number 147 | August 2011

bulletin

→ space for europe

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European Space Agency

European Space Agency

The European Space Agency was formed out of, and took over the rights and obligations of, the two earlier European space organisations – the European Space Research Organisation (ESRO) and the European Launcher Development Organisation (ELDO). The Member States are Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Romania, Spain, Sweden, Switzerland and the United Kingdom. Canada is a Cooperating State.

In the words of its Convention: the purpose of the Agency shall be to provide for and to promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space applications systems:

- by elaborating and implementing a long-term European space policy, by recommending space objectives to the Member States, and by concerting the policies of the Member States with respect to other national and international organisations and institutions;
- by elaborating and implementing activities and programmes in the space field;
- by coordinating the European space programme and national programmes, and by integrating the latter progressively and as completely as possible into the European space programme, in particular as regards the development of applications satellites;
- by elaborating and implementing the industrial policy appropriate to its programme and by recommending a coherent industrial policy to the Member States.

The Agency is directed by a Council composed of representatives of the Member States. The Director General is the chief executive of the Agency and its legal representative.

The ESA headquarters are in Paris.

The major establishments of ESA are:

ESTEC, Noordwijk, Netherlands.

ESOC, Darmstadt, Germany.

ESRIN, Frascati, Italy.

ESAC, Madrid, Spain.

Chairman of the Council: D. Williams

Director General: J.-J. Dordain

←

On cover:
A simulated launch campaign at Europe's Spaceport in French Guiana in May saw the first Soyuz rolled out to the launch platform. The Soyuz was raised into the vertical position on the pad in a 'dry run' that validated all the procedures for launch except fuelling of the vehicle. The first flight of a Soyuz from Kourou is set for 20 October

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→ contents

02

12

22

30

44

57

↑

ESA's Giotto spacecraft approaching Comet Halley

→ GIOTTO AND ROSETTA

Twenty-five years of comet science

Stuart Clark and Carl Walker
Communications Department, ESTEC, Noordwijk, The Netherlands

Twenty-five years ago, ESA made its mark in deep space. A small spacecraft swept to within 600 km of Comet Halley. The Giotto probe was nearly destroyed by the encounter, but what it saw changed our picture of comets forever.

As debuts go, it doesn't get any better than Giotto. The spacecraft was ESA's first deep-space mission and the first to perform a close comet flyby. But it also had a number of other very impressive 'firsts' and achievements to its credit.

It was the first mission to change orbit by returning to Earth for a gravity-assist manoeuvre. It was also the first spacecraft to encounter two comets and in doing so measure the composition of those comets. At Halley, it revealed the first evidence of organic material in a comet.

Yet the biggest triumph were the images of Halley itself. During the night of 13–14 March 1986, the first ever close-up images of a comet nucleus were received at ESA's European Space Operations Centre (ESOC) in Darmstadt, Germany.

"It may sound simple to say that but the picture was the best thing, the moment you saw it, it was tremendous," remembers Gerhard Schwehm, Giotto's former Deputy Project Scientist.

↑ Comet Halley's nucleus as seen by Giotto from a distance of around 600 km (Halley MCT/ESA)

↑

ESA's Gerhard Schwehm, then Giotto's Deputy Project Scientist, at his mission control console during the night of 13 March 1986

The image sequence taken by Giotto's Halley Multicolour Camera revealed a black, potato-shaped object, partially illuminated on the warmer, sunlit side with bright jets spewing gas and dust into space.

"It was a once-in-a-lifetime event and it had a big impact on the general public," says Gerhard. The scientific harvest from Giotto changed our perception of comets. By measuring its composition, Giotto confirmed Halley as a primitive remnant of the Solar System, billions of years old. It detected complex molecules locked in Halley's ices that could have provided the chemical building blocks of life on Earth.

"Giotto ignited the planetary science community in Europe – we had demonstrated that we could successfully lead demanding missions – and people started thinking about what else we could do," says Gerhard.

Twenty-five years later, the torch of comet science has been handed over to Rosetta, ESA's latest comet-chaser. In July last year, Rosetta flew by asteroid Lutetia and broke a record when it reached 400 million km from the Sun, becoming the most distant spacecraft ever to operate on solar power alone. But this June marks one of the most dramatic and distant stages of the probe's 10-year journey. At an ever-increasing distance from the Sun, the sunlight is even weaker and Rosetta's solar panels cannot produce enough electricity to power the probe fully.

> **"Comets are the unused 'building blocks' that missed out on forming the planets"**

→ Why are comets special?

Comets are the most primitive objects in the Solar System. Many scientists think that they have kept a record of the physical and chemical processes that occurred during the early stages of the evolution of our Sun and Solar System. What makes comets particularly important and extraordinary objects is the abundance of volatile materials.

This characteristic demonstrates that comets were formed at large distances from the Sun and have been preserved at low temperatures since their formation. Cometary material therefore represents the closest we can get to the conditions that occurred when the Sun and our Solar System were born.

Our knowledge of comets and asteroids has dramatically improved over the last 20 years. The major milestones were undoubtedly the first flybys of Comet Halley by Giotto and the Russian Vega probes in 1986. In 1991, NASA's Galileo spacecraft made the first near encounter with a main-belt asteroid, Gaspra, on its way to Jupiter.

More recently, NASA's Stardust spacecraft returned grains from a comet to Earth for the first time, and the NEAR spacecraft orbited asteroid Eros and eventually landed on it. JAXA's Hayabusa made contact with an asteroid (gently touching, not actually landing) in 2005 and collected samples which were returned to Earth in June last year. NASA's latest mission, Dawn, has started exploring the two largest members of the asteroid belt - Vesta and the dwarf planet Ceres - with major European cooperation.

During the same period, telescope observations from the ground and Earth orbit (for example, ESA/NASA SOHO and Hubble Space Telescope) have increased. They form the basis for understanding these small bodies, since we can now compare observations of a very large variety of objects, and can undertake wider investigations of cometary activity.

It was thought that asteroids and comets could be the same type of object, just in different stages of evolution. Indeed, the outermost asteroids show similarities with the cometary nuclei observed far from the Sun. The most distant 'asteroid', Chiron, whose orbit is outside that of Saturn, is considered to be a giant cometary nucleus. Furthermore, short-period comets (comets with smaller and faster orbits) should ultimately evolve into asteroids after the depletion of their volatile components.

However, from this wealth of new information, it is quite clear that there is a distinction between asteroids and comets; but surely there are 'burned out' (no longer active) comets among the asteroids. A better understanding of the relationship between asteroids and comets throughout the Solar System is thus an essential step in unravelling the first stages of the formation of our Sun and its neighbourhood.

ESA's Rosetta mission has been designed specifically to make investigations actually on and around a comet itself. Rosetta's lander, Philae, will provide information on the chemical and physical properties of a selected area of comet surface, while the main spacecraft will perform sophisticated analyses on the dust grains and the gas flowing out from the nucleus. The Rosetta orbiter will remain for most of the mission within a few tens of kilometres of the nucleus, where the analysed dust and gas is likely to be very similar to the surface material, and where it can be traced back to specific active regions on the comet surface. The physics of the outer coma and the interaction with the solar wind will also be studied.

"Rosetta is getting farther from the Sun, and soon there isn't going to be enough sunlight to power its systems, and hibernation is a necessary step to reach the final target," says Paolo Ferri, Head of ESOC's Solar and Planetary Mission Operations Division.

Ground controllers at ESOC issued the final command to switch Rosetta into 'hibernation' mode, triggering the last steps in the shutdown of the spacecraft, turning off almost all flight control systems including telecommunications and attitude control.

The probe will now coast unattended for 31 months, through millions of kilometres of cold deep space, with only its computer and several heaters active. These will be controlled automatically to make sure that the whole spacecraft does not freeze when its orbit takes it to 790 million km away from the Sun and back.

"We've planned for hibernation for some time, and it's a complex phase of the mission," says Andrea Accomazzo, Spacecraft Operations Manager at ESOC.

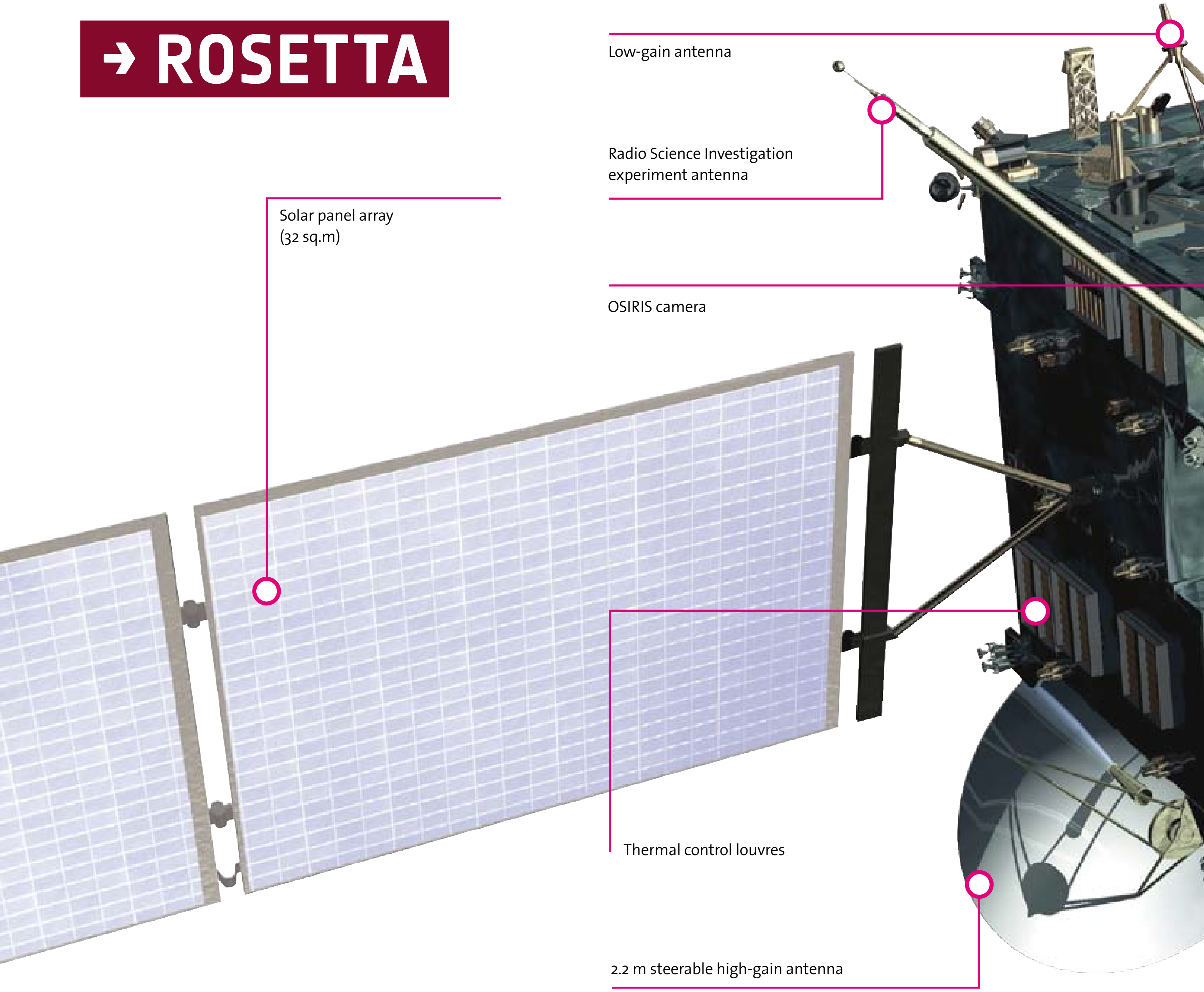
↑ Launched on an Ariane 5 in 2004, Rosetta will rendezvous with Comet 67P/Churyumov-Gerasimenko in 2014 and release a lander onto its icy surface (ESA/CNES/Arianespace-Service Optique CSG)

"Still, for the flight control team, it's an emotional moment. We're essentially turning the spacecraft off. We're already looking forward to January 2014 when it wakes up and we get our spacecraft back."

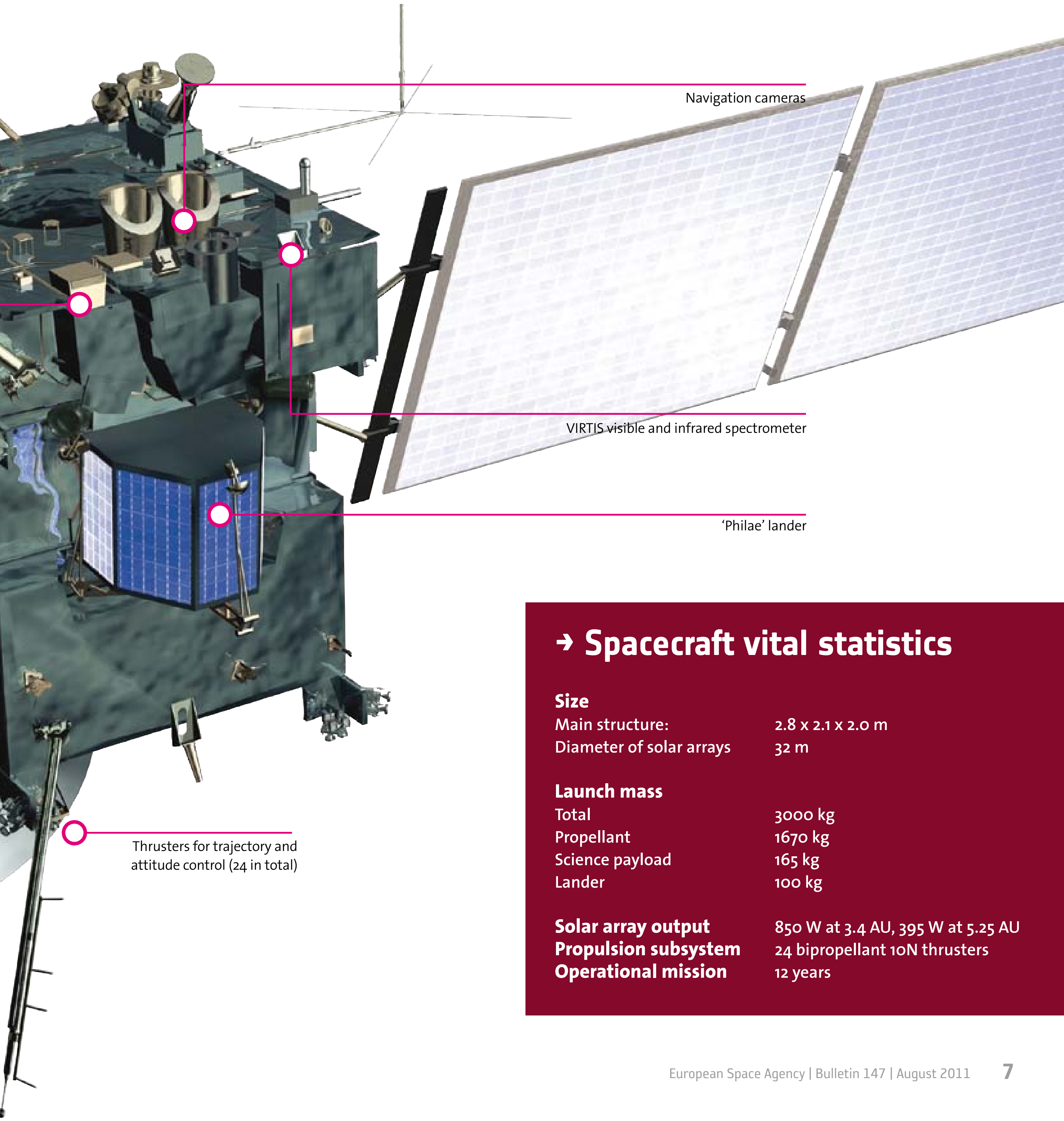
And they will, at precisely 10:00 GMT on 20 January 2014. A computer timer will wake the spacecraft, which will transmit a check signal seven hours later to let mission controllers know it has woken. Just as Giotto awoke 25 years ago, so will Rosetta, providing answers possibly to one of today's most interesting questions of science: did comets bring water and the chemicals necessary for life to Earth? ■

↑ Once Rosetta is aligned correctly, the Philae lander will eject from the orbiter and unfold its three legs, ready for a gentle touchdown

→ ROSETTA



after a ballistic descent. Immediately after touchdown, a harpoon is fired to anchor Philae to the ground and prevent it escaping from the comet's extremely weak gravity. Surface operations are planned to last for one week, but may continue over many months



→ Spacecraft vital statistics

Size

Main structure:	2.8 x 2.1 x 2.0 m
Diameter of solar arrays	32 m

Launch mass

Total	3000 kg
Propellant	1670 kg
Science payload	165 kg
Lander	100 kg

Solar array output	850 W at 3.4 AU, 395 W at 5.25 AU
Propulsion subsystem	24 bipropellant 10N thrusters
Operational mission	12 years

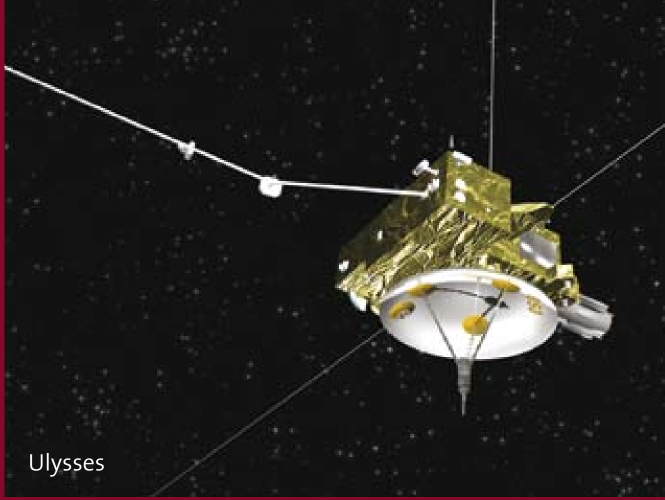
→ Where are they now?

Since the beginning of the Space Age, the world's space agencies including ESA have sent many other pioneering probes besides Giotto and Rosetta into the far reaches of the Solar System – and some are still going.

Giotto was finally switched off for the last time in 1992, after taking important observations of Comet Grigg-Skjellerup. In 1999, it made another Earth flyby but was not reactivated. Although it is possible that it may encounter Earth again, it will most likely cruise the Solar System forever.

More than 30 years after they left Earth, NASA's twin Voyager probes are now at the edge of the Solar System. Not only that, they're still working. On 13 December 2010, it was confirmed that Voyager 1 had passed the reach of the solar wind emanating from the Sun, effectively leaving our Solar System and entering interstellar space.

↑ Earth and the Moon in a single frame, the first image of its kind from a spacecraft, taken on 18 September 1977 by Voyager 1 when it was 11.6 million km from Earth (NASA)



Ulysses

After over 17 years of operation, the ESA/NASA Ulysses mission was officially ended in 2009. The spacecraft, which studied the Sun and its effect on the surrounding space for almost four times its expected lifespan, is now in an endless polar orbit around the Sun.

When scientific satellites reach the end of their mission and experts turn off all their instruments, some satellites will float on silently through the eerie darkness of space, but those in lower orbits will gradually lose altitude and fall through Earth's atmosphere to be burned up on reentry.

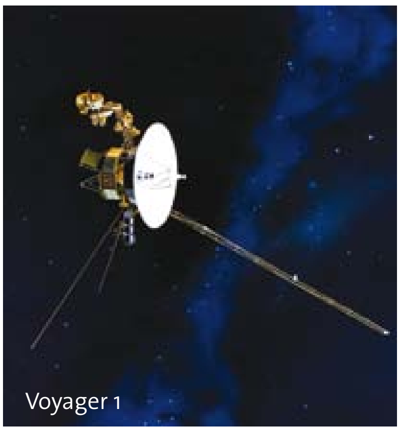
ESA's Infrared Space Observatory (ISO) gave astronomers a view of the cool and hidden Universe for three years, but it is expected to reenter Earth's atmosphere in 2014. On the other hand, Hipparcos will have to 'wait' around another 2500 years or so before it comes to its fiery end. Hipparcos pinpointed about 120 000 stars with astonishing accuracy during its lifetime from 1989 to 1993.

Originally intended to live for just three years, the International Ultraviolet Explorer (IUE), soldiered on for far longer. It carried on receiving ultraviolet light from objects, such as comets, stars and supernovae, for more than 18 years. This makes it one of the most productive satellites in the history of space astronomy. Scientists finally turned off IUE in 1996, but it will fly on in a high orbit for millions of years to come.

Helios 2

- **Fastest man-made object**
  Helios 2, the joint US/German solar probe, achieved a speed of over 250 000 km/h flying around the Sun in 1976.

- **Farthest man-made object from Earth**
  NASA's Voyager 1 is about 17 billion km from our Sun and will not be overtaken by any other



Voyager 1

spacecraft yet launched. It is estimated that both Voyagers 1 and 2 have sufficient electrical power to operate their radio transmitters until at least 2025, almost 50 years after launch.

- **Oldest surviving artificial satellite**
  NASA's Vanguard 1, launched in 1958, continues to orbit over 50 years later, just as it

Pioneer 6

↑ ISO at ESTEC in 1995

None of these ‘ghost’ satellites pose a threat to other space missions, since they are moving around Earth in relatively uncluttered high orbits. ESA’s European Space Operations Centre in Germany continues to monitor where these satellites are, and the possibility of a collision is very remote.

ESA archives all the data gathered by its missions, and these data are in constant demand from scientists all over the world. For example, Giotto’s comet flybys provided ESA scientists with invaluable experience for the Rosetta mission.

So although many of our satellites are destined to wander through the never-ending expanse of space, the information they supplied during their golden years still continues to help us here on Earth.

→ ESA extends science missions

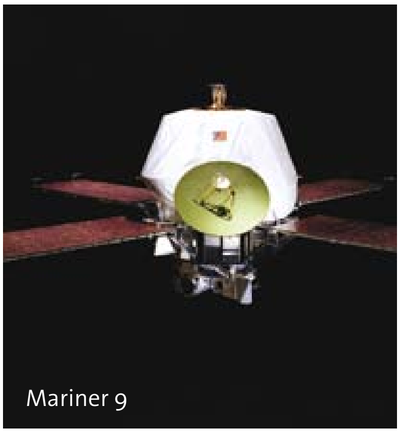
In 2010, ESA extended the productive lives of 11 of its currently operating space science missions, all of them working beyond their planned lifetimes, and all of them still delivering exceptional science. These world-class science missions will continue returning pioneering results until at least 2014.

“Their longevity is a testament to the care with which the industrial teams built these satellites, the expert way the project teams operate them, and the ingenuity of the scientists who keep thinking of new and valuable science investigations to make with them,” says Martin Kessler, Head of ESA’s Science Operations Department.

→ Hipparcos during testing in ESTEC’s Large Space Simulator in 1988

has done since the dawn of the Space Age. In a high orbit that promises to be stable for centuries, it has outlived most of the human beings who created it.

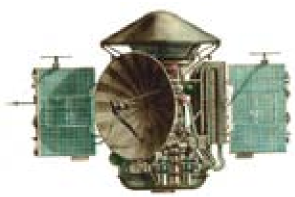
Oldest functioning spaceprobe
NASA’s Pioneer 6, launched in 1965 and now in solar orbit, was still operating after its 35th anniversary in 2000.



Mariner 9

First spacecraft to orbit another world
Arriving at Mars on 13 November 1971, NASA’s Mariner 9 became the first space probe to go into orbit around another planet.

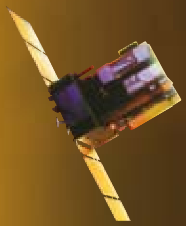
First spacecraft to land on Mars
The first probes to impact and land on Mars were the Soviet Union’s Mars 2 and Mars 3 landers on 27 November and 2 December 1971.



→ WHERE ARE THEY NOW?

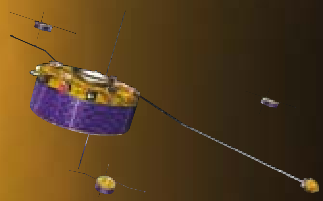
Venus Express

- **ESA's first probe to Venus**
  Collecting data on the complex dynamics and chemistry of the venusian atmosphere. Mission extended until at least 2014.



SOHO

- **Monitoring the stormy Sun**
  A joint ESA/NASA mission to study the Sun, from its deep core to the outer corona, and the solar wind. Mission extended until at least 2014.

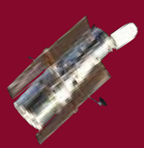


Cluster

- **Measuring our magnetic shield**
  Four spacecraft flying in formation, studying how the solar wind affects Earth. Mission extended until at least 2014.

→ Looking out into the Universe

Hubble



Expanding frontiers of the visible Universe
The NASA/ESA Hubble Space Telescope looks deep into space with cameras that cover the ultraviolet, optical and near-infrared parts of the spectrum.

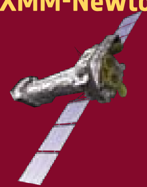
Planck

ESA's microwave observatory
The first European space observatory to study the Cosmic Microwave Background (CMB) – the relic radiation from the Big Bang.

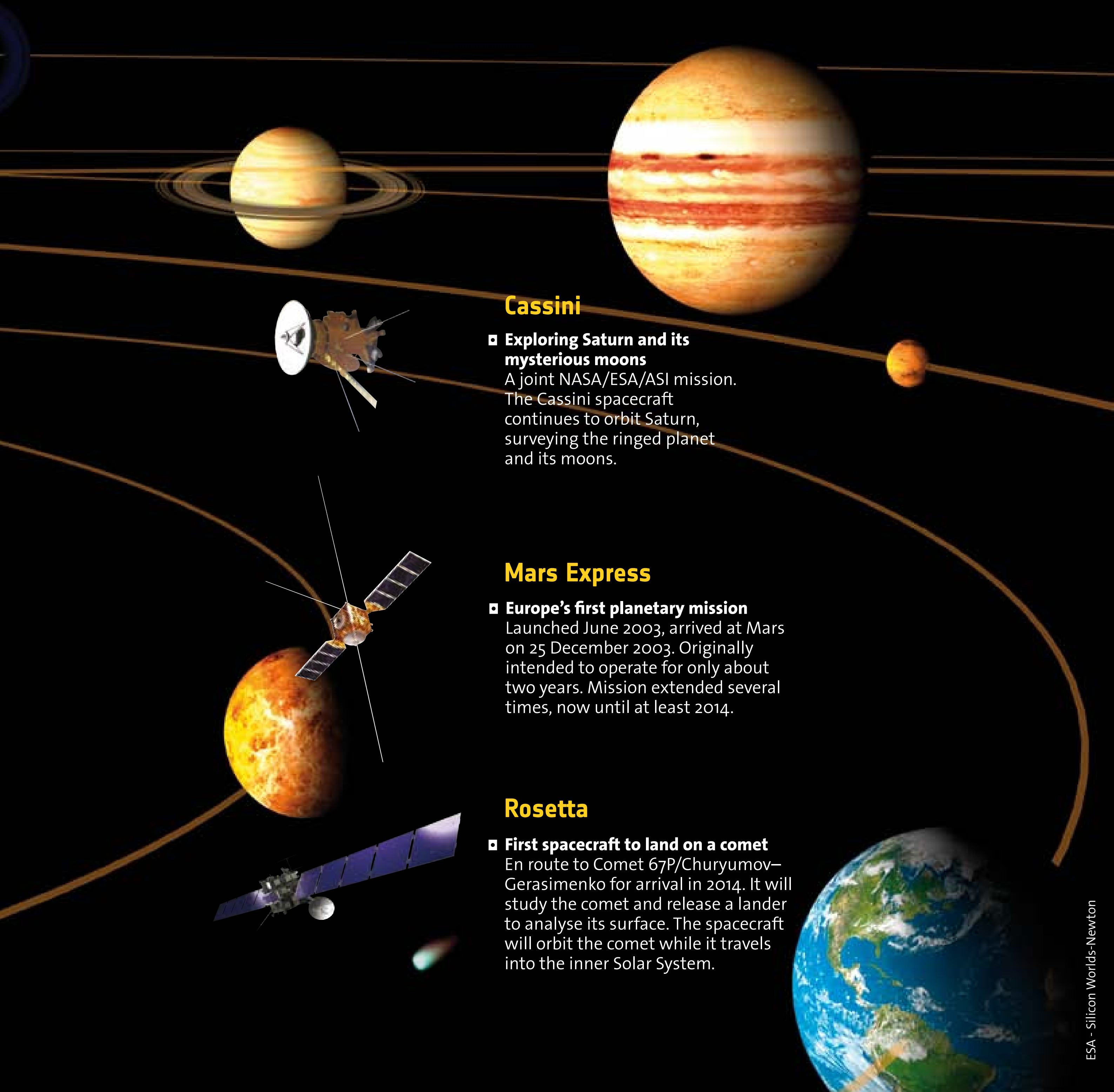
Herschel

ESA's giant infrared observatory
The largest, most powerful infrared telescope ever flown in space. Studying the origin and evolution of stars and galaxies to help understand how the Universe came to be the way it is today.

