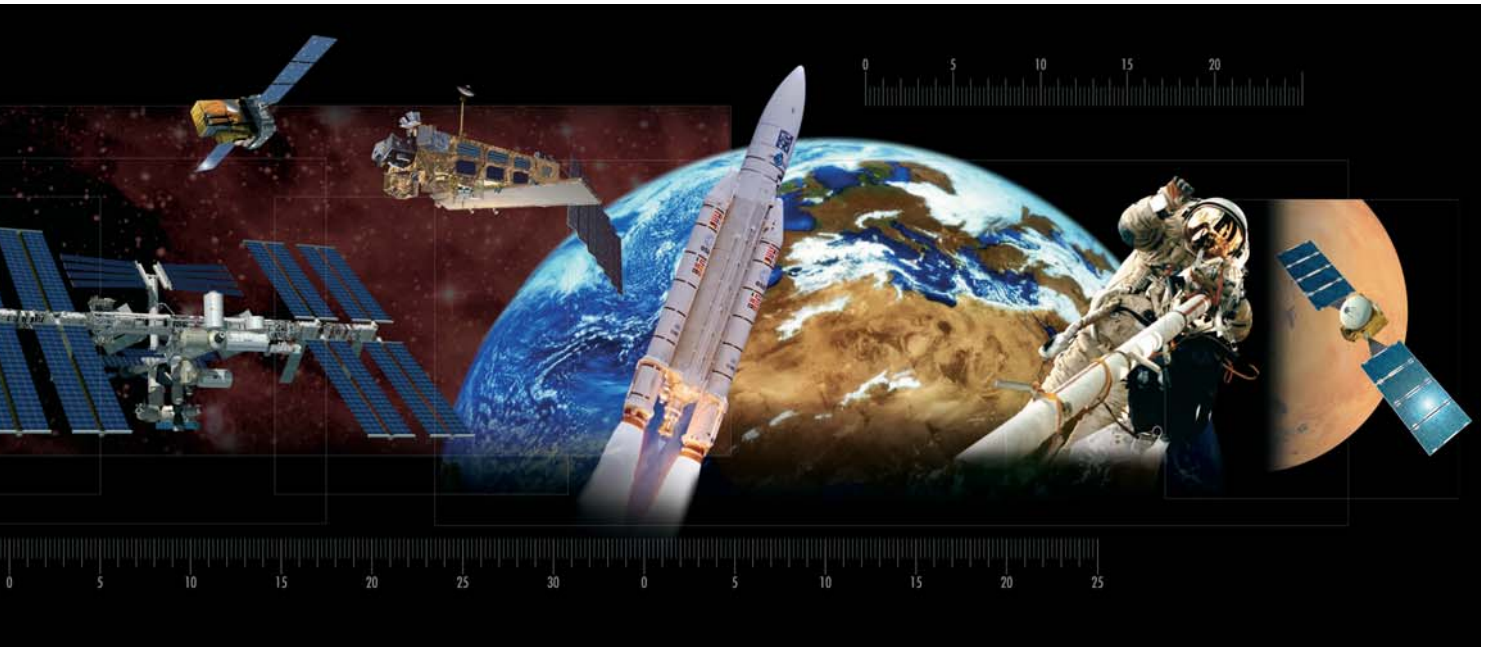

Annual Report 2006

European Space Agency
Agence spatiale européenne

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This Report is published in accordance with the terms of the Convention for the establishment of the European Space Agency, Article XII 1(b), which requireS the Director General to make an Annual Report to the Council.

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Activities

Facilities

Resources Management

Annexes

Foreword

It was another remarkably successful year for ESA and its partners in space, in many different ways.

For the Science Programme, the year was notable for the successful Venus Express orbit insertion on 11 April, the spectacular end to the SMART-1 mission on 3 September with its controlled lunar impact, the launch of two collaborative missions Akari (Astro-F) and Hinode (Solar-B) on 21 February and 22 September, respectively, plus the launch of the French mission COROT conducted in partnership with ESA and various Member States to search for exoplanets from space, marking another 'first' for Europe.

A further significant event was the successful launch from Baikonur on 19 October of MetOp-1, Europe's first polar-orbiting weather satellite, enhancing Europe's contribution to global weather and climate monitoring.

We also saw substantial progress being made on the International Space Station (ISS) programme, with the return-to-flight of the Space Shuttle and the resumption of ISS assembly after more than three years of great difficulties for the project. Thomas Reiter became the first European astronaut to undertake a long-duration mission on board the ISS. We are now looking forward to the inaugural flight of the Automated Transfer Vehicle (ATV) and to the launch of the Columbus labo-

ratory to be attached to the Station at the end of 2007. After a long development period and much uncertainty, Europe will finally be able to reap the benefits of its investment in this international partnership project.

In the launchers area, Arianespace carried out five Ariane-5 launches and put into orbit a total of 12 satellites plus one technology experiment. It also signed 12 new launch contracts during the year.

Turning to Galileo, after the successful deployment of GIOVE-A in January, the launch of the second test satellite GIOVE-B had unfortunately to be delayed because of an onboard computer failure during testing. Action is being taken to ensure that this problem does not have an impact on the completion of the Galileo In-Orbit Validation phase.

While acknowledging the difficulties we face in some areas, we should also be proud of our accomplishments. It is not possible here to pay full tribute to each and every one of the many individuals and groups whose dedication, hard work and professionalism contributed to achieving these successes. But I would still like to thank all those who made 2006 such a successful year and who are helping to implement ESA's vision for the future.

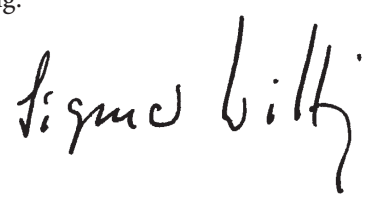
In addition, it was a busy year for the ESA Council. One of the main items on its agenda was the debate about the elaboration of the European Space Policy (ESP), which the Agency is developing together with the European Union. A Resolution on a common European space policy providing a framework for future action will be submitted to Ministers for adoption at the next ESA/EU Space Council in May 2007. Another important topic of discussion was the evolution of the Agency in terms of the expected increase in its number of Member States. Much work remains to be done on these very important subjects, which are crucial for ESA's future.

I am very happy to report that Council in June renewed the mandate of Jean-Jacques Dordain as Director General for a further four-year term through to July 2011. In October, he presented his Agenda 2011 document plotting the way forward for the Agency's future activities and evolution. He also presented the ESA Long-Term Plan 2007-2016, which serves as an important tool for dialogue between the Council and the Programme Boards in preparing for the future programme decision-taking at the next Council at Ministerial Level, planned for late 2008.

In February, the European space community was deeply saddened to hear of the death of former ESA Director General Antonio Rodotà. Many of us who had the pleasure of working with him remember him well for his warmth and charm as he led the Agency into the 21st Century. Another European space pioneer, Michel Bignier, died in October. He played a key role in the birth and development of the French space programme, and later at ESA as Director of the Spacelab Programme and Director of Space Transportation Systems from 1976 to 1986.

Jörg Feustel-Büechl left the Agency at the end of the year after more than twenty years of service. In December, the Council appointed Ludwig Kronthaler (D) as Director of Resources Management and he will join the Agency on 1 April 2007. He succeeds Hans Kappler, who retires at the end of May 2007 after having served as Director for Industrial Matters and Technology Programmes since June 1997 and Director of Resources Management since April 2004. On behalf of the Council, I wish to thank Mr Feustel-Büechl and Mr Kappler for all their work and for their contribution to ESA.

It is now time to look ahead to the challenges and opportunities of 2007. While much has been achieved since the beginning of the space age – and during this year we will be celebrating the 50th anniversary of the launch of Sputnik 1 – space exploration remains exciting and full of promise. We can look to the future with optimism, building on the successes of the past and on the exemplary talent and commitment of those in whose footsteps we are following.



Sigmar Wittig
Chairman of Council

Year in Review

2006 turned out to be an incredible year for ESA, with many highlights across all of the Programmes, and the Agency heavily involved in a wide range of missions and activities spanning the realms of space exploration, Earth observation and climate change, and satellite navigation.

It was also an excellent year for launchers, with five successful flights of Ariane-5 ECA, and the signature of 12 new launch contracts with Arianespace by commercial customers. Human spaceflight too logged some major milestones, with ESA astronaut Thomas Reiter completing the Agency's first long-duration mission on the International Space Station (ISS) and his colleague Christer Fuglesang completing a gruelling series of spacewalks to help extend and complete the ISS.

The first highlight of the year came early, when the GIOVE-A satellite started transmitting the first Galileo signals in space on 12 January, thereby securing the frequencies allocated to the Galileo system. This pilot satellite constitutes the first step towards Europe's own global satellite navigation system, a ground-breaking partnership project involving ESA and the European Commission that will provide a highly accurate and guaranteed positioning service under civilian control.

Less than two weeks later, MSG-2, the second member of Europe's new generation of weather satellites, transmitted its first image. Developed by ESA and operated by Eumetsat, it has replaced the aging Meteosat-8 as the prime satellite for monitoring the Earth's atmosphere and climate. With two more satellites already ordered, the MSG series will provide coverage until at least 2018. The data that the Meteosats are providing constitute a unique record of the evolution of our planet's climate over nearly three decades, serving as a continuous source of data for the fight against global climate change.

In February, as a further endorsement of ESA's commitment to addressing climate problems, the Member States gave the green light to build and launch CryoSat-2, to replace the original satellite lost through a launch failure in 2005. By monitoring the thickness of land and sea ice, it will help to explain the connection between the melting of polar ice and rises in sea level, and how this is contributing to climate change.

In science too, the quest continued to unravel the unknowns of our Universe, not least with XMM-Newton, ESA's scientific X-ray observatory mission. After just five years of operations, the mission saw the publication in January of the 1000th scientific paper based on XMM-Newton data. In April, Venus Express


MetOp

successfully entered orbit around its target planet, with its VIRTIS instrument already providing spectacular views of the south pole's cloud structure. After a complex series of successful manoeuvres to reach its final operating orbit, the mission's routine science operations began just two months later, in June. That same month, Mars Express celebrated three years in space and continues to send back spectacular images of the Martian surface and crucial data about how the atmosphere of our planetary neighbour functions.

May saw the delivery of the Columbus laboratory, complete with its suite of payload rack facilities, to Kennedy Space Center, in preparation for its planned launch to the ISS in December 2007. Three days earlier, on 27 May, it had been the Ariane launcher's turn to be

in the limelight, when Ariane-5 ECA set a new record for the vehicle by delivering a payload of close to 8500 kg, consisting of the Satmex-6 and Thaicom-5 satellites, into geostationary transfer orbit. There was also success for the new Vega small launcher's development programme, with the problem-free first test firing of its Zefiro-23 second-stage engine in Sardinia (I) on 26 June.

The highlight in August was down to Thomas Reiter, who became the first ESA astronaut to perform an EVA from the International Space Station.

On 3 September, observers around the world saw a small flash illuminate the surface of the Moon, when SMART-1 made its controlled impact on the lunar surface in the Lake of Excellence. The impact concluded a spectacularly successful mission that, in addition to testing innovative space technologies for future missions, had been exploring the Moon for 16 months, gathering a wealth of data on the structure and mineral composition of its surface. Also in September, ESA announced its new strategy for the future direction of its Living Planet Programme, addressing the continuing need to further our understanding of the Earth System and the impact that human activity is having on it.

In October, MetOp-A, developed jointly by ESA and Eumetsat, became Europe's first polar-orbiting weather satellite, also carrying instruments provided by CNES (F) and NOAA (USA). MetOp will provide a closer view of our planet's atmosphere from low Earth orbit, delivering data that will improve global weather prediction and enhance our understanding of climate change.

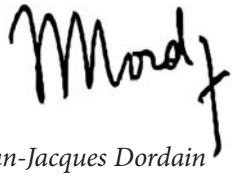
On 11 October I presented the Executive's 'Agenda 2011' document to Council, which sets out the Agency's main priorities and objectives for the next five years. It proposes an important evolution in the Agency and its activities. Behind this vision lies the desire to turn ESA into a global space agency by 2011, supporting the policies of its Member States and of the European Union (EU), developing a competitive economy, and contributing to the development of global policies and to the advancement of human knowledge. In effect, this vision will add an EU dimension to Europe's space policy and, by the same token, a space dimension to the political actions of the Union. The shape of ESA's future is also being determined by the imminent growth in the number of ESA Member States.

The two highlights that spring to mind for November are the fact that the Venus Express scientific mission celebrated its first anniversary in orbit, and there was the successful first test firing of Vega's first-stage motor in Kourou, French Guiana.

The year ended with another flurry of accomplishments, starting with the successful eighth flight of Ariane-5 ECA on 8 December. It was followed by ESA astronaut Christer Fugelsang's launch on 10 December aboard Shuttle flight STS-116 to the ISS. His 13 days of intense activity on the Station included three highly demanding spacewalks (EVAs). Another world first was achieved by ESA early in the month when its Artemis spacecraft established the first optical laser links with an aircraft, flying at altitudes of 6 and 10 kilometres. Earth-observation satellites will benefit particularly from this new technique for transmitting large volumes of data around our planet. On 22 December, Space Shuttle 'Discovery' landed safely at Cape Canaveral, bringing back Thomas Reiter and Christer Fugelsang, after completing one of the most complex assembly missions to date to the International Space Station.

With all of the above achievements and milestones, 2006 was certainly a highly successful year for the Agency, and one that contributed substantially to strengthening ESA's image and reputation as a European organisation synonymous with success. 2007 will be the 50th anniversary of the launch of Sputnik, marking the start of the space age as well as the 50th anniversary of the Treaty of Rome. With space and Europe constituting the two key dimensions of ESA, 2007 too promises to be an exciting year for the Agency. Concrete results from the investment that Europe has made over the last 20 years in the ISS will finally begin to be realised, with the launch of the first Automated Transfer Vehicle (ATV) and the deliveries of the Columbus laboratory and the Italian-built Node-2 to the Station. Other scheduled launches include those of Proba-2 and GIOVE-B and of a Russian Foton-M3 capsule carrying 17 ESA experiments. We should also have three ESA astronauts in orbit during the year.

Thanks to the continuous support of its Member States and to the expertise and dedication of its staff, ESA is putting the European flag at the leading edge of scientific progress, serving Europe's citizens, and boosting its industrial competitiveness.



Jean-Jacques Dordain
Director General

Directors

Director General

Jean-Jacques Dordain

Director of Science

D. Southwood

Director of Earth Observation

V. Liebig

Director of Telecommunications & Navigation

G. Viriglio

Director of Human Spaceflight, Microgravity & Exploration

D. Sacotte

Director of Launchers

A. Fabrizi

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M. Courtois

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G. Winters

Director of Resources Management

H. Kappler

Director of Legal & External Relations

R. Oosterlinck

Director of Reforms

J. Feustel-Büechl

Activities

Science

The year will be remembered for many successes, including the Venus Express orbit insertion, SMART-1 impacting the Moon, Cluster's survival of the long eclipse season and extension into new science, the excellent productivity of XMM-Newton, and many positive activities on the international front. In line with the Directorate's support role to the science community, the development and maintenance of scientific data archives continued to be an important task.

The archival approach initially developed for ISO has now been extended to XMM-Newton, Integral and planetary missions, including Mars Express, Rosetta and SMART-1. The Planetary Science Archive regularly releases Mars Express data (approximately 2 Tbytes of data have been made available so far this year) and in September the Huygens Data Archive was released. In solar terrestrial physics, the Cluster Active Archive opened on 1 February and has already attracted more than 250 users. An increased role in virtual-observatory activities has been undertaken and this is closely linked to the increased astronomical archiving tasks at ESAC.

Hubble Space Telescope image of the 'Antennae', the nearest and youngest example of a pair of colliding galaxies (Credit: NASA/ESA/B. Whitmore, STScI)

An issue that certainly occupied the attention of the Directorate and the Advisory Structure, in one way or another, throughout the year was the 2006 Science Programme Review. Emanating from the initial idea raised by the Chair of the Science Programme Committee (SPC) at the end of 2005, the February SPC supported a recommendation to request the setting up of an external review of the Science Programme. Accordingly, the Council adopted a Resolution to that effect at its March meeting and the SPRT (Science Programme Review Team), under the chairmanship of Dr Reinder van Duinen (NL), began its work in April. Based upon numerous meetings and interviews, both within and outside the Science Directorate, in addition to very detailed analysis of documentation, reports, etc., the SPRT delivered its final Report and recommendations to the Executive and the SPC on 5 January 2007.

