Space Activities in Europe

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Outline

- A short history of European collaboration in space
- ESA's Programmes
  - Space Science (Examples: Mars Express, Rosetta)
  - Telecom (Examples: AlphaSat, Small Geo)
  - Earth Observation (Examples: SMOS, Biomass)
- EU Funded Programmes
  - Copernicus (Examples: S1, S3)
  - Navigation (Galileo / EGNOS)
- European commercial use of space (Eutelsat, SES, Inmarsat, Avanti)

A bit of history…

European collaboration in space

The launch of Sputnik 1, the first artificial Earth Satellite in October 1957 triggered the “Space Race” between the USSR and the USA.
The Western European nations decided to have two different space agencies, one concerned with developing a launch system **ELDO** (European Launch Development Organization) and one for building satellites, **ESRO** (European Space Research Organisation).

Both organisations were established in 1964 by agreements signed in 1962. From 1968 to 1972, ESRO carried out numerous successful projects. Seven research satellites were launched into orbit. The initial ELDO programme involved the construction of a three-stage rocket plus a satellite test vehicle.

ESA's history (1)

ESRO and ELDO were merged to form ESA in 1975

ESA has 10 founding member states: Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom. These signed the ESA Convention in 1975 and deposited the instruments of ratification by 1980, when the convention came into force. ESA launched its first major scientific mission in 1975, Cos-B, a space probe monitoring gamma-ray emissions in the universe first worked on by ESRO.

ESA's history (2)

The other 12 countries followed

- 1980: Ireland
- 1986: Austria, Norway
- 1996: Finland
- 2000: Portugal
- 2005: Greece, Luxembourg
- 2008: Czech Republic
- 2011: Romania
- 2012: Poland
- 2015: Estonia
- 2015: Hungary

ESA Member States (as of Sept 2016)

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 [NO] and Switzerland [CH]

Special Associate Member: Canada [CA],

(Soon) Associate Member: Slovenia [SI]

Other EU states have Cooperation Agreements with ESA: Cyprus [CY], Latvia [LV], Lithuania [LT], Malta [MT] and the Slovak Republic [SK]. Bulgaria is negotiating a Cooperation Agreement. Discussions are ongoing with **Croatia.**

Cooperation between ESA & EU

- The Lisbon Treaty of 2009 reinforces the case for space in Europe and strengthens the role of ESA as an R&D space agency.
- ESA/EU Framework Agreement in force and extended to 2016
- ESA/EU Space Council ministerial-level meetings and related resolutions provide directions and guidelines

- Two flagship programmes: **Galileo, Copernicus**
- Arrangement with the European Defence Agency for cooperation on space and security
- Political Declaration by Ministers in November 2012 gave ESA DG the mandate to reflect ‘towards the European Space Agency that best serves Europe’, starting a process for the further evolution of ESA

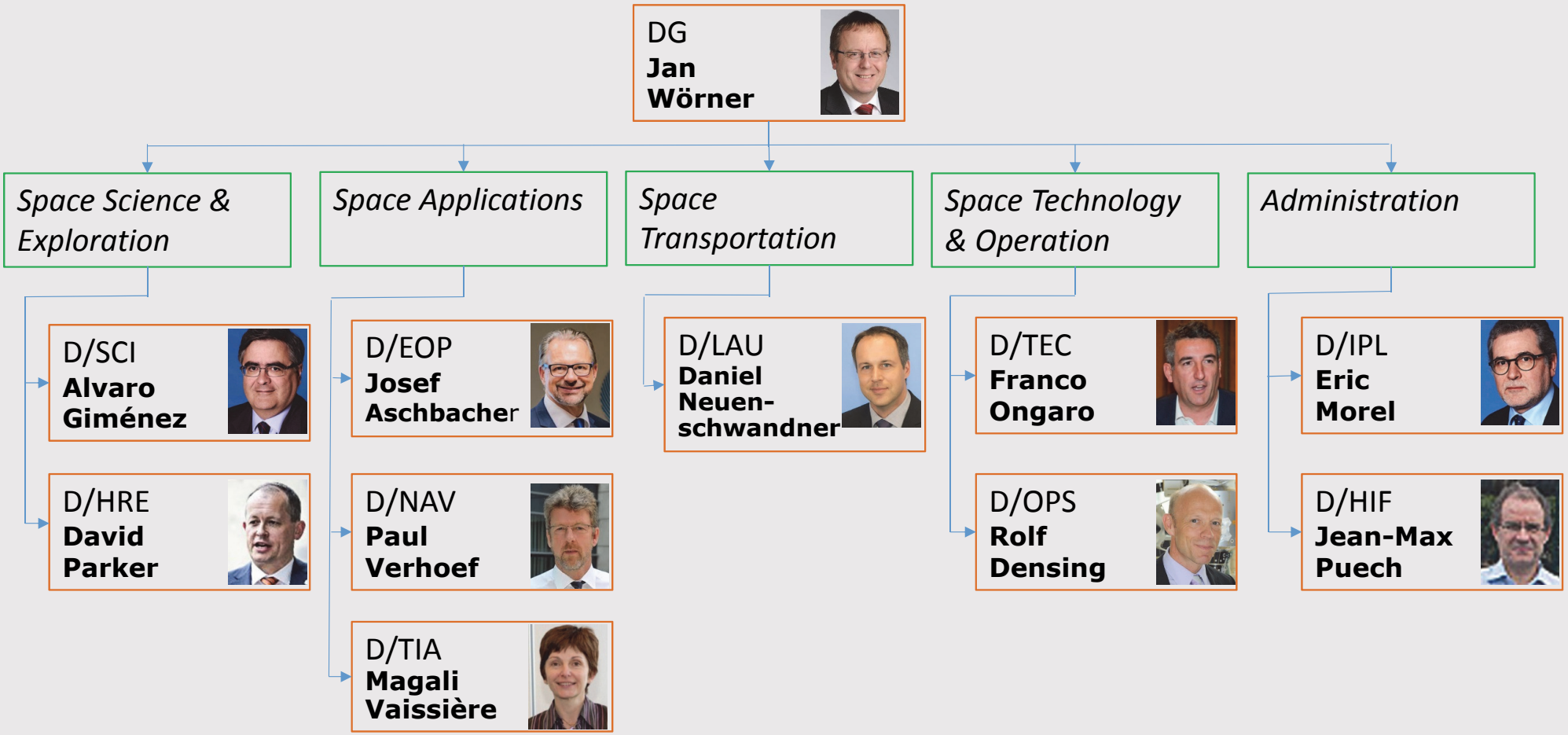
ESA's Programmes and Organization

ESA's Programmes

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

- **Space science & Exploration**
- **Human spaceflight**
- **Earth observation**
- **Launchers**
- **Navigation**
- **Telecommunications**
- **Technology**
- **Operations**

ESA's Organigramme (as of September 2016)

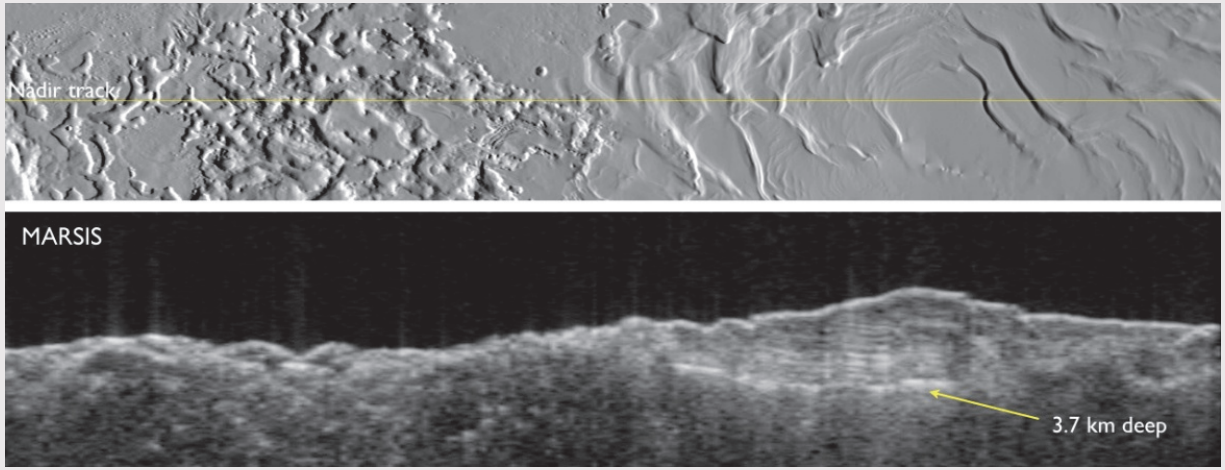


Some Examples for ESA Mission

MARS EXPRESS (1)

Mars Express (2003–) studying the Martian atmosphere and climate, the planet's structure, its mineralogy and its geology, and searching for traces of water.

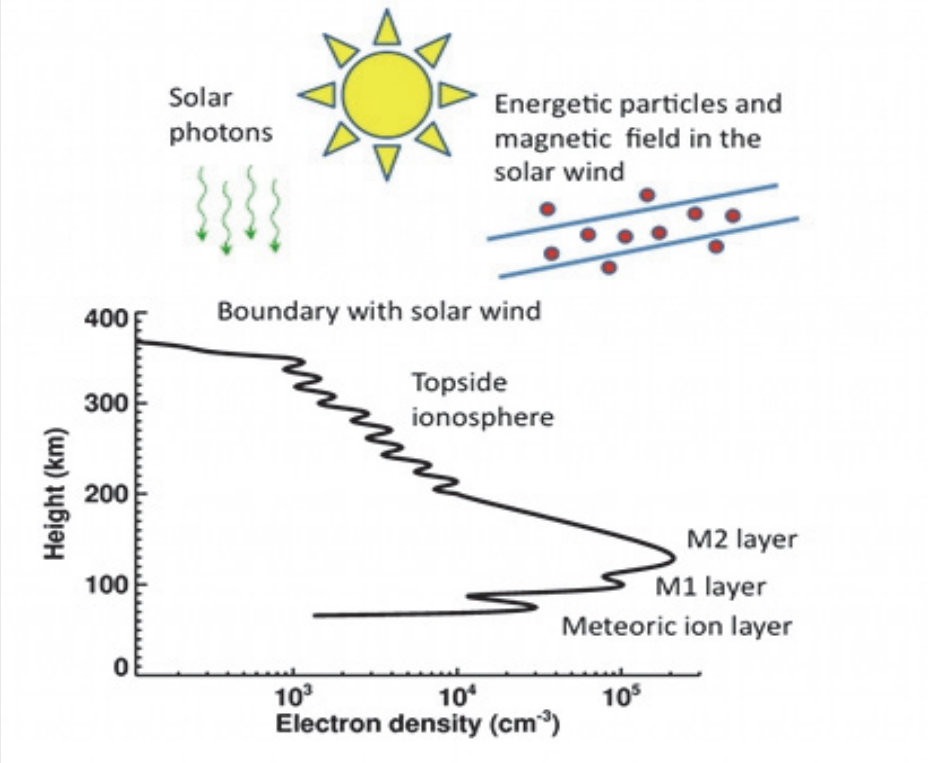
It has a **2-5 MHz radar** ("Marsis") on board which can penetrate the ground.