XMM-Newton



Detecting the Universe's hot spots
Increasing our knowledge of extremely high-energy objects created when the Universe was very young, helping solve many mysteries, ranging from black holes to the formation of galaxies.



ESA - Silicon Worlds-Newton

Cassini

- **Exploring Saturn and its mysterious moons**
  A joint NASA/ESA/ASI mission. The Cassini spacecraft continues to orbit Saturn, surveying the ringed planet and its moons.

Mars Express

- **Europe's first planetary mission**
  Launched June 2003, arrived at Mars on 25 December 2003. Originally intended to operate for only about two years. Mission extended several times, now until at least 2014.

Rosetta

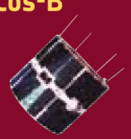
- **First spacecraft to land on a comet**
  En route to Comet 67P/Churyumov–Gerasimenko for arrival in 2014. It will study the comet and release a lander to analyse its surface. The spacecraft will orbit the comet while it travels into the inner Solar System.

Integral

Tracking extreme radiation across the Universe
The first space observatory that can simultaneously observe objects in gamma rays, X-rays, and visible light.

→ More pioneering missions

Cos-B



ESA's first scientific satellite
ESA's first satellite dedicated to a single experiment, to study sources of extraterrestrial gamma radiation. Originally only expected to operate for only two years, Cos-B functioned for over six years. Now in high geosynchronous orbit over the Atlantic Ocean.

IUE

One of ESA's longest-lived satellites
International Ultraviolet Explorer: An ESA/NASA/UK project, the first astronomical satellite in high Earth orbit. Launched in 1978, it had 18.7 years of uninterrupted orbital operations.

Huygens

Farthest landing from Earth ever made
Released by Cassini, ESA's probe made the most distant landing, the first ever in the outer Solar System, on Titan on 14 January 2005, a distance of about 1.2 billion km from Earth.

The advanced cockpit of the Airbus A380 features the latest interactive displays and avionics. Satellite telecommunications will be an integral part of the new European air traffic management system for safety communications in most phases of flights (Airbus/exm company/H. Goussé)

→ SAFE SKIES

Iris: satellite communication for air traffic management

Nathalie Ricard
Directorate of Telecommunications & Integrated Applications
ESTEC, Noordwijk, The Netherlands

On busy days, more than 33 000 flights are being controlled in European airspace, and the numbers are only expected to increase. By 2020, the number of yearly controlled flights is estimated to reach 17 million.

But while flights have increased, the way air traffic is managed has not progressed as swiftly. Communications between pilots and air traffic controllers are still mostly passed by voice over VHF or HF radio, which has been in use since the 1950s. Initial limited datalink services are starting to be introduced for safety communications with technology developed in the 1980s.

Management of European air traffic has not yet been fully integrated. In fact, Europe's air traffic management (ATM) system is organised on the basis of more than 60 different sectors, all controlled individually.

SESAR

In recognising the need to modernise Europe's ATM, the European Commission (EC) initiated the Single European Sky (SES) Policy. Part of the policy includes its technological pillar – the Single European Sky ATM Research Programme (SESAR). SESAR aims to develop a high-performance ATM system to enable the safe and environmentally friendly development of air transport.

Through the planned improvements, SESAR has an objective to save between 8 and 14 minutes per flight, as well as, up to 500 kg of fuel and up to 1575 kg of CO_2 on average. SESAR plans also to reduce the ATM-related cost by half.

Since 2007, a Joint Undertaking (SJU) manages the SESAR programme. The SJU, with Eurocontrol and the European Union as founding members, is funded one third by the EC, one third by Eurocontrol and one third from its members (industry, air navigation service providers and airports) with a budget of €2.1 billion. Fifteen members from the ATM industry have become members of the SJU. It coordinates and concentrates all relevant research and development, and is the design authority for the new European ATM System (EATMS). The SJU maintains the ATM master plan and the SESAR work programme.

In 2008, the value of satellite communications in the new ATM scheme was recognised through its inclusion in the ATM master plan. ESA played a large role in this recognition through its Iris Programme. ESA initiated Iris in 2007 as a means to support the adoption of satellite-based communications in the SESAR programme. It demonstrated the interest and feasibility of a satellite-based communication system to meet aviation's requirements.

With the inclusion of satcoms in the ATM master plan, a unique window of opportunity has been opened to develop a space-based solution to improve the safety of the European sky for citizens and benefit the European economy. Considering that any technology for aviation safety is expected to have a lifetime compatible with that of commercial aircraft, SESAR represents a once-in-a-century opportunity to introduce satellite-based communications in ATM.

> **“A unique window of opportunity has been opened to develop a space-based solution to improve the safety of the European sky for citizens and benefit the European economy”**

While satellite communications on board aircraft have been used for passenger communications for many years, they are not allowed as a primary means of communication for safety. What is fundamentally new with the concept of operations developed by SESAR is that it uses satellite communications as an integral part of the new European ATM system for safety communications, and in most phases of flights. Aircraft will be able to communicate while en route at cruising altitude, but also during take-off and landing, and while manoeuvering close to airports. This is fundamentally different from today's use of satellite communications and was – until now – not guaranteed with existing technology.

ESA is now implementing the design phase of the Iris programme with the support of the EC, SJU, Eurocontrol, the European space industry, air navigation service providers and aviation stakeholders.

↑ New air-ground links will provide more capacity and higher performance, and include a 'dedicated airport segment' connecting aircraft and ground systems while aircraft are at the airport

→ Northern flights

Air traffic is increasing over polar regions. However, reception of signals from geostationary satellites is poor in these areas. To overcome this problem, the satellite system being designed in Iris opens the possibility to use the same communication protocols on satellites in highly elliptical orbits (HEO), which would complement geostationary satellites. Such a satellite constellation would provide good coverage of Arctic polar regions and could carry payloads for ATM communications. Projects of HEO constellations are being studied in Russia and Canada.

New digital communications to increase air traffic efficiency

Provisions for the growth of air traffic and for the need of cost-reduction are driving aviation to adopt new digital communication technologies for the exchange of data between aircraft and ground control. A new concept of operation will be relying on the implementation of new features for aviation safety. One of the main elements of the ATM concept, known as '4D trajectory management' will manage flights more efficiently, and provide better integration of aircraft in the ATM system. Other major pillars of the concept include the principle of system-wide information management and automation increase.

New air–ground links will be required to provide more capacity and higher performance. The design of these links, together with the necessary business case, will be assessed and their use validated during the development phase of SESAR. Since data communication exchanges will become critical to maintaining efficient operations, the service will need to be constantly available. The technology therefore needs to be resilient, and the best way to guarantee this resilience is to have several independent communication means operating simultaneously.

Three new wireless communication technologies for air–ground links are therefore being developed within the SESAR programme:

- a 'ground-based segment' using line-of-sight connections between aircraft and ground stations and between aircraft, which will be used in continental airspace;
- a 'satellite-based segment' connecting aircraft and ground systems through a satellite infrastructure, which will complement the 'ground-based segment' in continental airspace and be used as primary means of communication in oceanic and remote airspace;
- a 'dedicated airport segment' based on WiMax standards, which is connecting aircraft and ground systems while aircraft are at the airport.

In continental airspace, the new satellite communication system will be used together with the new ground-based system. Since these two technologies have no common point of failure, the service will be constantly available by using at least one of the links. Satellite communications will be needed for datalink in continental airspace, both in high-density airspace and in remote areas, as well as being foreseen to become the primary means of voice and datalink communications in oceanic airspace.

Once SESAR confirms this approach and recommends the deployment of the technology, implementation of these links for operational use will take place from 2018 onwards, depending on the maturity of the technology. In order to introduce new datalink applications that would improve air traffic flow for all, it can be expected that the use of datalink services would be mandated for all aircraft flying under Instrument Flight Rules.

> **"SESAR represents a once-in-a-century opportunity to introduce satellite-based communications in ATM"**

Iris: a collaborative endeavour

Iris is a new type of initiative for ESA in which the space component is just an element in a much bigger system, and where ESA has to adapt to the schedule and constraints of a much wider initiative and a variety of stakeholders.

While SESAR is federating aviation stakeholders in the SJU, Iris is supporting and federating the European satellite industry to provide the most efficient space-based solution. The collaboration between ESA and the SJU is based on a clear definition of work packages and their interfaces, both technical and managerial. ESA's approach is to ensure that most of its research and development funding goes toward the space industry, which ESA is meant to support.

At the technical level, Iris requires innovative developments to meet the stringent performance requirements of future ATM safety communications on the one hand, and the business requirements of the airlines on the other. The former requires a very robust communication system and specific design to guarantee service availability in all flight conditions and on a 24/7 basis.

The latter requires drastically reducing the overall cost of ownership of the aircraft terminals when compared to today's most advanced satellite communication technology. An important issue to consider is that airlines would request that safety equipment does not require frequent exchange or major modifications during the aircraft's operational lifetime, which is, on average, about 30 years.

The Iris programme covers the technical effort but also all the institutional coordination effort necessary to assure that the system fully meets users' expectations. While it is part of the SESAR programme to standardise technology and to define the path towards service deployment for the new datalinks, for all matters concerning the satellite communication component, the Iris programme has to provide the necessary technical inputs and coordination support to the SESAR Joint Undertaking.

Since the inception of Iris, ESA has involved the best competences in the aviation, telecom research and industrial communities to make sure that the lessons of the past are applied and that a wide community participates and shares the decisions to be taken. Taking full account of the lessons learnt of previous programmes, Iris involves future users

→ Data are generated by a large number of users at unpredictable times, in messages that are infrequent and very short, but their timely delivery and integrity are critical (Eurocontrol)

← SESAR will bring the benefits of innovative technology to improve air–ground exchanges within European airspace (Eurocontrol)

in consolidating technical requirements, and the European Aviation Safety Agency (EASA) in clarifying requirements for the certification process.

It is the first time that a communication system is intrinsically conceived to be made immediately available all across Europe once deployed. The space component is just one element among the technologies foreseen in SESAR. However, since space systems cannot be 'test-flown', and are pan-European by nature, the deployment of satellite communication services leads to more complex issues than for systems deployed on a national basis, notably in terms of governance of the service provision.

Taking due account of this complexity, ESA is carrying out analyses of the business case with several potential future service providers, analyses of options for future ownership and service governance with SJU and the EC, and analyses of options for liability schemes with legal experts.

Because the aviation world operates on a global basis, any new ATM solution must be supported and coordinated on a worldwide basis. ESA's objective is to help the aviation authorities to deploy a globally valid solution that can be implemented in a modular way, supplied and operated by different parties. As a public institution, ESA sponsors the development of a truly open standard, fully in line with the Intellectual Property Rights rules of the International Civil Aviation Organization (ICAO), to promote a larger diffusion of space-based services than the quasi-proprietary and incompatible standards that are available in aviation today.

Standardisation at the level of ICAO requires coordination with the international stakeholders leading to support for this new standard. It will ensure afterwards that various world regions can deploy their own compatible satellite system infrastructure to allow aircraft to operate worldwide with the very same communication equipment.

Through ICAO standardisation, Iris will promote a European-developed standard and the associated technology on the worldwide market. A decision to deploy the satcom component developed in the Iris programme will exploit a 'first-mover' advantage for Europe: SESAR will bring the benefits of innovative technology to improve air–ground exchanges within European airspace.

Innovative technology at low cost to airspace users

Overall, the system designed within the Iris programme has to address:

- development of technical specifications for a new satellite communication standard;
- design of the user terminals to be installed on board aircraft and of the satellite system infrastructure for service provision in European airspace;
- design and procurement of the validation infrastructure required.

Design of the satellite system started in 2009, after two yeas of feasibility analyses. Most of the technical challenges revolve around designing appropriate communication protocols that guarantee integrity of the information exchanged while serving all aircraft simultaneously and maintaining the delay and reliability requirements.

A major element to dimension the system is the maximum data traffic generated by all aircraft flying simultaneously at any peak time within the service coverage of the satellite system. This data traffic determines the bandwidth and the spectrum required by the system, and a map of its geographical repartition is required to optimise the satellite beam sizing. Considering the geography of European air traffic flow, the highest density of air traffic is currently confined within a small geographical area between London, Paris, Frankfurt and Amsterdam.

Overall, technical challenges originate from the fact that data are generated by a large number of users at unpredictable times, that messages are infrequent and very short, and that their timely delivery and their integrity is critical. This is a very different set of characteristics than what most communication systems deliver (notably internet access or telephony for passenger communications), and this requires developing very specific communication protocols. As the exact characteristics of individual messages for new SESAR concept elements (e.g. 4D trajectory management)

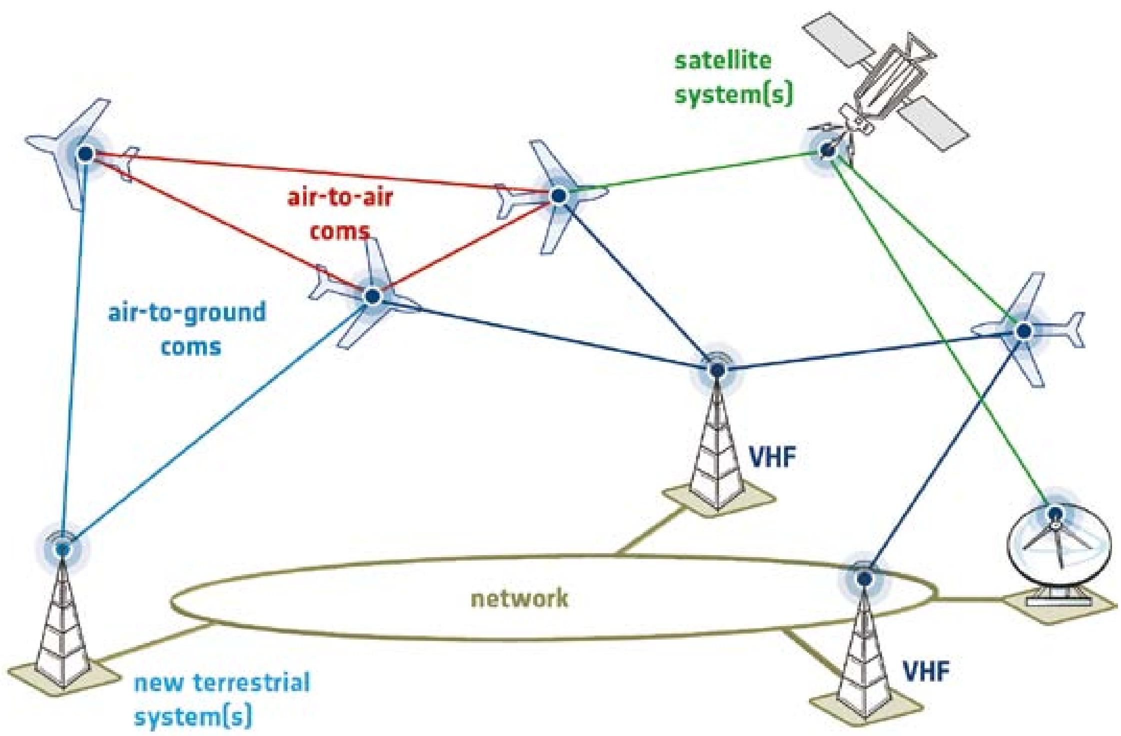
← The use of satellites for ATM safety and communications will be a major confirmation of the value of space as a means to benefit European citizens

are currently under definition by the SESAR Programme, the design also needs to be sufficiently flexible to accommodate new types of messages to be introduced in the future.

The design of aircraft user terminals is focusing on ensuring low cost. This includes procurement, installation, operations, maintenance and communication services prices. The aircraft antenna should be small and low cost, with minimal antenna drag like today's VHF antenna, as opposed to antenna used for broadband satellite communications for passengers, which are large, expensive and require more power. The location of antenna on the aircraft fuselage and the location of indoor units are being looked at on-board different aircraft types.

The aim is to minimise the cost of installing or retrofitting equipment, and to ensure continuous availability of the communication link even when the aircraft is manoeuvring.

User terminals are being given the central role in the system design and every system-level design trade-off decision is taken in view of reducing avionics equipment and service cost. From a technology development perspective, the main enabler is a High Power Amplifier technology with high efficiency gains and low power consumption so that forced air-cooling of the indoor unit can be avoided. This will allow installing terminals on many different aircraft types, and would guarantee that they are still usable in emergency conditions where onboard power is limited.



← A future communication infrastructure using Iris (Eurocontrol)

← The design of aircraft user terminals and location of antennas on aircraft fuselages are being looked at: antennas should be small and low cost, with minimal drag like today's VHF antennas

Aviation requirements for using a low-cost terminal moved the system complexity towards the space segment. The system relies on a satellite located in geostationary orbit, with necessary redundancies and spares.

The design and sizing of the satellite payload is a consequence of the maximum transmission rate from aircraft towards the satellite, which defines the size of the satellite antenna, and the number of simultaneous users coupled with the transmission rate from user terminals towards the satellite. Because there might be a need to have several service providers, the system has been designed with the capability to fragment the payload resources among several competitors. Because the service model has not been defined yet, the design has to cater for every option: there might be a single entity procuring the satellite communication system, but there might be competitive providers too, each with their own ground Earth station(s) anywhere within the service coverage area.

Two alternative approaches

Following a request from the European Commission, ESA split activities between those relative to the design of the system, and activities relative to operation/service provision. A system design study, called ANTARES (AeroNauTicAl REsources Satellite-based), defines a purpose-built system, while three competitive studies are preparing potential operators and service providers for future service provision. As an alternative approach, Iris also includes studies of adapting Inmarsat's SwiftBroadband system for provision of a safety service (called SwiftBroadband-Safety). The main difference between these two approaches lies with the business model and the system's governance.

Some crucial issues, of a non-technical nature, also need to be clarified for aviation to move ahead. These are, for example, long-term availability of the service, ability

→ On-going Iris studies

ANTARES
This Phase-B system design study involves 23 companies of the telecom and aerospace industries. ANTARES assumes that a purpose-built dedicated system is required for ATM communications. The study is defining the specifications of the telecommunication system, developing a testbed, designing the infrastructure required and developing prototypes of aircraft terminals.

THAUMAS
This study defines the modifications to Inmarsat SwiftBroadband that would be needed for the new datalink services defined by SESAR.

HERMES, OPERA and SIRIO
These three studies are carried out in parallel by industrial teams including communication service providers, satellite operators and air navigation service providers. Each study defines the satellite operation of the ANTARES system and analyses the business case for ATM safety communications via satellite.

The ATM Satcom Safety Board, chaired by the European Aviation Safety Agency (EASA) has been created to advise ESA and facilitate the future certification. Airbus is supporting ESA, bringing the perspective of an aircraft manufacturer. Several smaller technical support studies are also contributing to the Iris programme by investigating specific technical issues.

For more information, click on: telecom.esa.int/iris

to comply with ATM standardisation and certification requirements, stability of the airborne equipment during an aircraft lifetime, capability of the service provision model to comply with competition requirements and a fair rate charging policy to airspace users.

Other activities of Iris focus on detailed technical analyses; understanding aircraft manufacturers' requirements, and facilitate the preparation of the safety case. Specific regulatory activities also support the worldwide effort to define aviation long-term requirements for satellite spectrum in L-band, in preparation of the ITU World Radio Conference of 2012.

For the past year, the system design studies have analysed the impact of the performance requirements defined in the document used as a baseline by SESAR, which had been developed jointly by Eurocontrol and the FAA and used as input by ICAO. The studies consider several possible system options and carry out a sensitivity analysis. The purpose of this trade-off exercise is to determine which requirements are driving the overall system design, and which requirements contribute most to the system cost and complexity. There are currently five main uncertainties on system-level requirements:

1 - Security requirements to protect the data transmitted i.e. integrity, authentication, encryption, non-repudiation and access control;
2 - Robustness to intentional and unintentional jamming of any given link of the satellite communication system;
3 - Capacity of the satellite payload in terms of amount of data traffic at peak times of use;
4 - Capabilities of the aircraft terminal in terms of power available while still fulfilling the constraint of operation without forced-air cooling;
5 - Architecture of the ground segment, considering either the possibility to have several service providers with distribution of elements among them, or concentration of ownership of all elements under a single entity in a single location.

Options for these five points are analysed in ESA studies and conclusions are provided to the SJU showing their impact in terms of spectrum requirements, complexity and cost of the satellite system infrastructure, cost of user terminals, etc.

Concerning availability requirements, a derivation of performance figures from safety considerations is performed in cooperation with EASA, addressing notably the software assurance level. Overall these requirements will be defined by SJU by iterating with the Iris design studies, to allow aviation to make informed decisions. This consolidation will allow Iris studies to define a technical baseline by end 2011, and to progress in detailing the design and its associated cost. Once these elements are known, ESA will be able to prepare its proposal for further funding of the Iris programme in due time for the next Ministerial Council in 2012.

→ Why Iris?

ESA's air traffic management programme is named after Iris, the swift messenger goddess in Greek mythology. Daughter of Thaumas and Electra, Iris was a winged figure, associated with communication, messages and new endeavours. Iris appears in Homer's *Iliad*, when Zeus sends her to convey his orders to the other gods and to mortals, when Hera sends her to Achilles, and on other occasions appearing disguised as a human to convey information.

Deployment plans towards service provision in 2020

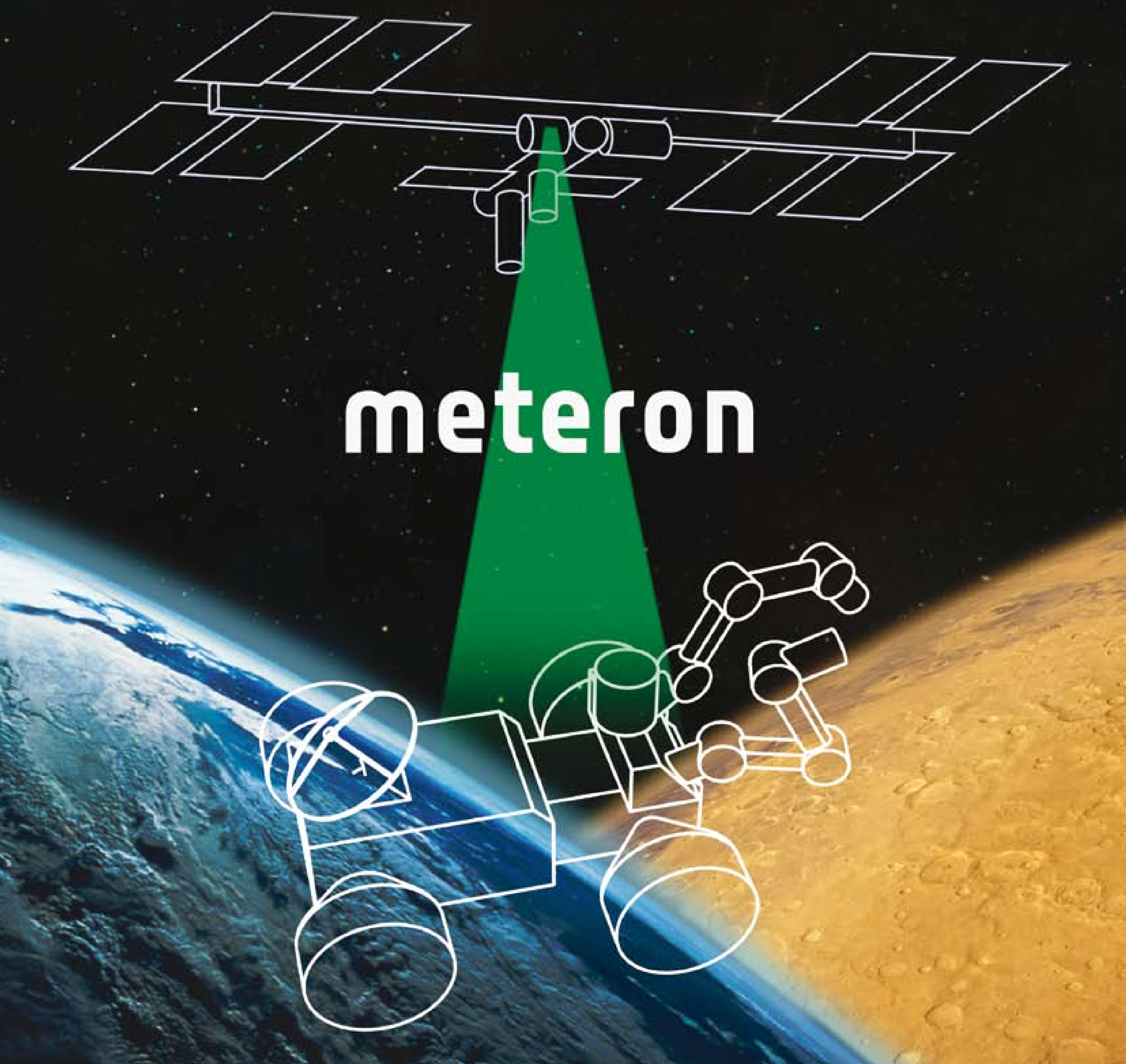
The master plan produced by SESAR indicates initial operation of the datalink for high-density continental areas in 2020. Besides being technically optimised for the air traffic of high-density areas in European airspace, this satellite system has to be defined, procured and operated according to the Single European Sky (SES) legislation. But before operational deployment can take place, the system must first be verified and validated, and aircraft equipment must undergo the airworthiness certification process that ensures it is safe for flight.

The validation infrastructure needs to be as close as possible to the system to be deployed operationally, so that the service can be tested in representative operational conditions. It will be developed and procured in the Iris programme, with support from the future owner of the operational system. Given the inherent costs of deploying a GEO system, is it likely that this infrastructure will not be used only for technical validation, but will later support the certification of the service provider and become a first building block of the operational system. The early deployment of space assets will also have a positive effect on the take up of user terminals and facilitate the allocation of satellite spectrum.

The European Commission is currently working on a proposal for the deployment of SESAR. With Iris, ESA Member States are placing satellite communications at the forefront of the world aviation industry modernisation programme. Iris will contribute to societal benefits in terms of industrial growth, environment protection and especially aviation safety, and prepare European industry and operators to consolidate and further their leadership in the field. The use of satellites for ATM safety and communications will be a major confirmation of the value of space as a means to benefit European citizens. As a component of the future ATM system defined by the SESAR programme and endorsed by ICAO, satellite communications will contribute to the safety, economic growth and environmental sustainability of a very important economic sector.

For more information:
telecom.esa.int/iris

ESA is paving the way for exploring the Moon and planets with tele-operated robots



→ METERON

Conducting robotic operations and experiments from orbit

Kim Nergaard and François Bosquillon de Frescheville
Directorate of Human Spaceflight and Operations, ESOC, Darmstadt, Germany

André Schiele
Directorate of Technical and Quality Management, ESTEC, Noordwijk, The Netherlands

Philippe Schoonejans, Bob Chesson and F. Castel
Directorate of Human Spaceflight and Operations, ESTEC, Noordwijk, The Netherlands

Astronauts being able to operate robots on the surface of another world – that is the ultimate aim of ESA's Meteron project, which is helping to prepare Europe for future exploration missions to the Moon, Mars or other celestial bodies.

Standing for 'Multi-purpose End-To-End Robotic Operations Network', the Meteron project is an ESA initiative to set up a communication and operations framework on the ground and on the International Space Station, and execute a series of remote robotics experiments.

Astronauts on the ISS will control advanced robots on Earth using 'telepresence' control equipment inside the European Columbus laboratory. They will demonstrate orbital remote control of Earth-based robotic systems operated from space.

"The ISS is the perfect orbital platform to simulate very realistic scenarios for human exploration, but first we have to set up a robust communication architecture and establish a smart operations system to allow astronauts, robots and our ESA control centres to work efficiently together; this is not as easy a task as it may seem," says Kim Nergaard, overall ESA coordinator of Meteron preparatory activities to be tested in orbit.

Many human exploration scenarios set up by inter-space agency groups have one main idea in common. At least initially, humans will not descend directly to the Moon, Mars or asteroids, but they will remain in an orbiter and, from this orbital vantage point, they will 'teleoperate' robots on the surface.

The main advantage of such a strategy, which is the opposite of the 'race to the Moon' in the 1960s during the Cold War, is to avoid perilous round-trip journeys down to the surface. Furthermore, the existing Space Station and its crews represent the ideal test-bed for the in-orbit demonstration of scenarios and operations required for a long-term exploration strategy.