Planning for the Future – the 'Cosmic Vision'

The implementation of the Horizon 2000 and Horizon 2000+ long-term plans for space science formulated over 20 years and 10 years ago, respectively, is now nearing completion with 14 scientific satellites presently in orbit, producing excellent results and putting Europe at the forefront of research in a number of fields. With the last missions in these programmes scheduled for launch by the middle of the next decade, there is now a pressing need to look ahead, building on a solid past and working today to meet the scientific, intellectual and technological challenges of tomorrow. Cosmic Vision 2015-2025, ESA's next long-term scientific programme, based on a vision that is founded on strong pragmatism and consolidated, proven ability, is the starting point for quests into the advancement of space science in a contemporary context. To ultimately explore our Universe, its mysteries and laws and to advance our understanding of nature, this vision has to capitalise upon:

- current scientific challenges and prevailing priorities in space research;
- consolidation of the European leadership in key scientific areas;
- available knowhow, resources and technological investment aimed at maximum scientific return;
- maintenance of European industrial and technological competitiveness;
- consolidation of ESA's ability in worldwide space science.

The Cosmic Vision 2015-2025 plan addresses four broad questions that are high on the agenda of research across Europe and elsewhere concerning the Universe and our place in it (see panel on next page).

Covering a decade (from 2015 to 2025) in the life of the Science Programme, the Cosmic Vision plan is to be implemented in three slices, with three corresponding Calls for Proposals for new missions. The first call was originally to be released in the first half of 2006. However, linked to the SPRT activity referred to above, the SPC and the Executive considered that there was a need to consolidate the programme, in order to allow the Cosmic Vision Call to start on solid programmatic grounds, while keeping the time between receipt of proposals from the scientific community and launch of the selected missions as short as possible. This exercise was an important activity during 2006 and, on the basis of an agreed strategy to deal with the existing and future commitments, is aimed at release of the first Call for Proposals in the first half of 2007.

In the meantime, early preparatory work on the technological aspects of the Cosmic Vision plan took place during 2006. Based on the broad scientific questions and the associated immediate goals spelled out in the Cosmic Vision plan, work was conducted throughout the year to study the space technologies likely to be required to achieve the scientific goals. This activity was performed mainly as an aid to the scientific community, with a view to establishing a range of possible realistic mission scenarios that might lead to candidate projects.

Missions in Operation or in an Archival Phase

Hubble Space Telescope
Launched 24 April 1990

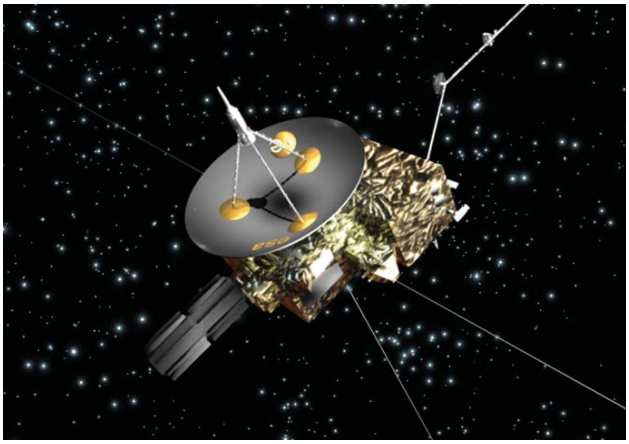
Following approval by the NASA Administrator, Servicing Mission 5 is expected to take place in summer 2008. In the meantime, the ESA/NASA Memorandum of Understanding (MoU) has been extended to 2010. Over 6000 publications have appeared in the refereed literature to date, about 30% of which include contributions from European astronomers. Observations with HST have discovered galaxies at the earliest epochs after the Big Bang and show a complex formation process for the first building blocks of the Universe. HST observations of distant supernovae confirm that the expansion of the Universe is accelerating.

Ulysses
Launched 6 October 1990

Ulysses has now completed its 16th year in orbit and started its third Southern Polar Pass on 17 November. One of the more surprising observations is the identification of a population of energetic ions that have a unique character and are ubiquitously present in the solar wind. Interestingly, the same spectral shape has been found in ion data recently acquired by the Voyager 1 spacecraft. All data from Ulysses are now in the public domain, and there have been more than 1350 publications to date. On 31 December, the spacecraft was at 76°S solar latitude and 2.6 AU from the Sun. In its 2006 report, NASA's Senior Review Panel recognised Ulysses' fundamental role in understanding the heliosphere and recommended continued support to the mission.

Scientific Questions where Important Progress can be expected in the Cosmic Vision 2015-25 Timeframe

1.	**What are the conditions for life and planetary formation?**
1.1	**From gas and dust to stars and planets** Map the birth of stars and planets by peering into the highly obscured cocoons where they form.
1.2	**From exoplanets to bio-markers** Search for planets around stars other than the Sun, looking for bio-markers in their atmospheres, and image them.
1.3	**Life and habitability in the Solar System** Explore *in situ* the surface and subsurface of the solid bodies in the Solar System most likely to host – or have hosted – life. Explore the environmental conditions that make life possible.
2.	**How does the Solar System work?**
2.1	**From the Sun to the edge of the Solar System** Study the plasma and magnetic-field environment around the Earth and around Jupiter, over the Sun's poles, and out to the heliopause where the solar wind meets the interstellar medium.
2.2	**The giant planets and their environments** *In situ* studies of Jupiter, its atmosphere and internal structure.
2.3	**Asteroids and other small bodies** Obtain direct laboratory information by analysing samples from a Near-Earth Object.
3.	**What are the fundamental laws of the Universe?**
3.1	**Explore the limits of contemporary physics** Use space's stable and gravity-free environment to search for tiny deviations from the standard model of fundamental interactions.
3.2	**The gravitational-wave Universe** Detect and study the gravitational radiation background generated at the Big Bang.
3.3	**Matter under extreme conditions** Probe gravity theory in the very strong field environment of black holes and other compact objects, and the state of matter at supra-nuclear energies in neutron stars.
4.	**How did the Universe originate and what is it made of?**
4.1	**The early Universe** Define the physical processes that led to the inflationary phase in the early Universe, during which a drastic expansion supposedly took place. Investigate the nature and origin of the Dark Energy that is accelerating the expansion of the Universe.
4.2	**The Universe taking shape** Find the very first gravitationally bound structures that were assembled in the Universe – precursors to today's galaxies, groups and clusters of galaxies – and trace their evolution to the current epoch.
4.3	**The evolving violent Universe** Trace the formation and evolution of the super-massive black holes at galaxy centres – in relation to galaxy and star formation – and trace the life cycles of matter in the Universe along its history.

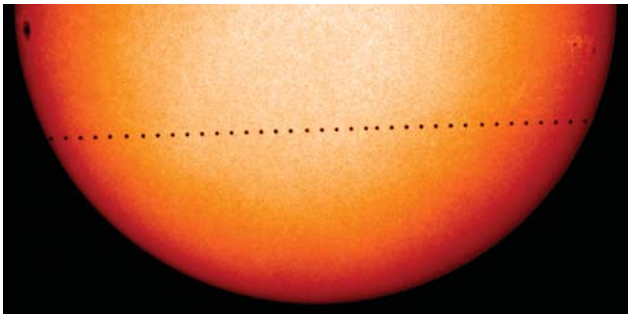


Artist's impression of the Ulysses spacecraft, which started its third polar pass over the Sun's southern polar cap on 17 November

ISO
Launched 11 November 1995

The ISO Active Archive Phase came to an end in December. Throughout the year, new Highly Processed Data Products were added to the ISO Data Archive. A total of 1400 papers have appeared in the refereed literature.

SOHO
Launched 2 December 1995



Mercury transit as seen by SOHO on 8 November

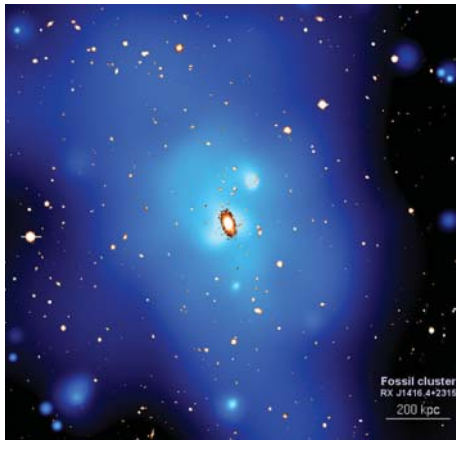
At its 115th meeting on 15/16 May, the Science Programme Committee approved the extension of SOHO science operations until December 2009. All data are now in the public domain and over 2500 papers have appeared in the refereed literature. On 9 August a Polish amateur astronomer discovered the 1000th SOHO comet in the Kreutz group of Sun-grazing comets; this faint object has been officially designated C/2006 P7 (SOHO) by the IAU Minor Planet Center. Before the launch of SOHO, only some thirty members of the Kreutz group were known. By the end of 2006, the total count of comet discoveries by SOHO stood at 1252.

Cassini-Huygens
Launched 15 October 1997

With giant Saturn hanging in the blackness and sheltering Cassini from the Sun's blinding glare, the spacecraft viewed the rings as never before, revealing previously unknown faint rings and even glimpsing its home world. This marvellous panoramic view was created by combining a total of 165 images taken by the Cassini wide-angle camera over a period of nearly three hours on 15 September

Each Cassini Titan flyby brings new surprises as the radar probes new territory. Lakes have been spotted near the north pole, and it has now been confirmed that they contain liquid methane, providing another piece of the puzzle regarding the complex methane hydrological cycle on Titan. Another unprecedented discovery is that of Enceladus jets near the south pole, which may indicate pockets of liquid water tens of metres below the surface. NASA is considering a two-year extension to the Cassini mission.

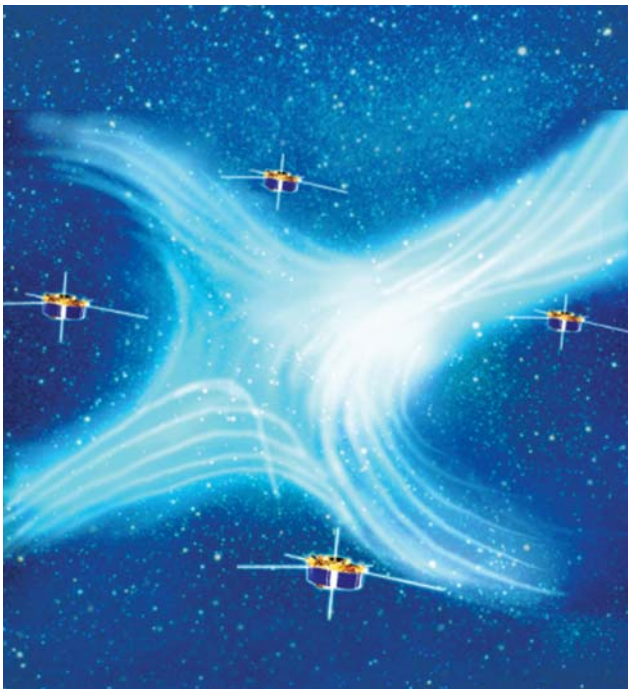
XMM-Newton
Launched 10 December 1999



XMM-Newton image of the fossil galaxy cluster

XMM-Newton continues to provide high-quality, high-impact scientific data. A preliminary version of the second XMM-Newton source catalogue was released in 2006, containing over 150 000 source detections – the largest X-ray catalogue ever produced. XMM-Newton has found evidence linking stellar remains to the oldest recorded supernova. By combining images from the Chandra (NASA) and XMM-Newton X-ray observations of a supernova remnant called RCW 86, the expanding ring of debris that was created after a massive star in the Milky Way collapsed and exploded can be clearly studied. The new observations reveal that RCW 86 was created by a star that exploded about 2000 years ago. This age matches observations of a new bright star by Chinese (and possibly Roman) astronomers in AD 185, and may be the oldest known recording of a supernova. Over 1260 refereed papers directly based on XMM-Newton results have now been published.

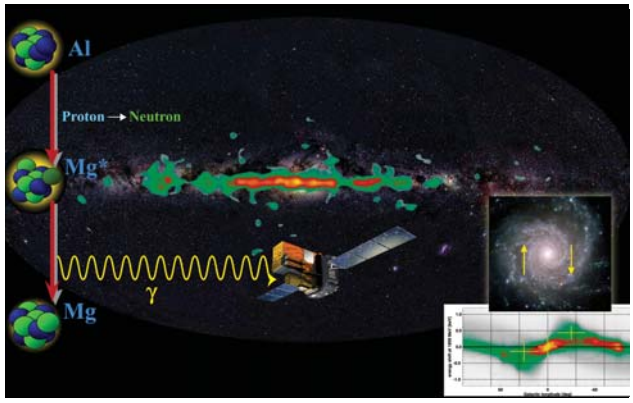
Cluster
Launched 16 July and 9 August 2000



Artist's impression of the four Cluster spacecraft encompassing a magnetic null region (Credit: Dr. Xiao and Prof. Pu, School of Earth and Space Sciences, Peking University, China)

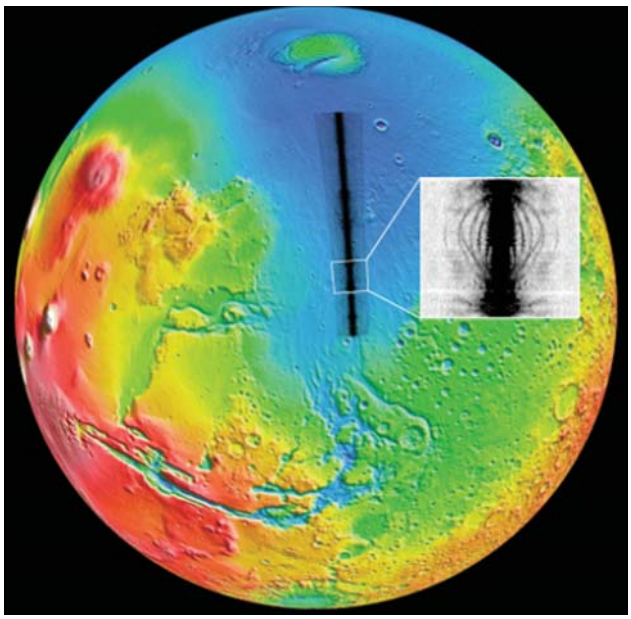
The Science Programme Committee at its 110th meeting on 9/10 February 2005 approved the extension of science operations for Cluster from 2006 to 2009. The Cluster Active Archive was opened on 1 February and a total of 351 users had registered by the end of the year. Various manoeuvres of the four Cluster spacecraft took place, including one in June-July which resulted in a perfect 10 000 km tetrahedron, and one in December when this was changed to a multi-scale configuration (like a 'flat pyramid') where the distance between Clusters 3 and 4 is 500 km and that between Clusters 1, 2 and 3 is 10 000 km. More than 520 papers have now appeared in the refereed literature (from both Cluster and Double Star).

Integral
Launched 17 October 2002



Radioactive decay as measured by Integral from Al 26, and the signature of galactic rotation

During 2006, Integral observed the Earth, or more correctly the Earth's shadow on the cosmic X-ray background. The intensity was found to be 10% higher than previously measured. The second Integral ISCRI source catalogue, containing more than 2000 high-energy sources, was made available via the Integral Science Data Archive at ESAC (E). Integral has detected gamma-ray lines due to the decay of radioactive titanium from the supernova remnant Cassiopeia A, which exploded in AD 1671. The precise determination of the line flux has enabled the amount of titanium synthesized in the supernova explosion to be reliably measured for the first time. This turns out to be 0.016% of the mass of the Sun, which is much higher than predicted by standard supernovae models. This has led astronomers to propose that Cassiopeia A is a very unusual supernova remnant, perhaps resulting from a very energetic explosion or one that was highly asymmetric.