Prime : AST-F Toulouse

MARS EXPRESS (2)

Marsis Radar also studies the Martian Ionosphere

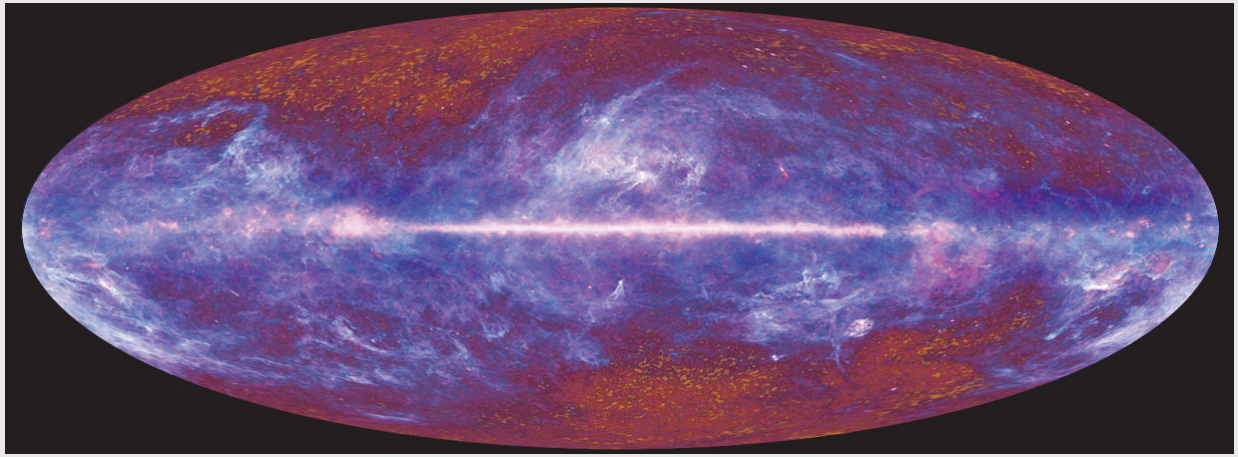


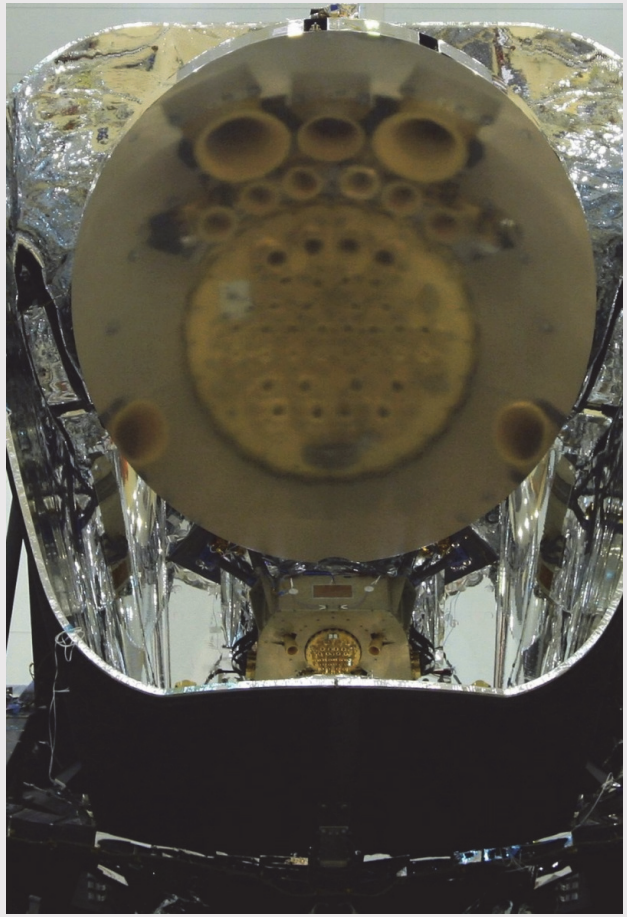
Mars has a weak ionosphere (compared to the one on Earth)

PLANCK (1)

Planck (2009–2013) studied relic radiation from the Big Bang.
From L2 it observed the radiation at the following frequencies:
30, 44, 70, 100, 143, 217, 353, 545, 857 [GHz]
Right: Planck telescope (offset Gregorian with 1.9 x 1.5 m primary mirror)

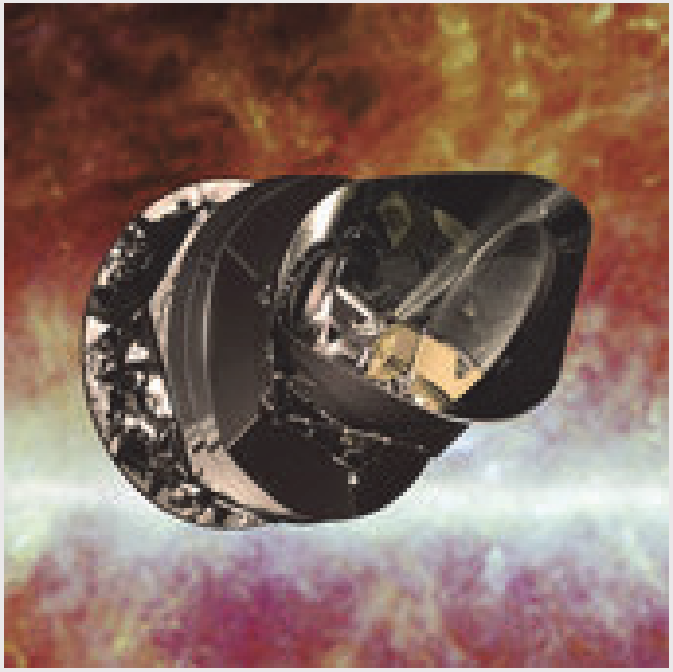
Below: first “all sky image” from July 2010:

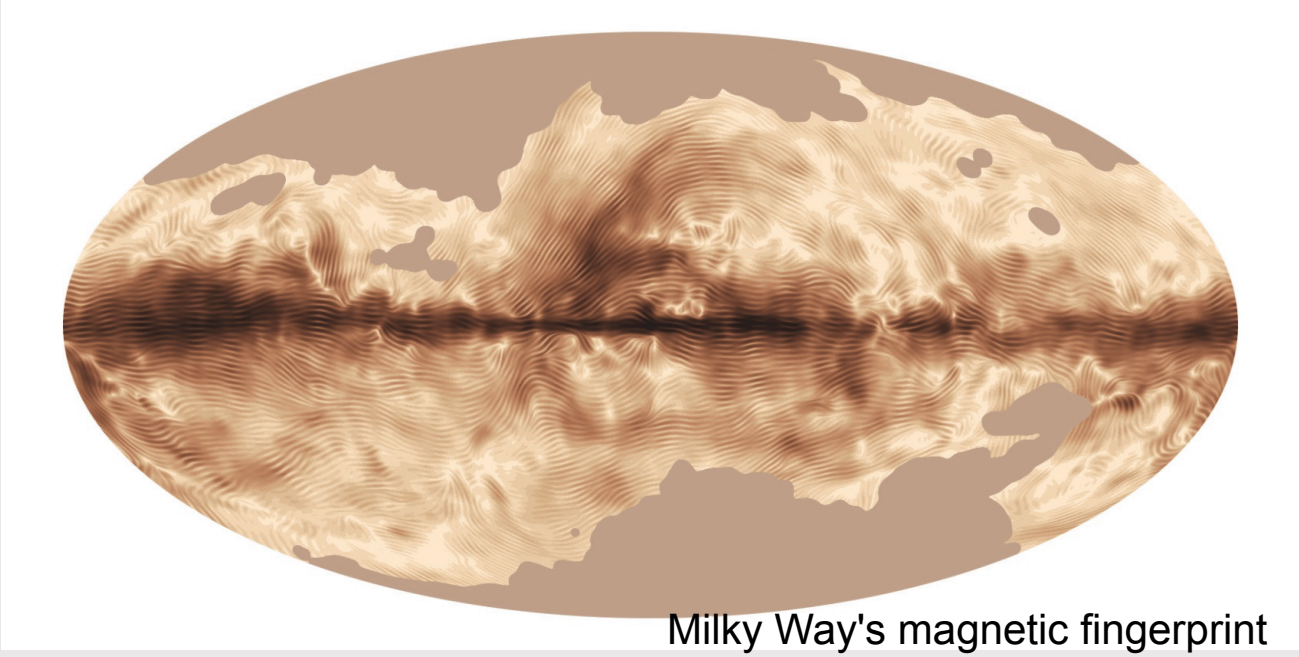




PLANCK (2)

Our Galaxy is filled with a mixture of gas and dust. These cosmic dust grains are aligned preferentially with their long axis perpendicular to the direction of the **magnetic field**. As a result, there is a net polarisation in the emitted light, which can then be measured.

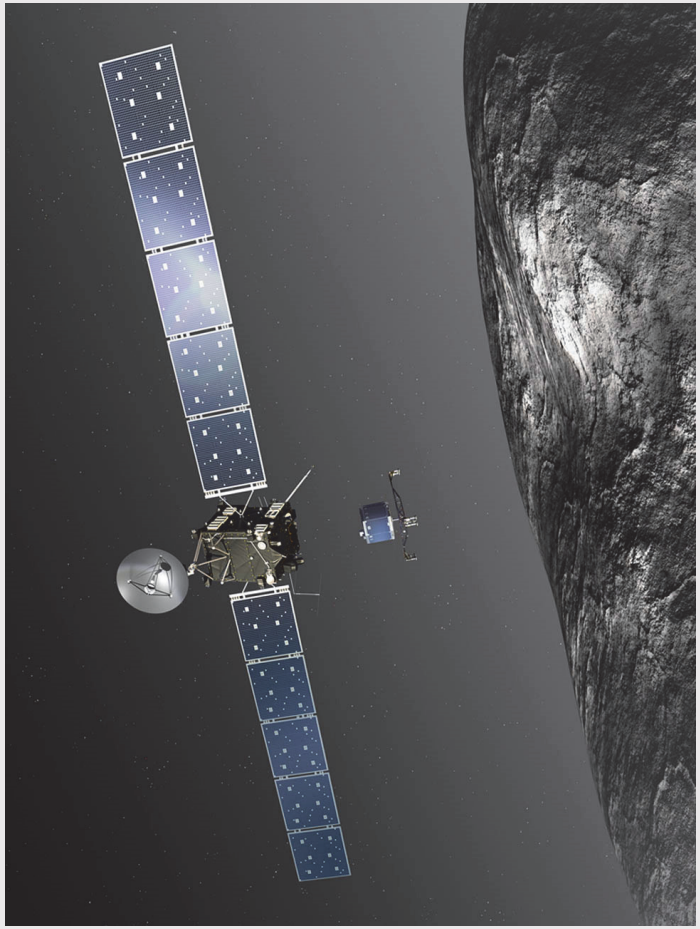




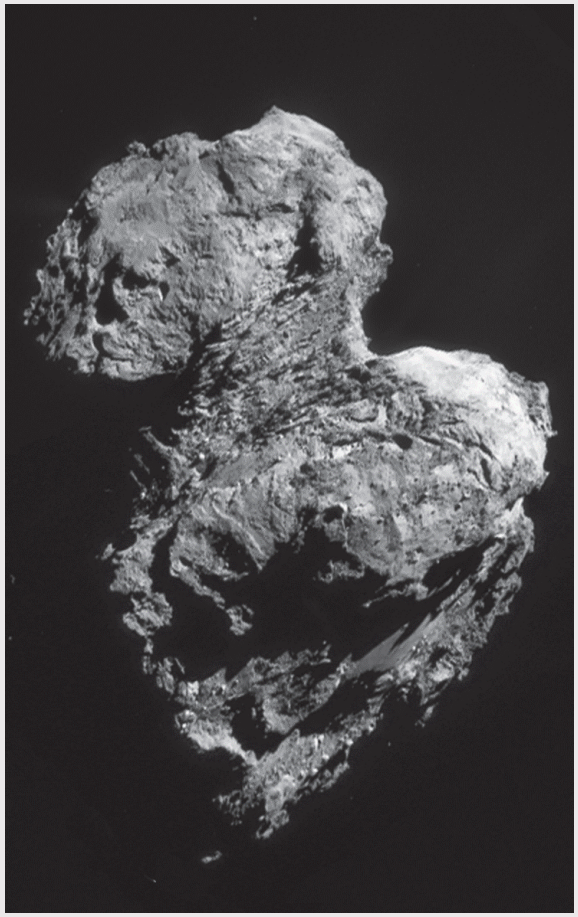
Milky Way's magnetic fingerprint

Rosetta (1)

