Exploration Envelope Programme (E3P) integrating the three ESA exploration destinations ‘as part of a single exploration process’. Its main activities will cover:

- International Space Station – Operations until 2024
- ExoMars – Trace Gas Orbiter and 2020 rover mission
- Luna-Resource Lander – Contributions to Russian-led Luna-Resource Lander, Luna 27 (2021)
- European Service Module – First Orion flight and second flight model (2021)
- Future Human Exploration
- SciSpacE – Science in Space Environment
- ExPeRT – Exploration Preparation, Research and Technology

# International Space Station (ISS)

The ISS unites USA, Russia, Japan, Canada and Europe in one of the largest partnerships in the history of science. Crews of up to six astronauts conduct research into life and physical sciences and applications, and prepare for future human exploration missions.

Europe’s two key contributions are the Columbus laboratory and the Automated Transfer Vehicle (ATV). Columbus provides a substantial part of the ISS’s research capability, specialising in fluid physics, materials science and life sciences. Europe has also provided almost 50% of the pressurised part of the ISS, including Cupola, Node-2 and Node-3.

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# European Service Module

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The European Service Module (ESM) is ESA's contribution to NASA's Orion spacecraft that will send astronauts to the Moon and beyond. The spacecraft comprises the ESM and the US Crew Module.

The ESM resembles ESA's Automated Transfer Vehicle, from which it evolved. Between 2009 and 2014, five Automated Transfer Vehicles delivered supplies to the International Space Station and helped to keep the outpost in orbit.

The first mission for the complete Orion spacecraft will be an unmanned flight to the Moon and back.

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# Europeans in space

Ulf Merbold (DE) | Wubbo Ockels (NL) | Claude Nicollier (CH)

The European Astronaut Corps was formed in 1998, uniting astronauts of several Member States, including:

Michel Tognini (FR) | Jean-Pierre Haigneré (FR) | Umberto Guidoni (IT) | Maurizio Cheli (IT) | Claudie Haigneré (FR) | Gerhard Thiele (DE)

# Flight-experienced astronauts




Christer Fuglesang (SE)

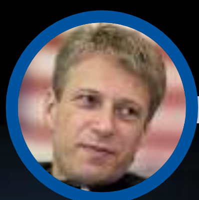

Reinhold Ewald (DE)


Jean-François Clervoy (FR)


Pedro Duque (ES)


Léopold Eyharts (FR)


Hans Schlegel (DE)


Thomas Reiter (DE)


Frank De Winne (BE)


Paolo Nespoli (IT)


Roberto Vittori (IT)


André Kuipers (NL)

# Next generation: flown and in training

•Based at the European Astronaut Centre (EAC), Cologne, Germany:

Luca Parmitano (IT), Alexander Gerst (DE) and Samantha Cristoforetti (IT) flew to the ISS in 2013, mid-2014 and end-2014 respectively. Andreas Mogensen (DK) flew in 2015, Tim Peake (UK) in 2015/16 and Thomas Pesquet (FR) is flying in 2016/17. Matthias Maurer (DE) began training in 2017.

# Robotic exploration



In cooperation with Roscosmos (Russia), two ExoMars missions (2016 and 2020) will investigate the martian environment, particularly astro-biological issues, and develop and demonstrate new technologies for planetary exploration with the long-term view of a future Mars sample return mission.

# ExoMars

The ESA-provided Trace Gas Orbiter is now in orbit around Mars (2016). ESA's ExoMars rover will be launched in 2020. Roscosmos will be responsible for the 2020 descent module and surface platform, and provides Proton launchers for both missions. Both partners will supply scientific instruments and will cooperate closely in the scientific exploitation of the missions. The Entry, Descent & Landing Demonstrator Module was deployed on 19 October 2016, but made a 'hard landing' on Mars after returning a large volume of useful data.

# ‘Moon Village’:
# A vision for global cooperation

The paradigm shift in space activities seen today is termed ‘Space 4.0’. ESA Director General Jan Woerner’s Moon Village concept seeks to transform this shift into a set of concrete actions. The ‘Moon Village’ is:

- An open architecture, rather than a single project with a fixed plan or defined timetable;
- A community coming together to share interests and capabilities;
- An environment where both international cooperation and the commercialisation of space can thrive.