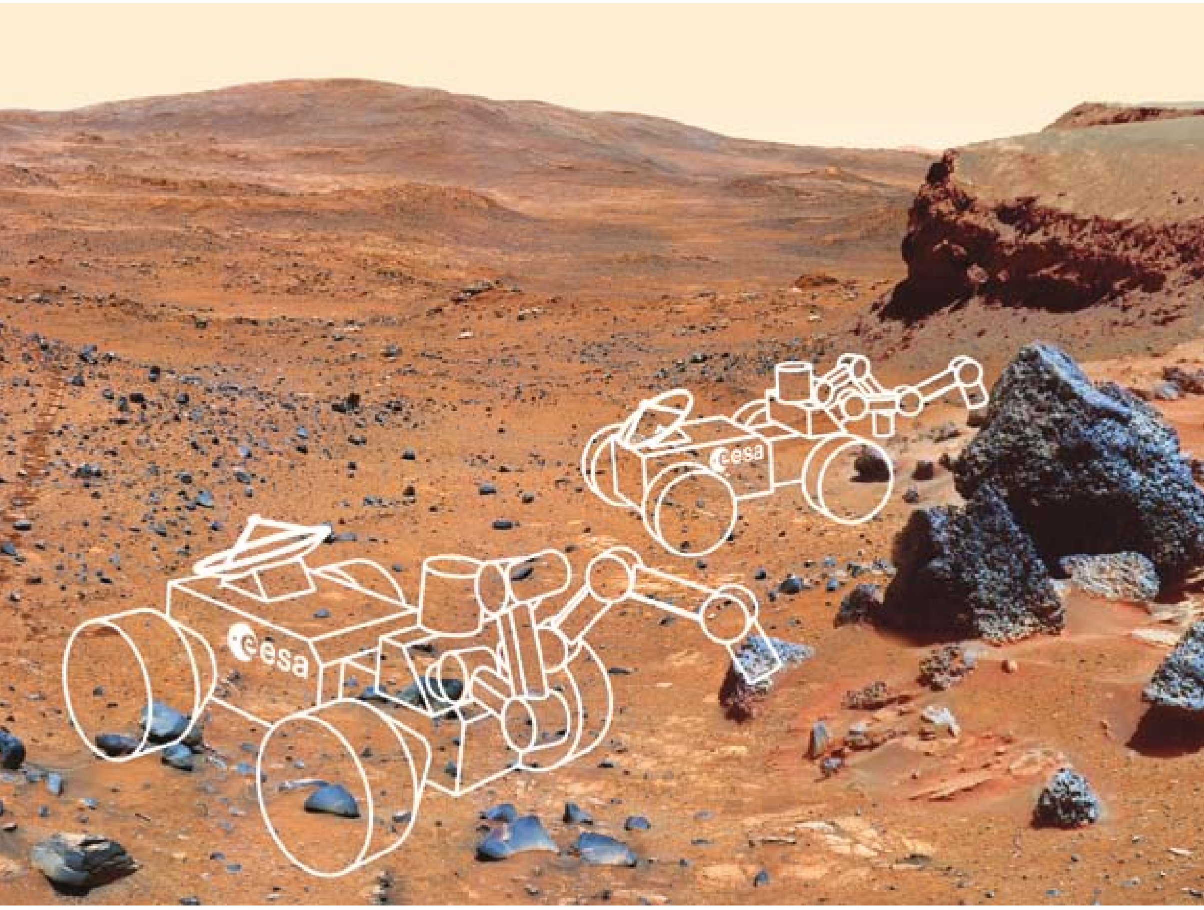
"One of the primary Meteron objectives is to lay out and make these scenarios more robust by running end-to-end operations of robots on Earth from the ISS. In terms of exploration, this programme will really answer the needs of the future," says Philippe Schoonejans, Head of Robotics in the ISS and Exploration Department of ESA's Human Spaceflight and Operations Directorate.

This became apparent once more in ESA's recent Call for Ideas for the use of ISS for exploration, where many ideas were submitted for operating Earth-based robots from a workstation on the ISS. The multitude of submissions shows the strength of the idea. ESA can take into account all suggested experiments and give opportunities to the countries, companies and institutes who have shown their interest by submitting their ideas.

Whatever course the future exploration of the Moon and Mars might take, it will require a sophisticated communication architecture, advanced operations tools and concepts, as well as the human–machine interface (HMI) technologies that support the activities between crews in orbiters and complex robot systems located on a remote planetary surface.

Human–robot architecture

"With advanced human–robotics interfaces and experiments, we will allow astronauts to control robots on a planet's surface with the sense of 'touch' and great intuitiveness," says André Schiele, in charge of the ESA Telerobotics & Haptics Laboratory in the Mechanical Engineering Department at ESTEC in the Netherlands.



←

Operations of rovers or robots on the martian soil could be conducted from an orbiter by the crew flying around the 'Red Planet' (ESA/D. Ducros)

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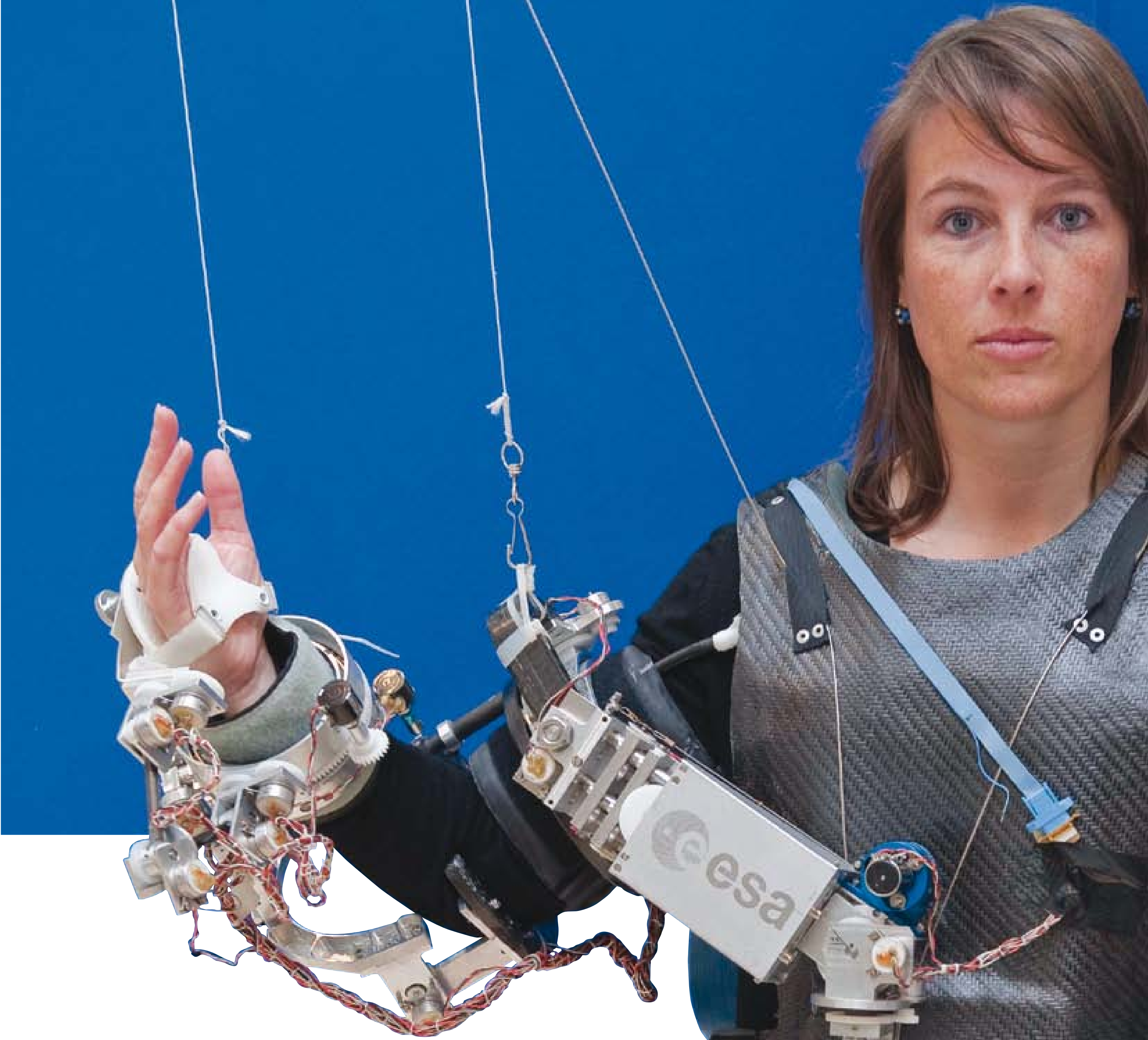
By 2014, orbiting crews will be able to wear a robotic 'skeleton' arm and glove, called the Exoskeleton, which is being developed and space-qualified in the Telerobotics & Haptics Laboratory at ESTEC, Noordwijk



"Thanks to these new 'haptic' devices and man–machine interface technologies, astronauts can have a real feeling of the forces that the arms of the robots are experiencing in their environment when they push against a rock or do more complex tasks, such as facility set-up. With Meteron, we will validate the added value of haptic devices and telerobotics technologies in space. We have developed such technologies together with our partners over the past years."

The operations architecture of such an end-to-end system, with operators in orbit and robots on the surface, must become increasingly autonomous and reliable. Operations might need to take place at great distances – and sometimes without Earth intervention. Longer delays resulting from these large distances between the orbiter, the planet and Earth. For example, the 'round-trip' light time from Earth to Mars varies between 6 and 45 minutes with an average of 20 minutes.

Communication experiments

"To make Meteron work, we shall test two types of communications with the ground, a real-time set-up and a different one which can tolerate a delay," says Bob Chesson, Senior Advisor to the Director of Human Spaceflight and Operations.

The first type, the real-time link, is dedicated to the bilateral control of a robot. This bilateral control will transfer force information between the crew and the robot system. To maintain good robotic dexterity, this communication loop is set up to have as low a communication delay as possible, with a goal of between 4 and 50 milliseconds for the round-trip delay.

For this communication chain an antenna, which is part of a Russian experiment called Kontur, located on the Russian Zvezda module of the ISS, will be used together with three ESA ground stations in Europe and one in Russia to simulate the robot communication system. The goal is to provide a nearly uninterrupted link of up to 20 minutes relayed between these four ground stations when the ISS flies over them successively at an average altitude 450 km and at 28 000 km/h.

Planned for 2014, ESA and Astrium are developing another communication link with an Inmarsat antenna to be installed on the outside of the Columbus laboratory. This antenna will provide a continuous communication link to the Inmarsat global network through its numerous ground stations and its eleven geostationary telecommunications satellites.

The second type of communication network is the Non Real-Time (NRT) communications chain, an existing experimental NASA communications route. One protocol standard currently being investigated as a potential candidate for deep-space missions is the Disruption Tolerant Networking (DTN) protocol. DTN will be used for non-real-time communication, since it can cope automatically with significant transmission delays, lack of planet-to-Earth visibility and resulting packet corruption or loss. Such a Meteron DTN network will include all the communication systems of the current ISS partners around the world, centred on the NASA TDRSS satellite communication system.

One of the experiments of Meteron will be to test remote operations with long delay, as it occurs when simulating Moon or Mars exploration scenarios. DTN will have to restitute all the packets of information once they have arrived at the other end of the chain. NASA, in collaboration with the University of Colorado in Boulder, is working together with ESA on the Meteron DTN experiment, and its engineers will also test new aspects of their DTN network during combined non-real-time and real-time operations in space.

As part of the Meteron preparatory activities, ESA has teamed up with NASA and the University of Colorado to set up a demonstration of one of the communication chains that will be used for Meteron. Later this year, a Meteron laptop in the Columbus laboratory will be connected to an experimental NASA and University of Colorado system in the US Destiny module of the ISS.

This experimental network will be used to demonstrate DTN and its software has already been delivered to the ISS by the Space Shuttle *Endeavour* in May. If all goes according to plan, ESOC operators will be able to communicate with the Meteron laptop in Columbus through the US experimental system as if it were on the same network. During these communication tests, a simple robot and control system will be used on the ground. It will allow the operations and communications engineers at ESOC to test their concepts and technologies prior to a full implementation of the Meteron system.

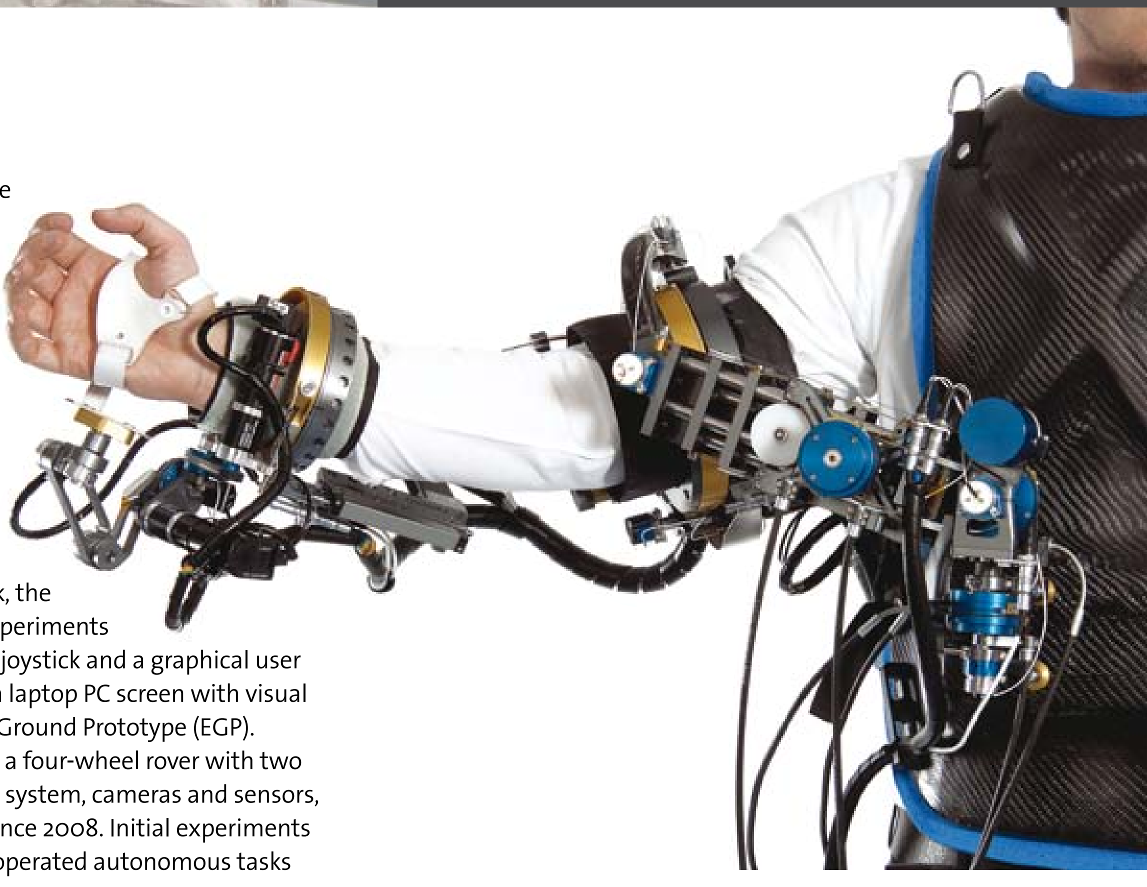
"Later on in cooperation with NASA and with the Robotics Institute of St Petersburg in Russia, Meteron will likely lead to the development of common standard interfaces between robotic control stations, in order to reach some interoperability of robotic systems between space agencies. In exploration programmes, such an initiative would allow much more flexibility to define joint scenarios. A remote NASA robot could be controlled by an ESA or a Russian workstation in orbit with multiple combinations among the partners," says Philippe Schoonejans.

This possibility of interchanging robots and man–machine interfaces between partners requires the standardisation of software for real-time communications. Some initial prototype work has started between the ESA Telerobotics & Haptics Laboratory and several NASA robotics centres with Meteron robotics preparatory activities. Some other partners, such as the Canadian Space Agency and the Russian space agency Roscosmos, have also expressed a strong interest in this project.

"Meteron will likely lead to the development of common standard interfaces between robotic control stations"

↑ Artist impression of the Exoskeleton with its 3D vision goggles being used in the Columbus laboratory on the ISS (ESA/D. Ducros)

↓ Another view of the ESA Exoskeleton under development at ESTEC's Telerobotics & Haptics Laboratory in the Netherlands



Robotics experiments

In parallel with setting up the end-to-end communication network – with the ISS loop – in cooperation with NASA and Russian partners, the ESA Meteron project will demonstrate novel robotic interfaces for the onboard segment with a gradual progression.

Initially, with only a delayed and one-way control downlink, the ISS astronauts will conduct experiments by sending commands with a joystick and a graphical user interface , that is to say from a laptop PC screen with visual icons, to the existing Eurobot Ground Prototype (EGP). 'Eurobot', developed by ESA, is a four-wheel rover with two arms, an advanced navigation system, cameras and sensors, that has been under testing since 2008. Initial experiments will concentrate on remotely operated autonomous tasks

↑ The existing Eurobot Ground Prototype (EGP) in two
→ different versions developed by ESA

↓ The humanoid robot "Rollin' Justin" developed by the DLR Institute of Robotics and Mechatronics (DLR)

and some limited real-time mobility tasks. At a later stage, Eurobot arms could be improved for telepresence tests. The Meteron programme will follow a gradual increase of complexity with different robots, including some of different space agencies.

By 2014, the orbiting crew will be able to wear a robotic 'skeleton' arm and glove, called the ESA Exoskeleton, which is being developed and space-qualified by ESA. On Earth, the German DLR humanoid robot, called 'Justin', will reproduce in real time the precise movements of the Exoskeleton arm and reflect its contact forces with the environment back to the arms of the astronaut crew. Just the slightest movement by the astronaut will enable Justin on Earth, or equally on a distant planet, to pick up and manipulate rocks or to perform dexterous tasks that require motor-sensory feedback. Later in the programme, the astronaut teleoperator will wear stereo vision goggles to have a realistic 3D view of the environment on the surface in addition to the haptic force feedback.

"The system we are setting up for Meteron will allow other robots on Earth to be controlled from the onboard segment. We are currently testing ground-based teleoperations between the Exoskeleton and various robot systems in our labs. Recently, we have also started collaborations with our partners at NASA to perform the first intercontinental teleoperation testing between the Exoskeleton and the new Robonaut R2 in Houston," says André Schiele, who is developing the Exoskeleton and coordinating the robotic experiments of Meteron.

Space-based operations

Once the Exoskeleton is fully tested on Earth, it will have to perform in a microgravity environment. Nobody knows how much impact the same system in space could have on astronaut's performances. On the ground, it is shown that such technologies improve remote situational awareness significantly, leading to improved remote control performance of human operators.

"With Exoskeleton in orbit, it will be an incremental step. In microgravity, we do not know how an astronaut will interact

with the force feedback given by the Exoskeleton. On Earth, the operator is stabilised by their feet. In zero 'g', we have to use very little force to do things. So the big advantage is to utilise the ISS to fly and test new hardware in order to learn," says Frank De Winne. De Winne is a veteran ESA astronaut with extensive experience in operating both ISS's Canadarm2

robotic arm and the Japanese robotic arm, which were used to transfer scientific hardware outside the ISS. He has spent more than six months in space during two ESA missions and was the first European commander of the ISS in 2009.

"It will always be difficult to have astronaut activities on a planetary or asteroid surface, so by improving the man–machine approach, we can augment drastically our capabilities for surface operations. It represents a big return on investment, and Meteron is a very valuable programme for future exploration," says De Winne.

The Meteron philosophy is to build an experimental infrastructure enabling in-orbit demonstration of existing technologies without requiring huge investments. François Bosquillon de Frescheville is the ESA engineer who came up with original idea and who now supports the next Meteron phase for communication and operations.

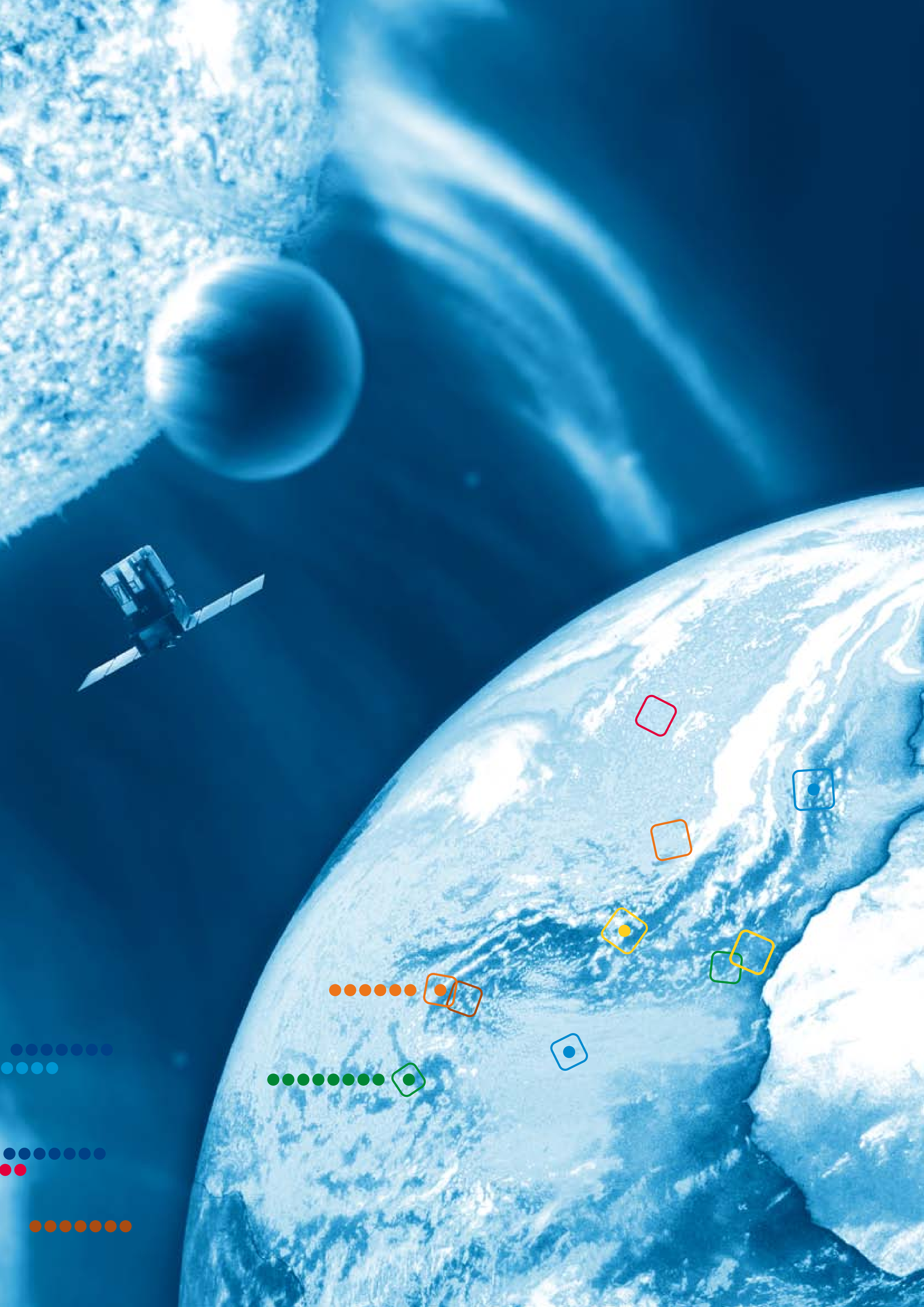
"The operational concept underlined by Meteron has the potential to scale down the cost of early human exploration while providing a global access to a planetary surface. It is among other reasons why Meteron has brought up an incredible enthusiasm with all the parties, within ESA and the other ISS partners," says Bosquillon de Frescheville.

The Meteron project involves two directorates at ESA: the new Directorate of Human Spaceflight and Operations and the Directorate of Technical and Quality Management. Within Human Spaceflight and Operations, the Mission Operations Department ensures the operation of the Meteron communications network. Technical and Quality Management is the engineering partner and brings in the knowhow for robotics developments. The ISS Programme and Exploration Department is in overall charge of the Meteron project and is directly involved via the Columbus Control Centre in Obefpfaffenhoffen, Germany, with the astronauts operating Meteron in the ISS Columbus laboratory.

"One of the key objectives of Meteron is to demonstrate end-to-end mission operations scenarios where all elements of human exploration missions are represented, both on ground and in space. The interaction between the various operations and engineering centres on ground and the crew in orbit, operating the robots and rovers, will be demonstrated through a series of simulations where the involved parties become part of the simulation as if it were a real mission. This will provide experience that is essential when planning and preparing for real human exploration missions," says Kim Nergaard.

→

On the ISS, ESA astronaut Frank De Winne and Canadian Robert Thirsk are working at the Canadarm2 workstation in the Destiny laboratory. They used the robotic arm to relocate the Pressurized Mating Adapter (PMA-3). Canadarm2 was also used to grab the Japanese H-II Transfer Vehicle as it approached the ISS in 2009 (ESA/NASA)



→ SSA PREPARATORY PROGRAMME

Precursor services for space surveillance, space weather and detecting NEOs

Nicolas Bobrinsky, Serge Moulin, Emmet Fletcher, Juha-Pekka Luntama, Gian Maria Pinna
Directorate of Human Spaceflight and Operations, ESAC, Villanueva de la Cañada, Spain

Detlev Koschny
Directorate of Science and Robotic Exploration, ESTEC, Noordwijk, The Netherlands

The European Space Situational Awareness (SSA) system will allow Europe to reach a very high level of autonomy in protecting its critical space infrastructure against space hazards, and at the same time improve the outcome of its international cooperation activities.

The SSA Preparatory Programme (SSA PP) was approved at the ESA Ministerial Council in November 2008. While the initial duration was estimated at three years, it has been extended by one additional year until the next Ministerial Council, currently planned for the end of 2012.

The SSA PP is an optional ESA Programme, and includes four distinct elements: Core, Space Weather, Radar and Pilot Data Centres. 'Core' covers requirements, architecture, data policy and security, as well the deployment, test and validation of precursor services in the area of space surveillance.

The 'Space Weather' element includes preparatory activities related to the space weather and Near-Earth Object (NEO) domains, and 'Radar' is aimed at the development, test and validation of one or several breadboard surveillance radars, validating the best possible technologies for such critical systems.

The 'Pilot Data Centres' element is enabling the implementation of precursor services in all domains. This includes also a Tasking Centre, in charge of coordinating all the activities of the SSA sensors network.

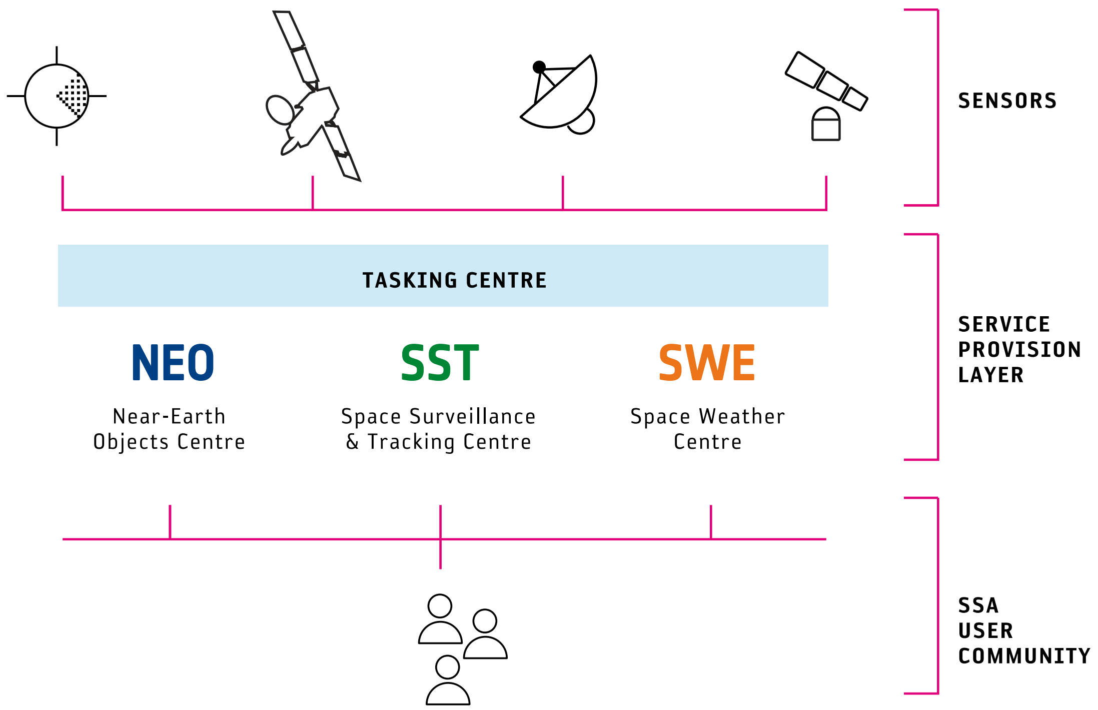
A service-oriented architecture

The detailed architecture of the future European SSA system is being defined during the SSA Preparatory Programme. It will be composed of ground and space segments. The ground segment will include a network of ground-based 'sensors', of both surveillance and tracking radars, optical telescopes and a number of Service and Data Centres for the various SSA domains, i.e. space weather, space surveillance and tracking and NEOs.