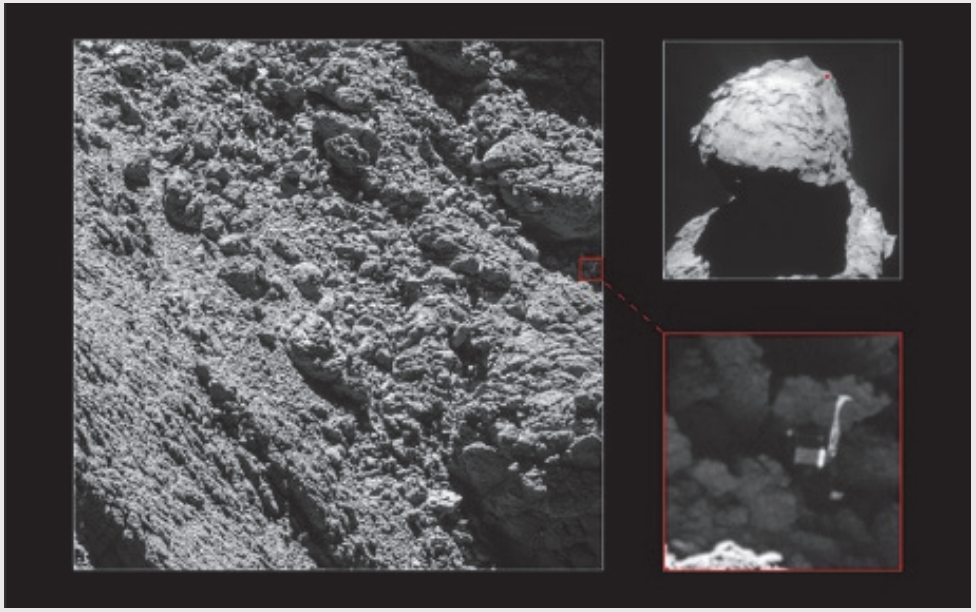
Rosetta (2004 – 2016) was originally supposed to visit comet 46P / Wirtanen. Due to a launch delay, the plan had to be changed and the new target was comet 67P / Churyumov–Gerasimenko. After several planetary gravity-assist maneuvers the spacecraft arrived at 67P and in September 2014 began to orbit it.



Rosetta (2)



The lander *Philae* detached from *Rosetta* on 12 November 2014. It landed on 67P but bounced twice (because the harpoons had not deployed) and eventually stopped in a crevasse. In spite of limited sunlight, the probe transmitted excellent scientific data back to the earth via Rosetta.



ESA Telecom Mission

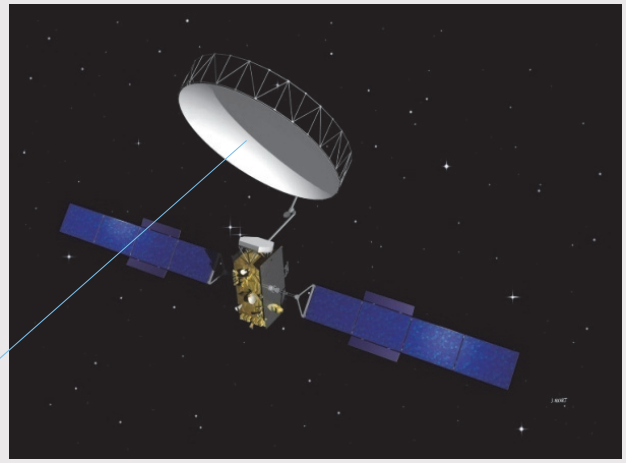
ALPHASAT (1)

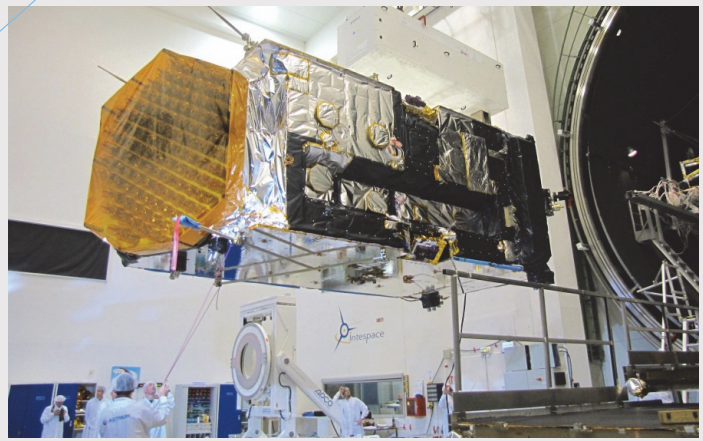
Alphasat, is the first satellite based on the Alphabus platform, jointly developed by ASTRIUM and THALES-ALENIA Space

Total launch mass: more than 6 tons,
Total Electrical power: 12 kW.

Alphasat was launched in July 2013 (in partnership with Inmarsat) and is positioned in GEO at 25 deg East.

The Alphasat mission offers mobile Broadband Global Area Network (BGAN) services using an 11 m deployable reflector.



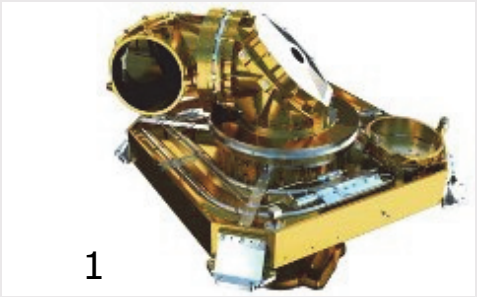


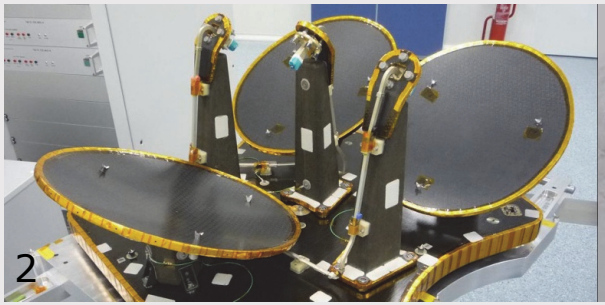
ALPHASAT (2)

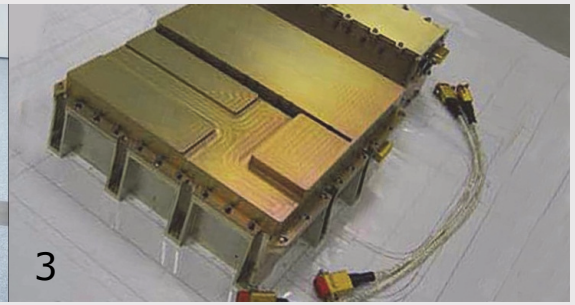
Technology Demonstration Payloads:

1. An advanced Laser Communication Terminal to demonstrate GEO to LEO communication links at 1064nm,
2. A Q-V Band communications & propagation experiment (The “Aldo Paraboni” payload)
3. An environment effects facility to monitor the GEO radiation environment.

Prime: AST-F



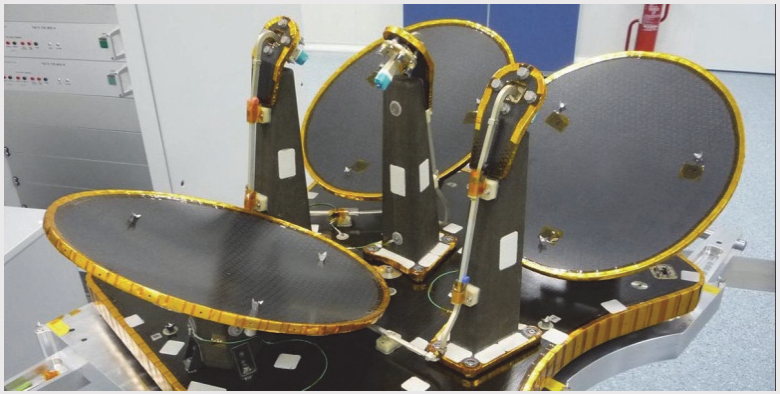


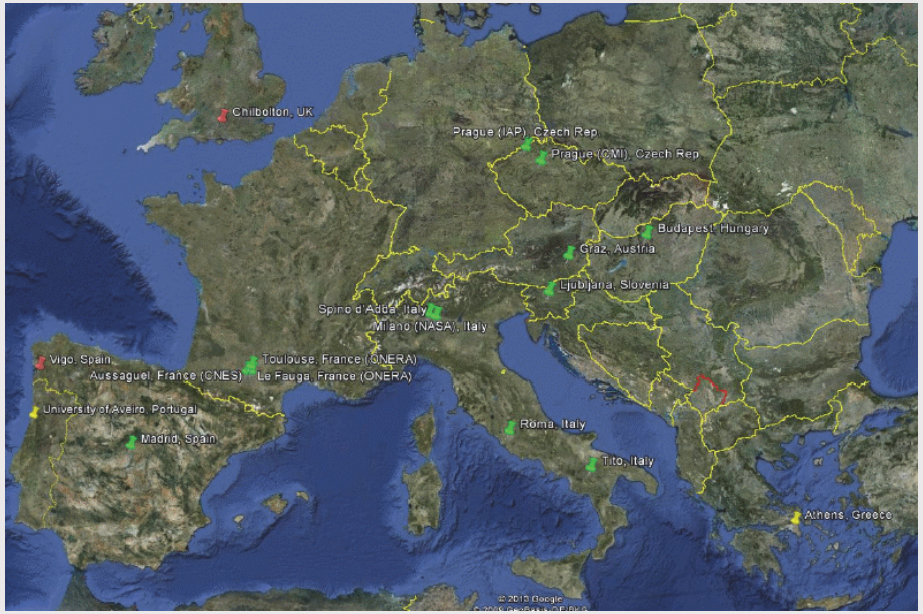


ALPHASAT (3)

Aldo Paraboni Payload

- Q/V Band Communication Payload Coverage Italy/ Austria
- Q/Ka Band Propagation Payload Coverage: all of Europe