# SPACE TRANSPORTATION

# The European launcher family

The Ariane and Vega launchers developed by ESA guarantee European autonomous access to space.
Their development and successful exploitation is an example of how space challenges European industry and provides precious expertise.

Ariane is one of the most successful launcher series in the world. Complemented since 2011 by Vega and Soyuz, they are all launched from Europe’s Spaceport in French Guiana.

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# Europe’s spaceport

European launchers lift off from the Centre Spatial Guyanais (CSG), Kourou, in French Guiana.

The CSG launch range is co-funded by ESA and France
and is operated by the French space agency CNES.

The launch infrastructure for the Ariane 5, Vega and Soyuz launchers at CSG is owned by ESA, maintained and operated by Arianespace, with the support of European industry.

# Launchers and technologies of the future: Ariane 6 and Vega C



European Ministers agreed at the Ministerial Council 2014 to develop Ariane 6 and Vega C. These launchers will provide guaranteed access to space for Europe at a competitive price without requiring public sector support for commercial exploitation.

- Ariane 6 – modular three-stage launcher with two configurations, using two (A62) or four boosters (A64);
- Vega C – evolution of Vega with increased performance and same launch service cost;
- Common solid rocket motor for Ariane 6 boosters and Vega C first stage;
- New governance for Ariane 6 development and exploitation allocating increased roles and responsibilities to industry;
- Vega C and Ariane 6 first flights – 2019 and 2020.

# Launchers
# and technologies of the future

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Space Rider

- An affordable, reusable, end-to-end integrated transport system offering Europe independent access to and from low Earth orbit.
- European opportunities for in-orbit validation of technologies.
- First launch on Vega C in 2020.

Future Launchers Preparatory Programme (FLPP) New Economic Opportunities (NEO)…

1. Develop competitive technologies for future launchers that will:

- include low development and production costs, and lower risks;
- shorten the launcher development phase to less than 5 years.

2. Invest in a more diversified launcher development portfolio focusing on:

- key technologies and new manufacturing processes;
- integrated demonstration before transfer into orbit;
- validating ultra-low cost engine demonstrator (Prometheus).

# ESA AND ITS INTERNATIONAL PARTNERS

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# Strong ties all over the world

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## Partnership: one of ESA’s key words

As a European research and development organisation, ESA is a programmatically driven organisation, i.e. the international cooperation is driven by programmatic needs and rationale.

- Strategic partnerships with: USA, Russia and China.
- Long-standing cooperation with Japan, India, Argentina, Brazil, Israel, South Korea, Australia and many more…
- EU Members, but not ESA Member States: enhanced cooperation and joint activities. European Cooperating States (ECS): Bulgaria, Cyprus, Latvia, Lithuania and Slovakia. Cooperating States: Malta. Discussions are ongoing with Croatia. Slovenia is now an Associate Member.

# ESA AND THE EUROPEAN UNION

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# United space in Europe

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As confirmed in the ‘Joint Statement on Shared Vision and Goals for the Future of European Space’, signed by the ESA Director General and the European Commission in October 2016, ESA and the EU share three core goals for the future:

- To maximise the integration of space into European society and economy;
- To foster a globally competitive European space sector;
- To ensure European autonomy in accessing and using space in a safe and secure environment.

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# Cooperation between ESA and the EU

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Policy coordination:

- Since 2004 the ESA/EU Framework Agreement has been the basis for cooperation between ESA and the EU (extended in 2016 until 2020).
- Article 189 of the Lisbon Treaty of 2009 gave mandate to the EU to develop a 'European' space policy, providing that it should establish appropriate relations with ESA.
- ESA/EU ministerial-level meetings and related resolutions provide directions and guidelines for policy development.

EU/ESA space programmes and R&D activities:

- ESA is implementing two flagship programmes for the EU:
  - Galileo
  - Copernicus
- Horizon 2020 − ESA provides support to the EU in its implementation of space research and technology objectives.
- Defence and Space − ongoing coordination between ESA, EC and EDA through different channels.