The space segment could be composed of a number of spacecraft for space surveillance and space weather, as well as a number of space weather 'piggyback' sensors on host spacecraft. The sensors will deliver the SSA raw data to the data centres, which will process them and provide the higher-level SSA services to the SSA user community.

From a ground data systems perspective, the most significant requirements of the SSA programme at system level can be summarised as reliability and dependability, security, performance, distribution, maintainability, modularity, interoperability, provision of services through federation of SSA assets, long-period support and life perspective of involved ground data systems.

In order to address these requirements adequately, it is envisaged to deploy the SSA ground data systems on a Common SSA Integration Framework (COSIF), based on a Service Oriented Architecture (SOA). The COSIF will enable the integration of existing sensors and applications



← The SSA system – a service-oriented architecture available from ESA Member States as well as the deployment of new SSA applications in a heterogeneous environment. It will serve as the backbone integration framework for all SSA ground data systems.

The specific SSA services (precursor services during the SSA Preparatory Programme) will be developed and integrated as components on top of this framework, consuming the framework services and providing in turn their own business logic in the form of new services to the end users and/or to other components of the system.

The provision of the SSA services to the users will involve a number of common functionalities, such as security, user management, communication, file and data transfer, data acquisition and visualisation, archiving, planning, scheduling, commanding, monitoring and automation. These will be provided in the form of generic reusable services on the COSIF integration framework.

COSIF will support and facilitate:

- rapid implementation of new SSA services;
- integration of existing SSA assets, developed in various software technologies;
- implementation of the SSA security and data policy requirements;
- provision of SSA services as web services and through Rich Web Client interfaces;
- provision of the common services and functionalities as generic reusable services on the framework;
- interoperability between SSA assets through message exchange;
- integration of the assets and services of third parties that may not be under the ESA control.

↓ Space debris orbiting Earth

As part of the Preparatory Programme, the evaluation of existing state-of-the-art SOA commercial and open source products available for the implementation of the SSA ground data systems has been performed. The results of this evaluation are taken into account in the definition of the future SSA system requirements and architecture.

Precursor services for Space Surveillance and Tracking

The Space Surveillance and Tracking (SST) segment of the SSA programme is devoted to the protection of the critical space infrastructure. Through the development of the precise technology required to sense, collate and analyse the paths of the hundreds of thousands of objects orbiting the planet, satellite operators can be warned of impending collisions, and security and civil services can be told of the possible reentry of objects across populated areas.

The precursor activities for SST are twofold. Firstly, we need to accurately design and cost a system that efficiently catalogues orbital debris and satellites within a specified accuracy. This accuracy is determined through consultations with an international 'Users Group' of satellite owners, system designers and domain experts and ensures that the system performance will be dimensioned to meet real needs. This process has now led to the creation of realistic mission and customer requirements. The inputs from these two documents will lead to system requirements and then architectural requirements. With this in hand, economic proposals containing options for a full SSA Surveillance and Tracking system can be put forward.

The second stream of activities is related to the development of prototype precursor services. In order to test real-world concepts, it is necessary to construct a prototype that can validate these theories. In SST, we need to validate the data sources, the sensors that scan space, as well as the data services that analyse the input data and generate the various warnings and alerts.

Because there are a number of active sensors that have been made available by the Member States for the SSA programme, it was necessary to evaluate their potential to contribute to an operational SST system. This was done by tasking these sensors with tracking known objects, primarily ESA satellites such as Artemis, Envisat, GOCE and Proba, but also satellites of CNES, Eumetsat and SES-Astra. Optical telescopes located in Chile, Cyprus, France, Spain and Switzerland participated in the evaluation as well as radar sites in France, Germany, Finland, Norway, Sweden and the UK. These tests are still ongoing, and will provide a strong indication about how these valuable assets can be efficiently integrated into a future SSA/SST system.

Space weather user domains

On the data management side, the Space Surveillance and Tracking Centre (SSTC) is being installed at the European Space Astronomy Centre in Spain. This centre will combine both the data management and service generation for the SST element of the programme. Different approaches to these challenging tasks can be tried with both real and simulated data in order to supply realistic performance and accuracy data that can be applied to a full operational system.

With this combined approach, performing the customer, system and architectural design activities on one hand and developing prototype precursor services to simulate an operational environment on the other, it is hoped that representative and reliable cost and capability estimates can be produced. These will both combine to reduce any risk in the development of a full system, with the confidence that the results presented will provide effective solutions to protect our critical space infrastructures.

The Tracking and Imaging Radar (TIRA), Bonn

Precursor services for Space Weather

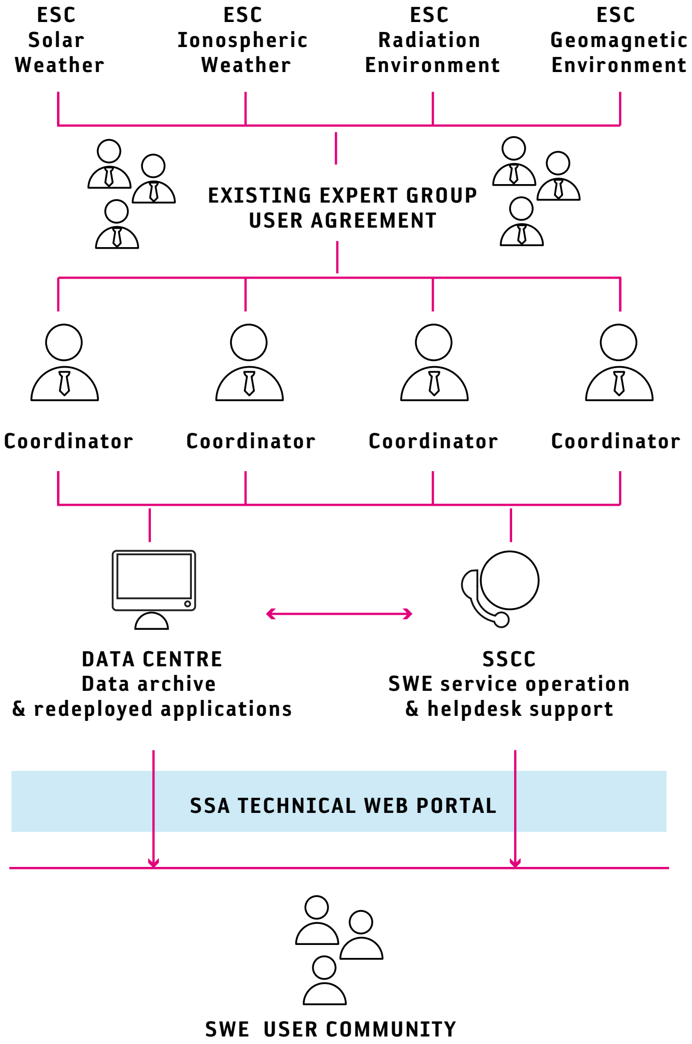
The SSA Space Weather (SWE) segment will establish services supporting the capacity to securely and safely operate the critical European space- and ground-based infrastructure and related services that are sensitive to changes in the space environment. These SSA SWE services will provide the end users information related to the monitoring of the Sun, the solar wind, the radiation belts, the magnetosphere, the ionosphere and the geomagnetic impacts of the space weather. These services will include near-real-time information and forecasts about the characteristics of the space environment and predictions of the space weather impacts on the elements of the infrastructure.

The SSA SWE system will also include establishment of a permanent database of space weather observations and products for analysis, model development and scientific research. The services are aimed at a wide variety of user domains including spacecraft designers, spacecraft

operators, human spaceflight, operators and users of transionospheric radio links and satellite navigation, operators of non-space-based systems like aviation, power grids and pipelines, and naturally space weather research community.

The establishment of the SWE precursor services in the SSA Preparatory Programme will be based on utilisation of the existing space weather expertise and assets in Europe. This bottom-up approach is very useful and allows rapid deployment of a number of services that can be rigorously tested and validated during the Preparatory Programme. Many of the services that can be federated into the SSA SWE system are already pre-operational and have an end-user community. In this way, the ESA SSA Programme is building on a large amount of work that has been carried out in a number of national and multinational programmes in Europe.
ESA has been strongly involved in the development of the European space weather capability, for example from 2003 to 2005, ESA carried out a Space Weather Applications Pilot Project. This resulted in the establishment of the SWENET service to support a large number of Service Development Activities related to monitoring and forecasting of the space weather and its impacts on the infrastructure. SSA SWE segment is also utilising the results of many studies and service prototyping work that were carried out within the ESA General Studies Programme before the start of the SSA Preparatory Programme (e.g. SEISOP).

Thematic coordination of the SWE services will take place through Expert Service Centres (ESCs). ESCs are consortia of expert groups that together will provide the SWE segment services related to their area of expertise. SWE Service Coordination Centre (SSCC) will be monitoring and coordinating the service provision, handling the day-to-day operation of the service network and providing the first level of user support. The SWE Data Centre established at Redu will host servers for some applications and the main database for the SSA SWE data.



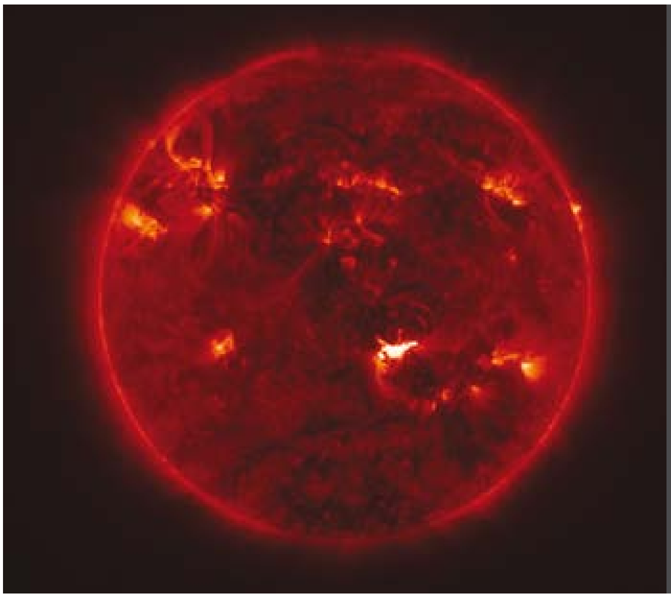
↑ Provision of the user services will be federated using existing European space weather expert groups and assets

The initial precursor services established in 2011 will include many critical functions that allow the end users to get monitoring information about the space environment and warnings about the expected solar events. For example, the services provided by the Solar Weather ESC include regular, provisional and forecast products like SIDC ursigram, sunspot index, forecasts of the sunspot index, GPS relevant ionospheric and geomagnetic conditions, CACtus CME detection products and SIDC fast-alert products for GOES X-ray flare alert, CACtus halo CME detection alert, disturbed geomagnetic conditions alert, all-quiet alert and Presto messages.

The Space Radiation ESC services will include support for the Space Environment Information System (SPENVIS) application that will be made available to the users. It is also foreseen that the AVIDOS application, which allows calculations of dose assessment of aircraft crew exposure due to cosmic radiation at high altitudes, will be made available to the users.

The Ionospheric Weather services will include products from the Space Weather Application Centre – Ionosphere (SWACI). These products focus on the near-real-time provision of gridded TEC information accompanied with byproducts such as spatial gradients, rate of change and medians over the European area.

Additional ionospheric services from other expert centres in Europe, along with additional precursor services addressing other user domains, will be added into the SWE system during the SSA PP. The SWE precursor services will also include end user access to applications developed for ESA programmes including SWENET, SEISOP, IONMON, EDID, SEDAT and the ODI database. These applications will be deployed in the SWE Data Centre.



←

X2.2 flare on 15 February 2011 as seen by ESA's Proba-2 spacecraft. The flare is the bright spot close to the middle of the solar disk. This was the first X-class flare of the ongoing solar cycle 24. The flare was associated with a coronal mass ejection (CME) that was directed towards Earth and created some concerns about a strong geomagnetic storm. However, in this case, the impact was small owing to the orientation of the interplanetary magnetic field with respect to Earth's magnetic field at the time of the CME arrival. The frequency of strong flares and associated CMEs is expected to increase as we approach the next solar maximum in 2013–14

The activities in the SWE segment also address the definition of the future SSA space segment. Many critical observations for the SWE services are only possible in space either as in situ observations of the environment, as monitoring of the solar electromagnetic radiation or as monitoring of the solar wind and the interplanetary magnetic field. There are many development activities for the next-generation space weather instruments ongoing in Europe as national programmes and as part of the ESA GSP, TRP and GSTP programmes.

The 'Implementation design study of Space Weather instruments' in SSA SWE segment activities is analysing the spaceborne observation requirements for the SWE services and identifying the sensors that are needed to fulfil them. This activity will assess the feasibility to fly some of these instruments as secondary payloads or 'piggyback' missions on already planned ESA, European partner or non-European spacecraft. The study will include detailed specification of the interfaces between selected sensors and spacecraft. Because it is expected that piggyback missions cannot fulfil all SWE observation needs, planning of the dedicated SWE missions will be addressed in later activities.

Precursor services for NEOs

Out of the vast asteroid population in the Solar System, about 8000 objects come within 50 million km of Earth. These are called 'Near-Earth Objects' (NEOs). Most pass by harmlessly, but if they impacted on our planet, they could cause significant damage. In 1908 an object of about 30–40 m in size exploded a few kilometres up in the atmosphere above Tunguska in Siberia. The shock wave flattened about 2000 sq. km of forest. Until a few years ago, it was thought only objects over 40 m in size could go through Earth's atmosphere and reach the surface, causing significant damage. Today, however, it is known that smaller objects, even down to 1 m, can survive to reach the ground and produce an impact crater, as happened in Peru in 2007.

The Near-Earth Object segment of the SSA programme (SSA-NEO) has the task to collect and provide information on the Earth-approaching asteroids, compute their 'miss distances' and probabilities of impact, and, via a defined decision process, provide information and warnings to political entities and other users. To do this, several elements are needed:

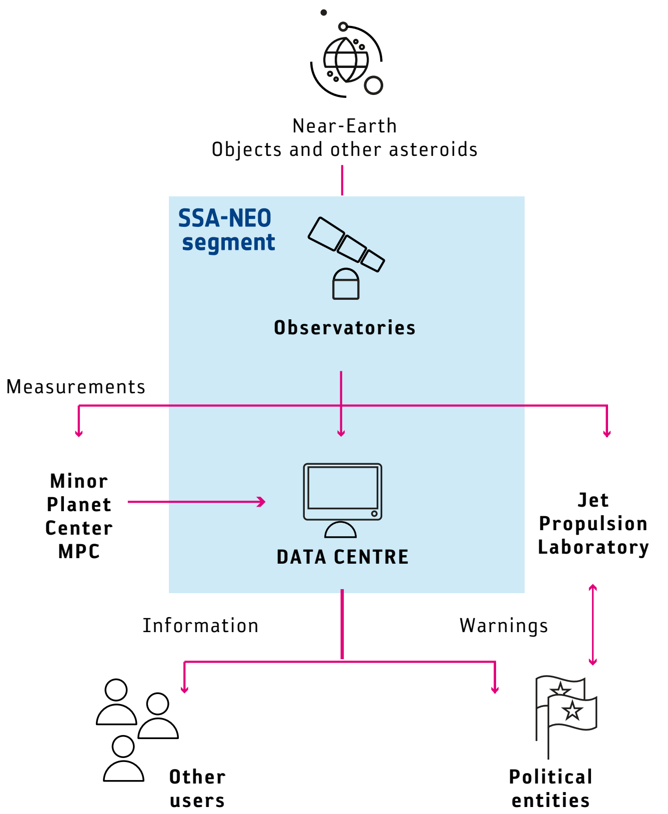
a) Observation networks, i.e. optical telescopes (ground- and space-based), radar systems and related planning and tasking systems
b) Data processing to determine impact risks and archiving
c) Mitigation capabilities
d) A decision structure

As part of the preparatory programme of SSA, a 'precursor system' is being built up, based on existing assets in Europe. For the observational network, existing telescopes will be used, for example, ESA's Optical Ground Station 1 m telescope on Tenerife. Another important observational asset in Europe is the La Sagra sky survey in Spain, which is operating a survey programme and has already discovered a number of NEOs. As for the data processing, an important existing European asset is the NEODyS system (NEO Dynamics Site). NEODyS takes the asteroid position measurements collected worldwide by the US-based Minor Planet Center and computes asteroid orbits.

These are extrapolated 90 years into the future and miss distances to Earth are computed. By propagating the measurement errors an impact probability is computed. The current 'risk list', i.e. objects with a chance of hitting Earth, contains more than 300 objects. Additional assets that are currently being integrated into the SSA-NEO system are the physical properties database of the European Asteroid Research Node (EARN) and ESA's Planetary Database.

↑

Artist impression of the Tunguska event of 1908. The explosion is believed to have been the air burst of a large meteoroid or comet fragment at an altitude of 5–10 km. Estimates of the object's size vary, but general agree that it was a few tens of metres across (D. Davis)



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Architecture of the Near-Earth Object SSA segment (SSA-NEO). Currently, all asteroid position measurements worldwide are collected by the US Minor Planet Center. SSA-NEO will provide a network of observatories, data-processing capabilities to determine the impact risk of NEOs, and a data distribution system

Concerning the political decision process, ESA is supporting discussions that take place within the UN Committee for Peaceful Uses of Outer Space (COPUOS). COPUOS had installed an 'Action Team' to advise on how to set up a decision process in the case of an imminent asteroid impact. ESA is represented in this Action Team.

If there really was a serious threat of an asteroid impact, it is important to understand its effects. An asteroid of 100 m diameter is predicted to hit Earth about every 1000 to 10000 years. If it plunged into the ocean a few hundred kilometres away from a coastline, it would generate a tsunami wave that would be devastating to nearby coastal areas. However, there are still many uncertainties in understanding the effects, and SSA-NEO will support studies to better understand them. If discovered early enough, such an asteroid could be deflected. Between 2004 and 2006, ESA made the most detailed study ever for a 'deflection mission', called Don Quijote. These studies will be continued and refined to prepare for such a case.

A key element for the complete SSA-NEO system after the preparatory phase will be a set of wide-field survey telescopes that would scan the whole sky once per night to detect objects about the size of the one that exploded over Tunguska up to three weeks before it could be expected to enter Earth's atmosphere.

Network of SSA ground-based sensors

The delivery to the various user communities of the proposed services highlighted in the previous sections will rely on measurements performed by a complex network of sensors that will continuously monitor the relevant environments for man-made objects orbiting around Earth, space weather events potentially affecting us and, last but not least, extraterrestrial objects approaching dangerously close our planet.

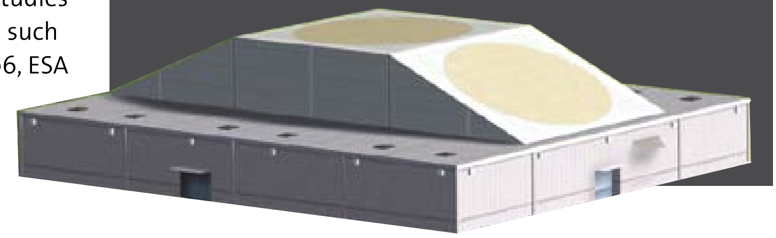
A wide range of sensor types is possible: such as radars, optical telescopes, magnetometers, radio navigation ground terminals and aurora observation cameras. The measurements carried out by this complex network of sensors will be eventually coordinated by a Tasking Centre, in charge to schedule the observations optimally.

Radar

Measurements by radars will be used across the three segments of the European SSA System. For the Space Surveillance segment, Europe plans to build up its surveillance radars, making it more independent from other space powers and also improving the completeness and quality of the available space surveillance data. Several studies have been performed in the last years and as baseline, for low Earth orbit (LEO) space surveillance, a ground-based radar system is under consideration. The radar system will be able to systematically survey all objects above a certain size and up to a specified altitude. These data will feed the SSA catalogue of man-made objects with physical and orbital information.

In recent studies, various architectures for the ground-based surveillance radar have been proposed (operating frequency, bistatic/monostatic configuration, CW/pulsed, modulated/unmodulated signal, transmitted power, probability of detection and false alarm, etc.) and development and running costs of the proposed systems were estimated.

↓ Artist impression of a future SSA surveillance radar



The final SSA surveillance radar is intended to cover the full 200–2000 km LEO region and to be able to detect objects of 10 cm diameter at a pre-defined altitude. The radar system will rely on phased array antennas, which offer the possibility to build the radar as a combination of several sub-array modules. With this modular structure, large parts of the full-size radar system design can already be validated by implementing a sub-set of the total amount of modules.

The SSA Phased Array radar will also work in a specific mode able perform active tracking of objects that require a detailed determination of their orbit. Although the SSA programme does not foresee to develop dedicated tracking radars, existing European resources will be used to maintain the necessary data quality in the SST catalogue.

Concerning the Space Weather element, radars will be used to measure the effects of the solar wind in Earth's ionosphere and magnetosphere. An example of the radar usage in the Space Weather field is the Super Dual Auroral Radar Network (SuperDARN). SuperDARN is a network of more than 15 radars collaborating in an international effort to study the upper atmosphere and ionosphere. The radars, located both in the northern and southern hemispheres, operate in the bands between 8 Mhz and 22 MHz. The radars essentially measure the Doppler velocity of plasma density irregularities in the ionosphere caused by the solar wind.

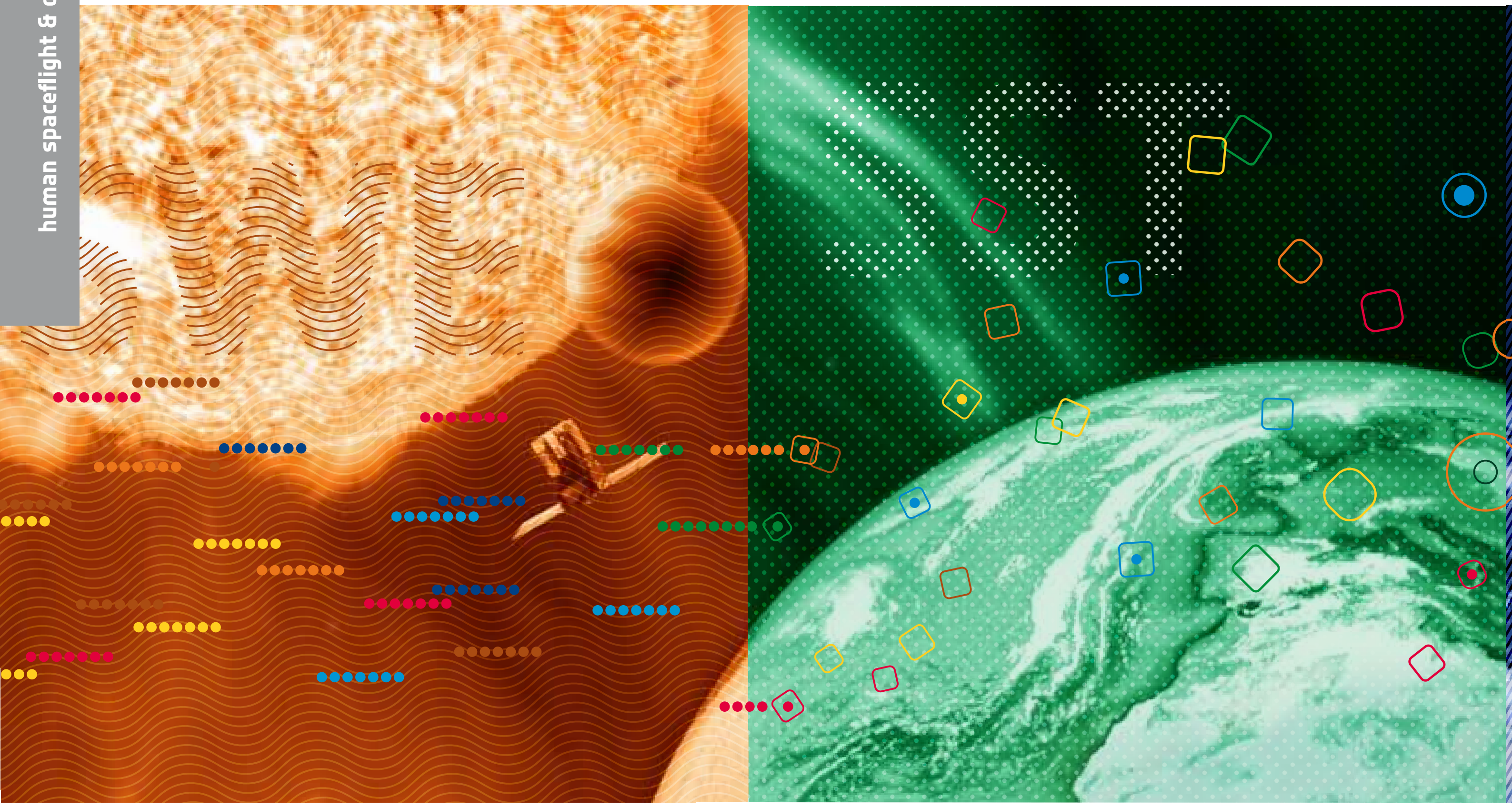
Finally, dedicated radars will be used in the framework of observations of NEOs. In particular, the refinement of Near-Earth Asteroid (NEA) orbits is crucial to precisely evaluate impact possibilities. In this task, radar astrometry is much more effective than optical astrometry because it provides exactly the information (range, range-rate) that optical astrometry does not, and can be extremely accurate, e.g. about 50 m in range, about 1 mm/s in range-rate.

Radars can be used to construct geologically detailed 3D models, to define the rotation state, and to constrain the object's internal density distribution. Such dish-based radars are usually greater than 50 m in diameter and, while receiving antennas of this size do exist or are in the course of construction, no transmitters of the required power exist in Europe today. Although there are no plans in the SSA Preparatory Programme to procure such capability, collaboration with other countries may be sought to ensure the required asteroids observations.

Telescopes

Optical telescopes will be used to survey and track space debris. The ground-based radar system for LEO space surveillance will be complemented with the detection of objects in other orbits (Medium and Geostationary Earth Orbit), which is traditionally done with wide field-of-view

Artist impression of the Don Quijote mission. While an asteroid orbiter studies the asteroid, an impactor spacecraft hits and deflects the object to ensure that it misses Earth (ESA/AOES Medialab)



optical telescopes. At these much higher distances, radars are penalised by the signal budget (proportional to the inverse of the fourth power of the distance), whereas the optical telescopes have the obvious advantage of using the Sun as an external source of illumination of the debris (the intensity of illumination of the targeted object is inversely proportional to the square of its distance from the observer). In addition, recent studies have shown that optical telescopes can contribute also to the survey of the upper LEO orbital segment, thus intersecting and complementing the orbital region typically covered by radars observations.

The optical telescopes that will be deployed in the framework of the SSA programme will form a coordinated network of stations that will ensure the continuous repetitive observation of the space debris. The number of stations and thus the total number of telescopes required depends essentially by the orbit regions that will be monitored and the weather effect that needs to be taken into account to ensure such continuous observation.

The size of the telescopes required to perform the observation required by the SST segment have primary mirrors in the order of 1 m, in order to ensure the detection of the faintest objects. A wide field of view will be required to effectively scan the sky repetitively with fewer instruments. A complex sky survey scanning strategy will also be implemented, different for each orbital region, in order to make the most effective usage of the telescopes network.

Finally, it is expected, in order to avoid as much as possible unnecessary and expensive design activities, to use the same telescopes for the tracking activities that will be required to improve the accuracy of the orbit of specific targets.

The SWE segment will use optical telescopes as well to perform observations of the Sun disc in specific spectral

↓ A network of surveillance telescopes will be used to complement the surveillance radars in the upper part of the LEO, as well as MEO, GEO and HEO orbital regimes

regions like the hydrogen alpha (H-Alpha) emission line, to detect flares and filaments created during solar activity by tracing the ionised hydrogen content in the gas clouds. Vector magnetographs, which are special types of imaging telescopes, will also be used for monitoring of the surface magnetic field of the Sun.

The usage of optical telescopes by the NEO segment will be very similar to that in the SST segment. Similar wide field-of-view telescopes will be needed of around the same size to ensure the detection of the smaller and/or less bright objects. The usage of the same instrument types across the SST and the NEO segments is actively looked at in order to maximise the synergy during the SSA system design phase. The sharing of the same instruments is also a possibility that is considered, although careful attention will have to be placed on the very different requirements of the SST segment with respect to the NEO segment in terms of security (which is a much stronger and driving requirement for the SST sensors than for the NEO segment) and location of the instruments (that for the NEO segment might require prime astronomical sites).