A ground-range projection of the 'radargram' obtained by the MARSIS sounding radar on board ESA's Mars Express on 6 July 2005 (orbit 1892), when the spacecraft was flying over the Martian lowland plains of Chryse Planitia. Rim walls and interior ring structures of impact basins produce parabolic-shaded echoes. The inset shows that parabolic-shaped echoes in the radargram project to circular arcs, indicating the presence of a buried impact basin
(Credit: ESA/ASI/NASA/Univ. of Rome/JPL/Smithsonian)

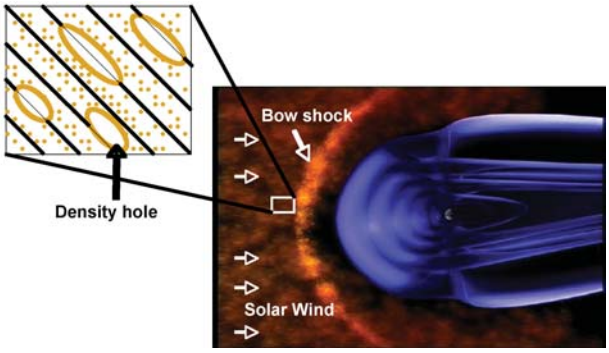
Mars Express
Launched 2 June 2003

The fourth major Mars Express eclipse season required extremely careful resource planning because it aligned with Mars at its furthest distance from the Sun. The extremely low power available to the spacecraft called for the use of a novel, so-called SUMO (Survival Mode) configuration. It also meant that operations had to be suspended for 6 weeks. The spacecraft then successfully passed through the Mars solar conjunction and mission science could be resumed on 6 November. The MARSIS experiment was successfully commissioned and science data taking re-started. Many exciting results obtained by the Mars Express instruments were published in major scientific journals, including: spectacular images from the HRSC, mineralogical mapping results obtained by OMEGA altering the 'classical' view on the role of water in Martian history, as well as the discovery of high-altitude ice clouds by SPICAM.

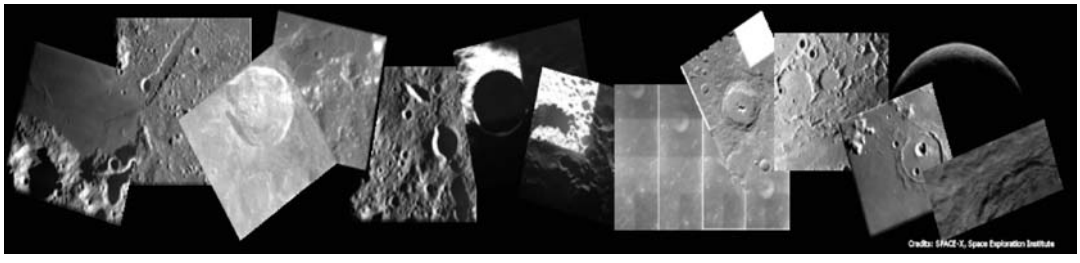
SMART-1
Launched 27 September 2003

On 19 June, a 17-day series of manoeuvres were started to change the orbit around the Moon to extend the spacecraft's lifetime from 17 August to 3 September and to move the impact site to the visible side. The actual impact took place on 3 September at 05:42:22 UTC at 46.2°W and 34.4°S. Images continued to be taken by the AMIE camera until close to impact. The Canada-France Hawaii Telescope (CFHT) observed the impact flash and radio telescopes from the Joint Institute for Very Long Baseline Interferometry in Europe (JIVE) received signals from SMART-1 until impact. This concluded a very successful mission that, in addition to testing innovative space technology, conducted a thorough scientific exploration of the Moon. For the last 16 months and until its final orbits, SMART-1 gathered data about the morphology and mineralogical composition of the lunar surface in the visible, infrared and X-ray wavelength ranges.

Double Star – Collaboration with China
Launched 29 December 2003 and 25 July 2004



The right-hand figure represents the Earth's magnetosphere surrounded by solar-wind plasma constantly flowing out of the Sun (coming from the left). The white rectangle indicates where recent observations have been performed by the Cluster and Double Star satellites, namely in the solar wind upstream of the Earth's bow shock (yellow arc). The left-hand sketch illustrates the density holes



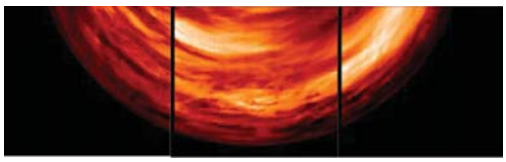
Mosaic of lunar images obtained with the SMART-1 AMIE microcamera, showing craters, volcanic, tectonic features and the polar regions

The Double Star mission has been extended for a second time, from January to end-September 2007. The European Payload Operation System (EPOS) coordinates operations for the seven European instruments on the TC-1 and TC-2 spacecraft and is running smoothly. Data are acquired using the Vilspa-2 ground station in Spain for 3.8 hours per day over an average of two passes per day. Over 520 papers have appeared in the refereed literature based on Cluster - Double Star results.

Rosetta
Launched 2 March 2004

Rosetta is continuing on its cruise phase, leading to a rendezvous with comet 67P/Churyumov-Gerasimenko in 2015. Two passive payload checkouts took place in March and August and two active checkouts in November and December, all of which were successful. The RPC magnetometer detected the tail of comet HMP at a large distance from the nucleus in July. Deep-space manoeuvre no. 2 was successfully performed on 29 September. Preparations are now underway for the Mars gravity-assist manoeuvre in February 2007, when Rosetta will pass over the planet at an altitude of 250 km.

Venus Express
Launched 9 November 2005



This false-colour view of Venus is a composite of three independent infrared frames captured by the Ultraviolet, Visible and Near-Infrared Mapping Spectrometer (VIRTIS) onboard Venus Express on 22 July 2006 over a time interval of about 30 minutes. Taken from a position 65 000 kilometres above the south pole at a wavelength of 1.7-micrometre, it shows the thermal radiation emitted by the atmosphere at about 15-20 km altitude on the dark side of the planet. The structure in the image is caused by the varying thickness of the cloud layer above this altitude; the brighter the colour the more radiation and less cloud
(Credit: ESA/VIRTIS/INAF-IASF/Observatoire de Paris-LESIA)

Following completion in January of the post-launch commissioning, the Venus Orbit Insertion took place on 11 April and the first scientific observations (the first infrared images of the South Pole vortex) took place on 12 April. The spacecraft and payload in-orbit commissioning took place during April and May, and the nominal science operations started on 4 June. The spacecraft successfully survived its first solar-eclipse season, as well as the first solar conjunction. The data acquired so far have addressed topics in all of the seven science themes defined as a part of the mission's scientific objectives. Among the many interesting results are the crisp images by the VIRTIS instrument of the south pole double vortex structure, and the measurements of the global wind fields at different altitudes and latitudes. Both of these features are strongly related to the yet unexplained atmospheric super-rotation that makes the atmosphere circle the planet in only four days, while the rotation of the solid planet itself is as slow as one revolution per 243 days.

AKARI (ASTRO-F) – Collaboration with Japan
Launched 21 February 2006

AKARI (formerly ASTRO-F) is the second space mission for infrared astronomy from the Institute of Space and Astronautical Science (ISAS) of the Japanese Aerospace Exploration Agency (JAXA). Its main objective is to perform an all-sky survey with better sensitivity, spatial resolution and wider wavelength coverage than IRAS, mapping the entire sky in six infrared bands from 9 to 180 micron. ESA is collaborating with JAXA/ISAS in order to increase the scientific output of the mission by capturing all of the possible data (providing tracking support from the ESA ground station in Kiruna, Sweden) and to accelerate the production of the sky catalogues, which will be extremely valuable in the exploitation of the Herschel and Planck missions, in return for 10% of the observing opportunities for European scientists in the non-survey part of the mission. Following its successful launch in February, the All-Sky Survey took place between May and November. Open-time observations started in September, 10% of which are European peer-reviewed programmes. ESA's contributions are the pointing reconstruction software, user support and ground-station coverage, all of which are performing well.

HINODE (formerly Solar-B) – Collaboration with Japan
Launched 22 September 2006

This is a Japanese-led mission with US and UK instrument participation and ESA ground support (subcon-

The Soyuz 2-1b + Fregat combination carrying COROT about 15 min before launch as the gantry was being moved away

tract with the Norwegian Space Centre). Its objective is to study the mechanisms that power the solar atmosphere and look for the cause of violent solar eruptions. The instruments were switched on at the end of October and all have successfully performed their initial engineering observations. Data taken during the Mercury transit on 8 November demonstrated the high quality of the telescopes.

COROT
Launched: 27 December 2006

COROT is a spacecraft developed by CNES (F) to detect exoplanets and to probe stellar interiors, to which ESA has contributed by providing the telescope baffle and onboard processing units. The launch took place on 27 December at 15:43:00 CET, with the first Soyuz 2-1b + Fregat combination injecting the spacecraft into a near-perfect orbit. The orbital parameters are so close to nominal that the planned inclination correction manoeuvre was discarded. Consequently, COROT begins its operations with an extra onboard fuel reserve, which may be used during an eventual extension of the mission. All onboard scientific instruments were switched on and tested during the first 7 days in orbit. All systems were found to be working correctly. The telescope hatch is due to be opened mid-January 2007. If the mission continues to operate nominally, scientific operations will start at the beginning of February.

Projects under Definition and under Development

Herschel-Planck
Launch: July 2008

The Planck spacecraft with the flight model service module (SVM) and a reduced payload module has undergone the first major acceptance test of the flight programme with the thermal and functional testing of the SVM and the Planck sorption coolers. The HFI and LFI instruments have completed their flight-model acceptance test and calibration campaigns and have been integrated with the Planck spacecraft.

The acceptance testing of the Herschel service module has been completed and the module delivered. The Herschel payload module (cryostat) was refurbished after the first thermal testing in the large space simulator at ESTEC early in the year, and has completed a major part of the final module acceptance test programme. The assembly of the flight models of the Herschel scientific instruments was completed and they have entered their final calibration phase. The delivery of the instruments is driving the overall schedule and the expected launch date for Herschel-Planck is mid-2008.

The Herschel and Planck telescopes have been fully acceptance tested under operational cryogenic conditions and are available for integration with the flight-model spacecraft.

LISA Pathfinder
Launch: End-2009

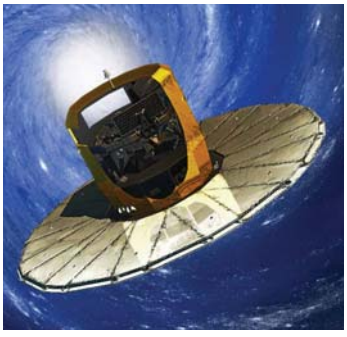
In February, the project successfully passed the Mission Preliminary Design Review, during which all the mission elements (spacecraft, payload, ground segment and launcher) were reviewed. All contracts for the procurement of subsystems and equipment have been assigned and the development work initiated. The European payload consists of the LISA Technology Package (LTP), the main experiment and core of the mission. During 2006, all of the most critical technological problems were tackled and largely successfully solved.

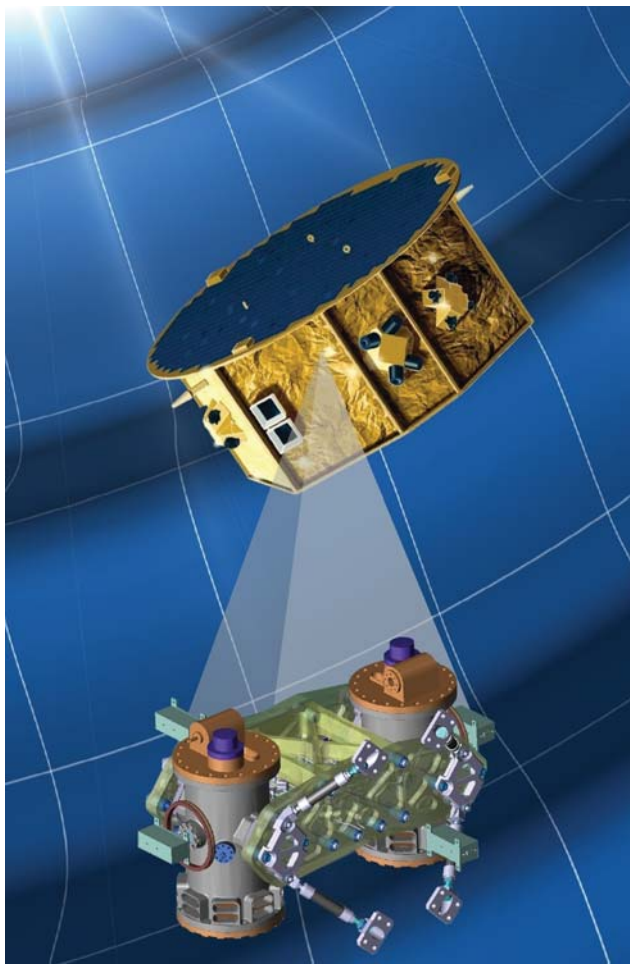
The launch towards Earth-Sun Lagrangian point 1, nominally to be performed by Vega (with Eurockot as the backup), is currently planned for the last days of 2009.

Microscope
Launch: End-2010

The CNES/ESA scientific mission Microscope, for the measurement of the equivalence principle with extreme accuracy, is due to be launched at the end of 2010 into a circular, 700 km-altitude, quasi-polar, Sun-synchronous orbit for a nominal duration of one year. ESA is providing the FEEP Electric Propulsion System (EPS) required for keeping the spacecraft in a virtually pure drag-free environment. The Microscope project at CNES is in Phase-B, which was extended after the Preliminary Design Review in February required further work on both the payload and the FEEP. The EPS testing and design activities at thruster and subsystem level are progressing in the framework of LISA Pathfinder, leading to a decision point in mid-2007.

Gaia
Launch: December 2011





Artist's impression of the LISA Pathfinder spacecraft at the first Earth-Sun Lagrangian point, after separation from the propulsion module. In the foreground is the core of the experiment, the LISA Technology Package (LTP), containing the free-falling test masses and the electrostatic and laser metrology systems

It was a very crucial year for Gaia, starting with the selection and confirmation of the prime contractor in February. Only days later, the Science Programme Committee reconfirmed the mission by approving the relevant cost-to-completion. Immediately afterwards, the kick-off meeting with the prime contractor was successfully held. The project required a fast start because the first major project milestone, the System Requirements Review, was scheduled for completion before the summer, i.e. less than 5 months after contract signature. It was successfully concluded at the meeting of the Review Board in early July.

In late spring and in parallel with the Review, the competitive selection of about 80 industrial subcontractors started. This activity is scheduled to last about 15 months.

An Announcement of Opportunity (AO) was released by ESA for the provision of the Gaia Data Processing and Analysis Centre. A European consortium has submitted a proposal that is currently under evaluation.

JWST
Launch: June 2013

The JWST mission was significantly consolidated during the year. The mission-level System Definition Review was successfully completed in early 2006. Significant progress has been achieved for all the critical new technologies specific to JWST, with nine of the ten having reached Technology Readiness Level 6.

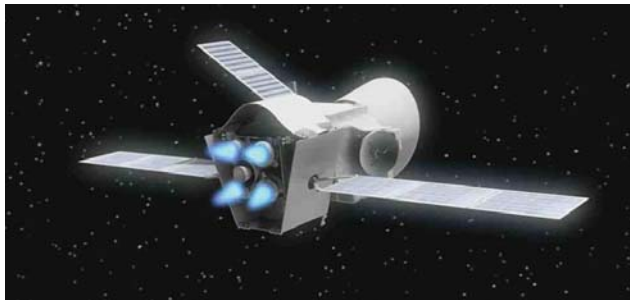
The NIRSpec instrument provided by ESA successfully completed its Preliminary Design Review and all main sub-assembly PDRs. All subcontractors are fully engaged and the detailed design phase is nearing completion.

The MIRI instrument provided by a European consortium of scientific institutes completed the sub-assembly Critical Design Review campaign and the instrument level CDR was kicked-off. The MIRI instrument structural thermal model test campaign was successfully completed. Manufacture of parts for the MIRI verification model is also nearing completion. Assembly of the verification model will start in January 2007.

JWST wavefront sensing and control testbed to demonstrate the feasibility of the active alignment approach for the main telescope. The testbed is a scaled-down model of the full telescope, including actuators

The definition study for the use of Ariane-5 ECA was initiated with Arianespace. All activities and NASA JWST budget allocations are compatible with the foreseen launch date of mid-2013.