Alphasat propagation terminals

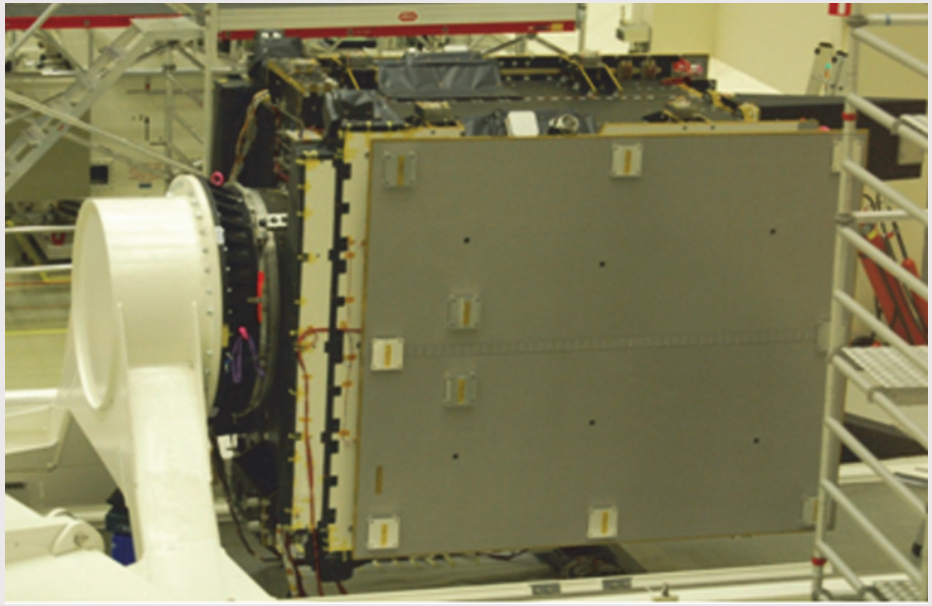
Objectives:

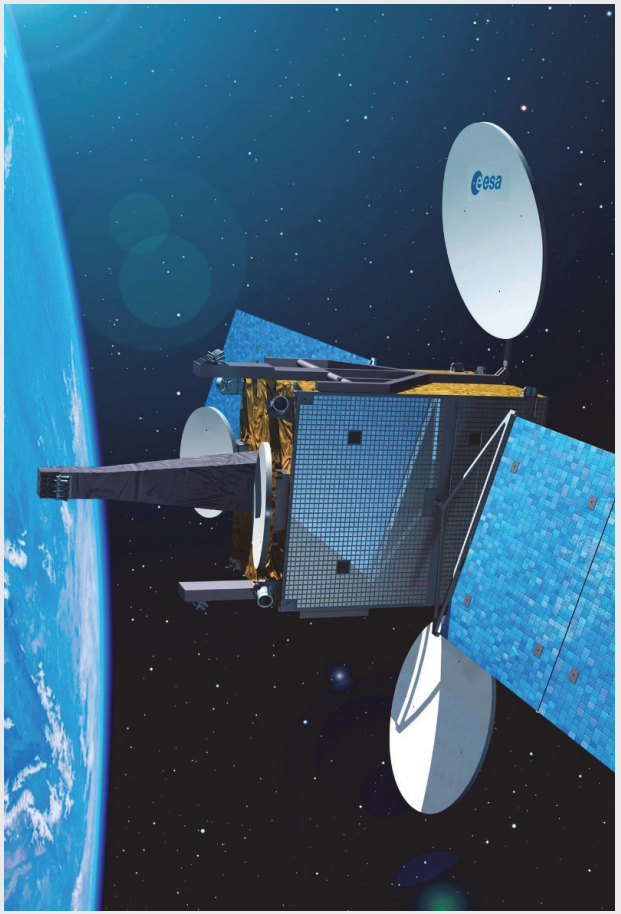
- Testing adaptive coding and modulation techniques (DVB-S2 standard) and ULPC
- Collect first and second order statistics of propagation impairments
- Conduct concurrent propagation and communication experiments

Small GEO (1)

Small GEO – general-purpose small geostationary satellite platform for the commercial telecom market offering payloads of 300 – 600 kg with power demand of 2 – 7 kW

Below: Engineering model of Small Geo.





Small GEO (2)

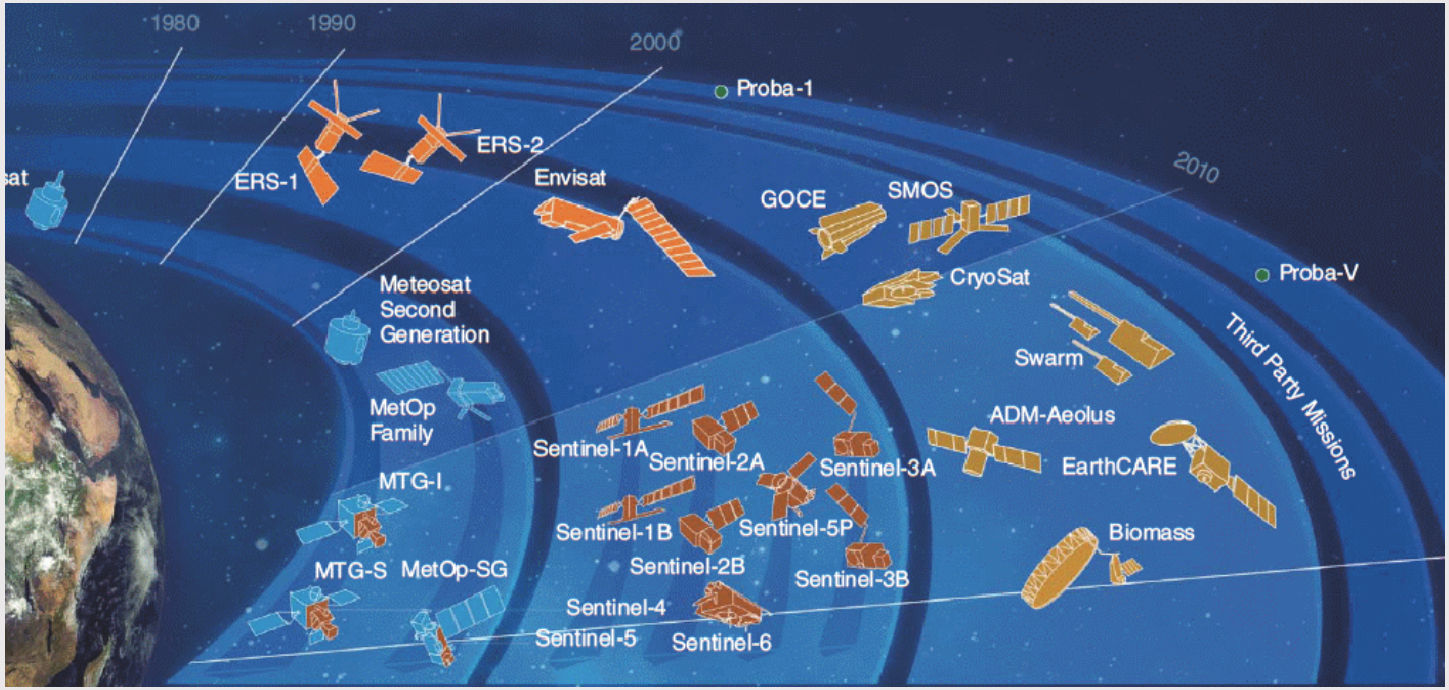
First mission in 2014 : Hispasat of Spain
Future missions such as EDRS-1, Heinrich Hertz and MTG are based on the same platform.

Below: Antenna under test

Prime: OHB Germany

ESA Earth Observation Missions

ESA's EO Missions



Meteorological Missions in partnership with EUMETSAT

Copernicus Missions in partnership with EC addressing operational user needs

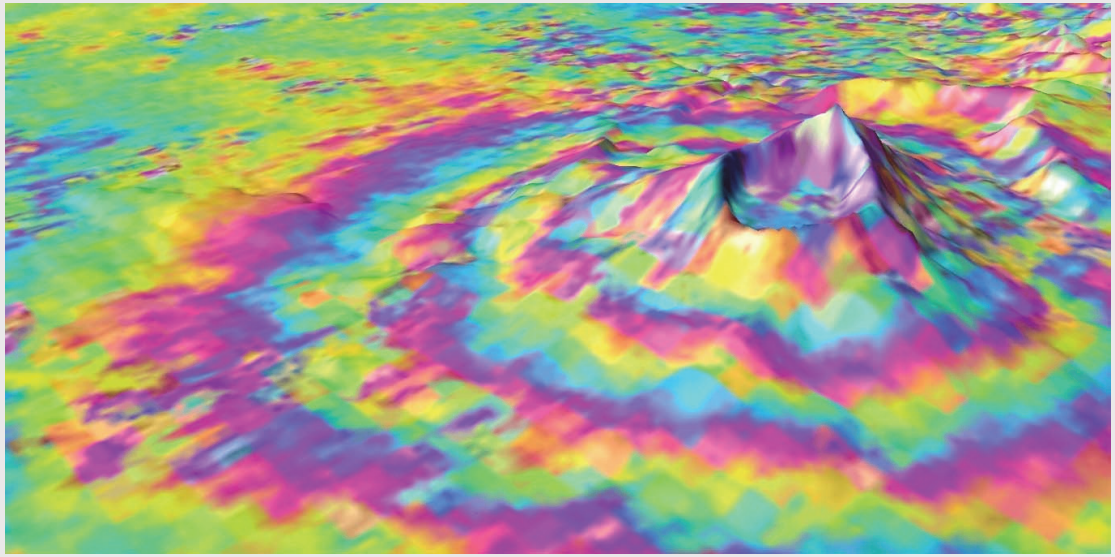
Earth Explorer Missions driven by scientific needs

Pioneers in μW Earth Observation

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

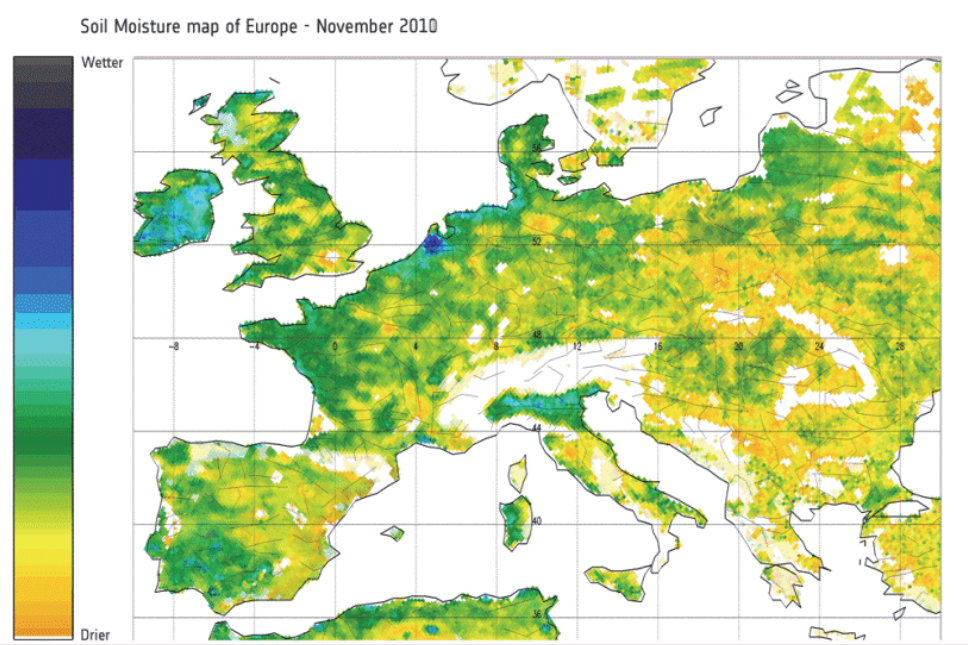
Envisat (2002–2012) the largest satellite ever built to monitor the environment.