Other dedicated sensors

Dedicated sensors or networks of sensors monitoring the near-Earth space environment will be required in particular by the Space Weather segment. These sensors include, for example, magnetometers used for the monitoring of the changes in Earth's magnetic field due to solar events and the related changes in the magnetospheric current systems generating for example impacts on the power grids.

Ground-based networks of fiducial GNSS receivers will be used to monitor the ionospheric electron content and scintillations impacting radio telecommunications and satellite navigation applications. Ionospheric monitoring will also be carried out with ionosondes, riometers, VHF/UHF receivers and all-sky auroral cameras. Finally, radio telescopes will be used for monitoring of the solar radio emissions and monitoring of the changes in the characteristics of the interplanetary plasma. These sensor systems will be based on existing sensors and networks, but additional or complementing sensors can be potentially added by the SSA programme.

Objectives of SSA Preparatory Phase and next phase

Already for the Preparatory Phase, the objectives of the programme are very ambitious, combining the consolidation of the mission, customer and system requirements, the definition of the full architecture of the future SSA system, elaborating on the relevant data policy, developing prototypes and providing an early demonstration on how the future precursor services in all SSA domains could be implemented. Not the least important, an estimate of the cost of the full SSA system will be delivered as an outcome of the system requirements phase.

The SSA Preparatory Phase provides also a unique opportunity to bring together the various SSA stakeholders from ESA, Member States, European institutions, as well as industries and scientific institutes. In addition, due to the sensitive nature of some of the activities, in particular in the space surveillance domain, an interaction with the military communities in Europe is also taking place, which contributes to formulate adequate governance and data policy schemes for the whole of the SSA.

It is also a clear objective of the SSA Preparatory Phase, to prepare the grounds for the next phase of the programme, where the emphasis will be put on the development of the essential components of the future SSA system, and their integration with already existing assets within ESA and Member States in view of the provision of the required services. For this purpose, important discussions are taking place with the competent European institutions (European Commission, European External Action Service) and Member States about the identification of the future SSA operating entities, which will be entrusted in the longer term with the SSA exploitation. ■

→ MAGISSTRA AND DAMA COME HOME

Soyuz TMA-20 returned in perfect conditions and landed with pinpoint accuracy and on time at 02:27 GMT on 24 May in Kazakhstan.

→ All 12 members of Expeditions 27 and STS-134 pose for a poignant last crew portrait of this size on the ISS (NASA/ESA)

Ending the MagISStra mission and their six-month stay in space, Paolo Nespoli's crew fired the main engine of their Soyuz earlier that morning to begin the descent. The parachutes opened about 40 minutes after beginning the descent; the small drogue chute first, and then the main canopy. This was a violent event: the capsule tumbled and spun, until the main chute was fully open and stabilised the ride.

Soyuz is a rugged and reliable spacecraft, but it does not provide the most comfortable ride back from the orbit. It takes a relatively leisurely two days to reach the ISS – but the return lasts only a few hours. "It was really an experience!" said Paolo. "After a nice and quiet life in space, the reentry was then rapid and rough – we were like shaken with a big hammer!"

After a check-up from the medical team waiting nearby, the three astronauts were flown by helicopter to the nearby city of Karaganda for the traditional welcome ceremony. Then Paolo and NASA astronaut Cady Coleman left for NASA's Johnson Space Center, Houston. Paolo had to complete the medical tests which were being conducted before and during his flight.

A few days later, on 1 June, Paolo's fellow ESA astronaut Roberto Vittori returned with the Space Shuttle *Endeavour* after a mission that added a pioneering experiment to the ISS. *Endeavour* touched down at NASA's Kennedy Space Center in Florida ending its last flight and after nearly 16 days in space, of which almost 12 days were spent docked to the ISS.

The mission's main task was to install the AMS-02 Alpha Magnetic Spectrometer cosmic-ray detector on the ISS that will hunt for antimatter and the mysterious 'dark matter'. Scientists from 16 different countries have already started analysing the wealth of data collected since May, looking for new and unexpected phenomena.

The mission's four spacewalks took the total spacewalking time needed for building, completing and servicing the ISS beyond 1000 hours. The mission also marked the first time that two Italians were together in space and it was also the last flight of a European aboard the Shuttle.

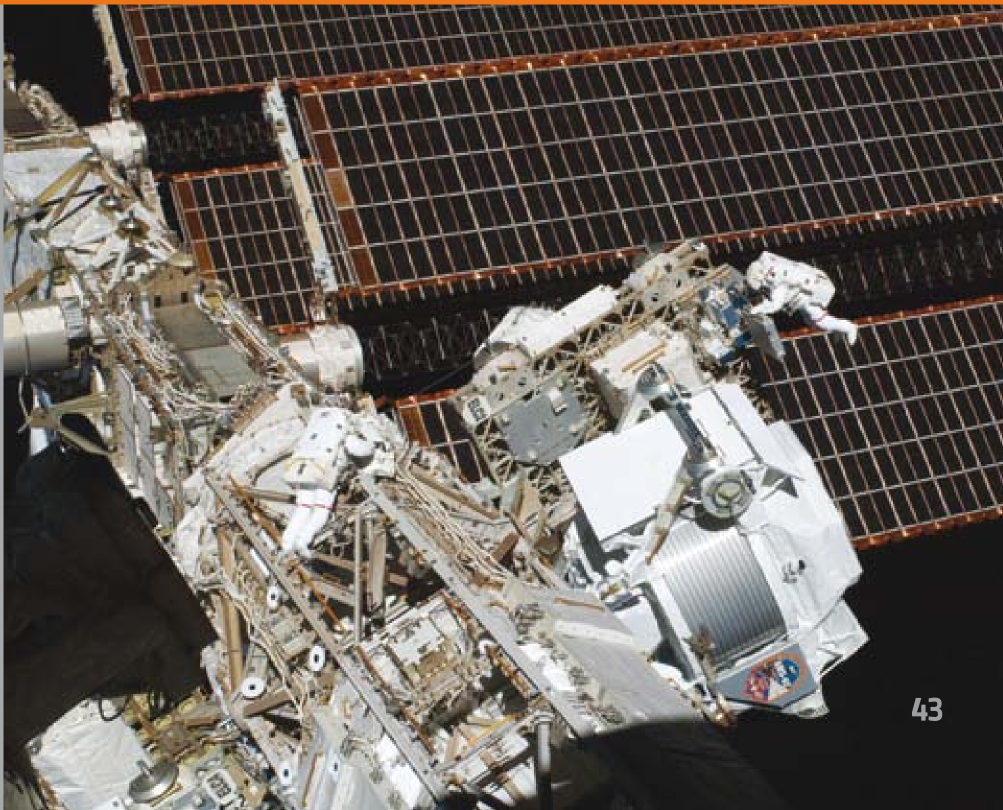
In 2012, the final pressurised module will be attached to the ISS: Russia's Nauka Multipurpose Laboratory Module, which is as big as Zarya and Zvezda. It will be installed on the Earth-facing docking port of the Zvezda module.

The European Robotic Arm (ERA), attached to Nauka, will be launched on the same Proton rocket, adding to ESA's contribution to the complex and boosting robotic operations on the station's Russian segment.

↗ Expedtion 27's Soyuz TMA-20 capsule suspended by parachute before landing on 24 May

← STS-134 rolls to a stop on 1 June, illuminated by spotlights as if in celebration of the grand finale for Space Shuttle *Endeavour*

→ The AMS-02 Alpha Magnetic Spectrometer cosmic-ray detector installed on the ISS

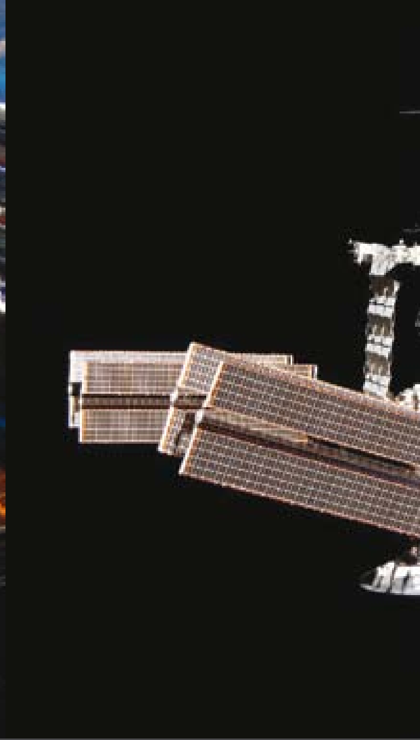


→ PHOTOGRAPHING THE DREAM

The story behind Paolo Nespoli's Space Station photos

Jari Makinen and Carl Walker
Communication Department, ESTEC, Noordwijk, The Netherlands

Working and living on the ISS, Paolo Nespoli succeeded in sharing his experiences with a constant flow of stunning photos and messages on social media



“Dreams are possible. We all should keep dreaming since even the most impossible dream sometimes can become a reality.”

When the Soyuz TMA-20 spacecraft undocked from the International Space Station, ESA astronaut Paolo Nespoli had a special job to do: capture unique images of the orbital outpost with the US Space Shuttle and Europe’s ATV ferry attached.

Seen on a TV screen on 23 May, it all looked very easy and smooth: Soyuz stopped about 200 m away and the ISS tilted to present a better view. Paolo took his photos through a small window in the Soyuz orbital module before returning to his seat in the descent module alongside crewmates Dmitri Kondratyev and Catherine Coleman for the landing.

“This was a complex and delicate manoeuvre that could have caused serious problems if not executed properly, but I felt it was worth the risk,” said Paolo, who had only few seconds to admire the view.

“Taking these pictures was not as straightforward as aiming the camera and shooting,” explained Paolo. “When we undocked, we were already strapped in our seats wearing spacesuits. Our suits and the three hatches between the landing and orbital modules were leak-checked. Normally after undocking, the seals are not broken any more because retesting them costs oxygen – there is not so much of it on board.”

The only problem was that the window from where the pictures needed to be taken was in the orbital module –

I purposely limited looking because I know I would have been mesmerised by the beauty of it.

by then already partly depressurised. Paolo had to remove his gloves, unstrap from his seat, carefully float to the hatch, repressurise the orbital module and open the hatch.

"I had to slide over Dmitri, paying attention not to hit the manual controls, and go up into the orbital module where I had left the cameras prepared before hatch closure."

Paolo recorded still photos and video alternately, while paying attention to the composition. "The position of the Earth, the reflections on the glass of the window, and I had to make sure that the lens was in the centre of the window. I really prayed that these would be good, since I was conscious of their value. But what was done was done – and I quickly forgot about them when I had to concentrate on closing correctly the hatch and suit leak checks and pick up the reentry and landing procedures."

For Paolo, taking the historic photos was an honour. "Since I was a kid, photography has been a hobby dear to me and all through my life photography had brought me to unusual places and made me live unexpected experiences.

"Like a photographer who has a gorgeous model in front of him, I was more concentrated on getting a good technical and artistic product than admiring it. I saw the view when changing from still to video images, but I purposely limited looking because I know I would have been mesmerised by the beauty of it," said Paolo. ■

→ LOOKING FORWARD TO RETURNING TO SPACE

This November, ESA astronaut André Kuipers sets off on the fourth European long-duration mission to the International Space Station, and becomes the first Dutchman to make two spaceflights.

André will be launched on Soyuz TMA-03M from the Baikonur cosmodrome in Kazakhstan. He will be Flight Engineer for Expeditions 30 and 31, flying with Russian cosmonaut Oleg Kononenko and NASA astronaut Don Pettit. They are scheduled to remain in space for nearly half a year, until the middle of May 2012.

This will be André's second visit to the ISS. He spent 11 days on the ISS on his Delta mission in April 2004. Back then, the ISS had only three main modules: Zarya, Unity and Zvezda. The ISS is almost complete and is shifting from assembly to a more operational phase, giving a boost to scientific research.

During the 169-day mission, André will conduct around 30 experiments covering different disciplines: fluid physics, radiation, biology and technology demonstration. He is himself a medical doctor who has been actively involved in microgravity research activities for more than ten years.

André will have several other tasks, such as being the prime operator for the rendezvous and docking operations of ESA's third Automated Transfer Vehicle, ATV *Edoardo Amaldi*. The largest vehicles serving the ISS today, ATVs deliver essential cargo, perform regular orbital reboosts and enable debris-avoidance manoeuvres. André will also take part in the berthing operations for the third Japanese Transfer Vehicle (HTV-3), an

unmanned spacecraft also used to resupply the ISS.

Space is possibly the most exciting platform from which primary and secondary school pupils can learn about life, biodiversity and climate change on Earth, so André will share his unique views of Earth from the ISS's Cupola and invite children to get involved in a wide range of educational activities.

He is also eager to share the sights and sounds of life in space with the rest of us as he circles Earth every 90 minutes. André has already started using Twitter, and he will also stay in touch through his own blog, ESA YouTube and Flickr.

↑ During Soyuz simulator training at Star City, Moscow, August 2011

↑ ATV rendezvous/docking training with Oleg Kononenko at EAC, Germany, July 2011

↑ Using the US Extravehicular Mobility Unit spacesuit, Houston, July 2011

↑ André has trained for spacewalks in Houston, USA, since 2006 when he was back-up for Frank De Winne on the OasISS mission

→ Practicing procedures for an emergency water landing, Star City, with Canadian astronaut Chris Hadfield in 2009 (CSA)

→ NEWS IN BRIEF

Paolo Nespoli's MagISStra mission comes to end on 24 May on the steppes of Kazakhstan as the Soyuz TMA-20 capsule fires retrorockets for a soft landing under its parachute canopy (NASA/B. Ingalls)

Pioneering environment satellite retires

After 16 years spent gathering a wealth of data that has revolutionised our understanding of Earth, ESA's veteran ERS-2 satellite is being retired.

This pioneering mission has not only advanced science, but also forged the technologies we now rely on for monitoring our planet. ERS-2 was launched in 1995, following its sister, the first European Remote Sensing satellite, which was launched four years earlier.

Carrying suites of sophisticated instruments to study the atmosphere, land, oceans and polar ice, these two missions were the most advanced of their time, putting Europe firmly at the forefront of Earth observation.

The twin satellites were identical, apart from ERS-2's additional instrument to monitor ozone in the atmosphere. Both exceeded their design lifetime by far, together delivering a 20-year stream of continuous data.

In 2000, ERS-1 unexpectedly stopped working and now it is time to bid farewell to ERS-2 before it succumbs to a similar fate. To avoid ERS-2 ending up as a piece of space debris, ESA will take the satellite out of service by bringing it down to a lower orbit while there is still sufficient fuel to make the careful manoeuvres.

The decision to retire ERS-2 was not taken lightly, but after orbiting Earth almost 85 000 times – travelling 3.8 billion km – the risk that the satellite could lose power at any time is clearly high.

The deorbiting procedure will be carried out over a number of weeks by spacecraft operators and flight dynamics experts at ESA's European Space Operations Centre in Germany. Starting on 6 July, a series of thruster burns will gradually lower the

Kepler's success

Europe's unmanned ATV space freighter plunged on command into Earth's atmosphere in June to end its mission, turning into a spectacular shooting star over the southern Pacific Ocean.

After a flawless undocking from the International Space Station, the Automated Transfer Vehicle (ATV) flew solo while mission controllers in Toulouse, France, prepared the craft for its fiery end.

↑ ATV's atmospheric reentry and break-up (D. Ducros)

Just before hitting the atmosphere, ATV *Johannes Kepler* was commanded to begin tumbling to ensure it would disintegrate and burn up safely. The destructive reentry happened exactly as planned over an uninhabited area of the south Pacific, about 2500 km east of New Zealand, 6000 km west of Chile and 2500 km south of French Polynesia.

"We broke many records with ATV-2," said Alberto Novelli, Head of ESA's ATV Mission Operations. "Not only was this the heaviest payload ever launched by ESA and the Ariane 5 rocket, but the ATV's engines also achieved the biggest boost for human spaceflight since the Apollo missions to the Moon: we raised the Space Station's orbit by more than 40 kilometres."

← Lead Mission Director Kris Capelle and Mission Director Mike Steinkopf, who was in charge during the last shift, at the ATV Control Centre in Toulouse just before the last deorbit burn on 21 June satellite's orbit from its current altitude of 800 km to about 550 km, where the risk of collision is minimal.

Eventually, ERS-2 will enter Earth's atmosphere and burn up. Its destruction will occur within 25 years, in accordance with European Code of Conduct on Space Debris Mitigation.

ERS-2 has been delivering data right to the end. In one of its last operations, the satellite was placed in an orbit that allowed it to capture radar images every three days of some of Earth's most rapidly changing features.

←

ERS-2, seen before launch at ESTEC in 1994

ATV-4 named *Albert Einstein*

With ATV *Johannes Kepler* flown and ATV *Edoardo Amaldi* already assembled, the next craft coming off the ATV production line has been named after the most famous scientist of all time: Albert Einstein. Launch is expected in early 2013.

Europe's ATVs are an essential contribution to the International Space Station. The vessels are named after great European scientists and visionaries to highlight Europe's deep roots in science, technology and culture. Naming ATV-4 after Einstein, as proposed by the Swiss delegation to ESA, reflects this approach. Einstein's contributions to humanity and, in particular, physics overturned our perception of the Universe, making him a major icon of 20th century science. ATV is also strongly linked to Switzerland: its structure is built by Swiss industry.

After launching ATV *Johannes Kepler* to the ISS in February, ESA plans to maintain a launch rate of one vessel per year. The next ATV, *Edoardo Amaldi*, completed testing in Bremen, Germany, and is being shipped to Europe's Spaceport in Kourou, French Guiana, in August for a launch in early 2012.

ATV *Albert Einstein* will be launched at the beginning of 2013.

←

The pressurised module of ATV *Albert Einstein* seen during manufacture in December 2010 in Turin (Thales Alenia Space)

ESA's high-thrust engine takes next step

The new main engine to power the successor Europe's Ariane 5 launcher was brought a step closer to reality when ESA signed a €60 million contract with a propulsion consortium.

ESA is preparing the Next-Generation Launcher (NGL) to meet Europe's institutional needs and safeguard its guaranteed access to space into the long term, ensuring it will continue to have effective and economic launchers at its disposal.

The work is being performed under ESA's Future Launchers Preparatory Programme (FLPP), which is identifying and studying new launch vehicle concepts and anticipating the technologies to make them possible.

A key development for Europe's next-generation launcher is its main engine. One objective of FLPP is to enable an informed decision to be taken later in the NGL programme, through studies and integrated demonstrators. Many configurations have been screened and studied, using two and three stages to orbit, different types of liquid and solid propellants and a cryogenic upper stage.

Liquid propulsion is promising for the main stage because of its flexibility, growth potential and track record. One of the candidates, the liquid-propellant High-Thrust Engine (HTE) demonstrator, will help to understand the key technology issues while developing European competence in propulsion system integration and advanced technologies.

A contract signed with the Joint Propulsion Team – a consortium of Astrium GmbH, Avio SpA and Snecma (Safran Group) – moves HTE to the next phase: the engine's preliminary design reviews in 2012, and possibly hot-firing tests performed around 2014.

→ NGL concepts under study. Left, first stage with cryogenic liquid oxygen and hydrogen engine, and upper stage with cryogenic reignitable engine; right: two solid-propellant main stages, with a cryogenic reignitable engine in the upper stage. Europe's NGL could be operational by 2025 or earlier (ESA/D. Ducros)

Mars500 reaches one year

The six men in the Mars500 facility near Moscow passed the 365-day mark in their isolation. The European crewmembers have been writing about the highlights, the monotony, team spirit and their determination to go on.

The crew of six – three Russians, two Europeans and one Chinese – walked from a press conference on 3 June 2010 into their isolation modules and began their virtual mission towards the Red Planet.

"Wow, it's already been a year," said Diego Urbina, one of the two Mars500 crewmembers from ESA, in his latest diary entry. "One way to visualise it is if you think of what you were doing exactly one year ago, and then picture yourself living in a windowless metal box from then!"

The Mars500 facility faithfully mimics every aspect of an interplanetary flight, as far as possible, without the crew really flying into space. Their 'craft' is composed of four sealed interconnected cylinders with a total volume of 550 cubic metres. They have their own private cabins and they live and work like the astronauts on the ISS.

ESA reentry vehicle on track for flight in 2013

Construction of the Intermediate eXperimental Vehicle (IXV) for its mission into space in 2013 was announced in June by ESA and Thales Alenia Space Italy.

Europe's ambition for a spacecraft to return autonomously from low orbit is a cornerstone for a wide range of space applications, including space transportation, exploration and robotic servicing of space infrastructure.

This goal will be achieved with IXV, which is the next step from the Atmospheric Reentry Demonstrator flight of 1998. More manoeuvrable and able to make precise landings, IXV is the 'intermediate' element of Europe's path to future developments with limited risks.

Launched into a suborbital trajectory on ESA's small Vega rocket, IXV will return to Earth as if from a low-orbit mission, to test and qualify new European critical reentry technologies such as advanced ceramic and ablative thermal protection.

The 2-tonne 'lifting body' will attain an altitude of around 450 km, allowing it to reach a velocity of 7.5 km/s on entering the atmosphere.

↑ ESA's IXV returning to Earth (ESA/J.Huart)

While making a controlled entry with thrusters and aerodynamic flaps, it will collect a large amount of data during its hypersonic and supersonic flight. The craft will then descend by parachute and land in the Pacific Ocean to await recovery and analysis.

← The Mars500 crew pose for a fun portrait in June

Irish President visits ESA's largest centre

On an official visit to the Netherlands on 3 May, the President of Ireland, Mrs Mary McAleese, included a visit to ESA's European Space Research and Technology Centre (ESTEC).

Mary McAleese was welcomed by Franco Ongaro, Head of Establishment at ESTEC and Director of Technical and Quality Management, and Directors Magali Vaissière and Thomas Reiter.

During her brief visit, the President was taken on a tour of the Concurrent Design Facility, the Test Centre and the Erasmus Centre. Thomas Reiter also showed her a training model of the Columbus module of the ISS.

The President greeted the 40 Irish staff and contractors working at ESTEC and concluded the visit by saying, 'I am impressed with what I have seen, and you should all be very proud of what you do to prepare the future for our children and grandchildren."

↑ Thomas Reiter, President McAleese, Dr. McAleese, Magali Vaissière and Franco Ongaro at ESTEC on 3 May

Space in your pocket…

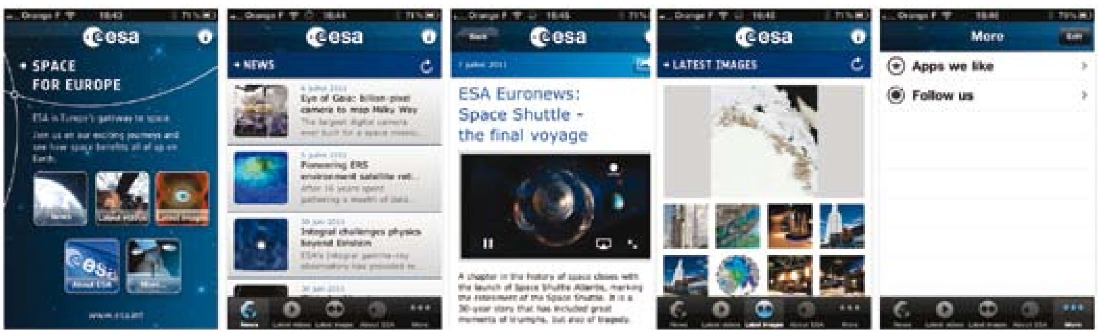
A new ESA iPhone or iPad application, or 'App', can now deliver a wealth of information on ESA missions, videos, images and news updates, at your fingertips.

The ESA App provides an easy and interesting way for the public to experience space exploration. It collects, customises and delivers a wide selection of up-to-date information from various online ESA sources. ESA content is delivered in a clear and intuitive way, wherever you are, making full use of the iPhone and iPad touch features.

You can access top news stories, videos, images, facts and figures, ESA's Twitter feeds, Flickr and Facebook links and other information in a convenient mobile package. This is now available free of charge for iPhone and iPad directly from the App Store at Apple.

This is an exciting new service for a growing audience who want to feel more involved in space developments.

ESA sees increasing awareness about space as a high priority, and wants to make space more accessible, not only to European citizens but also to viewers around the world. Tools such as this App allow ESA to provide easy access to its information for a wide public very quickly.



← ESA Application for iPhone and iPad

→ THE SATELLITE THAT KEEPS GOING… AND GOING…

Artemis: a celebration for satellite communications

Daniele Galardini with Jorgen Sandberg
Directorate of Telecommunications & Integrated Applications,
ESA Redu Centre, Redu, Belgium

↑ Artemis during testing in ESTEC's Large Space Simulator before launch in July 2001

Ten years ago, ESA's pioneering Artemis telecommunications satellite was dubbed 'Mission impossible'. But through hard work and ingenuity, Artemis became a 'mission accomplished', and is still operating today.

Artemis is considered a breakthrough in telecommunication satellites, clocking up a number of unique firsts in space. It created the first laser data link between satellites in different orbits; it was the first telecommunications satellite to be extensively reprogrammed in orbit; and it was the first to use 'ion propulsion' to reach geostationary orbit, 36 000 km up, after surviving the longest-ever drift to its destination.

Artemis has also demonstrated new technologies and plays a significant part in developing EGNOS, new mobile communication services and transmission of low and high data rates directly between satellites in low Earth orbit and their ground stations.

Thanks to the Artemis data relay payload, data collected by ESA's Earth observation satellite Envisat are delivered to customers effectively in real time and at a high data rate. Artemis also provides dedicated support to ESA's Automated Transfer Vehicles throughout the free-flying phase of their missions to the International Space Station. NASA's Tracking and Data Relay Satellite System (TDRSS) was the back-up for Artemis during the attached phase

↑ 12 July 2001: the ill-fated launch of Ariane 5 V142 with Artemis on board. After a perfect lift-off, its upper stage underperformed and placed the satellite in the wrong orbit (ESA/CNES/Arianespace)

> **Artemis has delivered a service availability higher than 99% over its entire operational life**

of ATV Johannes Kepler's flight, and Artemis backed up TDRSS during the other phases.

In 2008, Artemis leapt into service at short notice during the first ATV mission when NASA's TDRSS link was unavailable after Hurricane Ike struck the country. The ATV team in Toulouse, France, and their Artemis counterparts in Redu, Belgium, sprang into action. With only a few hours to prepare, they kept contact with the spacecraft throughout the night of 11 September.

Artemis has provided regular data relay services to the CNES SPOT-4 Earth observation satellite using the SILEX high data-rate optical link, and as one of its experiment payloads, a low data-rate link in S-band. Moreover, Artemis has supported JAXA's optical link communication experiment and the data link demonstration by CNES and ASI for unmanned aerial vehicles. The EGNOS payload has allowed European industry to develop navigation applications and to position itself in this market.

However, a malfunction 10 years ago could have ended the Artemis mission before it even began. In July 2001, Artemis was launched on an Ariane 5 from Kourou in French Guiana. After a perfect lift-off, an anomaly appeared when Ariane's upper stage fired, causing Artemis to be put in the wrong orbit.

An emergency operations team was quickly established to do its best to rescue as much of the mission as possible. The first potential danger to the satellite was passing through the Van Allen radiation belt. It was decided to use fuel, originally meant for circularising the planned transfer orbit into a 36000 km geostationary orbit, to get Artemis into a 17000 km circular orbit. This manoeuvre was performed perfectly and Artemis was safe. Now there was time to find the best way to get Artemis into geostationary orbit.

↑ On 30 November 2001, image data were transmitted for the first time by laser between two satellites. This was the spectacular demonstration of the SILEX (Semiconductor Intersatellite Link Experiment) system, where an optical link was established between Artemis in geostationary orbit and the French space agency's SPOT 4 in a low Earth orbit

A solution was found. After more than six months of preparation, testing and implementing new in-flight software, the ion propulsion technology payload on board Artemis was used to push the satellite to its final destination. After 18 months, Artemis reached its correct orbit on 31 January 2003.

Because the ion propulsion system was conceived as an experimental unit, and intended for an entirely different function, the new orbit-raising strategy required fine-tuning of the engine, as well as of its alignment mechanism operations. Originally designed for only 'station-keeping' once the satellite was in the correct orbit, the ion propulsion system turned out to be vital in the recovery manoeuvres intended to propel Artemis into geostationary orbit.

Nevertheless, enough opportunities were found to demonstrate that all payloads (S-band and Ka-band and optical data relay, navigation and L-band mobile payload) were available and that their performance was in line with pre-launch results. Correct operation of the closed-loop tracking system for the Ka-band inter-orbit antenna was also demonstrated. The antenna acquired a signal transmitted from Redu and maintained the link automatically while Artemis drifted slowly across the sky.

Inclination control was planned for Artemis, but has never been performed due to lack of fuel. This means antenna coverage is somewhat different to what it should have been, however Artemis continues to provide services to the scientific and industrial communities almost as initially expected.