BepiColombo
Launch: August 2013

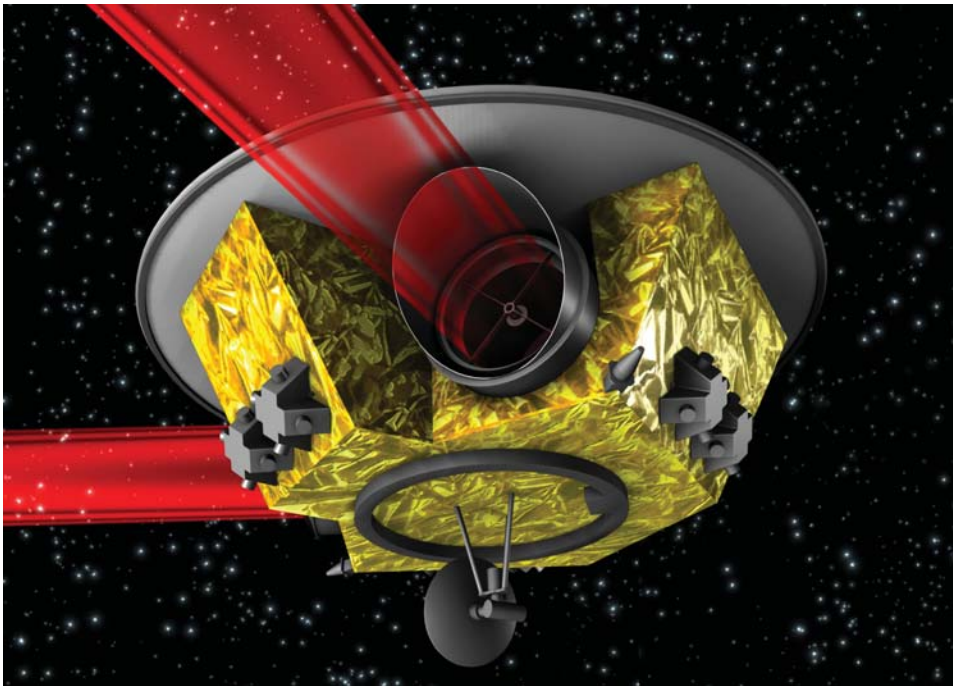


Artist's impression of the complete BepiColombo composite: Mercury Transfer Module, Planetary Orbiter and Magnetospheric Orbiter

The Invitation to Tender (ITT) for the implementation phase was issued at the beginning of the year. The industrial offers were received in May and their evaluation was completed in early July. The selected consortium core team was further optimised in the autumn, and the contract proposal was submitted to the Industrial Policy Committee (IPC) for approval. The request for approval and implementation will be presented to the Science Programme Committee (SPC) in February 2007.

Detailed payload definition continued under the leadership of the Principal Investigators. The Multi-Lateral Agreement between the payload funding agencies and ESA has been prepared, to formalise the commitment for payload procurement. The Memorandum of Understanding (MoU) for the collaborative programme with the Japan Aerospace Exploration Agency (JAXA) has been approved by the SPC. The detailed design phase for the Japanese Mercury Magnetospheric Orbiter is well underway.

The technology development activities continued with satisfactory results, one highlight being that the two candidate electric-propulsion engines successfully exceeded 4500 hours of testing. The availability of this



Artist's impression of one of the LISA spacecraft

propulsion technology is critical to BepiColombo due to the very large delta-V required for its journey to Mercury.

Definition of the mission operation and scientific operation centres was initiated, as well as detailed work with the launch-service provider.

Solar Orbiter
Launch: May 2015

2006 saw the initiation of two parallel study contracts, placed with Alcatel Alenia Space (F) and EADS Astrium SAS, to advance and breadboard the heat-shield technology that will enable Solar Orbiter to survive the gruelling heat flux that it will be submitted to in the vicinity of our star. This study also takes the spacecraft system design trade-offs and the accommodation of the scientific instruments a step further, in preparation for the definition phase.

On the payload side, 23 letters of intent from potential Principal Investigators were received, paving the way for further progress on the payload and its interfaces with the instrument proposers.

ESA and NASA have started analysing the possibility of combining the Solar Orbiter mission with NASA's Inner Heliospheric Sentinels on a common launch vehicle. Several attractive mission scenarios have been identified. A joint Solar Orbiter – Sentinels Science and Technology Definition Team has been set up to pursue this potential combined mission further.

LISA
Launch: 2017

The mission-formulation activity performed by Astrium GmbH produced very good results during the course of the year. System-level trade-offs were completed and allowed the definition of a baseline mission reference architecture. Some recent analysis results have indicated the possibility to further simplify the architecture of the scientific instrument complement and for this reason it has been decided to extend the mission-formulation contract until mid-2008.

The technology required by LISA was further matured in the course of 2006, both in Europe in cooperation with Member States and in the USA. A significant part relies on units currently being developed for the LISA Pathfinder mission.

Activities were started in the field of data analysis, both in Europe under the coordination of ESA and in the USA with the Mock LISA Data Challenge, the first round of which was successfully completed in December.

PRODEX / PECS

PRODEX is an optional Scientific Programme established to provide funding for the industrial development of scientific instruments or experiments proposed by Institutes or Universities and selected by ESA for one of its research programmes in science, microgravity, Earth observation, etc. The Agency provides both administrative and financial management knowhow and technical support. The countries currently participating in PRODEX are Austria, Belgium, Denmark, Ireland, Norway and Switzerland. The projects being developed range from small Earth-observation data-analysis programmes to fully-fledged instruments for scientific payloads.

The major PRODEX undertaking during 2006 was the completion and delivery of the four payloads for the Proba-2 mission: the Sun Watcher using APS detectors and image processing (SWAP) and the Lyman-alpha Radiometer (LYRA) focusing on the Sun's observation, the Thermal Plasma Measurement Unit (TPMU) and the Dual Segmented Langmuir Probe (DSLP) concentrating on monitoring the space environment. In addition, PRODEX contributed substantially to life- and material-sciences projects by making use of various facilities and flight opportunities (ISS, Maxus-7, STS-121 and 43rd parabolic flight campaigns).

Proba-2 TPMU flight model (Photo courtesy of CSRC, Brno, Czech Republic)

The PRODEX Office has also been entrusted since 2001 with the setting up and implementation of the arrangements and management structure for the Plan for European Cooperating States (PECS). Hungary was the first Participating State in this programme, followed by the Czech Republic. On 17 February, Romania signed an ECS agreement with ESA to participate in PECS from 2007.

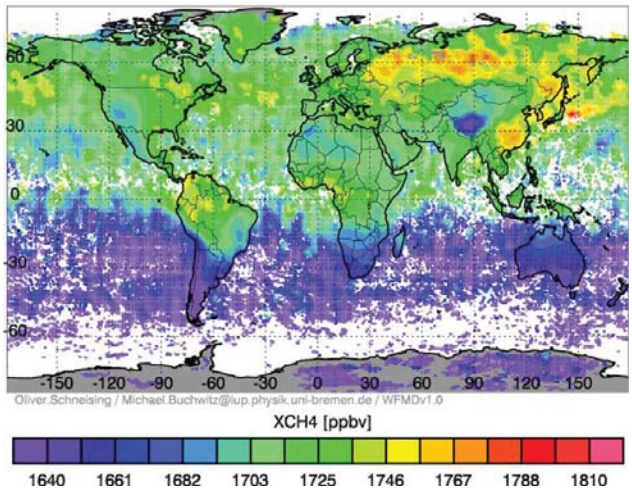
PRODEX Experiments or Experiment Subsystems finalised and/or launched in 2006

Proba-2	
• Lyman-alpha Radiometer (LYRA):	W. Schmutz (CH) J.-F. Hochedez, C. Jamar, M. D'olieslager, D. Gillotay (B)
• Sun Watcher using APS detectors and image processing (SWAP):	D. Berghmans, C. Jamar, S. Poedts (B)
• Dual Segmented Langmuir Probe (DSLP)	P. Travnicek (CZ)
• Thermal Plasma Measurement Unit (TPMU)	F. Hruska (CZ)
STS-121	
• Cardiocog-2:	A. Aubert, S. van Huffel (B)
• BASE	P. Cornelis, N. Leys, J. Mahillon, M. Mergeay, R. Wattiez (B)
• YING	F. Delvaux, R. Willaert, L. Wijns (B)
• ARISS	G. Bertels (B)
International Space Station	
• Effect of EVA on pulmonary function	M. Paiva (B)
• Solid Particle Mobility (SPM) in gases	A. Vedernikov (B)
43rd Parabolic Flight Campaign	
• Effects of gravity on human locomotion	N. Heglund, P. Willems (B)
• Grip-load force coordination	J.-L. Thonnard, P. Lefèvre (B)
• Dynamics of a vesicle suspension (BIOMICS)	F. Dubois (B)
• FEVCOM	O. Kabov (B)
Maxus-7	
• CETSOL	D. Browne (IRL)

Earth Observation

Eruption of Sicily's Mount Etna on 25 November, as seen by Envisat's MERIS instrument

The extreme rain and floods episode in Central Europe in spring 2006, affecting primarily Germany, Austria, the Czech Republic, Hungary and Romania, led to the most important series of activations of the International Charter on Space and Major Disasters. GMES (Global Monitoring for Environment and Security) services were used on a large scale in conjunction with Charter calls, under the leadership of ESA and DLR, to provide information to European and national authorities. In Germany, flood-extent maps derived from Charter data were made available through the federal emergency information system DeNIS.



Methane concentrations for the year 2005, measured with Envisat's Sciamachy instrument

The International Charter on Space and Major Disasters

Overall, the Charter was invoked 25 times, for events affecting Africa, Oceania, Asia and Southern America, at the request of national authorities, the European Commission or specialised UN agencies. It was feared that the Merapi volcano would erupt and Charter data were provided to support assessment of the situation. In response to the landslide that affected the Island of Leyte in the Philippines, JAXA provided imagery taken by its ALOS satellite for the first time. These data were the first available for this event. Some products were included in a report to the highest political authorities. Another example was the support provided to Dutch forces and UN organisations for the floods that affected Surinam.

By 31 December, a total of 116 activations had been registered since the opening of the Charter. The year was also marked by an increase in membership, with the application of the China National Space Administration (CNSA), and an increase in resources with the announcement that data from commercial missions such as GeoEye, DigitalGlobe and Formosat would also be made available under the Charter.

Global Monitoring for Environment and Security (GMES)

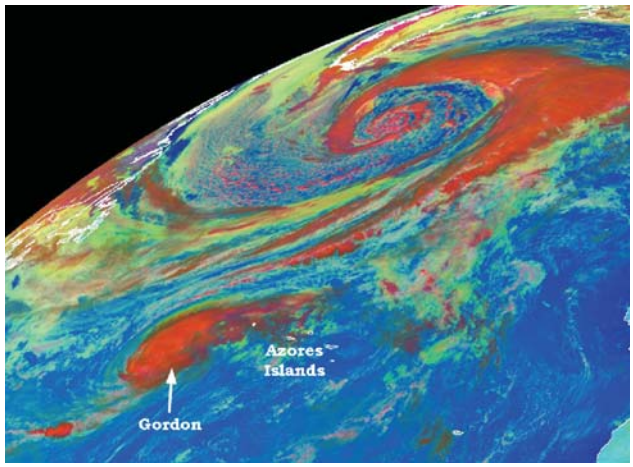
GMES, a European Union-led initiative, is the most complex and ambitious Earth Observation programme to date, with the goal of delivering operational information services for the environment and security from 2008 onwards. ESA has the mandate to develop the GMES space infrastructure, including the coordination of access to national and multinational missions.

The 'socio-economic impact study', completed in the autumn, gave clear evidence that GMES can provide a major economic as well as a strategic benefit for Europe and its citizens. Furthermore, the 'Stern Report'[1] has put a macro-economic value on the impact of climate change and argues for a major political effort to reduce the factors leading to climate change. With GMES, Europe is putting the right tools in place to monitor the impacts of climate change with high accuracy and at an early stage.

Programmatic Matters and the Relationship with the EC

On the European Commission (EC) side, the Seventh Framework Programme (FP7) for research, technology development and demonstration activities (2007-2013) was adopted by a Decision of the European Parliament and of the European Council in December. GMES represents the major element of the FP7 space-theme Work Programme, with an allocation in the order of 85% of the budget and ESA identified as the direct beneficiary of the funding related to both the coordinated provision of observation data and the development of the GMES-dedicated EO space infrastructure. ESA has also established the GMES Space Office with the mandate to coordinate GMES activities within ESA as well as with the EC.

[1] *Stern Review on the Economics of Climate Change*, published 30 October 2006, written by Nicholas Stern, former Chief Economist and Senior Vice-President of the World Bank.



Hurricane Gordon, observed by Meteosat-8 on 19 September, heading towards the Azores and of category-3 status

The GMES Fast Track Services Implementation Groups (for marine, land and emergency-response services) were established early in the year by the EC. Their mandate includes the assessment of space-infrastructure needs for the services themselves. In their reports, published at the end of the year, the Groups strongly endorsed the need for, as well as the overall concept of, the Sentinel-1, 2 and 3 missions.

Many GMES-relevant activities took place during 2006, two of which deserve particular mention: an international conference on 'A Market for GMES in Europe and its Regions – The Graz Dialogue' was held in Graz, Austria, in April in the framework of Austria's EU presidency. The 'Graz Roadmap for GMES' has triggered a number of actions in Europe such as the creation of a permanent GMES forum for European regions. In addition, the 'GSC Info Day' took place at ESRIN, Frascati, in April, providing programmatic and technical details of the GSC programme to ESA Delegates and the EC.

Discussions have started with Eumetsat regarding its role in and contribution to the GMES space component. Working assumptions have been agreed that relate in particular to the operation of the Sentinel-3, 4 and 5 missions.

GMES Space Segment

The definition studies for Sentinel-1, 2 and 3 advanced well, and in the case of Sentinel-1 were completed. For Sentinel-2 and 3 they will be finalised with the System Requirements Review in February 2007. The preparation of Phase-B2 also progressed well, with industrial activities planned to start in February 2007 for Sentinel-1 and in mid-2007 for Sentinel-2 and 3.

The projected launch of Sentinel-1 is in 2011 and that of Sentinel-2 and Sentinel-3 in 2012. Proposals for the Phase-0 study for Sentinel-4/5 were received and evaluated, with industrial kick-off expected early in 2007. The studies will be harmonised with the definition activities for the MTG and post-EPS missions, which should host the S4-S5 payloads.

Ground Segment, Data Access and Pre-Operations

These activities initiated under the GMES Preparatory Activities programme continued in 2006 under Phase-1 of the GSC Programme. As part of the ground-segment development, the activities have been split into the

Architecture and Design of the Generic Payload Data Ground Segment (PDGS), the development and evolution of generic PDGS elements, and the development of Sentinel-specific ground-segment elements.

As regards data access to national, Eumetsat and other missions, three main activities were initiated and are running in parallel: the preparation of GMES data-access agreements, the technical implementation of harmonised access, and capacity planning for all contributing missions. As far as the pre-operational support to GMES services is concerned, specific contractual activities were put in place for the delivery of data early in 2007 for the Land Fast Track Service, covering the period 2006-2008.

Missions in Operation

Envisat and ERS-2

Envisat marked four years of operations on 1 March, and the mission's success story continues. The number of Envisat data users continues to grow, addressing all aspects of Earth Observation, from Earth science (1200 scientific projects) to pre-operational GMES services.

Envisat continued to provide excellent Earth-science results throughout the year. As an example, ASAR data

Fires in Australia in December 2006, as seen by Envisat's MERIS instrument

were used to describe for the first time a very large magma intrusion event between two tectonic plates in Ethiopia. Envisat also observed dramatic openings in the Arctic's perennial sea-ice pack in August, extending from the Russian Arctic all the way to the North Pole, providing a remarkable fingerprint of current climate change.

To optimise mission data exploitation, ESA organises regular conferences with the various Envisat user communities. In 2006, the Altimetry Symposium (Venice, March) was a big success in terms of both the attendance and the quality of the presentations. Organised in collaboration with CNES, it celebrated '15 Years of Progress in Radar Altimetry' and gathered together the whole radar-altimetry community. The Atmospheric Science Conference (ESRIN, May) offered opportunities to report on the exploitation of Envisat atmospheric-chemistry data.