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# ESA's contribution to European space policy

ESA's Resolution on Space 4.0 provides a way forward for the evolution of ESA as THE space agency for Europe. Regarding ESA/EU relations, ESA Member States:

- Recalled the importance of the 'Joint Statement' signed by ESA DG and the EC;
- Invited ESA DG to strengthen cooperation between ESA and the EU to achieve common goals and programmes, for the benefit of European citizens, underlining the importance of establishing sustainable and mutually beneficial arrangements for cooperation;

In December 2016, in Lucerne (Switzerland), ESA Member States adopted a 'Resolution on their Vision of a United Space in Europe in the era of Space 4.0'

- Welcomed the Communication of the EC on 'A Space Strategy for Europe' suggesting strategic priorities for the EU in space and invited the ESA DG to develop the necessary principles to ensure ESA's ability to efficiently implement EU-funded space programmes and activities.

# ESA and Cyber security

- What is cyber security?
- Examples of space related cyber attacks
- How does ESA implement cyber security?
- Data protection
- Security and safety – risks from space: the Space Situational Awareness Programme

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# ESA and Cyber Security Introduction

**Space applications are fundamental for European citizens' daily life:**

- **For safety and security on Earth**
  - Disasters management (from Earthquake to Climate Change)
  - Transportation (railways, flights, sealing) and logistics
  - Secured communication
  - Surveillance (land, sea, air, space)
  - Critical Infrastructure
  - Energy
  - Agriculture and Water
  - Migration and border control

- **For safety and security in space**
  - Planetary Defence
  - Space Weather
  - Debris incl. mitigation, remediation, removal,…
  - Space Surveillance and Tracking

# What is cyber security?

Cyber security comprises **technologies**, **processes/policies** and **controls** that are **designed to protect systems, networks and data from cyber attacks.**

**What is a cyberattack?**

A cyberattack is deliberate exploitation of computer systems of technology-dependent enterprises and networks.

Cyberattacks use malicious code to alter computer code, logic or data, resulting in disruptive consequences that can compromise data and lead to cybercrimes, such as information and identity theft.

**What are the consequences of a cyber attack?**

- Cyber attacks can disrupt and cause considerable financial and reputational damage to even the most resilient organisation.

- If you suffer a cyber attack, you stand to lose assets, reputation and business, and potentially face regulatory fines and litigation – as well as the costs of remediation.

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# Examples of cyber attacks in space

**Navigation**

- **Denial of service :** On January 2010, a software update of the GPS Ground Segment caused a denial of service. Impact observed on 8,000 to 10,000 military receivers during several days
- **Spoofing:** In 2009, a group of students at the University of Texas at Austin successfully tested a GPS spoofing device to remotely redirect an $80 million yacht

**Observation Exploration**

- **Targeted interference and control take-over:** On October 22, 2008, Terra EOS AM–1 experienced nine or more minutes of interference. Achieved all steps required to command the satellite.
- **Viral attack** : The Windows XP-based laptops on the ISS were infected with a virus called W32.Gammima.AG in 2008, after a cosmonaut brought a compromised laptop aboard which spread the malware to the networked computers.

**Telecom**

- **Deliberate Jamming :** ARABSAT "Deliberate jamming incidents have dramatically increased in 2012 which indeed put a threat on services over Satellites"
- **Unauthorized access :** A "radio ham" captured the pictures/video of the NATO surveillance flights, during the Balkan War, as they were using an insecure satellite link.

# Examples of cyber attacks in space

Hackers-infiltr.pdf - Adobe Acrobat Pro

Hackers infiltrate 'two US satellites, could have taken complete control achieving all s... Page 1 of 6

**MailOnline**

## Hackers infiltrate 'two US satellites, achieving all steps required to command the satellite'

By Daily Mail Reporter

Last updated at 2:56 PM on 30th October 2011

Like | 51

Chinese hackers are suspected of grabbing the reins of four US government satellites in 2008 potentially crashing them to Earth or stealing valuable information, more than once.

NASA admits one of the two satellites was temporarily accessed twice in the summer and fall that year, though would not comment on the other.

'While we cannot discuss additional details regarding the attempted interference, our satellite operations and associated systems and information are safe and secure' NASA Public Affairs Officer Trent J. Perrotto said in a statement sent to Talking Points Memo.