Although the satellite itself is controlled by Telespazio from Fucino, Italy, the Artemis mission operations are run from ESA's Redu centre. Redu houses the Artemis Mission Control Facility, the Ka-band ground terminal with a

↑ Lanzarote, Canary Islands: the first image transmitted by laser between SPOT 4 and the SILEX system on Artemis (CNES/SPOT Image)

↓ The Artemis mission control team and ground segment support team at Redu, Belgium. Artemis successfully answered the call for emergency services for ATV due to outages at NASA mission control in Houston, Texas

13.5 m-diameter dish antenna, and serves as a user ground station with all the facilities used to test the status of the payloads.

"Artemis has delivered a service availability higher than 99 per cent over its entire operational life, including cases when there was conflict between service requests of users," says Daniele Galardini, Head of Redu and in charge of the Artemis programme.

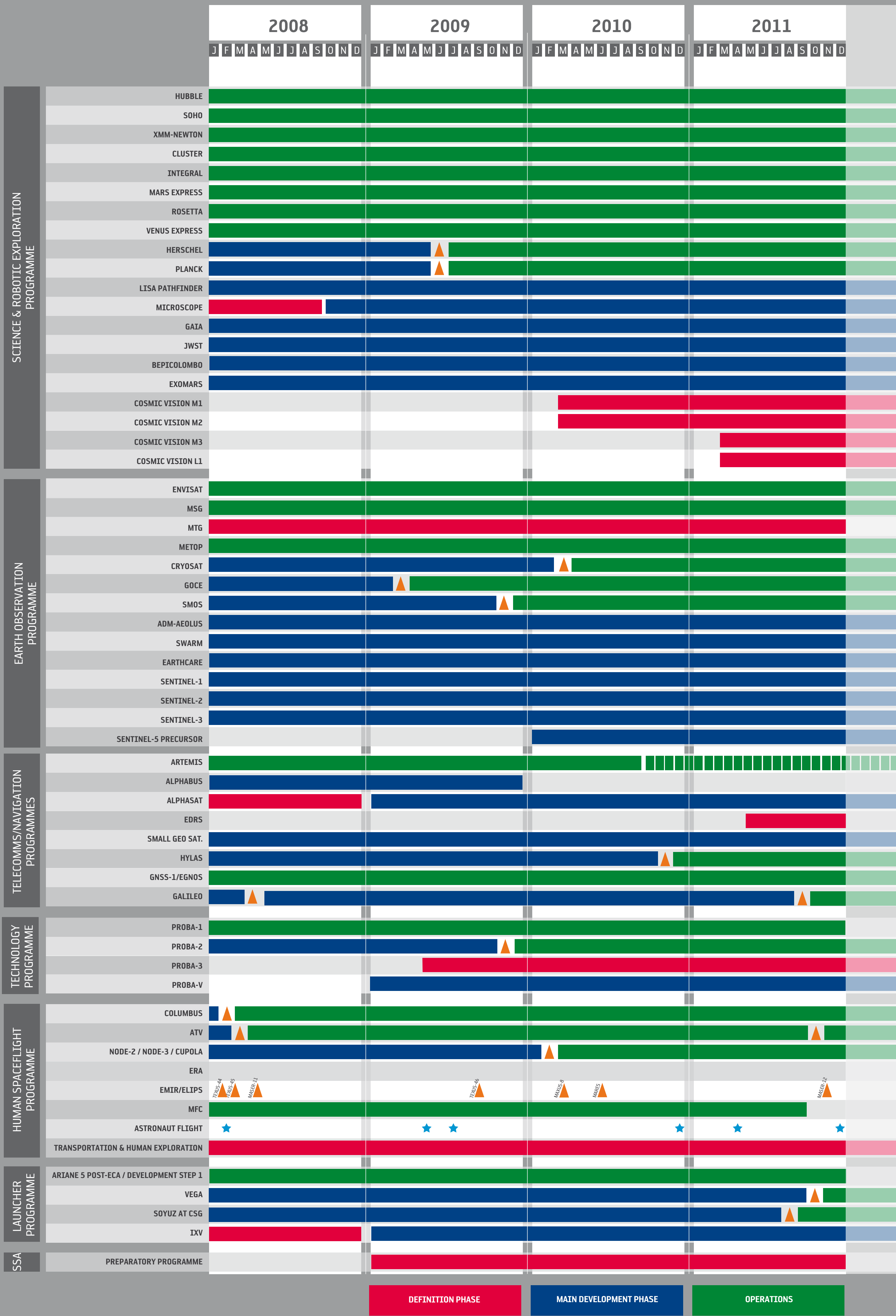
Today Artemis is not only a precursor of the upcoming European Data Relay Satellite (EDRS) system, but also can be regarded as an integral part of its infrastructure for the first years of operation.

"The capability and professionalism of the teams in Fucino and Redu are the basis of the success of Artemis. Thanks to everybody who believed in Artemis. Happy birthday and we look forward to the follow-on EDRS." ■

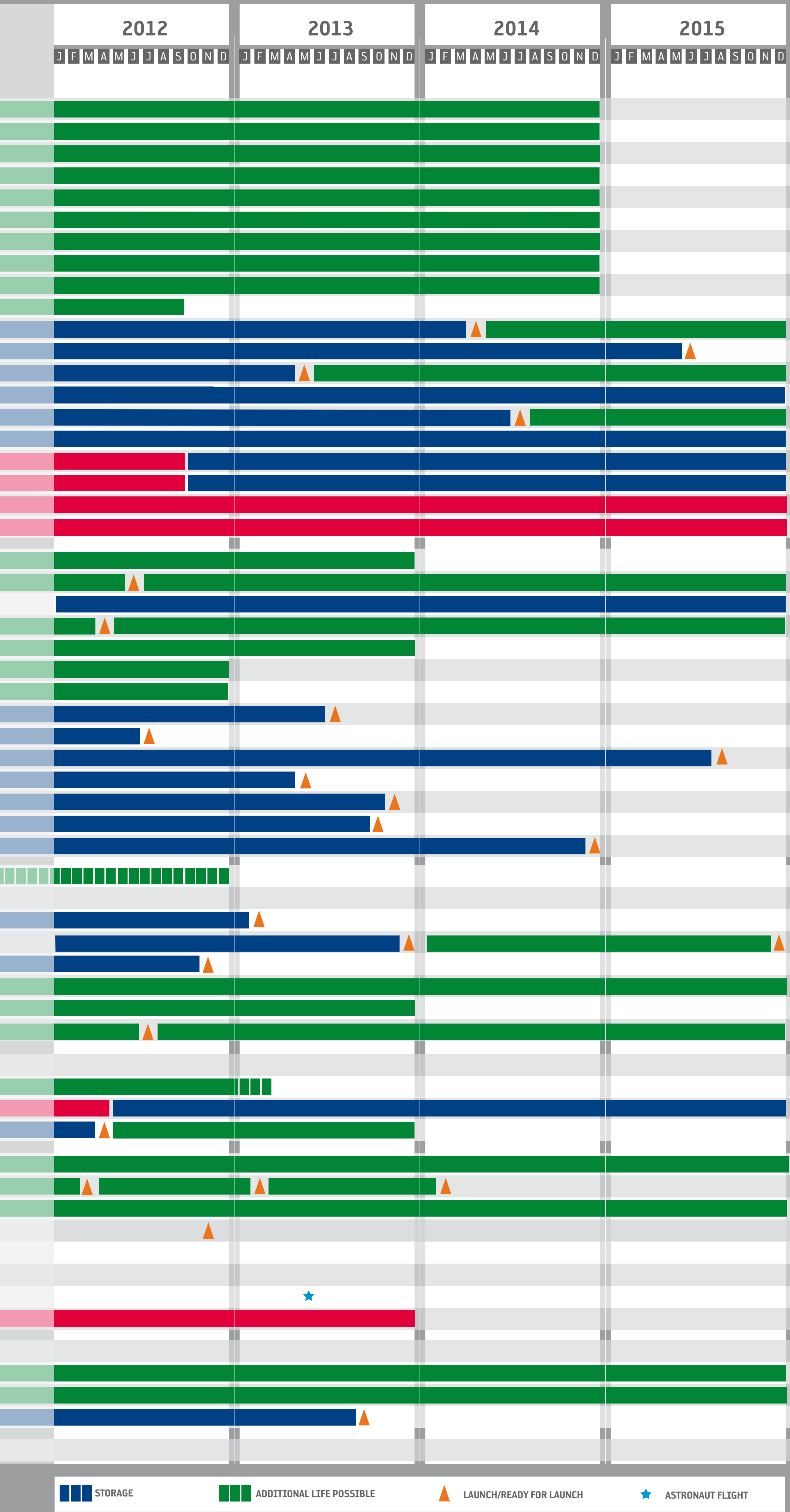
→ PROGRAMMES IN PROGRESS

Status at end of July 2011

ESA's ATV *Johannes Kepler* approaches the ISS for a docking on 24 February 2011



2008
2009
2010
2011
J F M A M J J A S O N D
SCIENCE & ROBOTIC EXPLORATION PROGRAMME
HUBBLE
SOHO
XMM-NEWTON
CLUSTER
INTEGRAL
MARS EXPRESS
ROSETTA
VENUS EXPRESS
HERSCHEL
PLANCK
LISA PATHFINDER
MICROSCOPE
GAIA
JWST
BEPICOLOMBO
EXOMARS
COSMIC VISION M1
COSMIC VISION M2
COSMIC VISION M3
COSMIC VISION L1
EARTH OBSERVATION PROGRAMME
ENVISAT
MSG
MTG
METOP
CRYOSAT
GOCE
SMOS
ADM-AEOLUS
SWARM
EARTHCARE
SENTINEL-1
SENTINEL-2
SENTINEL-3
SENTINEL-5 PRECURSOR
TELECOMMS/NAVIGATION PROGRAMMES
ARTEMIS
ALPHABUS
ALPHASAT
EDRS
SMALL GEO SAT.
HYLAS
GNSS-1/EGNOS
GALILEO
TECHNOLOGY PROGRAMME
PROBA-1
PROBA-2
PROBA-3
PROBA-V
HUMAN SPACEFLIGHT PROGRAMME
COLUMBUS
ATV
NODE-2 / NODE-3 / CUPOLA
ERA
EMIR/ELIPS
TEXUS-44
TEXUS-45
MASER-11
TEXUS-46
MAXUS-8
MARES
MASER-12
MFC
ASTRONAUT FLIGHT
TRANSPORTATION & HUMAN EXPLORATION
LAUNCHER PROGRAMME
ARIANE 5 POST-ECA / DEVELOPMENT STEP 1
VEGA
SOYUZ AT CSG
IXV
SSA
PREPARATORY PROGRAMME
DEFINITION PHASE
MAIN DEVELOPMENT PHASE
OPERATIONS



COMMENTS

LAUNCHED APRIL 1990 / OPS EXTENDED UNTIL 2014
LAUNCHED DEC 1995 / OPS EXTENDED UNTIL 2014
LAUNCHED DEC 1999 / OPS EXTENDED UNTIL 2014
LAUNCHED MID-2000 / OPS EXTENDED UNTIL 2014
LAUNCHED OCT 2002 / OPS EXTENDED UNTIL 2014
LAUNCHED JUNE 2003 / OPS EXTENDED UNTIL 2014
LAUNCHED MARCH 2004 / ARRIVES AT COMET 2014
LAUNCHED NOV 2005 / OPS EXTENDED UNTIL 2014
LAUNCHED 14 MAY 2009; OPS 3-5 YEARS
LAUNCHED 14 MAY 2009; OPS EXTENDED UNTIL 2012
LAUNCH APR 2014
LAUNCH MID 2015
LAUNCH MAY 2013 / NOMINAL MISSION END 2017
LAUNCH OCTOBER 2018
LAUNCH JULY 2014
LAUNCH JAN 2016 / MAY 2018
LAUNCH 2017
LAUNCH 2018
LAUNCH 2022 / 23
LAUNCH 2022

LAUNCHED MARCH 2002 / EXTENSION TO 2013
MSG-3 LAUNCH JUNE 2012, MSG-4 LAUNCH 2014
LAUNCH MTG-I-1 2018 / MTG-S-1 2019
METOP-B APRIL 2012 / METOP-C OCT 2016
CRYOSAT-2 LAUNCHED 10 APR 2010
LAUNCHED 17 MARCH 2009: OPS UNTIL END 2012
LAUNCHED 2 NOV 2009
LAUNCH MID-2013
LAUNCH JULY 2012
LAUNCH AUGUST 2015
LAUNCH MAY 2013
LAUNCH NOV 2013
LAUNCH OCT 2013
LAUNCH END 2014

LAUNCHED JULY 2001, OPERATIONS EXTENDED

LAUNCH EARLY 2013
LAUNCH EDRS-A, END 2013; EDRS-C, END 2015
LAUNCH END 2012
LAUNCHED NOV 2010; OPS 15 YEARS
OPERATIONS START 2008
GIOVE-A 2005 / GIOVE-B APR 2008 / IOV OCT 2011 & JULY 2012

LAUNCHED OCT 2001
LAUNCHED 2 NOV 2009 / OPS EXTENDED UNTIL 2011/12
LAUNCH 2015/16
LAUNCH APRIL 2012

LAUNCHED FEB 2008
ATV-3 MAR 2012, ATV-4 FEB 2013, ATV-5 FEB 2014
NODE-2: OCT 2007; NODE-3 WITH CUPOLA: FEB 2010
LAUNCH NOV 2012
TEXUS 46: NOV 2009, MAXUS 8: SPRING 2010,
MASER 12: NOV 2011
BIOLAB, FSL, EPM, EDR (EuTEF, SOLAR) WITH COLUMBUS MAR 2008
MSL: AUG 2009
VITTORI: MAY 2011; KUIPERS: DEC 2011; PARMITANO: MAY 2013
PREPARATORY ACTIVITIES INCLUDING LUNAR LANDER AND ARV

MATURITY KEY POINT 31 JAN 2011
FIRST LAUNCH END DECEMBER 2011
FIRST LAUNCH END OCTOBER 2011
SYSTEM ACCEPTANCE REVIEW, JULY 2013
LAUNCH READINESS REVIEW SEPT 2013

PRELIMINARY DESIGN REVIEW, DEC 2011

KEY TO ACRONYMS

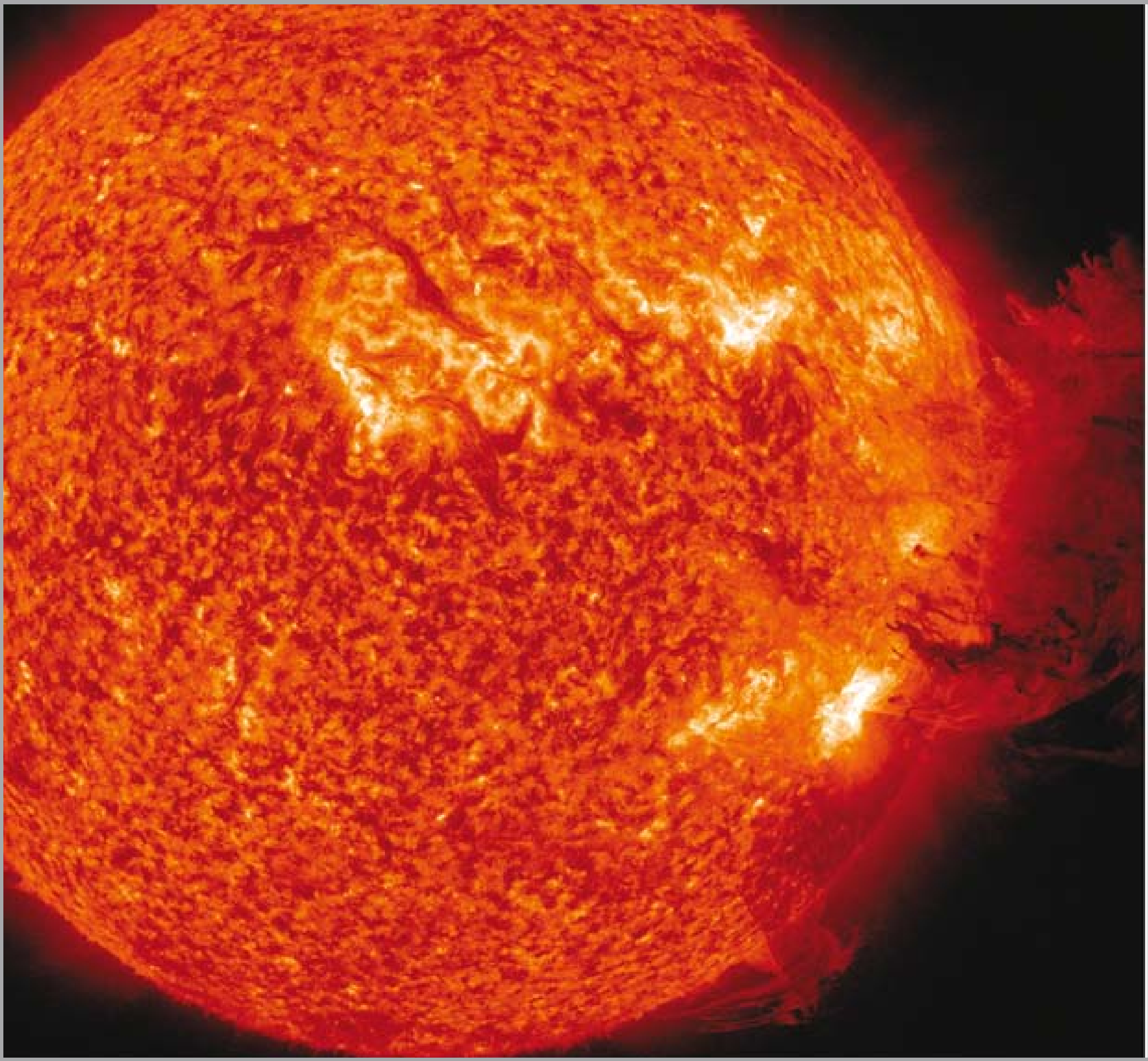
AM - Avionics Model	MoU - Memorandum of Understanding
AO - Announcement of Opportunity	PDR - Preliminary Design Review
AU - Astronomical Unit	PLM - Payload Module
CDR - Critical Design Review	PRR - Preliminary Requirement Review
CSG - Centre Spatial Guyanais	QM - Qualification Model
ELM - Electrical Model	SM - Structural Model
EM - Engineering Model	SRR - System Requirement Review
EQM - Electrical Qualification Model	STM - Structural/Thermal Model
FAR - Flight Acceptance Review	SVM - Service Module
FM - Flight Model	TM - Thermal Model
ITT - Invitation to Tender	

→ SOHO

On 7 June, the Sun unleashed one of the most spectacular prominence eruptions ever observed. Based on real-time LASCO data, space weather forecasters could determine within hours that Earth would receive only a glancing blow from the associated Coronal Mass Ejection (CME), not a major space weather-induced event as hyped in the media. The event originated from the almost spotless active region 11226 and was associated with a moderate M2-class X-ray flare. The CME and associated shockwave produced an S1-class radiation storm, which shows up as speckles in the LASCO images. This event is not only one of the most spectacular ever recorded, but also one of the best observed, with complementary data from several spacecraft and different vantage points (SDO, SOHO, STEREO, Proba-2). For movies of this event see: **http://soho.esac.esa.int/hotshots/index.html/**

→ XMM-NEWTON

By a stroke of luck, astronomers using ESA's XMM-Newton X-ray observatory have observed a neutron star in a peculiar X-ray binary system undergoing an extremely rare, intense flare. This four-hour outburst of X-rays was due to a sudden increase in the rate at which the neutron star was accreting matter from its companion, a blue supergiant star. The unprecedented detail of the



CME as recorded by SOHO's LASCO instrument a few hours after the prominence eruption from the Sun's surface on 7 June (NASA/ESA)

Artist's impression of a neutron star devouring a massive clump of matter

data provides the first substantive evidence to explain such luminosity variations in this type of binary system: the flare appears to be due to the ingestion of a massive clump of matter by the neutron star.

→ CASSINI–HUYGENS

Cassini–Huygens continues to perform excellent science in the Saturn system. The second extension of the mission, called 'Cassini-Solstice', started in October 2010 and is foreseen to last until September 2017.

Cassini has recently made passes directly through some icy fountains on Saturn's moon Enceladus, which were discovered in 2005. Analysis of the data *in situ* by the Cosmic Dust Analyzer revealed the existence of salty icy grains, whose existence can only be explained by flash-freezing of a salty liquid water reservoir suddenly exposed to space through the surface cracks. This is compelling evidence for the existence of a large liquid water reservoir, most likely in contact with a rocky core, beneath the surface of Enceladus.

Recent analysis of data from the Composite Infrared Spectrometer (CIRS), supports the possibility of existence of liquid water by demonstrating that Enceladus generates more heat than expected from current models of long-term heat production (a combination of radioactive decay and tidal interactions with Saturn and neighbouring moons).

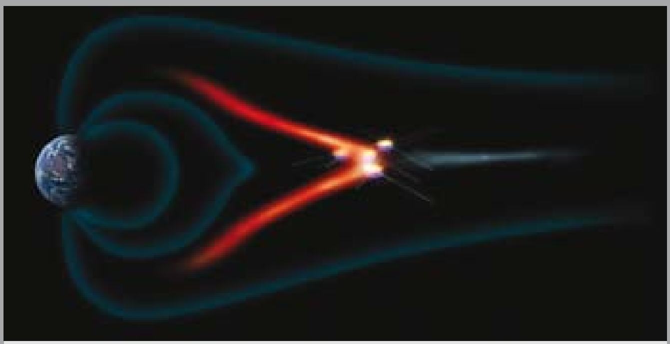
Enceladus is a tiny icy moon located in a region of the outer Solar System where no liquid water is expected to exist, because of its large distance from the Sun. These findings are therefore crucial new pieces of evidence that environmental conditions favourable to the emergence of life may even be sustainable on icy bodies orbiting gas giant planets.

The icy plumes of Enceladus (Cassini Imaging Team/SSI)

→ CLUSTER

The four Cluster spacecraft ended their long eclipse season in July. During summer, some of the spacecraft will fly at their lowest altitude since launch. At around 200–300 km, below the ISS, there are chances for ground-based observation of the spacecraft. In the next months, the spacecraft will target low-altitude regions including the inner plasmasphere and the auroral regions.

A recent result detailed *in situ* observations of wave-particle interactions in Earth's magnetotail. Heating and acceleration of plasma when magnetic reconnection occurs is a very active area of research and is key to understanding solar activity in the form of CMEs and other astrophysical processes. Observations indicate that particle energisation, seen also in solar flares, is carried out by a combination of reconnection and plasma jet interaction with the local magnetic field structure. This result highlights the key role of electron physics in reconnection. The observations show that wave generation strongly affects the electron dynamics, and plays a crucial role in the energy conversion chain during plasma jet braking. The key aspect of the result is the observation of persistent wave activity, which directly indicates the sustained pileup of the magnetic field. The results presented are of universal importance for solar and astrophysical environments.



Cluster observations confirm that acceleration of energetic particles in Earth's magnetotail is caused by magnetic reconnection, triggering plasma jets (light blue jet tailward of the Cluster satellites) followed by betatron acceleration which heats and further accelerates these jets towards Earth (red jets) (ESA/AOES Medialab)

→ INTEGRAL

Integral operations continue smoothly with the spacecraft, instruments and ground segment all performing nominally. The 17th SPI annealing from 26 April–16 May restored the energy resolution. The M2 solar flare on 7 June led to a shutdown of Integral instruments for the first time since the end-2006.

Galaxy Centaurus A is one of the favourite extragalactic objects of X-ray and gamma-ray astronomers because it is relatively close (about 12 million light-years) and harbours a super-massive black hole that accretes matter from its surroundings, producing a large amount of radiation, especially in the X-ray and gamma-ray domains. In addition, Centaurus A displays jets originating in the central engine, which shoot matter far out into the surrounding galaxy, up to distances of 50 000 light-years from the core. So, when we look at the heart of Centaurus A in the X-ray and gamma-rays regions, do we actually see emission coming from these highly energetic jets, or do we observe the matter which is heated during the accretion process?

Careful modelling of recent Integral data shows that the hard X-ray data are consistent with an origin in the accretion disk of the super-massive black hole, but also the jet might contribute. Most likely it is a mix of both components. Integral shows some aspects of Centaurus A that are typical for jet emission, like the smooth spectrum all the way up to the MeV range and the possible connection to the gamma-rays. But other aspects point toward accretion processes, like the iron line at 6.4 keV and the rather persistent X-ray spectrum.

The X-ray spectrum up to MeV range taken by Integral will be the best available for many years for studying Centaurus A.

→ MARS EXPRESS

Mars Express spacecraft and instruments are working normally, with the pericentre drifting towards the high northern latitudes on the night side. The MARSIS radar will soon probe the north polar cap for the first time under the right illumination conditions. Hopefully the Sun will not be very active at the time, since solar events such as flares can significantly impact the performance of the radar.

Three frames from the series taken by Mars Express during the Phobos–Jupiter conjunction on 1 June. The spacecraft was 11 389 km from Phobos, and a further 529 million km from Jupiter. (ESA/ DLR/ FU Berlin)

On 1 June, Mars Express acquired 104 spectacular images of the martian moon Phobos in conjunction with Jupiter. The camera's super-resolution channel was kept fixed on Jupiter, ensuring that it remained static in the frame. By showing the exact moment Jupiter passed behind Phobos, the observation improves knowledge of the orbital position of the moon. This information is important for planning Mars Express Phobos flybys and understanding the evolution of the moon's orbit, which can help to decipher its origins.

→ ROSETTA

On 8 June Rosetta was put into hibernation. The spacecraft was spun up to stabilise its attitude, after which the command to enter hibernation mode was released. As expected, the last radio pulse from the spacecraft was detected and, after six days of passive monitoring, hibernation entry was confirmed. During the hibernation period, Rosetta will reach the following record distances:

— 5.29 AU from the Sun on 3 October 2012
— 6.26 AU from Earth on 1 December 2012

The wake-up time has been set for 10:00 UTC, 20 January 2014, at which time Rosetta will be 5.39 AU from Earth and 4.49 AU from the Sun.

→ VENUS EXPRESS

Venus Express continues operating well. The increasing activity of the Sun has been detected also by the Venus Express sensors; a solar flare outburst in the direction of Venus caused an increased noise count on several sensors and a temporary blinding of the star trackers was observed. Two days later a similar event was observed by both SOHO and Mars Express. The effect on Venus' atmosphere of the increased solar activity will receive special attention during the coming year.

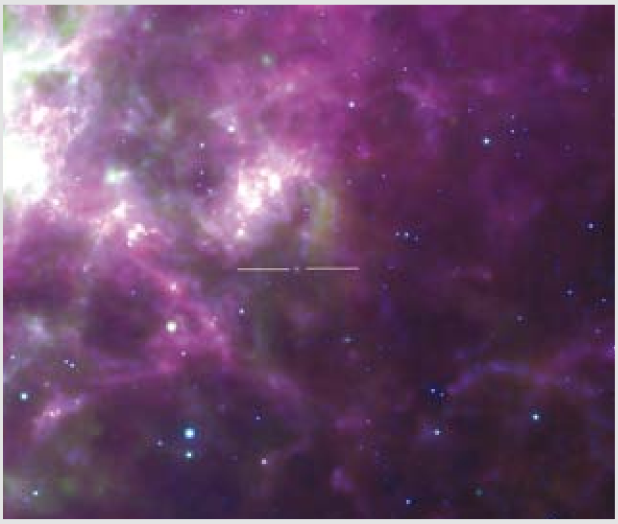
By now more than 3.5 Tbit of science data has been acquired and downlinked to ground, allowing many scientific objectives of the mission to progress significantly. In particular the field of comparative planetology has received a boost, as new data is needed for verification of new models and theories. As Venus has similar size, mass and basic composition to our own Earth, the two planets can be seen as 'twin planets', making them an ideal set for comparison. They might be expected to be fairly similar, but in fact they are very different, with Venus having surface temperatures of above 460°C and a pressure of over 90 bar. The evolutionary paths of the two planets are important in comparative planetology, and the two planets can be seen as being in different stages of their evolution. Of particular interest is the diversity in the state and the evolution of their atmospheres, especially when also considering other solar system bodies with atmospheres, like Mars and Titan.

The August issue of *Planetary and Space Science* is dedicated to comparative planetology and includes 24 original papers using data from Venus Express dealing with topics such as Interior and subsurface, atmospheric chemistry and clouds, atmospheric dynamics and climate, aeronomy and solar wind interaction, planetary evolution, and conditions for life. Venus Express clearly fulfils an important role in improving the understanding of how the planets of the inner Solar System work.