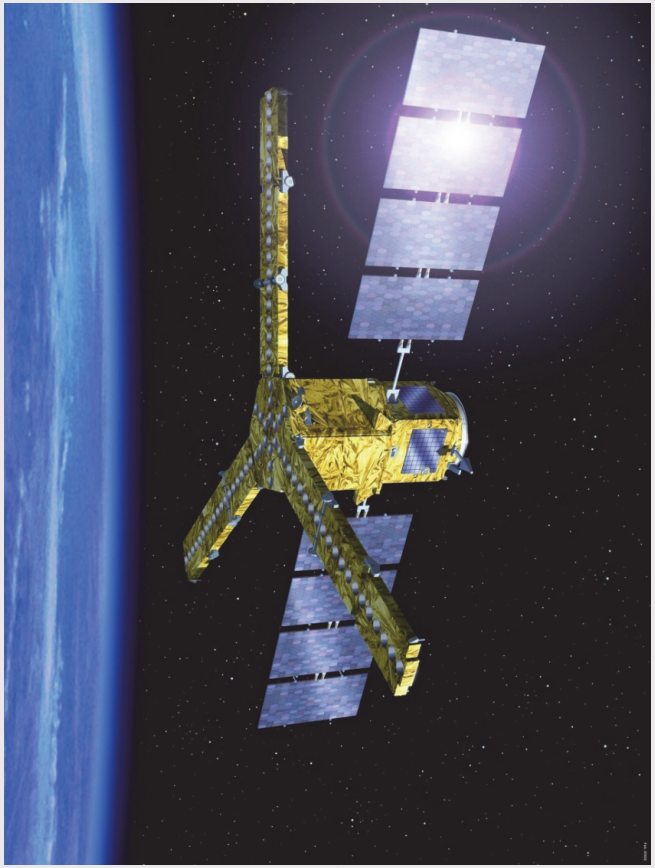
Below: InSAR Image of volcanic uplift



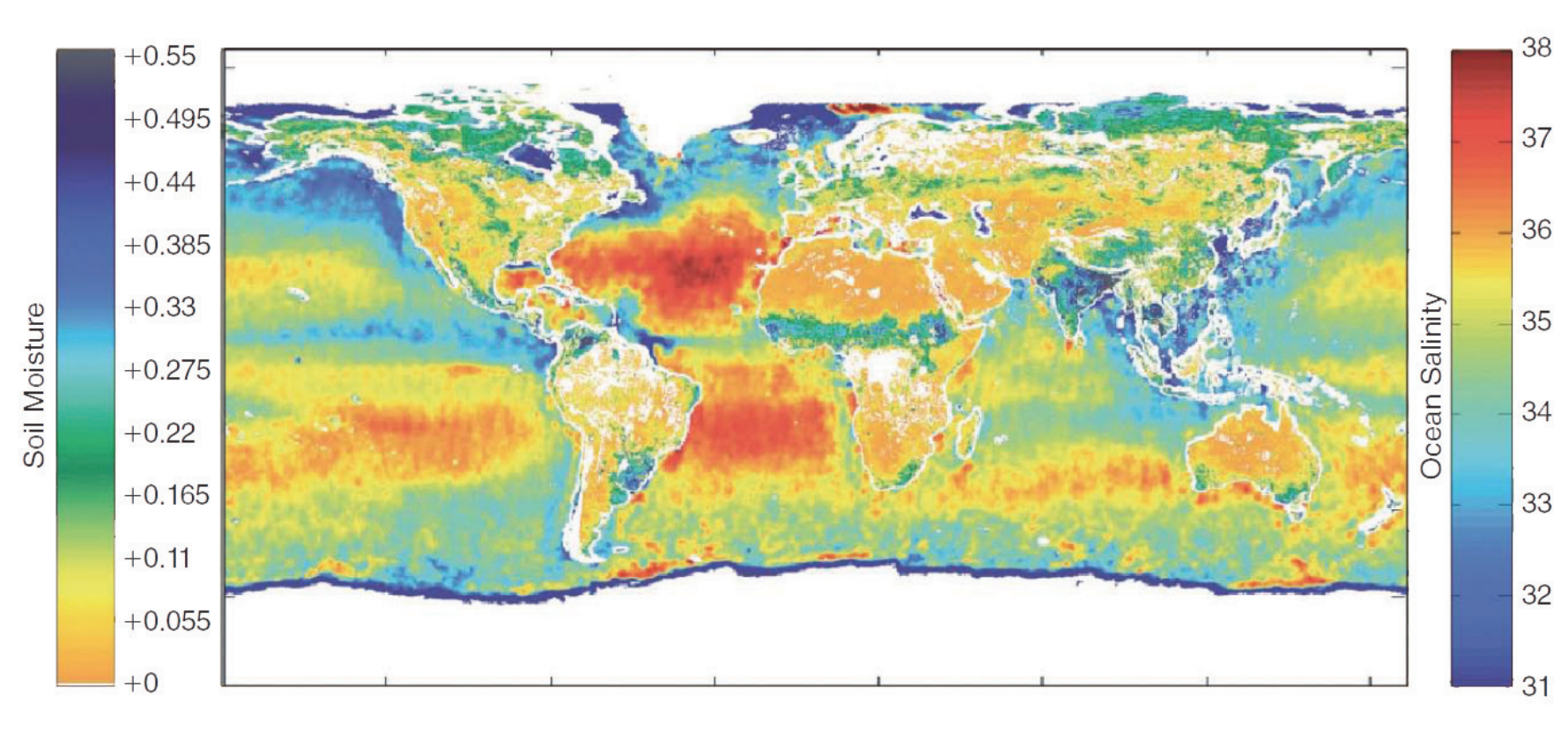
SMOS (1)

Launched 2009 to map **S**oil **M**oisture and **O**cean **S**alinity. It measures microwave radiation emitted from Earth's surface using a 1.4 GHz interferometric radiometer. Moisture and salinity decrease the emissivity of soil and seawater respectively, and thereby affect microwave radiation emitted from the surface of the Earth..



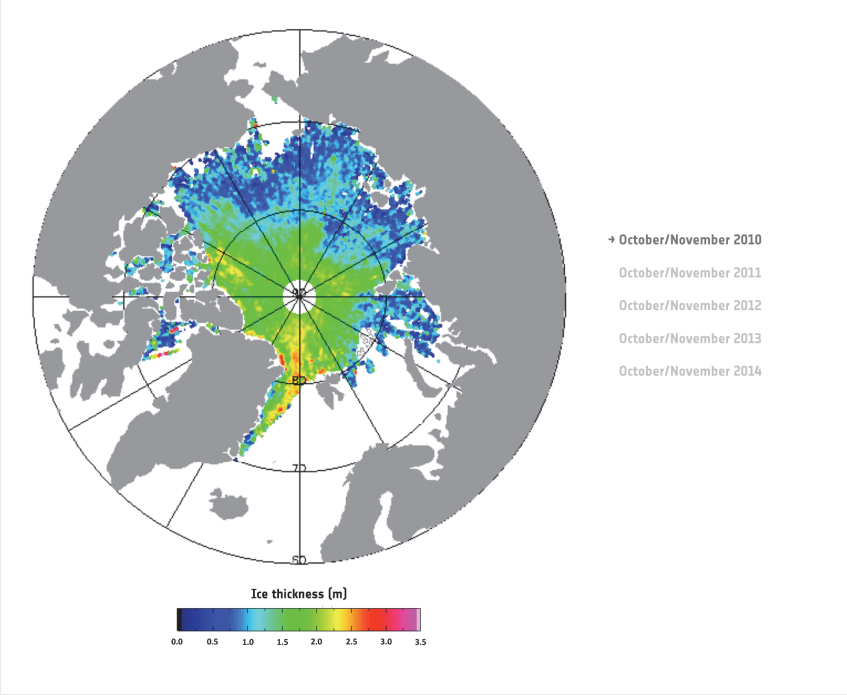


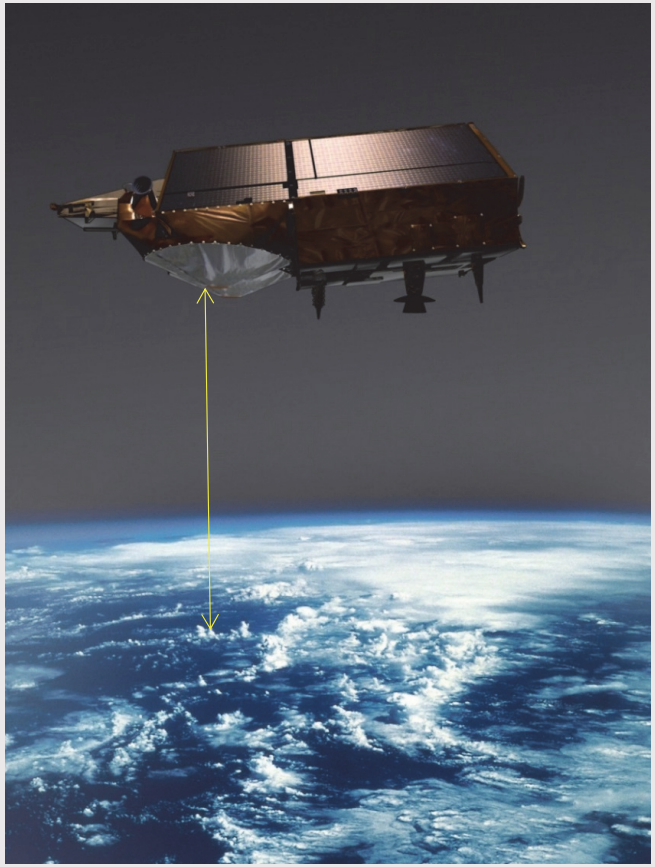
SMOS (2)



Global Map of Soil Moisture and Ocean Salinity derived from L-Band Radiometer of SMOS