On the payload side, anomalies affected a few instruments, the most serious being those with the Radar Altimeter's ultra-stable oscillator, for which on-ground corrections were successfully implemented. The transmission of Envisat data through Artemis was interrupted in October, which served to highlight the importance of the data-relay capacity it provides. A temporary data-acquisition scenario was quickly put in place using the European polar-acquisition stations until the nominal communications link with Artemis was restored in mid-November.

Envisat data accessibility was constantly upgraded, particularly through the internet, in response to increasing user demand for near-real-time data. In parallel, operations costs were further reduced, benefiting in particular from the transfer of the Envisat payload ground segment into the common multi-mission architecture. The visibility of Envisat results to the general public was further improved with the opening of the MIRAVI (MERIS Images Rapid Visualisation) web site, complementing ESA's data and product delivery to scientists. MIRAVI provides free access to MERIS images, usually within two hours of data acquisition.

ERS-2 operations proceeded smoothly throughout the year. In response to user demand, the production of ERS high-resolution data increased further to some 27 000 SAR products, the highest since the start of the mission! The unique SAR planning latency of 13 hours combined with very rapid production throughput demonstrates that the ERS system infrastructure is ready for focused GMES support. The ground-station network for receiving Low Bit Rate (LBR) data from the satellite has been extended to include a total of 12 ground facilities, with more than 2800 acquisitions scheduled per cycle. This network covers Europe, the North Atlantic, North America, the Arctic and Antarctic regions, China and part of the south-east Pacific coast.

Morover, this 'veteran' of European Earth observation from space is not getting tired yet. The continuation of ERS-2 operations for 2007 was approved by ESA's Member States in November, paving the way for the satellite's twelfth year of operations.

The Earthnet Programme

The Earthnet Programme has contributed to ESA's EO activities for almost 30 years, ensuring long-term sustainability beyond normal programmatic funding periods.

In the autumn, ESA's Proba spacecraft, one of the most advanced small satellites ever flown, celebrated its fifth anniversary. Launched in October 2001 as a technology demonstrator for a one-year mission, its performance has allowed it to remain fully functional and scientifically productive long beyond its planned lifetime. Operated as an ESA Third-Party Mission since 2004

under Earthnet's responsibility, it is today serving more than 100 EO projects and has acquired data over 1000 sites worldwide.

The Japanese ALOS satellite, launched on 24 January, has been an ESA Third-Party Mission since the signature of the relevant Memorandum of Understanding (MoU) in June. It carries two high-resolution optical and one L-band SAR instrument. ESA is acting as the ALOS European Data Node (ADEN), responsible for the acquisition, archiving and distribution of ALOS data to users in Europe, Africa and the Middle East. ESA acquired the first passes of the satellite on 28 April and 1 May at the Kiruna Esrange station and also supported JAXA's calibration and validation activities during the ALOS commissioning phase, which lasted until 24 October, when the satellite was declared operational and data and product distribution to the ALOS Nodes began.

Having signed an agreement with Spot Image to provide access to Spot-1 to 4 data for European scientific (so-called category-1) users, ESA is sharing in the ground-segment infrastructure for the coming years in return for access to more than 10 000 Spot Image products per year. Data were made available from the summer onwards, after GMES Service Element projects had served as pilot users from March.

Korea's Kompsat-2 was successfully launched on 28 July from Plesetsk, Russia. As the Korean Government was still reluctant about KARI joining the ESA Third-Party Mission scheme due to national-security aspects, KARI entered into a cooperation scheme with ESA via a consortium with European industrial partners.

In summary, during 2006 the number of different Third-Party Mission satellite instruments available to the EO user community increased to more than 25, with further growth in access opportunities to be expected in 2007. Accessibility catalogues and ordering procedures were further improved and harmonised with those of ESA's own missions.

Ground-Segment Harmonisation

The Ground Segment Coordination Body (GSCB), a group including satellite operating agencies established in 2005 to collaborate, cooperate and share respective ground segments, continued its work throughout the year and started preparations for its first workshop with industry in 2007.

The definition of interoperability standards made important progress through the so-called 'Heterogeneous Mission Accessibility' project, to be finalised during 2007. The project is now preparing for the implementation of agreed interface standards in order to achieve harmonised access to Earth Observation data for GMES, which implies upgrading the ground segments of each of the missions. Definition of a common policy for long-term data preservation was also started in the framework of the GSCB. Work commenced on the sharing of network infrastructures, with a focus on sharing a satellite link to repatriate data from stations in Antarctica.

During the year, the harmonisation of the infrastructure of acquisition stations and processing centres was completed, migrating the operations for ERS, Envisat and Third-Party Missions. Also the User Services were rationalised with a unified catalogue and on-line ordering. Finally, the harmonisation of the Mission Planning and the Quality Control Systems could be started. The latter activity aims at a generic infrastructure to be used for current and future EO missions.

ESA also contributed during the year to activities defined in the work plan of the intergovernmental Group on Earth Observations (GEO), providing expertise and knowhow for the GEO portal and clearinghouse and the GEONet activities.

Missions under Development

Earth Explorer Missions

GOCE

- *The Gravity Field and Steady-State Ocean Circulation Explorer (GOCE) mission is the first of the Earth Explorer Core Missions planned as part of the Agency's Earth Observation Envelope Programme (EOEP). It is designed to provide unique models of the Earth's gravity field and of the geoid, on a global scale and with unprecedented accuracy and spatial resolution.*

2006 saw the delivery of the platform flight model to the satellite prime contractor, followed by the start of system-level integration and test activities. It was a year of functional and performance testing at all levels. The manufacture of the gradiometer instrument was brought close to completion, with five out of six ultra-sensitive accelerometer flight models accepted and ready for final integration. The satellite-to-satellite tracking instrument was also delivered and integrated.

The ground-segment development was nearly completed with all but one facility delivered to ESA. All ground processors were accepted, and the ground segment entered its overall validation phase.

The planned launch date is December 2007.

SMOS

· *The Soil Moisture and Ocean Salinity (SMOS) mission will demonstrate the observation of two key Earth system variables from space, namely the soil moisture content over land surfaces and the amount of salt dissolved in the oceans. SMOS is a cooperative project between ESA, CNES (France) and CDTI (Spain).*

Having passed the Critical Design Review in late-2005, the payload based upon the MIRAS instrument moved into the flight-model production phase. Despite numerous small problems during the production phase, all subsystems were delivered and most integrated by the end of the year. The payload is therefore ready to commence its acceptance test programme in early 2007. The hardware of the recurrent Proteus platform for SMOS was completed in the autumn and formally accepted. The only missing item is the flight software, which is installed on a generic test bench for protocol verification with the payload engineering model.

For the flight-operations ground segment, all payload-related facilities have been delivered at least in an initial version; interface verification is in progress. The adaptation of the generic Proteus Mission Control Centre for SMOS is making good progress. The data-processing ground segment experienced some delays, but initial integration and testing of first versions of all facilities is expected to be achieved in mid-2007. A prototype version of the level-1 processor was delivered, and the prototype versions of the level-2 processors are expected in early spring 2007. Development of the operational processors has started.

A successful airborne campaign called 'Cosmos OS' was conducted over the Norwegian Sea, and data processing and interpretation is ongoing.

ADM-Aeolus

· *The Aeolus programme will provide the first ever measurements of wind profiles from space. These data are expected to substantially advance numerical weather prediction, especially when applied to extreme weather events.*

At the ADM-Aeolus Workshop held in September at ESTEC (NL), many prospective users predicted significant advances in numerical weather prediction when Aeolus data becomes available. According to some estimates, the data may have an impact on forecasting quality comparable to that of radiosondes.

The construction of the flight-model platform is well underway at Astrium. The flight-model telescope and instrument structure have been integrated. The telescope's performance has proved to be excellent. Testing of the instrument electronic chains was also well advanced by the end of the year. There were some delays in the qualification of the laser, which is a technological first for Europe, but these will be solved during 2007.

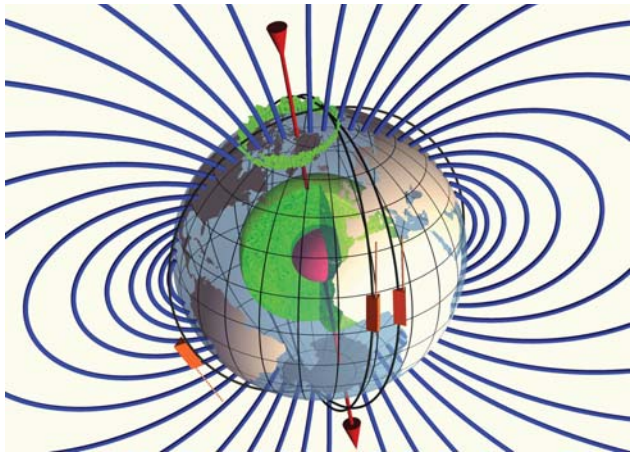
In October, the Aladin Airborne Demonstrator completed its first ground campaign at the German Meteorological Office's Lindenberg site. About 100 hours of data were obtained in parallel with five other lidars and a series of ground instruments. This will allow confirmation of important instrument design assumptions.

A review of the ground segment in November concluded that the design was good for the present stage of the project.

The launch is expected to take place in mid-2009.

SWARM

· *The primary aim of the Swarm mission is to provide the best survey ever of the Earth's geomagnetic field and its temporal evolution. It is expected to lead to*



The Earth's magnetic field is mainly produced by a self-sustaining dynamo in its fluid outer core. This will be measured, together with other contributions, by the three-satellite Swarm constellation (Credit: GFZ, Potsdam)

new insights into the Earth system by improving our understanding of the planet's interior and its effect on 'geospace', the vast region around the Earth where electrodynamic processes are influenced by the planet's magnetic field.

The definition phase for the satellite and its instruments (Phase-B) is ongoing and will be completed early in 2007 with the satellite Preliminary Design Review (PDR). The PDRs for the Absolute Scalar Magnetometer (ASM) and Electrical Field Instruments (EFI) have been completed. The procurement activity is well advanced.

The planned launch date of 2010 is maintained.

CryoSat

· *The CryoSat mission is intended to determine the fluctuations in the ice cover of the polar regions, both on land (principally Greenland and Antarctica) and in terms of floating sea-ice. These measurements will be invaluable in characterising ice-sheet mass balance and changes in sea-ice, and will contribute to the understanding of Arctic and global climate change.*

As the first Earth Explorer Opportunity mission, CryoSat was launched in October 2005, but a programming error in the launch vehicle caused a failure some 300 seconds into the flight, resulting in loss of the satellite. Work started in the last months of 2005 to prepare a recovery mission.

Less than six months after the launch failure, in late February 2006, the Earth Observation Programme Board formally approved the proposal to build and launch CryoSat-2 in order to fulfil the CryoSat mission. This decision was based on intensive preparation and a strong resolve by all parties. The unforeseen new financing need was met without requesting additional funding, by reallocating some activities and exploiting synergy with other missions.

CryoSat-2 has some changes from the original design, partly due to the need to replace equipment no longer in production, but also to introduce full redundancy into the payload. During the course of the year, the principal activities were the consolidation of these changes into the design, to be confirmed by the Critical Design Review (CDR), which started at the end of November, and the manufacture of elements unchanged from the original design.

The ground segment remains essentially the same, as it was ready to support the 2005 launch. It will, however, be necessary to port it to a new hardware base to avoid obsolescence. During 2006, the system was hibernated following the implementation of upgrades previously foreseen to be introduced during the commissioning of the original CryoSat mission.

The launch of CryoSat-2 is planned for March 2009.

Earth Watch Missions

Meteosat Second Generation

· *Meteosat satellites have been providing a reliable stream of data since the launch of the first Meteosat in 1977, helping to significantly improve weather forecasting. MSG is a series of four satellites (MSG-1 to MSG-4), to be operated until at least 2018 under the responsibility of Eumetsat, which will deliver 20 times more information – twice as fast and with higher ground resolution – than their Meteosat forerunners, resulting in a whole new range of applications.*

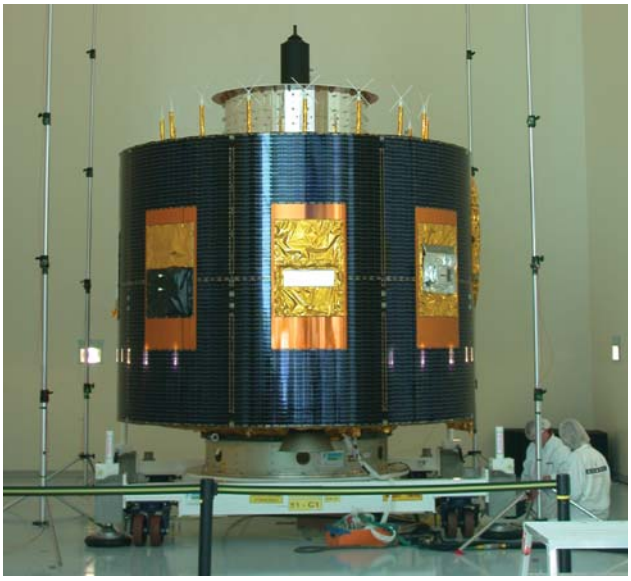
MSG-1 (renamed Meteosat-8 once operational) has completed its fourth year of successful operations. MSG-2 (renamed Meteosat-9) went through a successful commissioning at 6.5°W. In July, the spacecraft was relocated to 0° longitude, to become the official backup to Meteosat-8.

The MSG-3 spacecraft remained in long-term storage at Alcatel Alenia Space in Cannes (F), awaiting its own launch, currently foreseen for the beginning of 2011. The MSG-4 spacecraft is going through the final stage of test activities. The Pre-Storage Review (PSR) is foreseen for the first half of 2007, after which it will also be put into long-term storage awaiting launch in 2013.

MetOp

· *The three MetOp satellites developed by ESA constitute the space segment of the Eumetsat Polar System (EPS). Eumetsat is responsible for the ground-segment development and system operations.*

After a series of delays, caused initially by the non-readiness of the Eumetsat ground segment and then by a series of launch aborts due to minor issues, MetOp-2 was launched successfully on 19 October from Baikonur, on a Soyuz ST launch vehicle. It was renamed MetOp-A once in orbit. A successful early-orbit phase conducted by ESOC was followed by handover to the Eumetsat Control Centre in Darmstadt on 22 October. The commissioning phase is now underway, with the in-



The MSG-4 spacecraft being prepared for acoustic vibration testing at Alcatel Alenia Space in Cannes (F) (Photo: AAS, Cannes)

orbit verification having so far demonstrated excellent instrument and platform performance.

The project, both in ESA and in Industry, now enters a standby mode, providing support for Eumetsat's routine operations and storing the MetOp-1 and MetOp-3 elements (MetOp-B and MetOp-C) until their planned launches in 2010 and 2015.

Preparation of Future Missions

Earth Explorer Missions

EarthCARE
EarthCARE, developed in cooperation the Japanese space agency JAXA, will collect essential data for numerical modelling of the atmosphere and for global studies of the divergence of radiative energy, the aerosol–cloud–radiation interaction, the vertical distribution of water and ice and their transport by clouds, the vertical cloud-field overlap and cloud-precipitation interactions, and other urgently needed scientific information.

2006 was dedicated to bridging activities, including interfacing with the Japanese partners, and to risk-reduction tasks, as well as to the preparation of the Invitation to Tender (ITT) for the Phase-B/C/D/E1 procurement.

7th Earth Explorer mission
After having received 24 proposals for ideas for the seventh Earth Explorer mission – impressively demonstrating the strong interest of the worldwide scientific community in ESA's Earth Observation programme – evaluations by scientific, technical and programmatic panels resulted in a recommendation by the Earth Science Advisory Committee (ESAC) to commence assessment studies for six mission concepts. The Earth Observation Programme Board approved the proposal, and subsequently six Mission Assessment Groups (MAGs) were formed, allowing progress to be made with mission-requirements definition and the pre-feasibility (Phase-0) studies.

Earth Watch Eumetsat Missions

Meteosat Third Generation
The two pre-Phase-A studies were concluded in the spring, and in July the Eumetsat Council adopted the overall programme planning. The Phase-A ITT was subsequently prepared and issued by ESA, with the proposals being received shortly before year's end. ESA and Eumetsat are aligning their schedules for a common roadmap.