# Cyber attacks to ESA

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ZDNet UK / News and Analysis / Security / Security Threats

## Hacker takes credit for ESA 'breach'

*By Darren Pauli, ZDNet Australia, 18 April, 2011 14:40*

**NEWS A hacker claims to have breached the European Space Agency, gaining access to and publishing online what appear to be 200 usernames, passwords and email addresses related to the organisation, along with details of root servers and databases.**

In his blog, hacker TinKode listed email addresses allegedly linked to the Cern science institute, defence giant BAE systems and a string of others tied to the European Space Agency (ESA).

The breach also revealed logs with titles such as 'calibration sources' and 'orbit maintenance', according to TinKode. The attack was launched on 17 April, but it is not clear where it originated. Stratsec head of delivery Nick Ellsmore said that the veracity of the breach and the methods behind it cannot be verified, but noted that the leaked details appear authentic.

For more on this ZDNet UK-selected story, see European Space Agency hacked? on ZDNet Australia.

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ESA, European Space Agency, Hacker, Hack, Username, Passwords, CERN, BAE Systems

# Cyber attacks to ESA



## Anonymous Hacks European Space Agency, Releases Data Online

They did it for the 'lulz.'

By Adam Toobin on December 14, 2015 — Filed Under Cyberwarfare

After a series of high-profile attacks on targets potentially worth attacking — ISIS, the KKK, and Donald Trump — Anonymous, the online hacking collective, reaffirmed its commitment to chaos this weekend when it broke into the database of the European Space Agency and released names, emails, and passwords of officials online. There's no particular reason to think the hack put anyone at risk, but it represents an inconvenience for an agency that has better things to do than field calls from hacker aspirants (think: TK).



What could have possessed them to go after a target so seemingly undeserving compared to their other recent marks? According to *HackRead*, a 'representative' of Anonymous declared:

> BECAUSE XMAS IS COMING AND WE HAD TO DO SOMETHING FOR FUN SO WE DID IT FOR THE LULZ.

# Impact Assessment on cyber attacks to ESA

- Given that the hacks at ESA were focused on the ESA externally open networks, **there was no data loss or leakage from ESA protected internal networks**.
- Data stored on the external network servers is generally intended to be exchanged with the outside community, with open and free access for all, but with tracked access.
- Publication of the usernames and passwords was in any case a major security breach and could have resulted in some data reaching the wrong hands.
- The publication of usernames and passwords exposed the registered users to a security risk in the case where they selected a password identical to the one they use for other accounts.
- Prompt notification to the users about the incident has minimised this risk.

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# The cyber threats organisations face

- All Internet-facing organisations are at risk of attack. And it’s not a question of if you’ll be attacked, but **when you’ll be attacked**.

- The majority of cyber attacks are automated and indiscriminate, exploiting known vulnerabilities rather than targeting specific organisations. Your organisation could be being breached right now and you might not even be aware.

- The most effective strategy to mitigate and minimise the effects of a cyber attack is to **build an effective cyber security.**

- **Effective cyber security reduces the risk of cyber attacks**, and protects organisations and individuals from the unauthorised exploitation of systems, networks and technologies.

# How does ESA implement cyber security?

- ESA has one corporate information system that caters to all productivity and connectivity needs.
- ESA has developed data systems in support to its programmatic goals, like e.g., the Earth Observation Payload Data Ground Segment and the Galileo ground segment.
- Data systems are normally located in specific De-Militarized zones subject to specific access policies and dedicated protection.
- ESA has a specific data policy on the basis of which the data systems  of each programme are configured to determine access and use of data.
- Each Programme appoints a responsible security officer. ESA security officers are operationally linked and connected in a network of expertise

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# How does ESA implement cyber security?