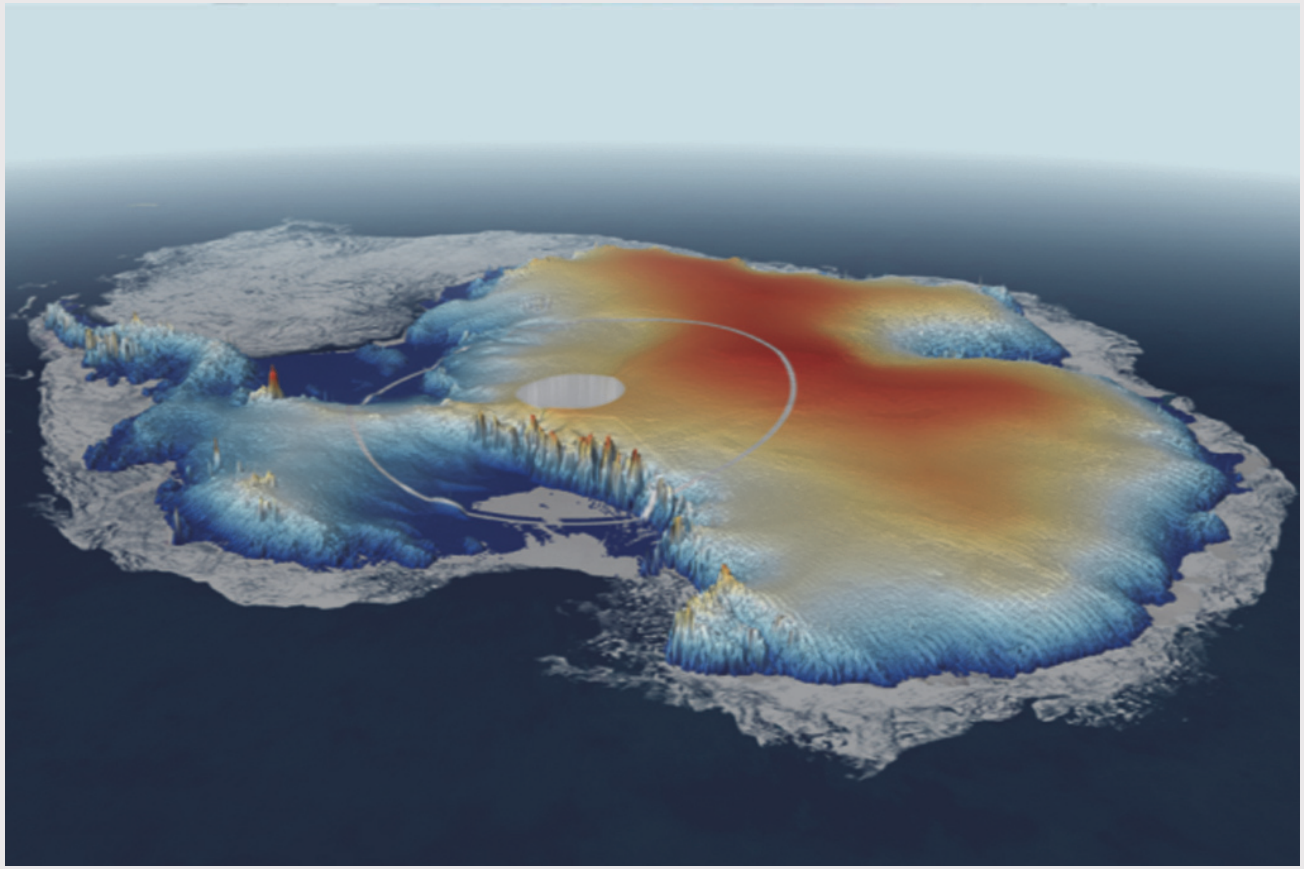
CRYOSAT (1)





CryoSat-2 (2010–) studying Earth's ice cover. Its main instrument ("SIRAL") is a **13.7 GHz radar altimeter** which can operate in pulse width limited mode, in synthetic aperture radar (SAR) mode and in SAR interferometric (SARin) mode.

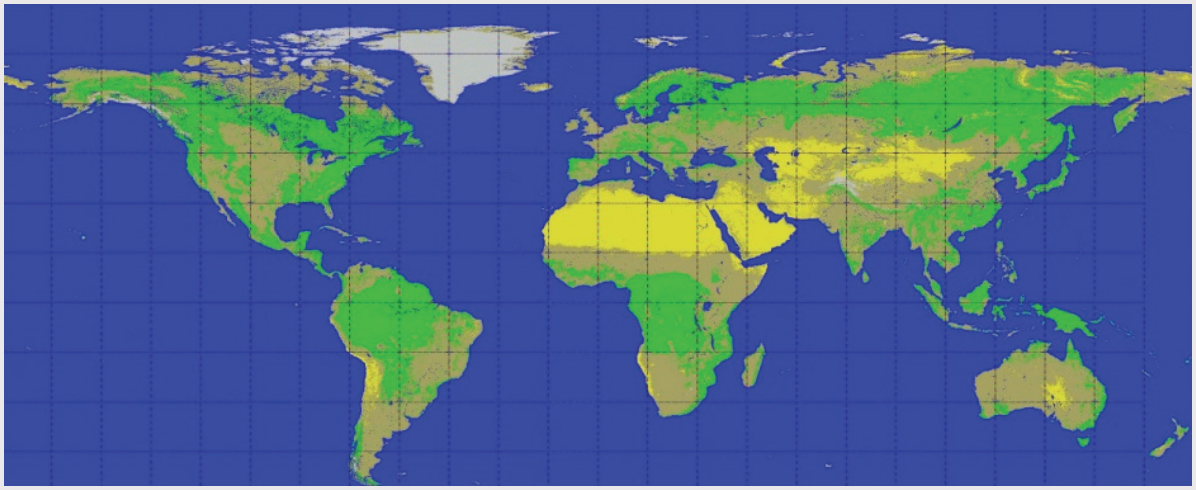
CRYOSAT (2)

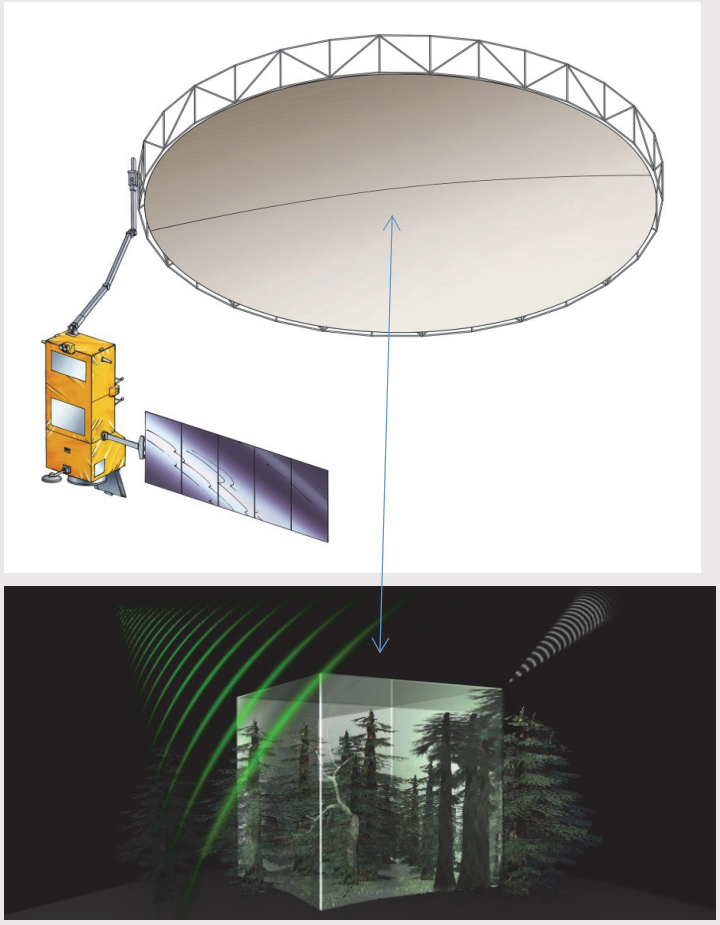


Antarctic Ice-cover derived from CRYOSAT observations

BIOMASS (Explorer Mission)

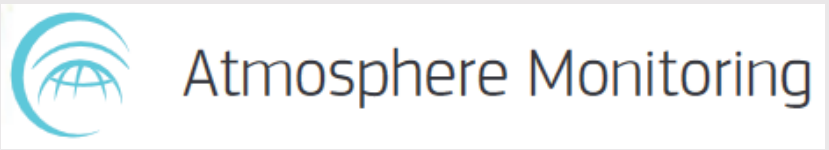
Biomass aims to take measurements of forest biomass to assess terrestrial carbon stocks and fluxes. The mission employs a novel P-band synthetic aperture polarimetric radar operating at **435 MHz** and a 6 MHz bandwidth. In addition to valuable data on forest biomass, the choice of radar sensor means that the mission could also provide new information on ice-sheet thickness and internal structures in cold regions, subsurface geology in arid regions, as well as data on soil moisture, permafrost and sea-surface salinity.

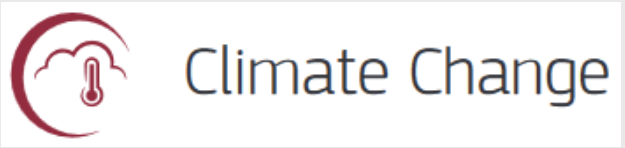




EC Copernicus Programme

Copernicus Services

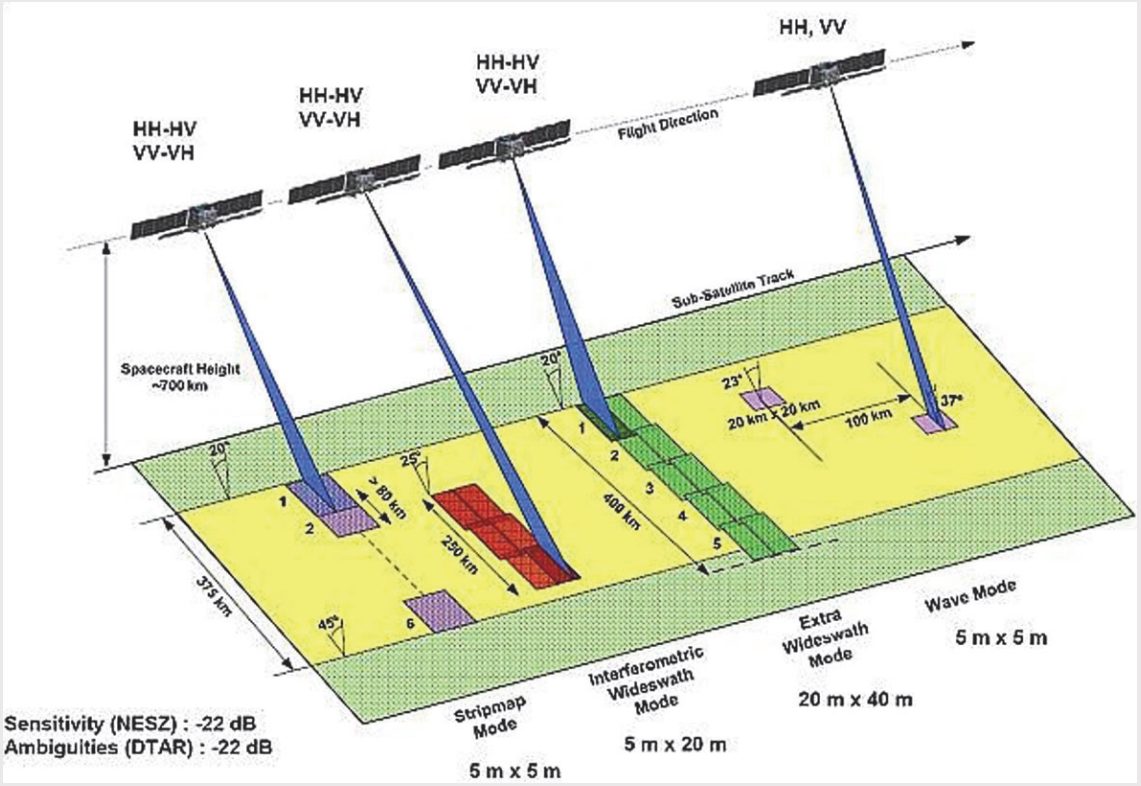




Data from the SENTINEL satellites and from ground observations are collected 24 / 7.
The data are processed in near-realtime and they are available free of charge.