Post-EPS
2006 was dedicated to the preparation of pre-Phase-A activities. User requirements compiled by five Application Expert Groups, led by Eumetsat and supported by ESA, were presented and discussed at the First Post-EPS User Consultation Workshop in March, and further elaborated into observation requirements by the Post-EPS Mission Experts Team. This work, a pre-requisite for the pre-Phase-A, is expected to be concluded by spring 2007.

Services Development and Applications

The main Data User Element (DUE) and Data User Programme (DUP) activities were again dedicated to the management of running contracts and the starting of new projects, in close collaboration with user institutions. Besides the impressive total of 25 projects already running within DUE[2] , covering a wide variety of topics from sea-surface temperature monitoring to combating desertification, three new projects could be negotiated and kicked-off: GlobModel, aimed at stimulating the use

[2] Medspiration, Contrail, GlobWetland, DesertWatch, Aquifer and AquiferEx, GlobAerosol, GlobIce, GlobCover, GlobColour, SevesEO and fourteen so-called Innovators.

of Earth observation by the Earth-system-modelling user community; Diversity, dealing with EO services supporting the implementation of the UN Convention on Biodiversity; and GlobVolcano, helping volcanological observatories and other users (like civil protection agencies) in their work by the integration of Earth Observation data and technologies. On the DUP side, the GlobCarbon, Dudes and Temis projects continued to run to plan during the year. Various user-consultation workshops throughout Europe helped foster relationships and provided valuable input for the manifold contracts managed.

The CEOS report[3] describing the coordinated response by space agencies to the needs expressed in the Global Climate Observing System (GCOS) implementation plan identified the ESA GlobCover, Medspiration and GlobColour projects as sources for essential climate variables.

During 2006, ESA again continued to grow European industry capabilities in offering EO-based services through the EO Market Development (EOMD) programme. The complete EOMD activity portfolio is now composed of five main elements:
- 9 remaining contracts focussing on specific EO services;
- 7 remaining contracts focussing on innovative issues;
- 7 new contracts on corporate sustainable development;
- 4 new contracts on EO service-industry-wide issues;
- 12 contract extensions to explore specific market opportunities.

For the first group of activities, coming to an end after three successful years, customer feedback on the four requirements for sustainable services – *useful, available, reliable and affordable* – has revealed strong future prospects in the renewable-energy sector, e.g. wind, hydro-power and solar energy.

Expected key results of ongoing activities and the continued dialogue with industry will form the basis for the planning of the value-added element under the third Earth Observation Envelope Programme (EOEP-3), to start in 2008.

ESA contributed in many ways during the year to the promotion of the capabilities of Earth observation, both by organising and by participating in a variety of events.

Besides the already mentioned Altimetry 2006 Symposium in Venice (I), the Atmospheric Science Conference in May addressed significant advances in atmospheric chemistry thanks to Envisat and ERS-2. The GMES, DUE and EOMD programmes were successfully presented to the 4th EO Business Network meeting in Vancouver the same month. The CEOS contribution to the GEO 2006 Work Plan, a major task elaborated during the course of the year, was enthusiastically accepted by the GEO Secretariat.

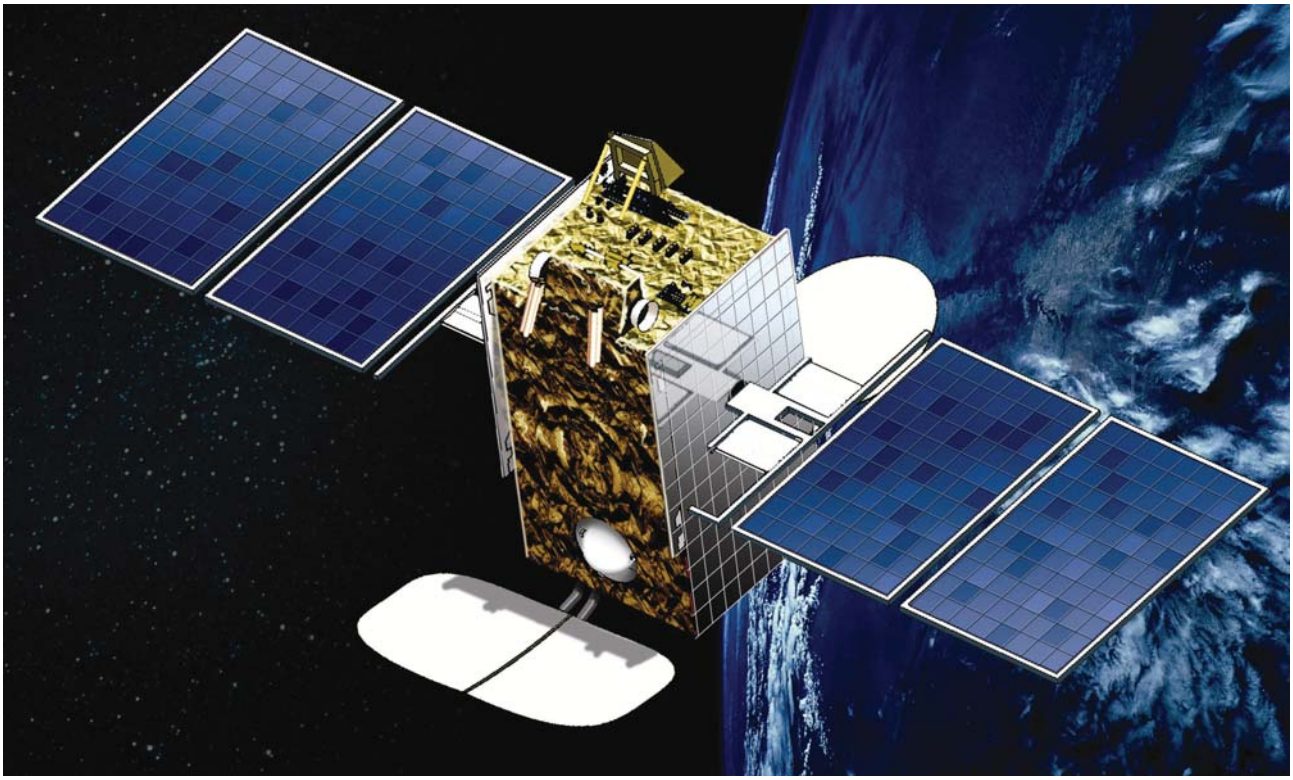
Cooperation agreements in 2006 were stipulated as another important way of creating synergies in Earth observation. The preparation of an agreement between ESA and the European Maritime Security Agency (EMSA) marked an important cornerstone in cooperation with user entities. This agreement, which will be signed in early 2007, whilst addressing one of the three fundamental objectives of the Living Planet Programme, namely 'Preserving the Earth and its Environment', is also establishing solid groundwork for future GMES services, as EMSA has the task of reducing the risk of marine pollution and enhancing the overall maritime safety system in the European Community.

International presence strengthens ESA's leadership in supporting International Conventions through the use of EO data, and in broadening user awareness and promotion. The successful cooperation with UNESCO was continued in this context. The TIGER initiative was presented to and was formally endorsed by the African Ministerial Council on Water (AMCOW) in Entebbe (Uganda) in February.

Last but not least, the year saw many highlights in outreach, education and international scientific cooperation. For example, the Envisat Summer School (ESRIN, 31 July to 11 August) attracted 73 students from 21 countries, with 12 leading international scientists giving 54 hours of lectures and workshops on Earth system monitoring and modelling. The 3rd DRAGON Symposium in Lijiang (China) in July, organised with the Chinese Ministry of Science and Technology (MOST), brought together some 170 European and Chinese scientists. The ESA-MOST Training Course on atmospheric remote sensing in October, hosted by the Peking University in Beijing, was attended by 55 PhD-level trainees from 30 institutes in China. In an effort to bring Earth Observation even closer to the public, ESA created a special layer of content that has appeared since November on Google Earth, enabling people to see hundreds of ESA satellite images including natural phenomena and manmade landmarks.

[3] *Satellite Observation of the Climate System:* The Committee on Earth Observation Satellites (CEOS) Response to the Global Climate Observing System (GCOS) Implementation Plan

Telecommunications



Artist's impression of Hylas

The first Alphabus mission, called Alphasat, will be developed by ESA and a satellite telecommunications operator that is being selected through an open competition. Alphasat will be operated and exploited by the chosen operator throughout its in-orbit lifetime.

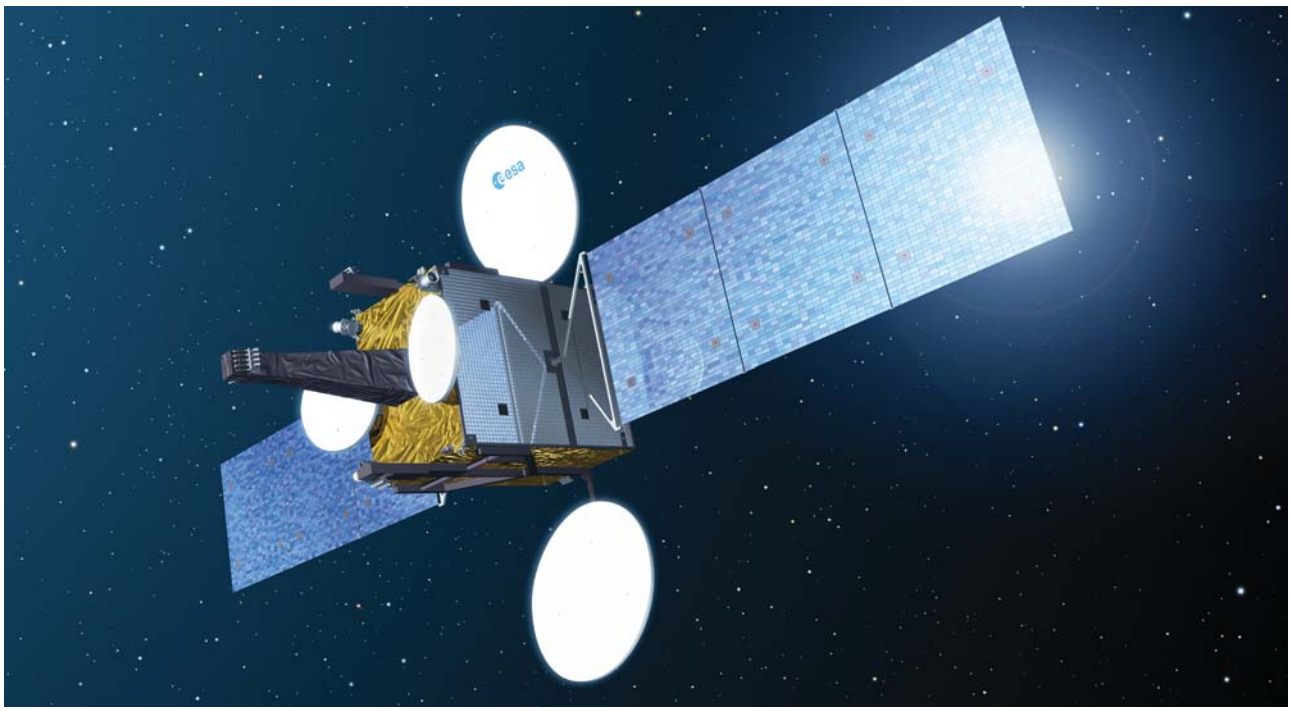
Alphasat

The Telecommunications Department initiated a process to define the payloads that will take advantage of the first Alphabus platform. Along with a choice of ESA Technology Demonstration Payloads approved by the Member States, the Agency organised a selection process after a call for candidate payloads for the first Alphabus flight model. Proposals from Eutelsat together with Telespazio and Inmarsat are in the final selection process, which is expected to be completed in 2007, allowing finalisation of Alphasat's configuration for a launch around 2011.

A Cooperation Agreement for the development of Alphabus, Europe's next generation of telecommunication satellites, was signed on 16 March in Paris by ESA and France's Centre National d'Études Spatiales (CNES). The Alphasat/Alphabus approach demonstrates the complementarity of the institutional and private players in strengthening Europe's position in the satellite communications market.

Hylas: Flexible Satellite Solutions

On 15 May the contract for the innovative flexible broadband satellite Hylas between ESA and Avanti Screenmedia Group PLC was announced in London (UK). Hylas is a hybrid Ka/Ku-band satellite with European coverage, which will be used mainly to provide broadband Internet access and to distribute and broadcast High-Definition Television (HDTV). The contract covers support for the development of the most



Artist's impression of Small Geo Sat

innovative elements of this new system. The supplier of the Hylas satellite is EADS Astrium Ltd.

With a launch mass of around 2100 kg and beginning-of-life power of 3.5 kW, Hylas is a moderately sized satellite that allows the scalable introduction of new enhanced services with limited technical and financial risk. The satellite's launch is currently planned for late-2008, with an expected lifetime of 15 years at its orbital position of 33.5°W.

Small Geostationary Satellite Initiative

The Small Geostationary Satellite initiative (ARTES-11 programme) is the result of the decision taken by ESA Member States during the Council at Ministerial Level in Berlin (D) in December 2005, to support the development a new European spacecraft-platform product line for small geostationary communications satellites. ESA has therefore established a new element ARTES 11 in its Advanced Research in Telecommunications Systems Programme, composed of two sub-elements. Sub-element 1 covers the development and first flight-model manufacture of a generic platform by an industrial team led by OHB (D). SSC (S), Oerlikon (CH) and Luxspace (Lux.) make up the rest of the industrial core team. Sub-element 2 covers the development, validation and launch of the first satellite mission, which will provide flight heritage for, and an in-orbit demonstration of the platform. Selection of the payload for the first protoflight satellite model is planned for late-2007/early-2008, with a launch by the end of 2010. This will ensure an adequate level of heritage and in-orbit validation for the Small GEO Platform.

Successful Completion of AmerHis

In November in Madrid, ESA, the Spanish Centre for Industrial Technology Development (CDTI) and Hispasat, a Spanish telecommunications satellite operator, marked the successful completion of the AmerHis system implementation. AmerHis, an advanced communications system that serves as a 'switchboard in space', is based around an onboard processor carried by Hispasat's Amazonas satellite. This processor has the capacity to decode incoming signals from the satellite's four transponders, switch data streams between transponders, and encode them for re-transmission. Each transponder covers one of the four geographical regions served by the satellite, namely Europe, Brazil, and North and South America. AmerHis offers broadband interconnectivity to users anywhere within the four geographical areas covered by Amazonas, with highly efficient usage of the available communications capacity.

The AmerHis concept

Under the terms of an agreement between ESA, CDTI and Hispasat SA, ESA funded and managed a contract for the implementation of the onboard processor and its complementary terrestrial infrastructure and terminals, known collectively as the 'AmerHis System'. The main funding came from Spain's contribution to ESA's ARTES Programme, with additional support from France, Norway and Canada. The industrial consortium was led by Alcatel Espacio (E), which was also responsible for the development of the onboard processor. The Amazonas satellite was launched on 5 August 2004 and the payload has been successfully subjected to extensive in-orbit testing. The AmerHis ground segment, comprising the Network Control Centre (NCC), the satellite gateways and the user terminals, has been operational since April 2005. Final acceptance of the ground segment took place on 14 July 2006 and it has since been operated by Hispasat, marking a new era for AmerHis as a commercial satellite.

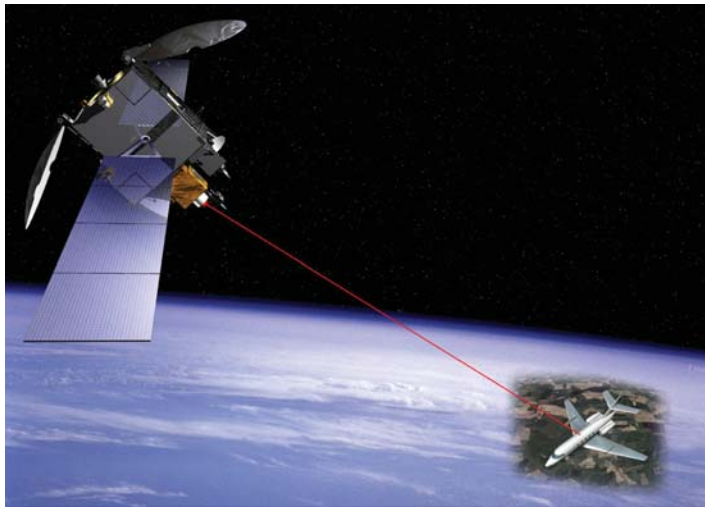
Another World First for Artemis

Artemis, ESA's advanced relay and technology mission satellite, successfully relayed optical laser links from an aircraft in early December. These airborne laser links, established over a distance of 40 000 km during two flights at altitudes of 6000 and 10 000 metres, represented a world first.