→ HERSCHEL

Herschel continues to work well, which was the main conclusion from the 2nd In-Orbit Performance Review carried out in ESOC on 26 May. The review was preceded by the third measurement of the remaining superfluid helium in the cryostat. The measurements to date together with modelling indicate that Herschel could continue performing observations until some time in the spring of 2013. As planned, the second and final in-flight call for Herschel observing proposals was released to the worldwide scientific community on 9 June.

An exciting recent Herschel science result involves the famous supernova in the Large Magellanic Cloud (LMC) that exploded 24 years ago, labelled SN1987A. The LMC is a companion galaxy to the Milky Way, and because of its relative proximity of about 160 000 light-years, this supernova is the most well-studied in history – but only now in the far infrared.



Composite Herschel/SPIRE and Spitzer/IRAC/MIPS image of a portion (slightly smaller than the extent of the full moon) of the Large Magellanic Cloud. The position of SN1987A is indicated by the bar. Blue indicates 8 µm, green 24 µm, and red 250 µm emission (ESA/Herschel/AAAS/HERITAGE consortium)

The actual Herschel detection of SN1987A was a big surprise. The HERschel Inventory of The Agents of Galaxy Evolution in the Magellanic Clouds (HERITAGE), a Herschel Key Programme, has conducted a uniform survey of the Magellanic clouds, including the position of SN1987A, but it was not specifically targeted. Based on existing knowledge of dust in supernovae, it was not anticipated that Herschel would detect it.

The measurements indicate that the LMC contains roughly 1000 times more dust (solid grains containing a variety of heavy elements including carbon, silicon and iron) than indicated by much earlier observations performed in the near- and mid-infrared wavelength ranges. Based on the new Herschel data, the amount of dust present is estimated to be nearly equivalent to the mass of the Sun. This result not only yet again demonstrates the importance of Herschel in obtaining observations in a part of the spectrum previously poorly exploited, but it also hints at a possible explanation of the origin of the heavy elements observed in the very early Universe.

→ PLANCK

Planck is now well into its first operational extension, and in August 2011 will complete its fourth sweep of the complete sky. In January 2012, the dilution cooler on board Planck and the detectors of the HFI will cease to operate due to lack of cryogenic fluid. However, the LFI detectors may continue to operate for a period between a few months and one year.

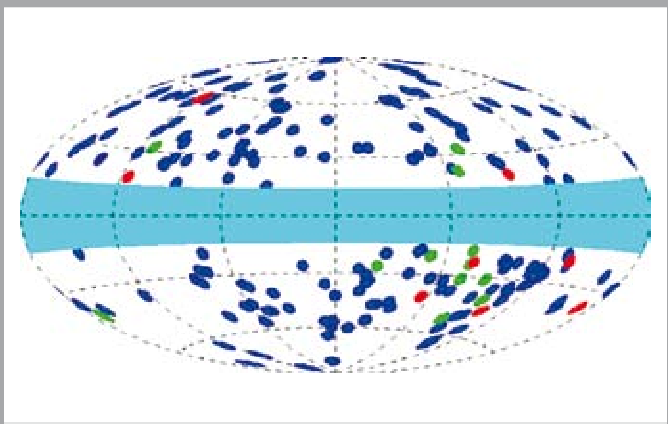
On 11 January, the Planck Collaboration presented its first science results, concerning compact and diffuse foreground emission sources, at a public conference held in Paris, France. One of the earliest scientific efforts carried out by Planck is a search for clusters of galaxies using the Sunyaev-Zel'dovich effect, which is a distortion of the spectrum of the Cosmic Microwave Background (CMB) due to interaction of the CMB photons with the hot electrons in the intracluster medium. The survey, which has benefited from a fruitful collaboration with ESA's XMM-Newton observatory, probes a wide range of cluster masses and other properties, which is unprecedented for a Sunyaev-Zel'dovich sample.

With its power to detect cosmic material at incredibly low temperatures, Planck has also completed the first unbiased, all-sky survey of compact cold and dusty objects in our own galaxy, the Milky Way, and at the same time, the first all-sky survey of cool dust in other galaxies. These extensive data sets allow astronomers new insight into the earliest phases of star formation.

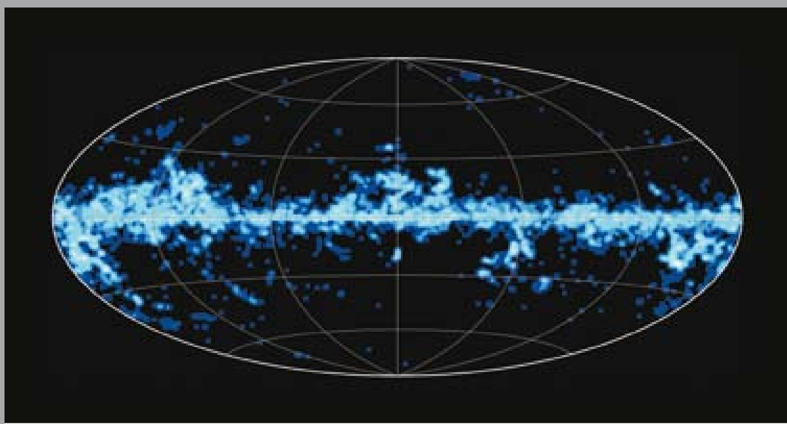
Another interesting result concerns mysterious components of the Milky Way. Thanks to its broad spectral coverage and very high sensitivity, Planck is peering deep into the interstellar medium of the Milky Way and is discovering new components and physical mechanisms taking place there. The results emerging from Planck's first all-sky survey include strong evidence for the presence of extremely rapidly spinning dust grains, an excess emission explained in terms of a previously poorly-quantified 'dark gas' and the characterisation of an excess emission arising from the interstellar medium that permeates the Small Magellanic Cloud, a nearby galaxy orbiting our own Milky Way.

→ COROT

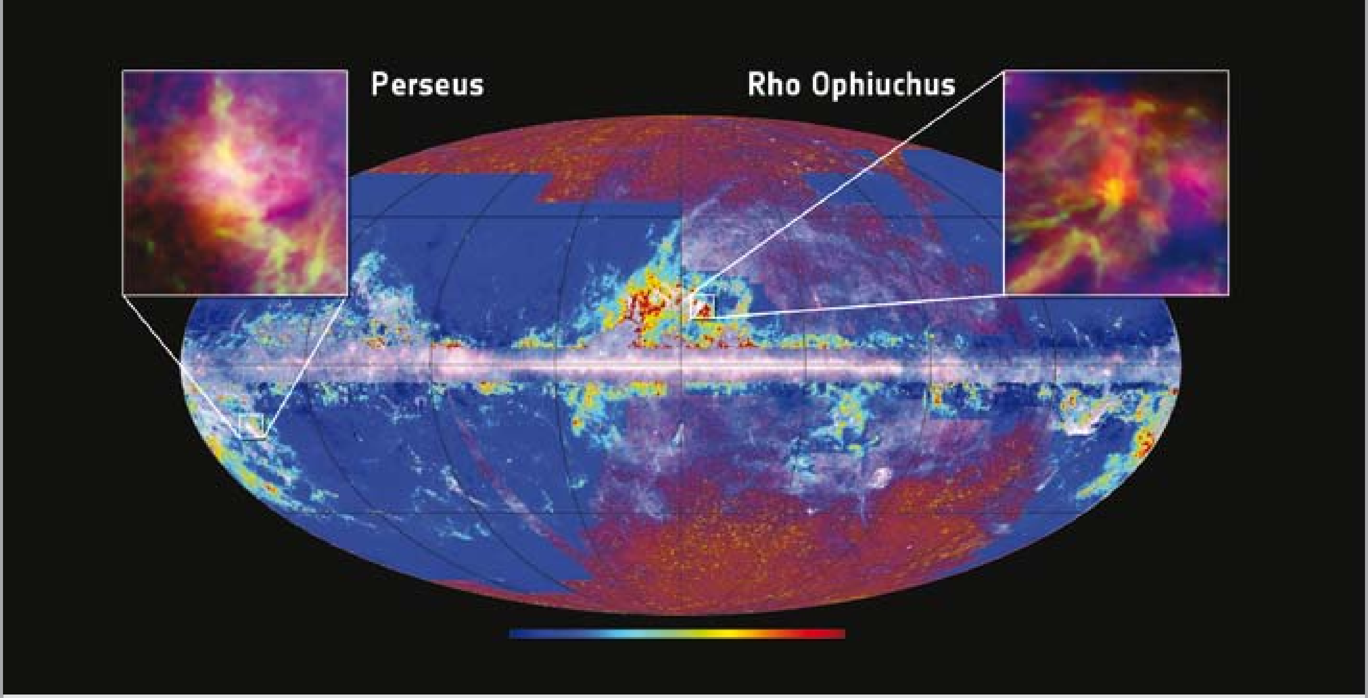
At the second COROT symposium held in Marseille in June 2011, 10 new exoplanets were announced, exhibiting a wide variety of sizes and orbital parameters, demonstrating the increasing variety found in planets orbiting stars other than our Sun. Apart from several hot Jupiters, the new exoplanets



The distribution across the sky of the galaxy clusters and cluster candidates detected by Planck during its first all-sky survey and listed in the Early Sunyaev-Zel'dovich sample



The density of cold cores in the Milky Way as detected by Planck during its first all-sky survey through its three highest frequency channels



The distribution, over about 63% of the sky, of the excess emission (sometimes referred to as 'dark gas'), one of the new, mysterious components of the interstellar medium studied by Planck, superimposed on top of the all-sky image from Planck's first survey, which highlights the two major emission sources in the microwave sky: the cosmic background and the Milky Way. The insets show two regions of star formation in the Milky Way, the Perseus and the Rho Ophiuchus molecular clouds, where Planck has detected anomalous emission due to nano-sized spinning dust grains. Both images are colour-composites based on three images taken at 0.4 GHz from a ground-based survey in 1982 and at 30 and 857 GHz by Planck, respectively, and have an angular size of 5 degrees each

include one slightly smaller than Saturn as well as two Neptune-like objects orbiting close to the same star. This brings the total of exoplanets newly discovered by COROT to 26, with several hundred candidates still to be investigated in detail before they can be either confirmed as exoplanets or discarded as so-called 'false-positives'.

Exoplanetary science now has more than 565 objects to study, of which for more than 150 transiting planets we know both radius and mass and thus the density. This allows us to start drawing conclusions about the physical conditions as well as the evolutionary status for statistically significant numbers of exoplanetary systems.

→ GAIA

Integration of the PLM structural/FM was completed in June. Nine of the ten FM mirrors were manufactured and delivered to the prime contractor Astrium. Seven of them were integrated on the PLM for the mechanical qualification test campaign at Intespace Toulouse. Optical alignment verification performed before and after vibration confirmed the required stability of the telescope line of sight.

Integration of the Focal Plane Assembly FM is progressing and all 106 flight CCDs have been mounted and aligned. The large memory unit (PDHU) and the Micro Propulsion controller (MPE) have been delivered for integration on the SVM. The Deployable Sunshield Assembly FM is manufactured and the first deployment test in the cleanroom, at ambient conditions, took place in Sener. Integration of the Radial Velocity Spectrometer optics is complete and the functional performance and environmental test campaign has started. TNO is working on the Basic Angle Monitor system (the instrument which will measure the variation of the two telescope angles in orbit); precision alignment of the optical paths is almost finished.

The second System Validation Test is complete. The test lasted five days and several flight operation procedures were exercised by ESOC, commanding the spacecraft AM at Astrium in Stevenage. The Mission CDR was completed in April.

Gaia's PLM during the mechanical qualification tests at Intespace Toulouse (Astrium SAS)

→ LISA PATHFINDER

The LISA Pathfinder FM in launch configuration has completed the sine vibration test in IABG, Ottobrunn. The science module (SCM) FM has been separated from the propulsion module FM. The latter is then mated with the SCM SM and will undergo the Vega compatibility shock tests in July. The SCM FM has been stripped of the dummy LISA Technology Package (LTP) units used during the vibration test and has been equipped with all the LTP FM units for the EMC test and Thermal Vacuum test planned for August and September/October respectively. Only the micro-propulsion thruster FMs and the LTP Core Assembly (LCA) are missing. The LCA is replaced by a Thermo-Optical simulator capable of performing an interferometry measurement during the thermal vacuum test, which would not be possible with the LCA FM.

Functional verification of the spacecraft is continuing, both at Real Time Test Bench and Software Verification Facility level. Software version 3.0 is being used for all functional tests.

A series of additional tests are carried out on the FEEP micropropulsion system in order to confirm the cause of the failure that occurred late in 2010. In parallel, ESA and industry are studying the implementation of alternative micro-propulsion systems (a Gaia-type cold gas system and a reduced version of the Radio-frequency Ionisation Thruster developed for telecommunication and Earth observation applications) as backup that could be implemented if FEEP testing were unsuccessful. Fortunately, FM hardware is not required until late in the integration sequence and a decision needs only to be made in mid-2012.

The American Disturbance Reduction System payload flight hardware was previously integrated on the SCM. All units of the LTP have been delivered for test at the LTP Architect followed by integration in the SCM, except the LCA, which is subject to necessary redesign activities on the caging mechanism. This redesign is being performed by industry.

Two breadboards of alternative caging lock devices have been developed and will be soon submitted to test. The best concept will be selected in October.

Due to the delay of the LCA and the uncertainties with the FEEP qualification, launch of LISA Pathfinder will not be possible before April 2014.

→ MICROSCOPE

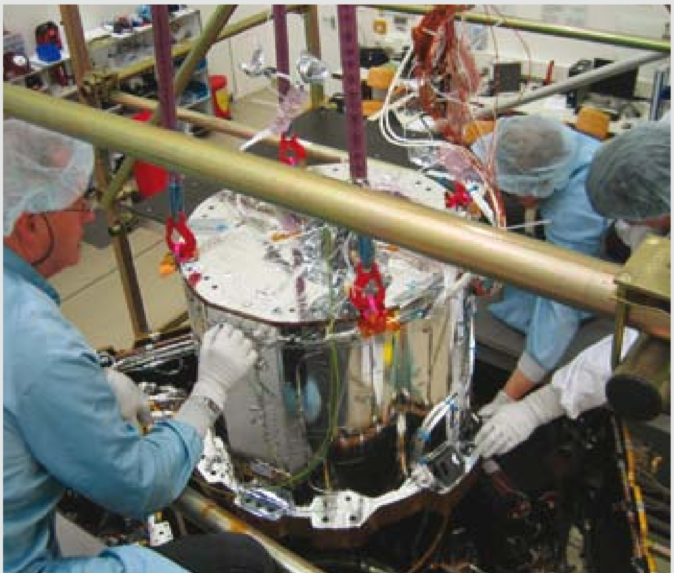
All activities on the ESA-provided Micro Propulsion System for Microscope are on hold pending a CNES decision on whether to proceed with the implementation phase of the programme. The decision is expected over the summer.

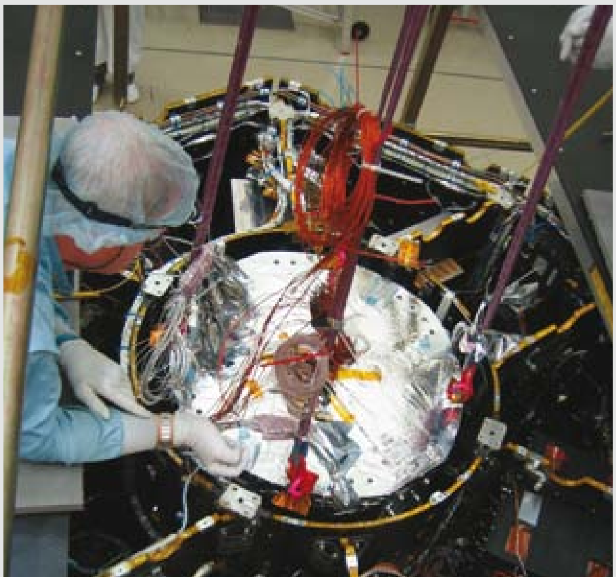
→ JAMES WEBB SPACE TELESCOPE

Significant technical progress has been achieved by NASA, notably on the telescope. Twelve primary mirror segments (PMS) have completed final polishing and gold-coating. Final cryogenic verification testing of the first six flight PMS assemblies is ongoing. A full-size pathfinder of the back plane structure supporting the PMS has been delivered and will be used to build a telescope pathfinder to train the integration and test activities. NASA is still replanning the mission activities, but launch readiness will not be earlier than mid-2017. An updated project plan is expected by the end of July.

The Micro Shutter Array (MSA) was not activated in the first cryo verification test of the NIRSpec instrument due to contamination identified during the acoustic test. The MSA has now been cleaned and is awaiting integration. The flight spare detectors have been delivered to ESA from NASA, with better performance than the flight detectors; however, they are not considered flight worthy, mainly due to the growing number of hot pixels also seen on most other detector

The thermal optical qualification model of the core assembly of the LISA Technology Package being integrated in the Science Module FM by Astrium Ltd and GmbH personnel in IABG's integration facility in Ottobrunn, Germany (Astrium)





chips. The origin of this problem has now been identified and new detectors should be available in two to three years. Following the first instrument cryo cycle, small damages to the SiC optical bench have been identified below a few glue points fixing the grounding harness, which will need repair. A repair method without disassembly of the instrument has now been commissioned. The testing of Grating Wheel and Filter Wheel flight spare mechanisms has been completed and delivery is ongoing. These are the last European equipment flight spares to be delivered.

The MIRI detector system, including updated software, has been delivered by NASA/JPL and accepted by ESA and the European Consortium. The cryo verification test of the full instrument is ongoing, with the first functional tests at operational temperatures and the thermal balance test being completed. 'First light' has been seen by both the imager and the spectrograph and is as expected. JPL is continuing with further tuning tests of the detector system to optimise the performance. Their findings will be used for the final characterisation of the instrument.

Launcher-related activities are progressing as planned, with the final data from the last coupled load analyses provided to NASA. The next technical interface meeting is planned for September.

→ BEPICOLOMBO

Integration in Turin of the Mercury Planetary Orbiter (MPO) STM is in the final stage. All major hardware is now integrated, including most of the STM hardware of the 11 scientific instruments. The Mercury Transfer Module STM is being assembled in Stevenage with the propulsion and thermal control systems. Equipment-level CDRs were conducted, clearing the way to begin the manufacturing of flight hardware. The electric propulsion thruster started its qualification test programme. The flight spacecraft structures continued under manufacture.

Optical Bench Payloads on the Mercury Planetary Orbiter STM

The spacecraft Engineering Test Bed (ETB) was further completed with spacecraft subsystems in Friedrichshafen and subsequently the integration of remaining three (of 11) EMs of the MPO instruments will be performed. Preparation for higher-level ETB systems tests has started. The instrument CDRs started in May, with three completed and the rest running until end 2011.

The programmatic impact of the natural disaster in Japan on the Mercury Magnetospheric Orbiter (MMO) schedule was fortunately small. The CDR Board has authorised start of the MMO mechanical and electrical interface check campaign for the spacecraft FM. Some open issues on thermal test interpretation and MMO separation from MPO will be addressed during a CDR closeout planned for autumn 2011.

The proposal for Ariane 5 Launch Services was received and evaluated. The ground segment completed the initial compatibility test with the deep space transponder. The Mission Control System development started.

→ EXOMARS

An evolution of the cooperation with NASA, from a two-rover mission to a single combined rover in 2018, has changed the context of the programme. A series of negotiation meetings were held during April and May to reduce the price and modify the implementation plans for the 2018 mission. On 7 June, an agreement with industry was achieved for the 2016 mission, including the Trace Gas Orbiter and the Entry, Descent and Landing Demonstration Module. Due to the ongoing restructuring discussions with NASA, activity on the 2018 mission is constrained to study work and some essential subcontractor activities for the coming months.

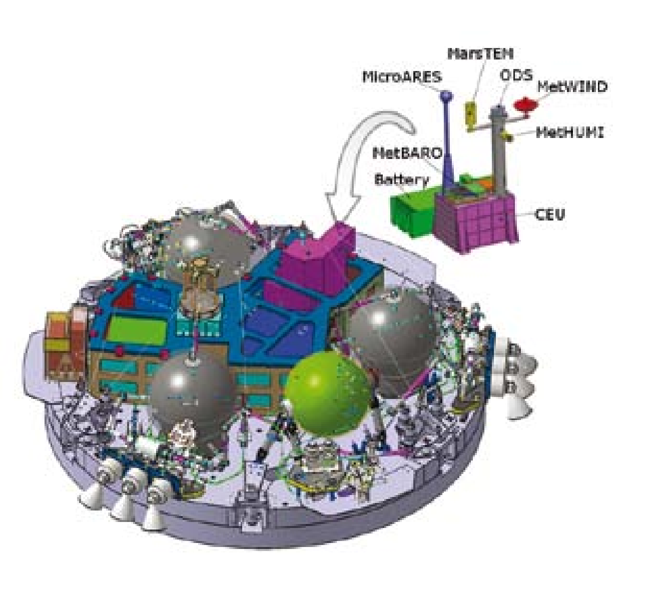
This major success enabled the programme to proceed with the Phase-C/D contract for the 2016 mission. The Programme Board for Human Spaceflight, Microgravity and Exploration approved the ExoMars programme at its meeting on 26 May, pending successful industrial negotiations and confirmation of the overall 1 billion euro cost cap. The agreement with industry was sufficient to maintain the programme envelope imposed by the Participating States in the Aurora Declaration.

To allow the Industrial Policy Committee (IPC) to consider the ExoMars Phase-C/D/E1 Rider Proposal on 29 June, a commitment letter from NASA was needed, confirming partnership in the cooperation for the 2016 and 2018 missions. Unfortunately, NASA was unable to deliver the letter in time. The Director General decided to postpone the decision to the September IPC. In the interim, ExoMars will continue working towards the 2016 launch date with minimal funding, to ensure the essential elements of the future exploration programme.

Study activities for the 2018 mission have been moving forward with basic agreements on the architecture, which is primarily based on re-use of elements of the NASA Mars Science Laboratory (to be launched later this year). The second phase of the ESA/NASA Joint Engineering Working Group study has begun and will continue into the fourth quarter of 2011 when the agreements for the basic responsibilities between the agencies should be established. Once this and the appropriate reviews are completed, further design work may begin and the relevant project teams in NASA and ESA can begin anew to build up their activities leading to the launch in May 2018.

Regarding payload, work is continuing on the Trace Gas Orbiter instruments and the first versions of Interface Control Documents (ICDs) were delivered by the instrument teams and JPL. The ExoMars Entry and Descent Module (EDM) Surface Payload has been selected after an AO process. The winning proposal, called DREAMS, will now start defining its basic interfaces with the EDM and establishing the necessary interface documentation. The instruments of the Pasteur Payload will now be accommodated within the 2018 single rover, and some modifications are under consideration to allow this.

Once on the surface, DREAMS will function as an environmental station for the two to four days of the EDM surface mission. This dedicated suite of sensors will measure the wind speed and direction (MetWind), humidity (MetHumi), pressure (MetBaro) and surface temperature (MarsTem); it will also measure the atmospheric optical depth (ODS) and the electrical fields at the planet's surface (MicroARES).



The science package accommodated on the ExoMars Entry, Descent and Landing Demonstrator Module surface platform (TASI/DREAMS/ESA)

→ HYLAS

Hylas 1 has just completed seven months in orbit and has continued with solid and steady progress through the commercial operations phase since 4 April. All existing broadband customers of Avanti, previously served through satellite capacity leased from a third-party operator, have been migrated onto Hylas 1.

All onboard satellite resources are fully operational and the satellite has activated all its eight Ka-band spot beams specifically designed for broadband services over selected European market areas.

The Ground Segment is also fully functional to support the high availability required by broadband users and includes novel features that will allow monitoring and control of the accurate pointing of the satellite antenna spot beams by a network of sensing stations, for improved communication performances.

In ESA, the Hylas project will be completed in June 2012 with an assessment of the satellite and ground segment performances over a period of 15 months of broadband service routine operations.

→ SMALLGEO

The first satellite to fly on the SmallGEO satellite platform was officially named and its logo was unveiled at the Paris Air and Space show on 23 June. The commercial operator, Spanish company Hispasat, chose the name AG1 for its new satellite. Hispasat AG1, due for launch in 2013, will be the first satellite to use Europe's new SmallGEO platform, developed through a public–private partnership between ESA and Germany's OHB. The presentation of the Hispasat AG 1 mission logo shows the commitment of Hispasat, OHB and partners in pursuing the programme objectives.

Hispasat AG1 will provide Spain, Portugal, the Canary Islands and the Americas with fast multimedia services through its reconfigurable Redsat payload, which offers good signal quality and flexible land coverage.

→ ALPHABUS AND ALPHASAT

The Alphabus platform was formally accepted for its first satellite, Alphasat I-XL, on 16 June, marking an important milestone on its journey to space. At the Paris Air & Space Show at Le Bourget, the industrial consortium behind Alphabus (Astrium and Thales Alenia Space) together with ESA and CNES announced that its technical requirements have all been met.

The Inmarsat extended L-band (XL) payload is the Alphasat main payload, and will support advanced geomobile

Alphasat with deployed solar wing in preparation for mechanical test campaign (Astrium)

communications and augment Inmarsat's Broadband Global Area Network (BGAN) service with its coverage centred over Africa and providing additional coverage to Europe, the Middle-East and parts of Asia. The satellite is currently under final preparation for the mechanical test campaign which will take place during the summer. Launch of Alphasat on Ariane 5 is scheduled for the first quarter of 2013.

Hosted Payloads

An Alphasat Hosted Payload workshop took place in Lisbon on 9/10 June. Close to 80 participants, including members of Europe's satcom industry and ESA national delegations, attended the workshop, which focused on the four hosted payloads that will be launched on board Alphasat:

- Laser communication and Ka-band downlink
- Q/V-band communication and propagation
- Star tracker
- Environmental testing and radiation sensor

A discussion chaired by Magali Vaissiere, ESA's Director of Telecommunications and Integrated Applications, concluded that hosted-payload opportunities with ESA should be further explored by setting up public–private partnerships embarking institutional payloads on commercial satellites.

All flight hardware or representative models of the hosted payloads have been integrated on the Alphasat satellite ready for the mechanical test campaign.

Alphasat Ground and User Segment and Applications

As part of the Alphasat Ground and User Segment programme, Inmarsat and ESA have together initiated the development of innovative value-added applications based on Inmarsat BGAN (Broadband Global Area Network) and GSPS (Global Handheld Service) services using the Alphasat and Inmarsat 4 satellites. The responses to the open call for proposals are currently under evaluation.

→ EUROPEAN DATA RELAY SATELLITE

In response to the large number of replies from last the Call for Interest in March, an AO for hosted payloads on board the European Data Relay Satellite (EDRS) is planned for July.

Negotiations are in their final phase. There is strong pressure on launch dates, because of the need to begin EDRS operations in time for the Sentinel-1 and -2 missions. Under a Preliminary Authorisation To Proceed, the industrial consortium already had to start the SRR, the first major programme milestone, planned for June. After the SRR, detailed technical definition of the mission will continue through Phase-B2, with the PDR planned for early 2012.

→ ARIANE 5 POST-ECA

The Vinci M4 engine test campaign started at the DLR Lampoldshausen facilities. The Thrust Chamber tests are continuing and a 77-second burn test was performed in April. Test activities on the Vinci Liquid Oxygen Turbo-Pump, on dynamic seal package erosion, have begun at ULG. The final presentation of the Hybrid Propulsion H_2O_2 Engine Technology Readiness Level improvement activity took place in early April.

→ VEGA

The launch vehicle Flight Programme Software CDR is complete. The Roll Attitude Control Subsystem main tests to qualify the subsystem for the maiden flight are complete, in particular the first subsystem firing tests and the thermal tests allowing start of the qualification review.

On the Vega Launch System, the mechanical system tests were performed with a full scale model integrated on the launch pad, including rehearsal of off-nominal operations and launch vehicle unmounting. The objective of these tests was to validate the mechanical and electrical interfaces between the vehicle and the ground segment.

The P80 Solid Rocket Motor flight unit is complete, with the exception of the igniter, which will be integrated just before transfer to the Vega launch pad, in line with safety and storage constraints. The final acceptance loop of the various subsystems of the ground segment is close to completion with the preparation of the relevant End Item Data Package.

→ SOYUZ AT CSG

A simulation of the Mobile Gantry procedures phase was performed on 29 April. The objective was to validate the coordination of the teams and the operation sequence in the Mobile Gantry during the hour previous to launch. The remaining rolling tests of the PFRCS (the trailer used to transfer the Upper Composite between S3B facilities and launch zone) were also completed.

Regarding the Operational Qualification phase, the Test Readiness Review was held on 1 April and the Operational Qualification campaign for the ST-A launcher configuration started the same day under Arianespace's responsibility. The launcher was transferred to the launch zone on 29 April and back to the MIK on 7 May. Two rehearsals with the launcher on the Mobile Gantry were performed and two dry runs (simulations without filling the tanks and with Mobile Gantry removal) were performed on 5 and 6 May.