SENTINEL 1 (Copernicus Mission)

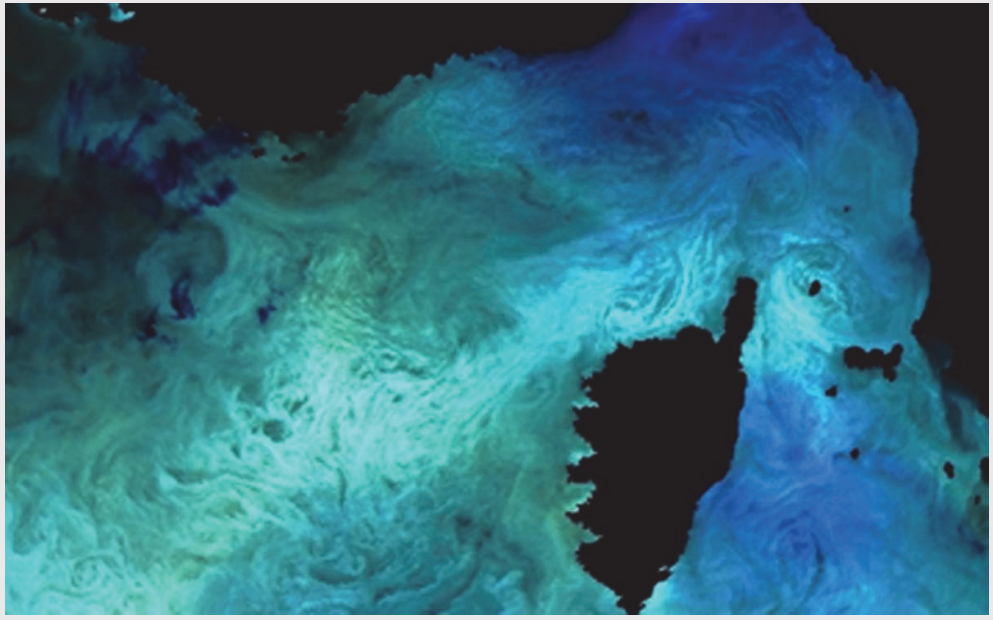
Copernicus is a joint ESA / EC initiative. **SENTINEL 1** (launched 2014) is a Synthetic Aperture Radar satellite operating at 5.4 GHz, able to operate at 4 modes:

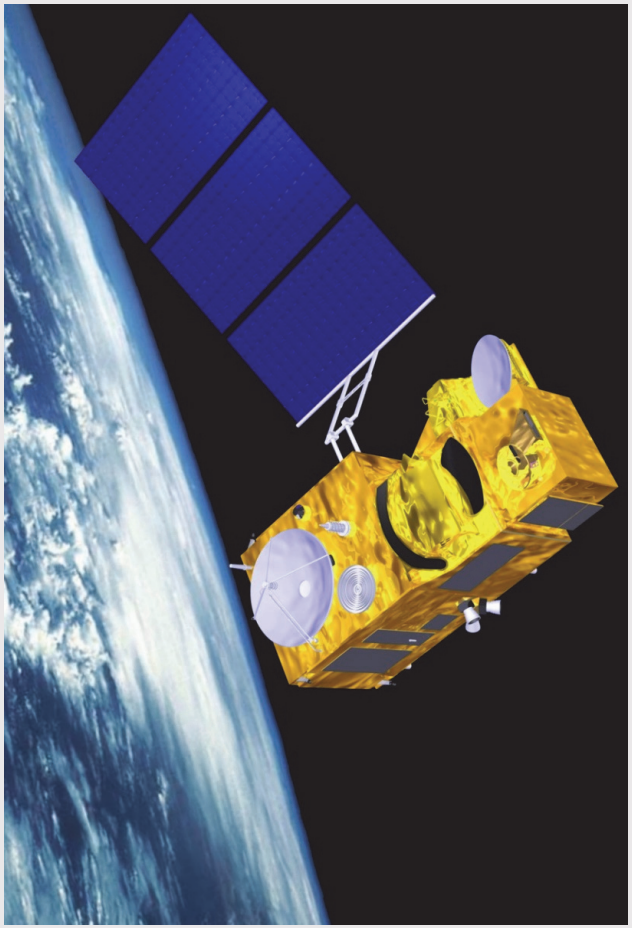


SENTINEL 3 (Copernicus Mission)

SENTINEL 3 is a satellite for observing the ocean but also land surfaces. The main instruments are: a 13.7 GHz / 5 GHz altimeter, a surface temperature radiometer and an ocean and land colour instrument.

Below: Sea Surface Temperature around Corsica

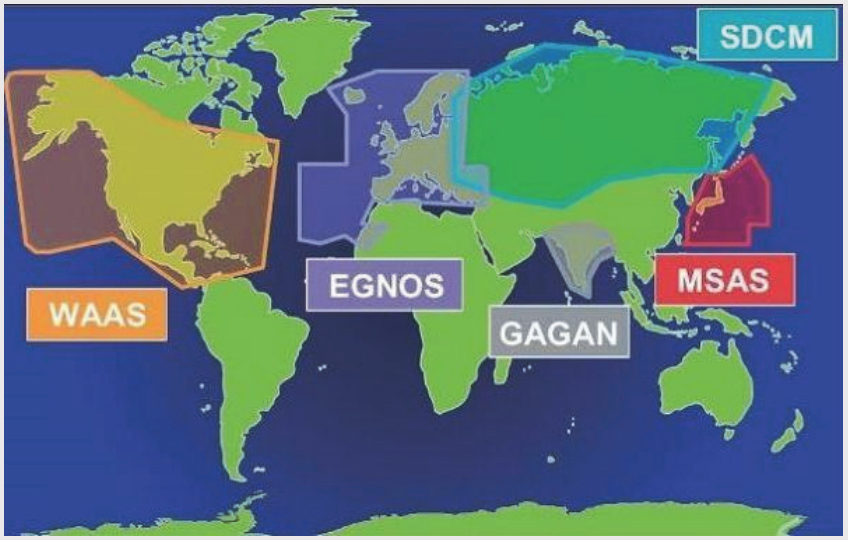




EC Satellite Navigation Missions

EGNOS

EGNOS – The European Geostationary overlay system

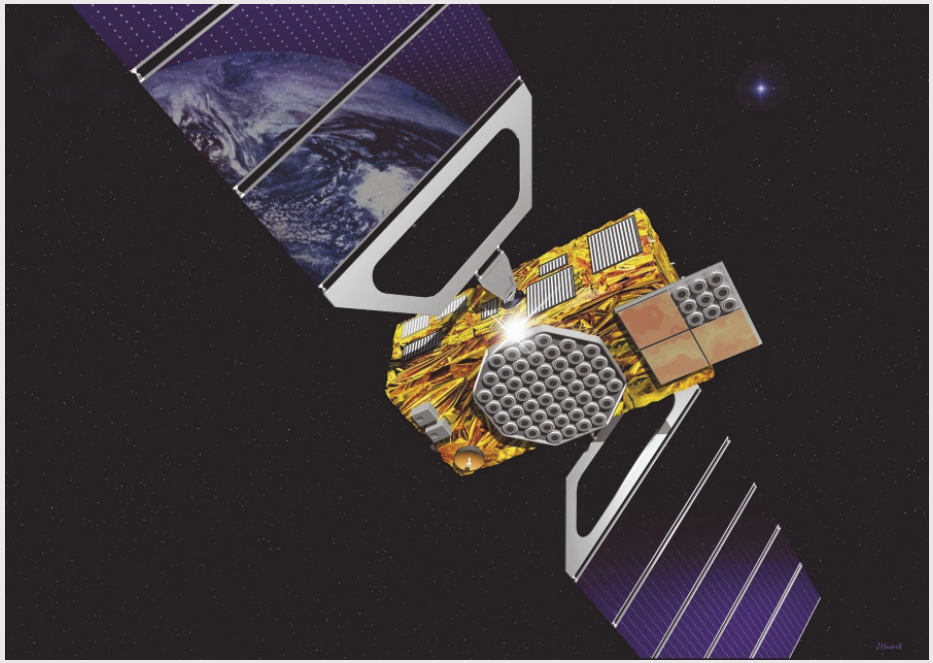


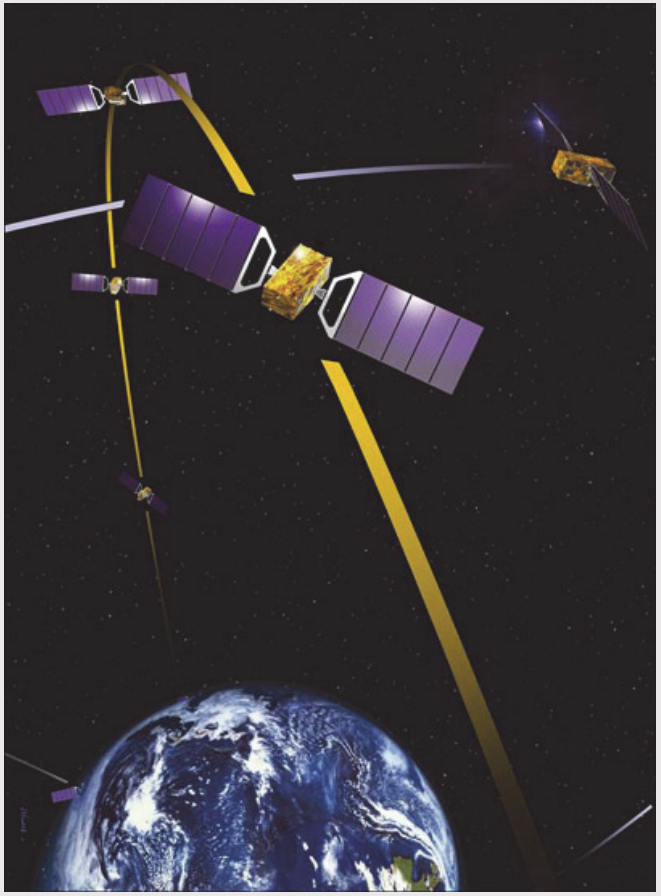
EGNOS is one of the interoperable SBAS systems which can provide **integrity** to satellite navigation for safety-of-life critical applications. Integrity is defined as “Probability of HMI < 10^{-7} Per Approach”

One challenge is the ionosphere which is observed on the ground and transmitted as a 5x5 degree grid.
In order to verify that serious ionospheric storm conditions do not cause “Hazardous Misleading Information” (HMI) , a number of ionospheric scenarios were created and fed into the EGNOS Simulator.

GALILEO: Satellite Navigation (1)

Galileo will provide global positioning service under civilian control. The full Galileo system will consist of 30 satellites and the associated ground infrastructure. Galileo is a joint initiative between ESA and the European Union.