The relay was set up through six two-way optical links between a Mystère 20 aircraft equipped with the airborne laser optical link LOLA (Liaison Optique Laser Aéroportée) and the SILEX laser-link payload onboard Artemis, in geostationary orbit at 36 000 km altitude – a feat equivalent to targeting a golf ball over the distance between Paris and Brussels.

These tests were performed by Astrium SAS (F), the prime contractor for both LOLA and SILEX, as part of the airborne laser optical-link programme conducted by the DGA (French MoD procurement agency) from its Flight Test Centre at Istres in southern France. The ESA ground station at Redu (B) also contributed by managing the Artemis SILEX payload operations.

Artemis continues to relay data in the Ka-band from Envisat, ESA's Earth observation satellite that has been providing a comprehensive view of the oceans, land, atmosphere and ice caps since 2002. Since November 2005, it has also been relaying optical signals from Kirari, the Japanese Optical Intersatellite Communications Engineering Test Satellite. This first-ever two-way optical communication illustrates the value of laser technology for the development of future Earth observation systems.



The first ever laser link between a satellite and an aircraft was made by Artemis in December

Action Plan on Satellite Communications for Civil Protection

At the same time as advancing technology, ESA is supporting the development of applications for the provision of services to meet users' needs, to support industry and economic growth, and to participate in improvements to health, education and security. In particular, it is analysing the potential for adapting space telecommunications tools to the needs of civil protection, having set up an 'Action Plan on Satellite Communications for Civil Protection' with an advisory board that met twice in 2006, in June and November. The members of this advisory board include representatives from seven civil protection authorities and the European Commission, representing no less than 30 countries.

Their goal is to arrive at an understanding of where and how satellites can offer good solutions either as a complement to what already exists, or even as a complete replacement. For example, the satellite system could act as a redundant backup for the usual communications ground links, but should also be able to replace them at any time in case of disruption to the terrestrial channels. Very often the problems are logistics-related – uncharged batteries, unplugged wires and similar occurrences – small problems that can potentially cause a failure of the overall system. This is where the experience of the civil protection agencies becomes paramount if the space sector is to develop tools that truly meet users' needs. Pilot projects reflecting these needs are currently being selected, with ESA being the organising body for designing space systems for future demonstrations.

Navigation

For satellite navigation, 12 January was an historic date with Galileo signals being transmitted for the first time. Thanks to GIOVE-A, launched on 28 December 2005 from Baikonur, Galileo became a reality in space and these signals allowed the frequencies allocated to the European system by the International Telecommunication Union (ITU) to be exploited by 3 March, well before the June 2006 deadline.

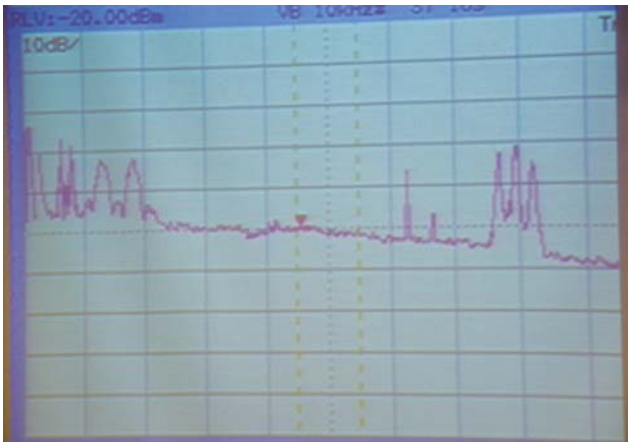
First Galileo Signals in Space

The test results from GIOVE-A for all of the critical technologies involved (atomic clocks, signal generators, etc.) have been excellent, the payload performance in orbit being very similar to that in the ground-based reference tests. The Medium Earth Orbit (MEO) characteristics are also in line with expectations, GIOVE-A being the first European satellite to be put into this particular orbit at an altitude of 23 260 km.

With GIOVE-A operational, a real Galileo system prototype is now in place, with a Control Centre in Guilford (UK), a Mission Control Centre at ESTEC in Noordwijk (NL), and the routine transmission of navigation messages to a worldwide network of stations.

In-Orbit Validation Contract

ESA and Galileo Industries GmbH signed a 950 million Euro contract on 19 January for the development and construction of the first four satellites of the Galileo navigation system and their associated ground systems. The signing ceremony took place at the Federal Ministry of Transport in Berlin in the presence of the German Federal Minister of Transport, Building and Urban Affairs, Mr Wolfgang Tiefensee, ESA's Director General, Mr Jean-Jacques Dordain, and senior representatives from the project's industrial partners: Alcatel, EADS, Finmeccanica, Galileo Industries, GSS and Thales.



The first Galileo signal transmitted on 12 January

Signature of the In-Orbit Validation contract on 19 January in Berlin (D)

This contract reflects the current task devoted to ESA within the Galileo Programme, namely: to translate a great European project into a mini-constellation of four satellites backed by an extensive network of ground stations, thereby providing a solid basis for the subsequent full deployment of a thirty-satellite constellation. Following the preliminary authorisation to proceed with 150 million Euros of work, signed on 21 December 2004, the overall In-Orbit Validation contract was therefore on track, drawing on ESA and EU funding accessible under the GalileoSat programme.

New Era for EGNOS

Another developmental milestone was reached by the European Geostationary Navigation Overlay System (EGNOS), a joint project involving ESA, the European Commission and EuroControl, with the transition in July from ESA's EGNOS System Test Bed (ESTB) to the 'production' EGNOS system for the provision of GPS augmentation services over Europe. Over the previous six years, the ESTB had considerably improved the application of navigation, positioning and timing services in a multitude of fields, including aviation, maritime, road and farming. This was a significant preparation effort for when the completed EGNOS system will serve Europe in a fully operational and commercial mode, including its later cooperation with the Galileo system.

The EGNOS System Test Bed was a reduced version of EGNOS, the development of which was financed by ESA Member States with contributions from the European Commission. It was under ESA management, with major participation by European industry, notably Alcatel Alenia Space (F), GMV Sistemas (E), Thales (UK), the German Aerospace Centre (DLR), and Kongsberg-Seatex (N). The ESTB signal was broadcast using a transponder on the Inmarsat-III satellite. The ground segment consisted of a number of reference monitoring stations throughout Europe and beyond, and two processing centres. The control centre was located at the premises of the French space agency (CNES) in Toulouse (F), where data archiving, post-processing and satellite uplinking were also undertaken. The data-processing centre was hosted by the Norwegian Mapping Authority at its Hönefoss centre. ESA's Navigation Laboratory at ESTEC in Noordwijk (NL) hosted a dedicated server, known as SISNeT (Signal in Space through Internet), which provided the user community with navigation data.

A blind person testing an EGNOS-based guidance system in Madrid (E) in June

The route of the first trans-African flight using EGNOS and the ESTB

The ESTB signal, first broadcast in February 2000, provided the opportunity to validate new developments in a realistic environment, helping navigation equipment manufacturers and application developers to test their products and allowing users to familiarise themselves with the system. The ESTB also allowed the EGNOS system to be tested outside Europe, including a joint European–Chinese demonstration on the Yangtze River and the first EGNOS-guided flight across the African continent.

Stabilisation of the EGNOS Signal

The EGNOS story goes on, enriched by the valuable ESTB experience, allowing Europe to provide greatly improved positioning services. The system was subject to important performance improvements during 2006, including one associated with the Satellite-Based Augmentation Service (SBAS) standards: the new MT0/2 message aligning EGNOS with the de-facto standard of the American WAAS system in order to ensure worldwide interoperability of user equipment. Finalisation of the operational-procedure baseline also progressed, leading to improved availability of the EGNOS signal through a significant improvement in Navigation Land Earth Station (NLES) operations. The deployment in December of the new V2.0.3 software release made EGNOS's performance the best in the World for an SBAS, with an accuracy of better than 2 metres. In November, EGNOS signal availability reached 100% for the first time.

Launchers

There were important milestones in Europe's launcher activities in 2006. Five successful Ariane-5 ECA launches confirmed the reliability of the vehicle while, in parallel with its commercial exploitation, new versions are being qualified and new components are being developed to further increase its dependability and reduce costs.

Ariane-5 is currently the only launcher operated from the European Spaceport, but it will soon be a member of a family of launchers exploited commercially by Europe when Vega and Soyuz also become operational.

Vega successfully passed several major development milestones with the firing tests performed with the Zephiro-23 and P80 engines, the upper composite's mechanical qualification, and the separation and structural tests. A key development step has been reached with the Critical Design Review for the launch system, which will trigger the start of the qualification phase.

The Soyuz launch site has changed the landscape of the Guiana Space Centre (CSG) with its huge excavation and construction works. Work on the launcher itself to adapt it to commercial exploitation from CSG is well underway.

Preparation for the future was another important field of activity. Here the Future Launchers Preparatory Programme (FLPP) initiated important activities including system concept studies and technology maturation/demonstration activities. They will prepare the

Launch of Ariane-5 ECA flight L533 on 13 October from Europe's Spaceport in Kourou (Fr. Guiana), carrying the DIRECTV 9S, Optus D1 and LDREX2 spacecraft (Photo: ESA/CNES/Arianespace - Photo Optique Video CSG)

way for the development of a new launcher based on mature technologies, as well as for the development of the Next Generation Launcher.

The overall importance of the European launcher sector was further underlined in 2006: after the successful Ministerial Conference in 2005, several countries decided to increase the resources devoted to the ESA Launcher Programmes still further by making additional contributions.

Ariane

A total of five successful launches took place during the year, confirming Ariane-5 ECA in its role as workhorse for Arianespace launch services. On 12 March, flight L527 successfully put two telecommunications satellites, Spainsat and Hot Bird 7A, into Geostationary Transfer Orbit (GTO). This first flight of the year was the result of a launch campaign based on the new industrial organisation, with EADS-ST responsible for launch-vehicle integration. On 27 May, flight L529 successfully placed two more telecommunications satellites, Satmex 6 and Thaicom 5, into GTO. With a combined mass of around 8300 kg, these two satellites set a record for the largest payload mass carried into GTO. On 11 August, flight L531 also delivered JCSAT-10 and Syracuse 3B into perfect orbits, while on 13 October flight L533 successfully orbited DIRECTV 9S, Optus D1 and LDREX2. Launch L534 rounded off a busy year on 8 December with its mission to place WildBlue-1 and AMC-18 into GTO.

The generic qualification of Ariane-5 ECA was confirmed at the final Steering Committee Meeting in December. The results will be presented at the beginning of 2007 to the Ariane Programme Board, which will be requested to pronounce the official qualification.

The work to qualify Ariane-5 ECA in its PA2 configuration with welded boosters, a new Vehicle Equipment Bay using fibre placement technology, and the new Horizontal Separation System (HSS3), was ongoing. The welded boosters were successfully flown on flight L534 in December.

Launch on 8 December of Ariane-5 ECA flight L534 from Kourou, carrying the WildBlue-1 and AMC-18 satellites into Geostationary Transfer Orbit (GTO)
(Photo: ESA/CNES/Arianespace - Photo Optique Video CSG)

Static test firing of the Zefiro-23 second-stage engine of Europe's new Vega launch vehicle on 26 June at the Italian Salto di Quirra test centre on Sardinia

Regarding Ariane-5 GS, changes to the Ariane-5 launch manifest during the summer affected the schedule for the next launch. This is now planned for the first half of 2007 and includes a re-ignition experiment on the upper stage EPS (Etage à Propergols Solide) in preparation for the first ATV launch using the EPS's multiple-ignition capability.

Work on the adaptation of Ariane 5 ES-ATV continued throughout the year. Its first ATV launch is foreseen to take place in summer 2007. The Aestus upper-stage engine qualification tests were completed. The final strength tests on the new Vehicle Equipment Bay specifically developed for the ATV were also completed successfully.

Within the ARTA 2007-2010 programme, the Frame Contract with CNES was signed on 24 November. Negotiations with Snecma and Europropulsion are ongoing. The Vulcain-2 ARTA 6 test campaign ended in December, with extensive tests being conducted on the suspect LH_2 turbopump dismounted from L529 during the launch campaign in May.

Following completion of a last test in February, the further Vinci activities are now covered under the FLPP-2 programme. The hand-over of information and implementation of the related activities to be performed in the coming years has started.

Industrial activities within the ACEP programme aimed at consolidating the Ariane-5 launcher for commercial use and its further evolution began with work on the Separation System, Payload Adaptor System and ESA Station upgrades.

Vega

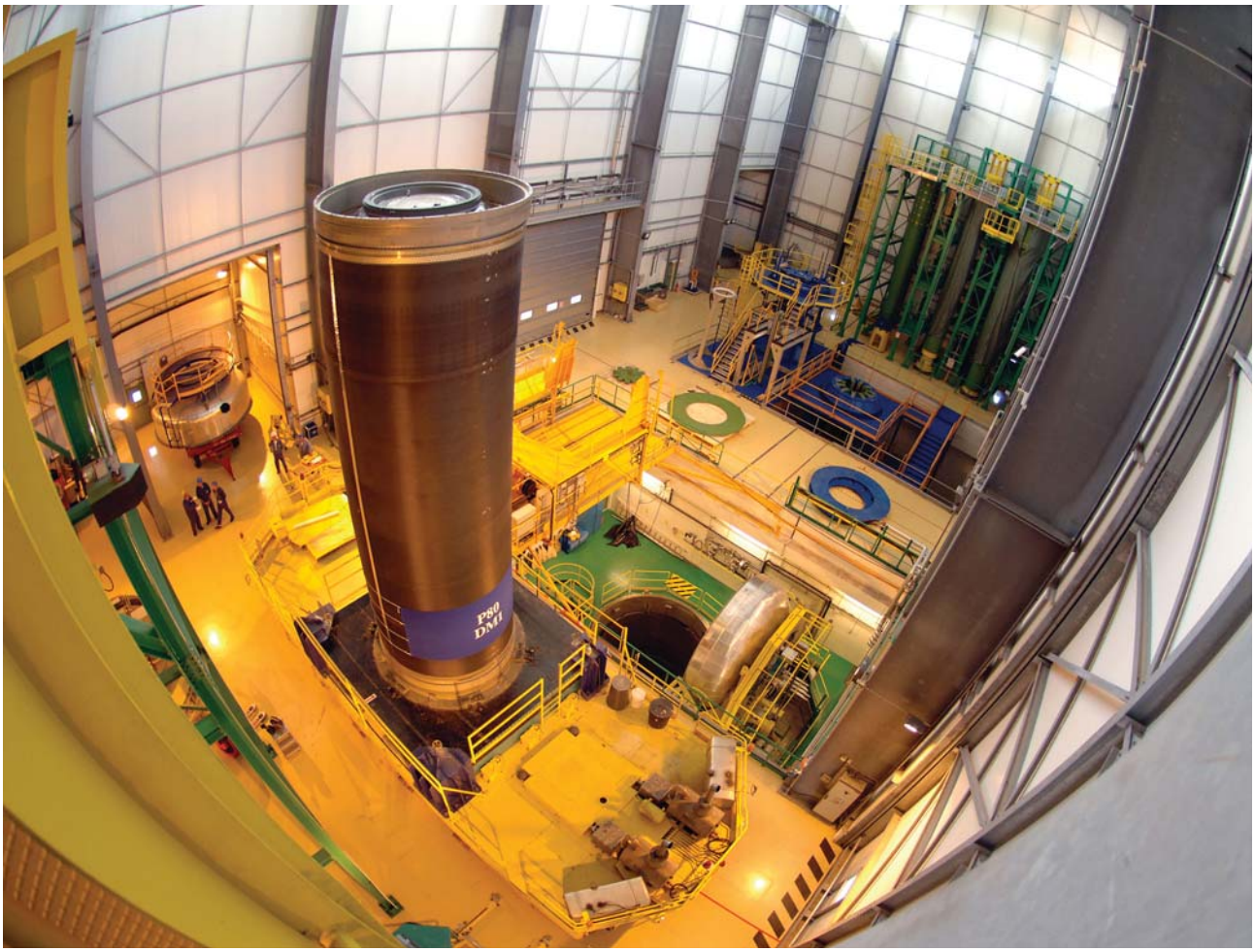
Following the Zephiro-9 third-stage solid motor test in December 2005, investigation of the recorded data showed that the motor's performance was slightly lower than predicted. A working group was set up to investigate and propose corrective measures. The resulting modifications are currently being implemented and will be tested during the next motor firing scheduled for the end of February 2007.