- **Physical**: zoning, access control for data centers;
- **Personnel:** clearances, trust, peer control;
- **Information protection:** classified vs unclassified;

- **Information assurance:** All systems are subject to ISO 27001 certification: Vulnerabilities + Threats = Impact -> Risk assessment -> Countermeasures -> management decision -> ISMS
  - To assure the properties of:
  - **Confidentiality -** encryption
  - **Integrity -** MAC
  - **Availability -** redundancy
  - **Authenticity -** identity management**,** cross check, access control, signature of data
  - **Non-repudiation -** notarization, certificates

# How does ESA implement cyber security? Data Protection

- **Take appropriate measures to secure data, for example:**
  - State of the Art Encryption
  - Appropriate compartmentalization of processes
  - Access management and reconciliation
  - Regular audits to keep systems up to date, lessons learned and ongoing improvement

- **Perform a Data Protection Impact Assessment (DPIA) for high risks of:**
  - loss data, unauthorised access, destruction, use, modification or disclosure, e.g. the Cloud and sensitive personal data

- **Consult the Data Protection Officer on:**
  - whether to perform a DPIA
  - which safeguards to apply towards mitigating risks to the rights and interests of Data Subjects
  - evaluation of the conclusions

- **Planning**: high risk issues must be spotted early - add time for the evaluation process

# How does ESA implement cyber security?

**Risk: Data leak - prevention and resolution of Data Protection Incidents:**

- assign clear roles and responsibilities to Data Protection matters
    - Who does what, how, when
- risk analysis: implement <u>prevention and emergency measures</u>
- put controls and audits in place

**If there is a leak:**

- investigate, analyse the impact, number affected, likely consequences
- take action to mitigate adverse impact and to prevent future breaches
- Contractors should inform ESA in writing of the breach (contractual stipulations)
- inform the Data Protection Officer immediately when a data leak becomes known
- the Data Protection Supervisory Authority examines incidents

# How does ESA implement cyber security? The issue of protecting Personal Data

ESA is not subject to national or EU laws and regulations on personal data protection. However ESA has adopted a Personal Data Protection Policy whose principles are in line with EU GDPR:

- **Adopted** with ESA Council on 13 June 2017 (ESA/C(2017)79,rev.1)
- **Applicable as of 1 March 2018** with ESA /ADMIN/IPOL-LEGI(2018)01 issued on 5 February 2018 with 1 year transition phase

**Main objectives:**

- To effectively ensure protection of Personal Data processed by the Agency or disclosed to the Agency
- Increase awareness within ESA with respect to Personal Data protection
- Establish governance and operations necessary for the effective Personal Data protection

# How does ESA implement cyber security? The issue of protecting Personal Data

**a) Personal Data** means any information concerning an identified or identifiable Data Subject (provided that the identification of the said Data Subject may be done without unreasonable efforts), e.g. login, ID number, test data (if related to a real person), IP address, an online identifier.

**b) Sensitive Personal Data** means Personal Data that can reveal without unreasonable efforts the racial or ethnic origins, political opinions, trade union membership, religious or philosophical beliefs, health or sexual life, genetic or biometric data, criminal convictions of a Data Subject e.g. physical health data, sick leave.

**c) Data Subject** means an individual who is the subject of Personal Data

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# Concluding remarks

## There are different motivations behind cyber attacks

- **Competitors**, possibly by means of third parties: they are after undisclosed information, IPR, sensitive and commercially valuable knowledge
- **Cyber-criminals:** financial gain (of some sort)
- **Employees:** ranging from negligence to open hostility
- **Hacktivists:** politically and socially motivated to hamper space advance
- **Nations/States:** information, strategic advances, testing new types of attacks /cyber war, gain technological advantage
- **Terrorists:** Motivations of political-religious nature, aiming at critical infrastructures of different nature (e.g. health, energy, water, transportation, telecommunications, access to space)

# Concluding remarks

Unfortunately, whatever the level of protection, the possibility of a data breach through cyber attacks is always there.

As we move to the Internet of Things World, the continuous digital evolution around us is irreversible. The digitalization of manufacturing capabilities, Industry 4.0, Space 4.0, etc., and has expanded the opportunities for cyber attacks also in the space sector.