After the site was declared ready for the first flight and the completion of a simulated launch campaign, an official ceremony marking ESA's transfer of the Soyuz launch site to Arianespace took place on 7 May.

→ FUTURE LAUNCHERS PREPARATORY PROGRAMME

Intermediate eXperimental Vehicle (IXV)

The IXV Phase-C activities are reaching completion with the system CDR started on 1 April completed with the Board meeting on 13 May. In parallel, the industrial proposal for the Phase-D activities has been evaluated and negotiated.

Closure of Phase-C and start of Phase-D are foreseen to take place in June/July, confirming the development master planning for the mission into space in 2013.

Next Generation Launcher (NGL)

Four launch vehicle concepts are being analysed; the related design Key Point is planned to take place at the end of June.

For the High Thrust Engine (HTE), following the Architecture Key Point of the SCORE-D (Stage COmbustion Rocket Engine Demonstrator), the SRR was completed with its Board Meeting on 2 May. A contract between ESA and the Joint Propulsion Team was signed, moving HTE to the next phase: the engine's PDRs.

Regarding solid propulsion, the Manufacturing Release Review of the Pressure Oscillation Demonstrator is in progress. The industrial proposal for the continuation of the activity post-MRR has been delivered and is under evaluation.

The industrial activities on the Cryogenic Upper Stage Technologies (CUST) are progressing according to schedule. The PDR of the Gas Port Phase Separator was held in April.

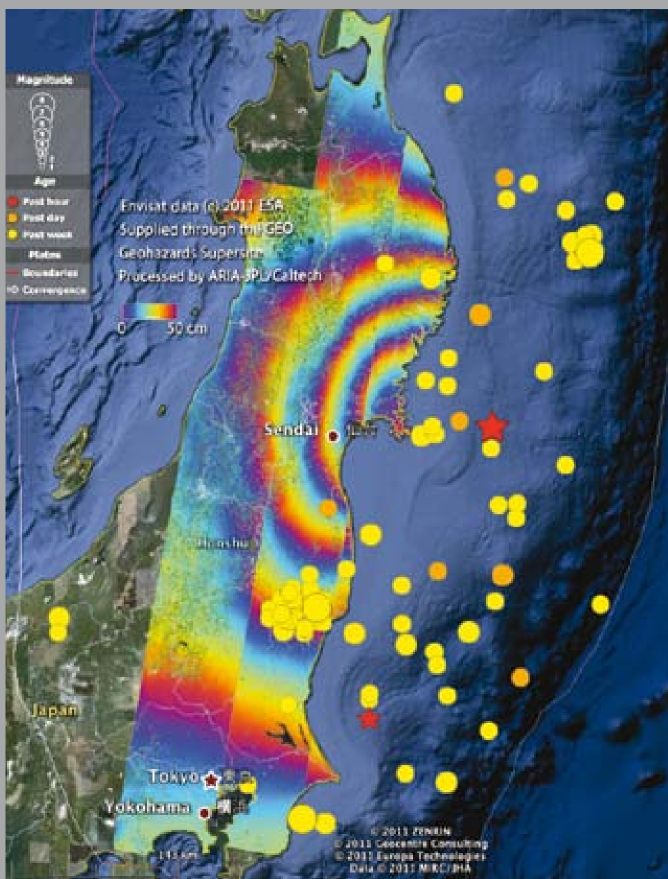
→ ERS-2

For its last months of operations, ERS-2 was moved in March to a three day repeat cycle, called ERS-2 Ice Phase. The objective of the ERS-2 Ice Phase was to acquire SAR data in a similar way as for the ERS-1 Ice Phases of 1992 and 1994, mainly focusing on the polar ice-stream dynamics that influence ice-sheet mass balance and sea-level rise.

The ERS-2 Ice Phase was completed on 4 July when the instruments were switched off, ending 16 successful years of ERS-2 operations. Deorbit manoeuvres were initiated on 6 July, with the objective of gradually lowering the circular orbit from 800 km to an altitude where the satellite will reenter the atmosphere within less than 25 years, in compliance with international guidelines on space debris mitigation.

→ ENVISAT

Envisat is fully operational in its new orbit configuration (30-day repeat cycle) implemented since October 2010. All instruments are providing high-quality data, with no anomalies during recent months.



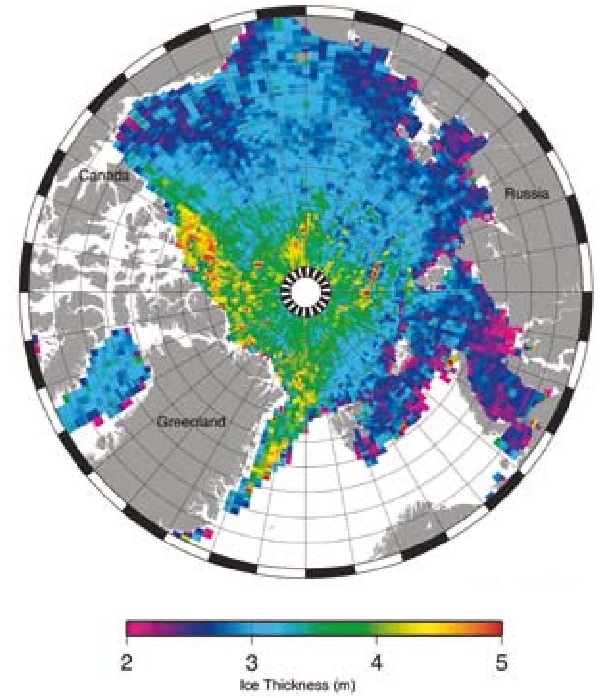
Envisat ASAR image of ground displacement following the Japan earthquake of March 2011

To reduce hydrazine consumption, the tight repetitive orbital control required by SAR Interferometry is no longer maintained in the new orbit configuration. However, careful implementation allows tight orbital control within a latitude band centred around 38 degrees, where many tectonics and volcanology areas are located. This allowed Envisat to provide a detailed map of the ground displacements following the disastrous earthquake in Japan in March.

→ GOCE

GOCE completed its nominal mission lifetime in April and its operations have been extended until December 2012. After just two years in orbit, GOCE has already gathered enough data to map Earth's gravity with unrivalled precision and scientists now have access to the most accurate model of the 'geoid' ever produced.

Since launch, GOCE has been flying at an altitude of only 255 km. Predictions of solar activity and the available margin of the satellite's power subsystem indicate that this altitude can be maintained throughout 2011. This favourable power situation, together with the excellent thermo-elastic performance of the platform, will allow science operations to continue even during eclipse seasons.



Sea-ice thickness in the Arctic Ocean, January/February 2011 (CPOM/UCL/ESA)

→ SMOS

The radio frequency interference situation in particular over Europe continues to improve thanks to the joint efforts of the SMOS scientific team and the ESA Earth Observation Frequency Management team.

The first SMOS science workshop will take place on 27–29 September in Arles, France.

→ CRYOSAT

CryoSat continues to perform well, acquiring and generating science data systematically. A major upgrade of the processors will be completed by the end of this year, followed by the first reprocessing campaign.

The first Arctic sea-ice thickness map was presented at the Paris Air & Space Show, Le Bourget in June. Exceptionally detailed data from January and February were used to generate this map, as the ice approached its annual maximum over regions close to the North Pole, never before seen by a satellite altimeter. This first result demonstrated the mission's potential in detecting variation of ice thickness over Earth's ice fields. The coming months will be dedicated to completing this picture, and thus achieving the primary mission objective.

→ ADM-AEOLUS

Laser transmitter FM integration and test are under way, producing positive results regarding both energy extraction and insensitivity to misalignment. The instrument electronics have been modified for continuous mode and have been tested for interface compatibility.

The full power intensity test on transmitting and receiving optics demonstrated degradation in two optical elements. Work is progressing on refurbishment of the unit with new wave plates with higher damage margins.

Development of the *in situ* cleaning subsystem is advancing well, with the first oxygen-compatible development model being delivered. Priming and low-flow-rate simulations have validated the subsystem's performance.

→ SWARM

The environmental test campaign of the second satellite FM is ongoing. Mechanical tests are complete and the satellite is being temperature cycled in the thermal vacuum chamber of IABG (Munich).

Activities on the first satellite are on hold awaiting the repair of the Power Conditioning and Distribution Unit, while the third satellite is still awaiting delivery of the accelerometer and Electrical Field Instrument (EFI). A second accelerometer has been delivered by VZLU (CZ); the third is expected soon.

Recent integrated system tests demonstrated that the EFI communication interface was not compatible with the satellite. Furthermore, testing of a modified EM of the EFI (with a fix for the interface problem) showed that a number of software updates were required. Fixes for these and the interface issue are being prepared on a spare board in order to allow early delivery of the EFI FM for satellite no. 3.

The magnetic test campaign for the characterisation of the satellite is ongoing. Testing of the ground segment facilities for the Level-1b algorithms is ongoing.

→ EARTHCARE

Finalisation of Phase-B and preparations for Phase-C/D are nearly complete. The satellite configuration and system budgets are stable with adequate margins. The detailed design of most avionics units is progressing well and in some cases the EMs of the spacecraft units are being tested.

Actions identified during the ATLID PDR are progressing well and the performance analyses have been refined. Breadboard testing of the lidar UV transmitter and the detector assembly has started. Selection of contractors for the lower level instrument units resumed after consolidation of the instrument bi static design. Development of the other two European instruments, Broadband Radiometer and Multi-Spectral Imager, is progressing.

In Japan, the JAXA Cloud Profiling Radar (CPR) Ground Segment System Design Review, covering the instrument simulator, was initiated in advance of the EarthCARE Ground Segment PDR planned for the last quarter of 2011. The impact of the March earthquake on the CPR SM has been assessed and a recovery plan has been prepared. No impact on the (revised) overall schedule is anticipated.

→ METEOSAT

Meteosat-9/MSG-2

The satellite is in very good health and performance is excellent. Based on experience with MSG-1 and the history to now, the prediction for fuel availability to perform full orbit control (N/S and E/W) is at least four more years.

MSG-3

The first part of the Integrated System Test (functional and performance verification of the satellite and all subsystems), and the Optical Vacuum Test are complete. Testing will continue until the end of September and the final preparation sequence will be adjusted according to the final launch date. The open points from the preliminary mission analysis (by Arianespace) have been resolved, in particular the ability of the satellite to cope with the higher tension required by the new adaptor/clamp band combination. The fit check and drop test with the adaptor have been performed, with nominal results. Confirmation by Arianespace of the launch date is expected in September (the launch window is currently June to August 2012).

MSG-4

Manufacture of the replacement part for the SEVIRI Drive Unit is ongoing. Meanwhile the disassembly has started; once completed, all parts will be checked again and prepared for re-assembly.

→ MTG

The MTG SRR Board was convened in mid-April and completed. One conclusion was the need for improved technical consolidation across the Core Team, to ensure compatibility of the main elements and retain commonality across MTG-I and MTG-S satellites as far as is practicable. In response to this finding, Thales Alenia Space France, the prime contractor, has adapted the Phase-B2 logic, introducing a Baseline Design Review in November 2011 and delaying the formal PDR to the second quarter of 2012.

In parallel with the technical baseline consolidation, the Best Practice Procurement process is under way, with more than 15 procurements released and over 40 scheduled in the next three months. In total over 80 procurement actions are scheduled, covering more than 110 different items.

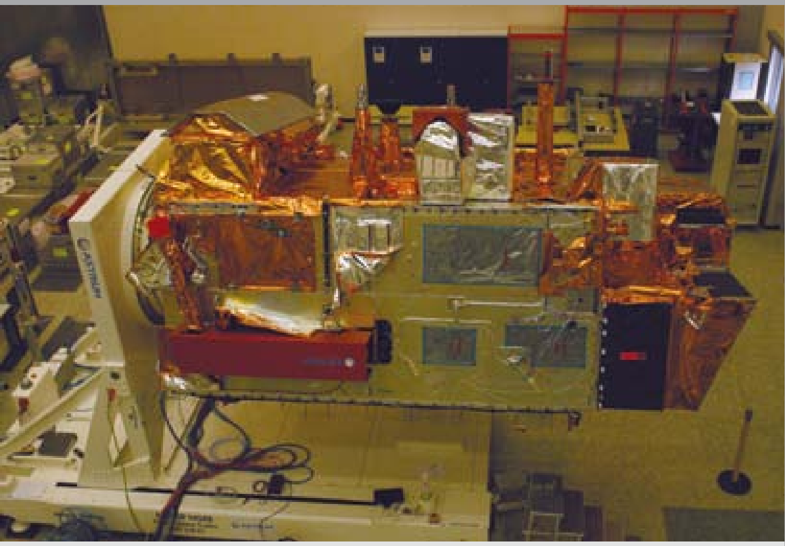
The MTG Cooperation Agreement with Eumetsat for the implementation of the full programme was unanimously agreed by both ESA and Eumetsat Councils. The final step to allow Phase-C/D to commence will be the formal price conversion at the conclusion of Phase-B2, and the submission of the revised Contract Proposal to IPC scheduled for the third quarter of 2012.

→ METOP

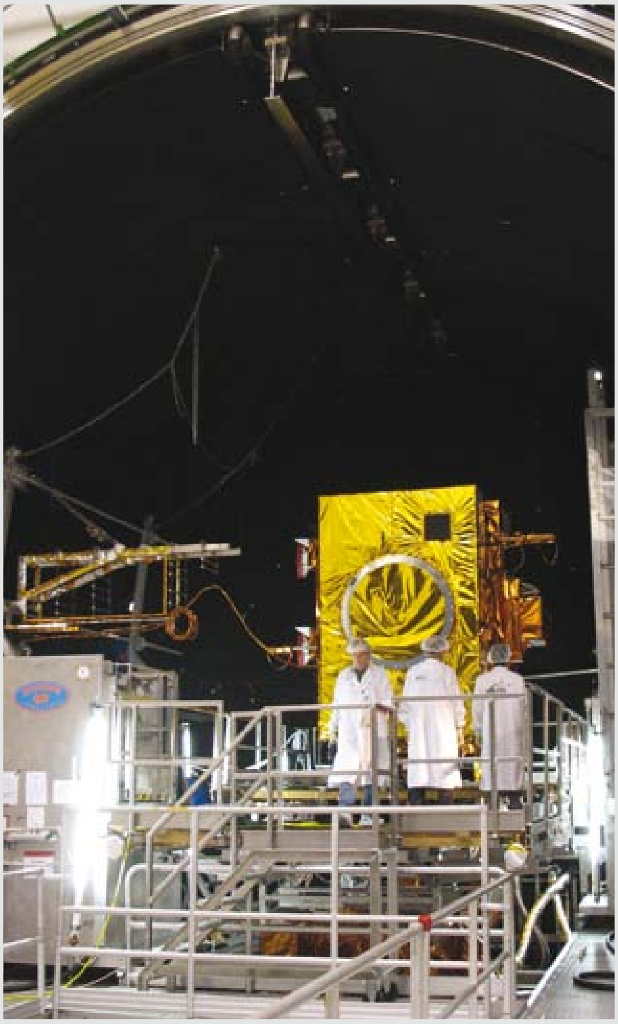
MetOp-A

The satellite and all remaining instruments continue to perform excellently in orbit. The increased coverage will last until MetOp-B is declared operational.

GOME2 is producing good scientific data, but an investigation group is working to evaluate the unexpected throughput behaviour that could in future lead to some science limitation. The throughput has been much more stable over the last 12 months.



MetOp Payload Module in the Friedrichshafen clean room, completing re-integration of all instruments (Astrium)



MetOp Service Module inside the SIMMER thermal vacuum chamber ready to start the final module test (Interspace)

MetOp-B

The PLM, SVM and solar array were taken out of storage after four years in preparation for satellite integration. The PLM is at Astrium, Friedrichshafen, the SVM is at Intespace, Toulouse, and the solar array is at Dutch Space, Leiden. Satellite integration will be performed at Astrium Toulouse.

All PLM instruments are back from calibration and most are already re-integrated and tested. The SVM has completed all reference tests and is inside the SIMMER facility ready to start the thermal cycle test. The solar array is starting its test campaign.

ESA, Eumetsat and Starsem have agreed to fix the MetOp-B launch window as 9 April to 20 May 2012. Launch preparation is progressing well, with the Final Mission Analysis Review, agreement on all ICDs and closure of the first two phases of the safety submission. The launch campaign will start with transport to Baikonur in January 2012, for launch by Soyuz/ST and Fregat-M in April 2012.

MetOp-C

The PLM, SVM and solar array have been assembled into the MetOp-C satellite. The satellite's functional and mechanical (sine vibration and acoustic) tests were completed; the satellite was subsequently disassembled and the modules are being prepared to re-enter storage.

GOME2 is unmounted and waiting for the TNO facility availability to conclude the calibration.

MetOp-C is to be launched from CSG, Europe's Spaceport at Kourou, French Guiana, in October 2016 but needs to be ready as a back-up for MetOp-B from mid-2013.

→ SENTINEL-1

GMES Sentinel-1 is progressing with Phase-D as planned. The platform development in Thales Alenia Space Italy is ongoing. The test campaign of the integrated avionics test bench has been completed.

Sentinel-1 Electronic Front-end Qualification Model (Thales Alenia Space)

The SAR instrument development (Astrium, Friedrichshafen) is also progressing with the manufacture of the flight equipment. After the success of the qualification campaign, production of the flight Electronic Front-end modules (Thales Alenia Space Italy) has commenced. Test campaigns for the antenna tiles have successfully qualified the thermo-mechanical design and verified antenna performance. Integration of the flight tiles has already begun. The SAR Electronics (Astrium, Portsmouth) EM is integrated and testing is in progress.

The Interface CDR of the Optical Communication Payload has been completed. The launcher Preliminary Mission Analysis with Arianespace for a Soyuz launch from CSG is progressing according to plan.

→ SENTINEL-2

A close-out report covering all CDR action items was delivered in May.

The payload instrument EMs are undergoing testing: the Visible and Near Infrared (VNIR) EM detection chain was successfully tested, and the Short Wave Infrared (SWIR) detection chain completed thermal vacuum testing at Astrium-Friedrichshafen. The Global Positioning System receiver, the star trackers and the Inertial Measurement Unit have been integrated and tested with ground segment equipment and test benches connected to the satellite Engineering Functional Model.

Several equipment and subsystem FMs have already been delivered to the prime contractor (e.g. silicon carbide instrument structure and mirrors, calibration and shutter mechanism).

The Optical Communication Payload for Sentinel-2A, developed by TESAT-D under the responsibility of DLR, is undergoing mechanical design optimisation to be followed by final qualification.

Image quality activities conducted by CNES in support of Sentinel-2 commissioning and payload data segment development are proceeding, as evidenced by a successful Image Quality Facilities Review conducted in May. The selection of launch services for the two satellites was finalised on 29 June of one Rockot (Sentinel-2A) and one Vega (Sentinel-2B) launch.

→ SENTINEL-3

OLCI and platform CDRs were completed in the past months. The SLSTR instrument CDR took place in April, however formal closure is expected only in October when the final results of the instrument EM and STM test campaigns will be available. The satellite CDR was completed in April, apart from open aspects related to the SLSTR.

The Payload Data Ground Segment PDR was completed in April. At spacecraft level, following completion of EQM testing, manufacture of PFM units is ongoing. PFM propulsion equipment is almost all delivered, with tank delivery expected in August, allowing integration of the propulsion elements on the platform to start in September. Availability of the satellite structure is confirmed for October.

At instrument level, SRAL EM testing has been completed and antenna FMs for both the A and B satellites have been delivered. The SLSTR STM is under integration, and start of testing, including both a mechanical and a thermal campaign, is planned for August 2011. Similarly, the SLSTR EM is being completed for parallel functional testing.

→ SENTINEL-5 PRECURSOR

Satellite/system Phase-A/B1 studies with OHB and Astrium UK are complete. Following submission of updated proposals, one of the two competing contractors will be selected in the summer. Phase-B2/C/D/E1 start is scheduled for October. ESA Best Practice procurement process for the TROPOMI payload elements was concluded in May. A TROPOMI payload-level PDR was held in May.

→ HUMAN SPACEFLIGHT

Space Shuttle *Endeavour* lifted off from Kennedy Space Center on on 16 May for her last mission to the ISS, carrying ESA astronaut Roberto Vittori (IT). The STS-134 mission,

Space Shuttle *Endeavour* and its six-member crew head toward Earth orbit and rendezvous with the ISS, with the launch of STS-134 from NASA's Kennedy Space Center on 16 May (NASA)

Two Italians meet on the ISS: Paolo Nespoli and Roberto Vittori

ATV *Johannes Kepler* approaches the ISS in February

named DAMA (from the initial letters of 'dark matter') delivered the Alpha Magnetic Spectrometer (AMS-02), an instrument designed to track elusive antimatter and 'dark matter' in the Universe.

STS-134 docked to ISS on 18 May. For the first time in ISS history, two Italian ESA astronauts were on the ISS at the same time: Paolo Nespoli had been serving as Flight Engineer for Expeditions 26 and 27 since December 2010.

21 May marked another historic moment: His Holiness the Pope had an in-flight call with the crew of the ISS, which was the first papal call to the ISS. The Pope addressed the astronauts in English, and also had a special word with the two astronauts in Italian. Giorgio Napolitano, the President of the Italian Republic, had an in-flight call with Nespoli and Vittori on 23 May.

On 24 May, Nespoli returned safely to Earth on Soyuz TMA-20 with his Expedition 26/27 crewmates Dimitri Kondratyev and Catherine Coleman, after his 159-day MagISStra mission. MagISStra was the third long-duration mission for a European astronaut on the ISS. Space Shuttle *Endeavour* made its last landing on 1 June after a 16-day mission, bringing back to Earth its six-man crew including Vittori.

→ SPACE INFRASTRUCTURE DEVELOPMENT/ISS EXPLOITATION

ATV *Johannes Kepler*

Johannes Kepler undocked from the ISS on 20 June in completion of its mission, which had carried 1760 kg of dry cargo (including food, clothes and equipment), 860 kg of propellant and 100 kg of oxygen to the ISS. All 4535 kg of the propellant was used for ISS propulsive support. This included performing several reboosts of the ISS, raising the orbit by more than 40 km. Before undocking, *Johannes Kepler* was loaded with 1300 kg of waste from the ISS. The reentry into the atmosphere happened exactly as planned on 21 June, over an uninhabited area of the south Pacific.

ATV *Edoardo Amaldi*

Edoardo Amaldi is currently planned for launch in early March 2012. The European part of the acceptance campaign is currently nearing completion. *Edoardo Amaldi* will be shipped to Kourou in August 2011. The ATV-3/Ariane 5 Final Mission Analysis began in mid-June. A small gain in upload performance has been confirmed. *Edoardo Amaldi*'s load will include 280 kg of water, 100 kg of gas, 860 kg of propellant to be transferred to the Russian segment of the ISS, about 2.9 tonnes of propellant for ISS propulsive support, and up to 2.5 tonnes of dry cargo.

An end-to-end test between the vehicle and the ATV Control Centre will be performed before the shipment, to verify good communication links. Training and preparation of operations for this new mission have already started at the ATV-CC.

→ ISS UTILISATION

About 30 ESA experiments and education activities were performed during Paolo Nespoli's MagISStra mission. After his return to Earth on 24 May and his subsequent direct return to Johnson Space Center in Houston, he also performed post-flight Baseline Data Collection for the Human Physiology experiments.

All the ESA experiments, plus a variety of additional experiments for NASA, JAXA and CSA, were accomplished despite the tight constraints on crew time resulting from the unusually heavy vehicle traffic to the ISS during the MagISStra mission.

External Payloads

Another of the periodic Sun visibility windows opened on 27 June for the SOLAR facility to acquire scientific data. Sun visibility windows are open when the ISS is in the correct orbital profile in relation to the Sun. The SOLAR payload facility has been studying the Sun's irradiation on orbit with unprecedented accuracy across most of its spectral range for more than three years. This has produced excellent scientific data during a series of Sun observation cycles. Following conclusion of the detailed technical feasibility study for on-orbit lifetime extension, the science team will be able to continue gathering further science data in a period of increasing solar activity up to 2013 and possibly beyond.

Successful data acquisition is ongoing for the Vessel Identification System (commonly known as the Automatic Identification System, AIS), using its Norwegian receiver, and telemetry is still being received by the Norwegian User Support and Operation Centre in Trondheim via ESA's Columbus Control Centre in Germany.

Life Sciences

Nespoli performed the CARD experiment using a suite of physiology instruments from the Cardiolab and the Pulmonary Function System which was also used for undertaking four different rebreathing sessions across the two days of the experiment. On 27 April, Nespoli drew some blood samples, which were centrifuged and stored in one of the European-built MELFI freezers. Data were sent back to Earth on 27 April. The CARD experiment examines increased cardiac output and lowered blood pressure (caused by dilated arteries) in the face of increased activity in the sympathetic nervous system (which normally constricts arteries) in weightlessness.

European Science and Research Facilities in Columbus

The Erasmus Recording Binocular 2 (ERB-2) was activated by Nespoli on 17 May and a file transfer was carried out from ERB-2 to the Video Management Unit of the European Drawer Rack. Data were sent to the ground from the Video Management Unit. ERB-2 is a 3D video camera that takes advantage of high-definition optics and advanced electronics to provide a vastly improved 3D effect for mapping the ISS.

Materials and Fluids Research

The Fluid Science Laboratory has been used for the Geoflow-2 experiment, which has been undergoing processing in the Fluid Science Laboratory since 21 March. The main experiment parameters of Geoflow-2 are the core rotation speed, electrical field, temperature gradients and liquid viscosity variation. Good quality interferometric images were received in real time, and associated data from the experiment and structural dynamics data from the Microgravity Measurement Apparatus have been downlinked.

Geoflow-2 is investigating the flow of an incompressible viscous fluid held between two concentric spheres rotating about a common axis, as a representation of a planet. For Geoflow-2, the incompressible fluid will be nonanol and not silicon oil as in the first Geoflow experiment. Nonanol varies in viscosity with temperature (unlike silicon oil) to provide a different aspect of research with a closet simulation to Earth's geophysical conditions. The Geoflow-2 science runs form part of an exhaustive scientific programme of experiment processing which will last a couple of months.

The European Modular Cultivation System is being prepared for the Gravi-2 experiment which is currently scheduled for late 2011. Gravi-2 builds on the initial Gravi experiment in determining the gravity threshold response in (lentil) plant roots.

Educational activities

'Mission X – Train like an Astronaut', a MagISStra education pilot project performed with Nespoli, has been officially completed. About 4100 children (aged 8–12 years old) from 12 countries, 40 cities and 128 teams participated in the project.

Paolo Nespoli works with European Recording Binocular 2 (ERB-2) camera in the Harmony node of the ISS

The closing event of Mission X at ESTEC in the Netherlands, with ESA astronaut Frank De Winne (centre back)

Mission-X is an initiative of international space agencies and organisations to encourage healthy, active lifestyles among children. Using the unique example of space explorers, the participating agencies seek to motivate and educate young people worldwide that good fitness and nutrition are life-long endeavours.

→ CREW TRANSPORTATION AND HUMAN EXPLORATION

Expert

Vehicle integration at the Thales Alenia Space Italy has been completed, with final testing in progress. Negotiations with the Russian partners on the launch are expected to be finalised before the end of 2011. The launch of Expert is currently foreseen for the spring of 2012.

Lunar Lander Activities

Since the start of Phase-B1 in 2010, the Lunar Lander programme has seen increasing support, with Canada, Spain and Belgium joining the programme alongside Germany and Portugal, and Germany increasing its contribution to the programme. Industrial proposals from Canadian companies are under evaluation and ITTs are being prepared by the prime contractor, Astrium ST Bremen, for additional activities with Spanish and Belgian industry.

The Arianespace Soyuz launcher performance analysis has confirmed the basic assumptions for the mission design and spacecraft mass in lunar transfer orbit.

In support of the Phase-B1 industrial study, for which a model payload was defined in an earlier stage, six contracts financed by ESA's General Studies Programme have been placed with European companies and scientific institutions for a detailed evaluation of potential payload configurations. The evaluation of the landing sites' terrain morphology by two groups of scientists, headed by Profs. G. Neukum and I. Crawford, has been completed with very positive results.

International Architecture Development and Scenario Studies

As part of the overall scenario analysis process, a workshop on 'Future Human Spaceflight and Exploration Scenarios' was held in May to present interim study results and discuss topics relevant for the development of a strategic plan for human spaceflight. Topics included the status of work on the Global Exploration Roadmap performed by ISECG, the role of commercial initiatives, aspects of future international coordination and cooperation, and future ISS and infrastructure development priorities for Europe.

Initiation of Phase-2 Scenario Studies is planned for September/October, including an analysis of potential European interests and roles in commercial initiatives.

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