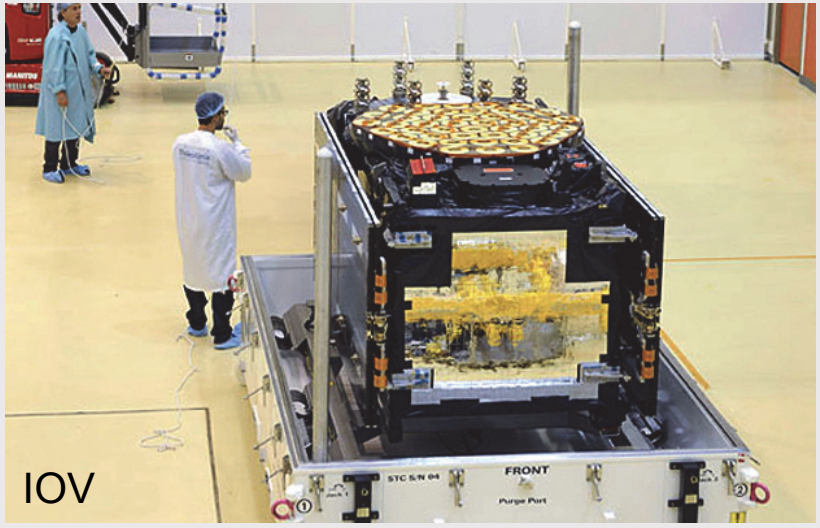
GALILEO: Satellite Navigation (2)

GIOVE-A (2005–) first Galileo test satellite

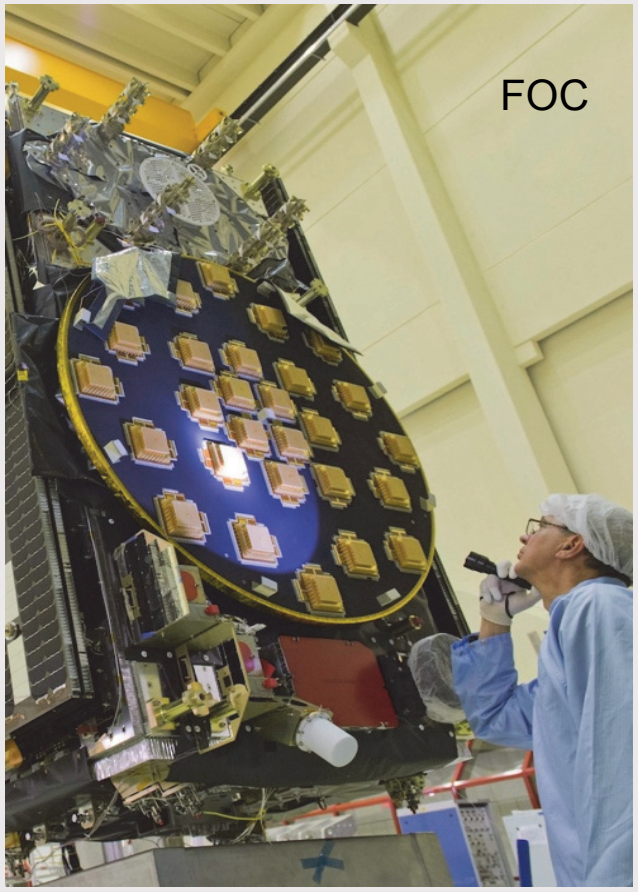
GIOVE-B (2008–) validated the technologies

Galileo IOV (2011/13) In-orbit Validation satellites (2+2 satellites)

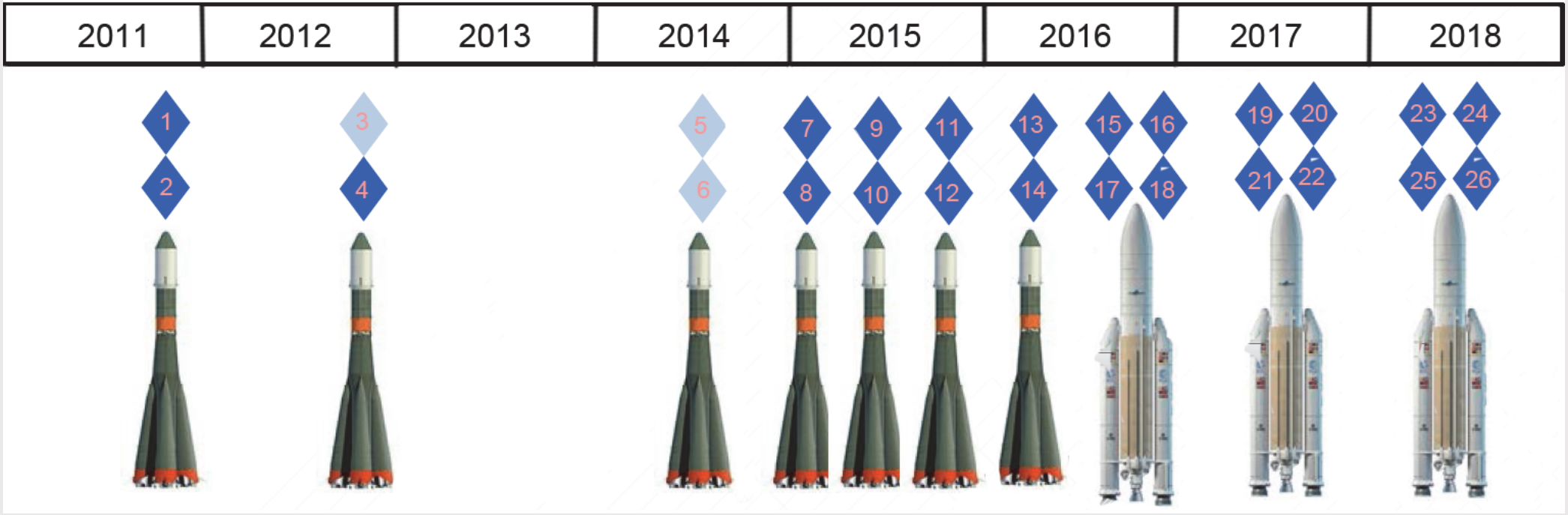
FOC – Full Operational Capability; opening initial services (Open Service, Search & Rescue, Public Regulated Service), 18 satellites, from 2015 onwards.



IOV


FOC

Galileo Launch Schedule



26 Galileo FOC Satellites are to be deployed by mid 2018
Soyuz can launch 2 spacecraft, Ariane 5 can launch 4 spacecraft.

European Commercial Space Ventures

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 national space agencies:

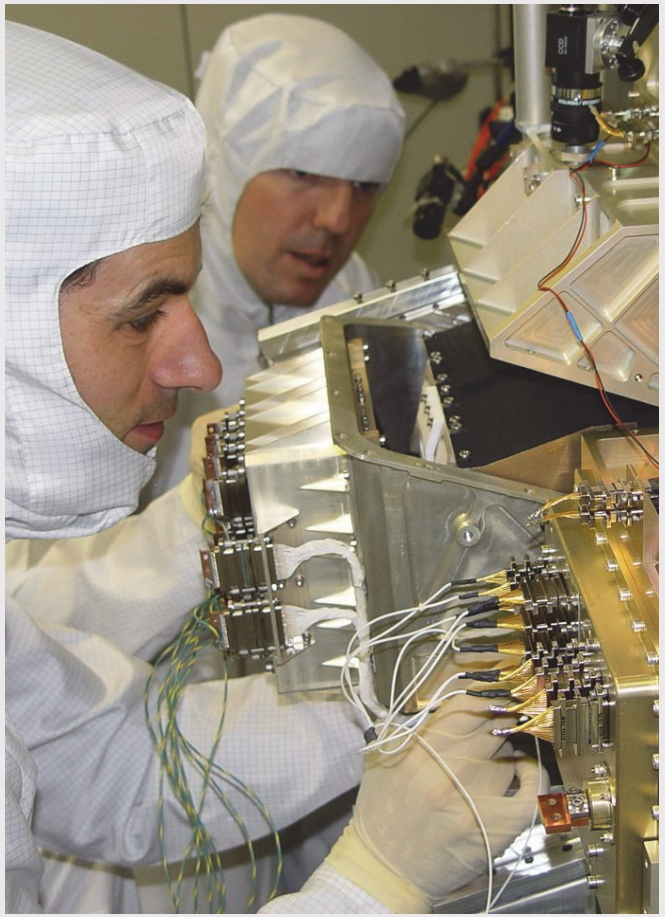
- the European space industry sustains around 35,000 jobs
- Europe is successful in the commercial arena, with a market share of telecom and launch services higher than the fraction of Europe's public spending worldwide
- European scientific communities are world-class and attract international cooperation;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

ESA'S Industrial Policy

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.



Birth of commercial operators

ESA's '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*

Telecomms: *Eutelsat* and *Inmarsat*

European Commercial Use of Space (4 Examples)

EUTELSAT
Was set up as intergovernmental Agency in 1977 and started operating geostationary satellites in 1982.
Since 2001 Eutelsat is a private company. Today Eutelsat is operating a fleet of 38 Satellites providing DTH and government services

SES
Was set up as a private company in Luxembourg in 1985.
SES operates a fleet of 40 satellites providing DTH and government services

INMARSAT
Was set up as intergovernmental Agency in 1976 and privatized in 1999.
Today, Inmarsat operates a fleet of 12 satellites providing global mobile maritime and aeronautical as well as land mobile satellite services

AVANTI
Was set up as a private company in the UK in 2007.
Operates two Ka-band satellites.

CONCLUSIONS

- Europe has, in the span of the last 50 years, made remarkable achievements in space research, space operations, space applications and space technology.
- A good part of these successes are a result of international collaboration.
- Often, space applications are driving innovation and technology development in other sectors (high power, high efficiency, high frequencies)
- Many countries have profited from being member of PECS (Plan for European Cooperating States) before becoming member of ESA

Thank you - hvala !

HRVATSKA SEKCIJA - ODJELI DRUŠTAVA

Zajednički odjel za zrakoplovne elektroničke sustave te geoznanosti i daljinska istraživanja

Interesi članova društva za zrakoplovne elektroničke sustave pokrivaju organizaciju, projektiranje, razvoj, integraciju i rad složenih sustava za različita okruženja poput svemira, te zemljine atmosfere i površine. Takovi sustavi uključuju navigaciju, radar, sonar, telemetriju i daljinsko upravljanje.

Društvo za geoznanosti i daljinska istraživanja pokriva teoriju, razvoj i ostvarenje sustava za motrenje i daljinska istraživanja Zemlje, oceana, atmosfere i svemira, te procesiranje i interpretaciju prikupljenih podataka.

Poziv na predavanje "Space activities in Europe"

16.09.2016. u 19:13

Odjel za teoriju i primjenu mikrovalova (MTT), Odjel za antene i širenje elektromagnetskih valova (APS), Združeni odjel AES i GRS, Odjel komunikacijskih sustava HATZ te Zavod za radiokomunikacije Fakulteta elektrotehnike i računarstva pozivaju vas na predavanje:

Space activities in Europe

koje će održati **Bertram Arbesser-Rastburg**, Senior Advisor, SpaceTec Partners, Austrija/Njemačka.

Predavanje će se održati u **petak 23. rujna 2016. u 10:00 sati** u TCR FER-a (telekonferencijska dvorana), zgrada A – prizemno.

Sažetak predavanja i životopis predavača nalaze se u nastavku obavijesti.

Abstract:

The lecture provides an overview of the key milestones in European exploration and utilization of outer space. It will focus on the collaborative achievements since the 1960s in the areas of telecommunication, earth observation, satellite navigation and space science. A short history of the European Space Agency will be also be presented together with the key programme milestones. The commercial use of space in Europe will be discussed, citing companies such as SES, Eutelsat, Inmarsat and Avanti as examples. Finally the ongoing programmes funded by the European Commission, Copernicus and Galileo are introduced and discussed.

Biography:

Bertram Arbesser-Rastburg studied Electrical Engineering at the Technical University of Graz. In 1983 he joined INTELSAT in Washington, D.C., where he was responsible for propagation experiments in tropical regions. In 1988 he moved to the Netherlands and started working for the European Space Agency where he was initially responsible for planning and implementation of wave propagation studies for all aspects of satellite communication and navigation as well as wave interaction studies for earth observation. In 2007 he was appointed Head of the Electromagnetics & Space Environment Division of ESA, responsible for R&D and project support in the fields of Antennas, Propagation, EMC and Space Environment. From 2007 to 2015 he was also Chairman of ITU-R SG3 (Propagation). He is now a private consultant for space related R&D questions and for R&D management. He is president of the Austrian Institute of Navigation (OVN), Fellow of IEEE, and member of EurAAP, EuMA, URSI, IEICE and ION.

Davor Bonefačić

Popis obavijesti