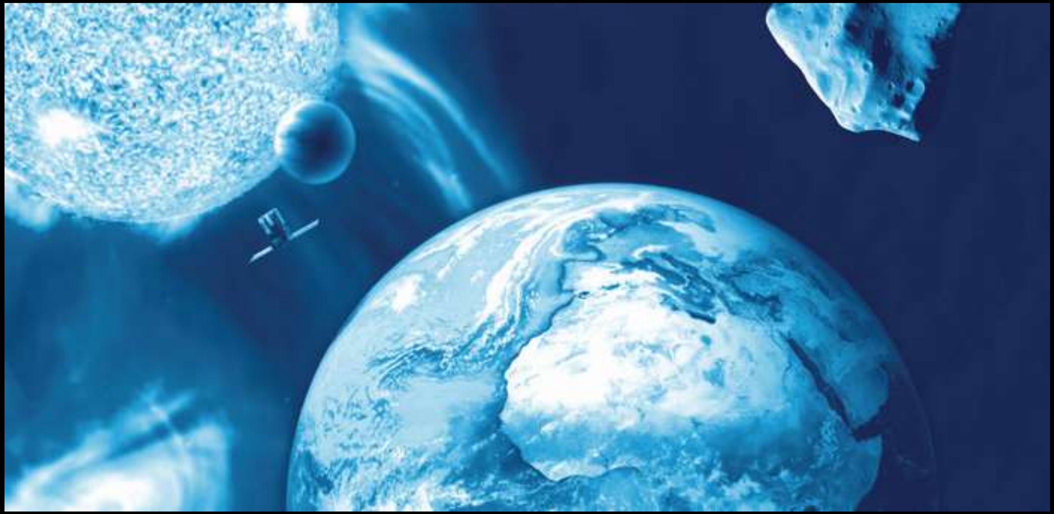
ESA must continue to be an exponent of cyber security for its own systems but also for its partners, in particular industry that often has specific expertise, which is particularly vulnerable to theft or loss. The benefits to innovation and digitalization must in fact be balanced with protecting a business's interests.

It is also fundamental to think of how to respond and recover from a data breach in the fastest and smoothest way possible in order to reduce the risk to cause serious business disruption. This is done via best practices and specific policies.

# 1. SSA - Space Situational Awareness

## insights of a growing new progamme

## 2. **Detecting space hazard**



Space activities are risky

- payload build-up;
- launching;
- in orbit positioning.

Once in space…

Hazard stems from

- **potential collisions between man-made objects (space debris) in orbit;**
- **harmful space weather;**
- **potential strikes with natural objects** (asteroids that cross Earth's orbit).

# 3. Why Europe needs SSA

- **Space-based systems have become indispensable** to services critical to Europe’s economies and government functions, including those related to security. **This dependency will increase in the future**.

- Any shutdown or loss of services from these systems would seriously affect an enormous range of commercial and civil activities
- **Until today, Europe’s access to information on what is happening in space was largely dependent on non-European Sources.**

- For this (and other reasons) Europe needs **autonomous SSA capability**.

# 4. Why Europe needs SSA (cont'd)



- Developing further the European SSA capabilities will strengthen the competitiveness of European industry.

- In the area of space weather, Europe already has expertise and assets providing high-quality scientific data – processed, usable data – to a wide variety of customers. But these capabilities are largely fragmented across national and institutional boundaries.

- There's a need for space-weather applications tailored to European users' needs.

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# 5. SSA the "youngest" ESA programme (legal perspective)

- SSA is an <u>optional programme </u>(Art. V.1.b. ESA Convention) started on 1 January 2009 and extended at 2016 Ministerial Councils until 2020.

- Objective: "support the European independent utilisation of and access to space for research or services, through providing timely and quality data, information, services and knowledge regarding the environment, the threats and the sustainable exploitation of the outer space." (SSA Declaration).

- The programme includes three main areas:
- STT - Survey and tracking of objects in Earth orbit (and GTO)
- SWE - Monitoring space weather
- NEO - Watching for Near Earth Objects

**For all these fenomena we assess the risk and study mitigation measures**

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# 6. DECLARATION

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- The Declaration is an “Act of States” (not an act of ESA) which is subscribed by the states participating to the programme.
- It is considered as an agreement of public international law - in a simplified form (G. Lafferranderie).

It is through the Declaration that the Participating states to any optional programme decide how to conduct such programme:

- AGREE that SAA Programme is executed in successive periods as an ESA optional programme (in accordance with the Agency’s rules and regulations and on the basis of the programme proposal of the Director General).
- APPROVE its general objectives and technical content.
- AGREE to allocate a financial envelope.

# 7. IMPLEMENTING RULES (IR)

IR are the rules according to which the programme is executed.

They are not approved by the Programme Board but recommended to the ESA Council for approval.

Their purpose with respect to the programme is (Art. 1, SSA IR):

- define the specific conditions governing its execution;
- define the rules and procedures applicable to the programme (in conformity with the provisions of the Convention);
- provide the terms and conditions relevant to the activities carried out for the programme.

# 8 IMPLEMENTING RULES (Art. 2)

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**Define the role of the Programme Board** (Art.2) which shall:

- monitor and coordinate and follow the execution of the Programme;
- examine and recommend the Programme's cost plans;
- examine and adopt the Programme work plans;
- monitor the distribution of the industrial work;
- approve the agreements and arrangements required for the implementation of the Programme;
- provide its recommendations to Council, in particular on governance and data policy.

**The Agency** shall be responsible for the overall technical and financial management of the Programme (Art.3)

# 9. Implementing rules

<u>Information, Data and Intellectual Property Rights (Art.7)</u>

- Ownership, access, use and disclosure => governed by the ESA Rules on Information, Data and Intellectual Property (ESA/REG/008): *“The Agency considers that the originators of Information, Data and Intellectual Property are best placed to exploit it”.*
- Information, Data and Intellectual Property originated by a Contractor of the Agency is owned by the Contractor.

- In certain cases, given the special nature of the Agency’s activities, the Council may decide that the ownership of Information, Data and Intellectual Property may remain with the Agency.

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# 10. Benefits for European industry

Significant return on investment for Member States in the SSA Programme through contracts issued to European industry.

- Phase 1 (2009–2012): 25 contracts for €30 million.
- Phase 2 (2013-2016): contracts for €35 million.
- Until 2020, SSA is budgeted at €95 million

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# 11. **European cooperation**

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Cooperation is a crucial aspect of SSA activities:

- European national and regional authorities;
- National space agencies;
- National research establishments;
- Other international agencies and organisations (NASA, NOAA, US Defense Department, UN, ESO, etc.).

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# 12. Developments

- Significant SSA infrastructure has been developed including:
- Space Weather Coordination Centre, Space Pole, Brussels, Belgium
- Space Weather Data Centre, ESA Redu Centre, Belgium
- NEO Data Centre, ESA/ESRIN, Italy
- Space Surveillance and Tracking Data Centre, ESA/ESAC, Madrid, Spain
- SSA Tasking Centre, ESA/ESOC, Darmstadt, Germany
- Development and installation of a monostatic test radar, Santorcaz, Spain
- Development and installation of a bistatic test radar, France
- Initial design of the SSA FlyEye automated telescope to enable full-sky NEO scan.

# 13. About space debris tracking SST

- SST is the ability to detect and predict the movement of space debris in orbit around the Earth.

  Data generated through an SST system can be used to actively protect space-based infrastructures.

  Any SST system can be considered – in a very simplified way – as a 'production line' for observation data.

- A **catalogue** of all potentially dangerous objects that orbit Earth is maintained **so that this data can be used by a diverse range of end customers.**

## About SST

- DATA **main use :**

- prediction (calculation) of collisions between operational satellites and other satellites or pieces of space junk
- **warn satellite operators of any potential risks and take consequent measures (ex.** manoeuvring out of the way).

- Who has the competence to warn and to give instruction on measures to be adopted?

- **A system of governance and of data management is needed (SST).**

# Governance and data policy

- A governance and data management is needed in order to ensure that the right people receive the right information at the right time.
- Users must be authorised to receive data about a specific object.
- Protect the catalogue and the applications from unauthorised modification, substitution or use.
- Question of liabilities…?

# Governance and data policy



- Some question still to be answered :

- Where does the technological capability come from?
- Where data to be used by the Authority will be coming from?
- Will the collision analysis be precise enough to rely on it?
- Will the data provider be responsible (and liable in case of damage) for the consequences deriving from such data?

- **Until these questions remain open it is going to be very difficult to define a competent authority in this respect.**