The first static firing test of the Zephiro-23 second-stage motor successfully took place on 26 June in Sardinia (I); this motor will undergo an additional ground firing test to complete its development and qualification.

On 30 November, the P80 motor was successfully ignited for its first static firing test at CSG (Fr. Guiana). The data collected showed that the firing closely followed the predicted pressure curve. This concluded the first set of development tests conducted for the Vega launcher in 2006.

Major system and subsystem tests, such as the upper-part mechanical qualification test performed at the ESTEC Test Centre in August-September, the separation

The first static firing test of Vega's first-stage P80 motor on 30 November at Europe's Spaceport in Kourou (Fr. Guiana) (Photo: ESA/CNES - Photo Optique Video CSG)



The Vega P80 motor in the Guiana Propellant Plant (UPG) in Kourou (Fr. Guiana) in September (Photo: ESA/CNES - P. Baudon)

Excavation of the large Russian-style flame duct for the new Soyuz Launch Complex (ELS) at Europe's Spaceport in Kourou (Fr. Guiana) in March
(Photo: ESA/CNES - Photo Optique Video CSG)

tests and the main structure and equipment qualification tests, were also carried out successfully. Moreover, the functional simulation testing of the avionics and software began in Colleferro (I) in July.

The Critical Design Review, the last major milestone of the Vega programme for 2006, was kicked-off as planned on 20/21 December at ESRIN (I). This is a major event in the Vega development programme, since it will allow assessment of the detailed design activities and provide the go-ahead for the activities leading to the full qualification of the launch system. Another major milestone in the programme, the Ground Segment Design Review, had already been kicked-off in May in ESRIN: the new mobile-platform design has been accepted and the design of the mobile gantry has been revised to be compatible with the existing foundations and maximum expected loads.

After the first qualification launch, the exploitation of Vega will be under Arianespace's responsibility.

Soyuz at CSG

The Kourou skyline changed considerably during the year with: temporary facilities being erected at various locations around the site; a stone crusher being erected to allow the rock from the flame-chute excavations to be re-used; work on the foundations for the Launch Operations Centre and the air-conditioning facility being initiated; and hoisting equipment being installed at various points around construction site.

On the industrial-review side, the programme saw two major events: the Preliminary (industrial) Design Review for the civil, electrical and mechanical installation which took place in Toulouse (F), and the Critical (industrial) Design Review for the first batch of Russian equipment, undertaken in Moscow (Ru). On the launch-system side, the Critical Design Review is now scheduled for first the quarter of 2007.

Future Launchers Preparatory Programme (FLPP)

The consolidated contract with NGL Prime SpA for FLPP-1 activities, including systems, experimental vehicles, propulsion and materials and structures, was signed in November.

The NGL Expendable Launcher Vehicle and Building Blocks system concept studies started, based on the agreement reached following the conclusions of the Launcher System Workshop.

The FLPP-2 Implementation Plan was approved and the first procurement actions started. Among them, taking benefit from the existing Vinci development assets, an expandable cycle demonstration programme has been started within FLPP-2. The first contract for the Expander Demonstrator was signed in December, and covers all propulsion technology and test activities for the maturation and expansion of the expander cycle technology for application to future launchers.

Industrial activities on the Intermediate eXperimental Vehicle (IXV) are ongoing, targeting a System Requirements Review by mid-2007. Special efforts were made to finalise the mission scenario with respect to landing-site selection with mitigated safety risks. Both ground landing (Kiruna in Sweden and Woomera in Australia) and sea landing (Pacific Ocean) options were taken into account. A Round Table involving European experts took place in December, with the objective of identifying the best scenario for maximising experimentation objectives with minimal safety risks. The sea-landing option is retained as the preferred option.

Guiana Space Centre (CSG)

The new contract covering the operational maintenance of the CSG launch range for the period 2006-2011 was signed by ESA and CNES in September, being retroactive to 1 January 2006. The tendering process for the renewal of the industrial service contracts at CSG for the period 2007-2011 was finalised at the end of the year with the selection of a number contractors to undertake the service activities encompassed by 21 separate work packages. The new industrial landscape resulting from this tender action, which forms part of the reorganisation of operations at the range, will allow substantial cost savings.

Human Spaceflight, Microgravity and Exploration

Christer Fuglesang (right) and Thomas Reiter reunited on board the International Space Station

The year saw a series of important milestones and successes in the International Space Station programme. The launch of Space Shuttle 'Discovery' (STS-121) to the ISS on 4 July with ESA astronaut Thomas Reiter on board not only brought the Shuttle system back to full operational status, but also marked the return to a permanent crew of three on the Station.

During his 171-day 'Astrolab' mission, Reiter carried out a broad range of experiments, both scientific and educational, as well as a series of ISS system activities. Also launched, and successfully commissioned in the US laboratory 'Destiny' were ESA's European Modular Cultivation System (EMCS), the -80°C Freezer (MELFI), and the Percutaneous Electrical Muscle Stimulator (PEMS).

A series of Heads of Agency (HoA) meetings, involving the Space Station Control Board (SSCB) and the Multilateral Control Board (MCB), took place at Kennedy Space Center (KSC). The outcome was a revised ISS configuration and a sequence of 16 Shuttle flights, with a further two for logistics, to complete the ISS assembly sequence.

The container carrying Columbus being removed from the Beluga transport aircraft at Kennedy Space Center

The ATV undergoing testing in the LEAF facility at ESTEC (NL)

On 9 December, Space Shuttle 'Discovery' carried ESA astronaut Christer Fuglesang to the ISS to start the 'Celsius' mission, making him the first Swedish astronaut to visit the ISS. The Shuttle's payload included the Integrated Cargo Carrier (ICC), the third ISS Port Truss segment, logistics materials and supplies.

Fuglesang took part in his first EVA, along with NASA's Robert Curbeam, to move the 1.8 tonne truss, part of the girder like backbone of the ISS, into position, helped by the Canadarm 2 operated from inside the Station. The second of Fuglesang's planned EVAs was primarily to rewire part of the ISS to include the solar panels that had been installed in September. A subsequent problem during the attempted retraction of a solar panel on another truss gave Fuglesang and Curbeam the opportunity to go on a third, unplanned, EVA. After a spacewalk lasting over six and a half hours they successfully freed the jammed solar array, allowing it to fully retract.

When Thomas Reiter and Christer Fuglesang returned together in December from their missions it marked the dawn of a new era for ESA's human spaceflight and ISS endeavours: no longer just visitors in orbit, ESA can be truly regarded as one of the proprietors in space.

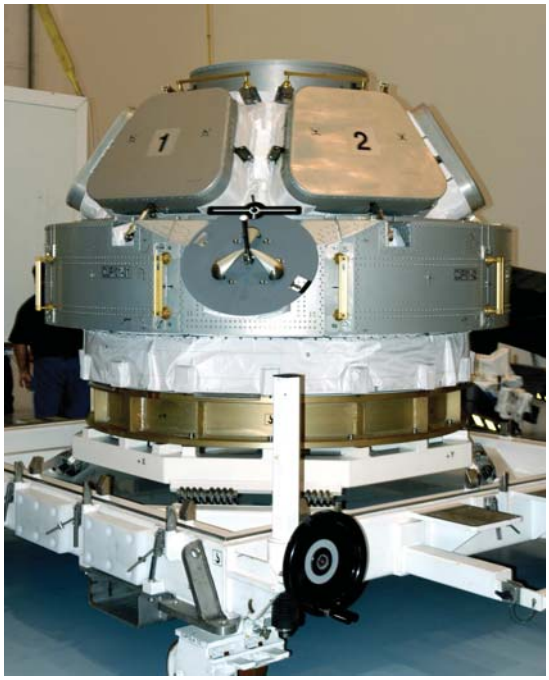
Columbus

On 2 May, a ceremony, attended by the German Chancellor Angela Merkel, was held at European Aerospace and Defence Systems in Bremen (D), the prime contractor for Columbus, to celebrate the completion of the laboratory's development prior to its shipment to KSC.

The Columbus Final Acceptance Review (FAR) was completed at a NASA-ESA Board meeting on 16 May, and shortly thereafter it was delivered, along with its four multi-user payload racks – the Biolab, Fluid Science Laboratory, European Physiology Module and European Drawer Rack – to KSC. The Phase-1 ground processing at KSC was successfully completed, and Columbus is now in storage there until its scheduled launch at the end of 2007.

The Qualification and Acceptance Review for the Columbus Control Centre has been successfully conducted. The Centre was also involved in an end-to-end system validation test with the User Support and Operations Centres (USOCs). In December, the Flight-operations Readiness Review was successfully conducted at the Control Centre, involving experts from

ISS Node 3



The Cupola at NASA

ESA, NASA, the German Aerospace Agency (DLR), the Japan Aerospace Space Agency (JAXA) and industry.

ATV

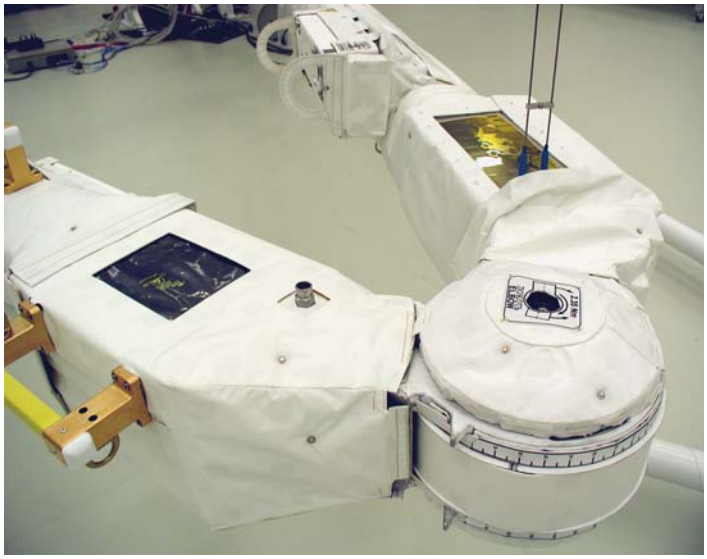
The testing and integration activities on the first Automated Transfer Vehicle (ATV), 'Jules Verne', progressed well. Acoustic vibration and leak tests were successfully conducted in the Large Environmental Acoustic Facility (LEAF) at ESTEC (NL), along with the thermal-vacuum test. The functional system qualification testing in the Flight Simulation Facility (FSF) at Les Mureaux (F) also advanced well. A number of functional qualification tests were successfully performed and some major bilateral interface tests were also completed. Minor instabilities were addressed and some components underwent requalification.

Qualification and acceptance of the ATV Control Centre neared completion and the corresponding qualification and acceptance review process got underway.

The Ariane-5 configuration for the first ATV launch was formalised in a meeting between the ESA, CNES and Arianespace managements.

Other Flight Elements

The Italian ESA astronaut Paolo Nespoli has been assigned to the crew of the Shuttle flight (STS-120) that will carry Node 2 to the ISS. Functional testing of Node 3 was successfully completed and mechanical activities begun. The go-ahead was given to initiate the Preliminary Acceptance Review. Discussions are



The ERA elbow joint

ongoing with NASA to transfer more activities from KSC/Boeing to Alcatel Alenia Space in Turin (I), effectively keeping the module in Europe until late 2009. The Cupola, already in storage at KSC, is awaiting the allocation of a launch flight.

The European Robotic Arm (ERA) Mission Preparation and Training Equipment (MPTE) was shipped to Russia in February. Roscosmos subsequently announced a long delay, until the end of 2009, in the launch of the Russian MLM module, which will host the ERA. The ERA flight model will be stored in The Netherlands in the meantime, all activities in Russia were frozen, and negotiations are continuing to resolve the associated contractual issues with Dutch Space. The industrial activities have also been realigned to absorb the delays incurred with minimum impact to the available funding.

The Atomic Clock Ensemble in Space (ACES) payload facility completed its Mission Preliminary Design Review, conducted in cooperation with CNES, and no showstoppers were identified that would hamper the mission's implementation.

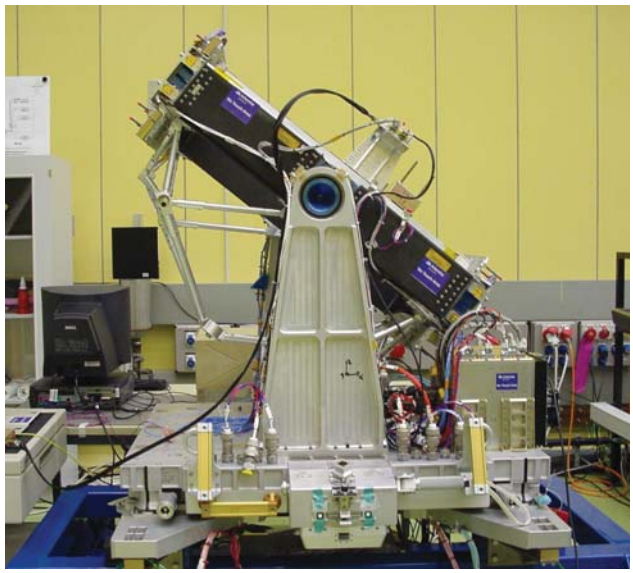
Utilisation

An international ISS Utilisation Symposium was held in Toledo (E), with around 60 science papers being presented and participation from NASA, JAXA, Canadian Space Agency and Russian representatives, as well as ESA and Member State delegations.

The Preliminary Acceptance Review for the Material Science Laboratory (MSL) was successfully completed and the flight hardware shipped to Marshall Space Flight Center for integration into MSRR-1. This unique multi-user facility is scheduled for launch on the ULF-2 Shuttle flight in 2008 and will be accommodated in NASA's 'Destiny' module under the cooperative Early Utilisation Agreement.

The system-level qualification and acceptance testing of ESA's sophisticated Muscle Atrophy Research and Exercise System (MARES) ground models proceeded according to plan. Launch of the flight model was re-confirmed by NASA for 2009. MARES will be accommodated as part of the NASA's Human Research Facility and ESA's European Physiology Modules in Columbus.

The EuTEF



The SOLAR engineering model during functional testing

The development of the Analysing Interferometer for Ambient Air (ANITA) has been completed and it is now due to be launched on Shuttle flight 13A.1 in summer 2007. It will be accommodated in a NASA Express rack in 'Destiny' and features novel means for measuring a large range of volatile ISS cabin-air constituents.

The development of the following Columbus experiments scheduled for flight 1E progressed well:

- Fluid Science Lab Experiment Container GeoFlow (geophysical flows);
- Biolab experiment WAICO (cell biology);
- Flywheel (physiology/countermeasures);
- EuTEF (exobiology, fundamental physics, technology package);
- SOLAR (three solar-irradiation instruments).

In addition, the Protein experiment (organic crystal growth) is scheduled for launch on Shuttle flight STS-123 in the Protein Crystallisation Diagnostics Facility (PCDF), and subsequent execution in the European Drawer Rack (EDR).

Following their launch on Shuttle flight STS-121 and their successful commissioning by Thomas Reiter at the beginning of his 'Astrolab' mission, the -80°C freezer MELFI and the European Modular Cultivation System (EMCS) began to support the scientific experiment programme. Following its in-orbit commissioning, the NASA plant-biology experiment Tropi was successfully run in the EMCS, located in the 'Destiny' module. ESA's GRAVI experiment, exploring root growth under various gravitational conditions, was also initiated by Thomas Reiter in the EMCS, with ground support from the Norwegian User Support Operations Centre (USOC). The Pulmonary Function System (PFS) has been commissioned as part of NASA's Human Research Facility, and is being used both for scientific experiments and novel ways of evaluating ISS crew fitness. The Portable Glove Box (PGB), delivered by Progress flight 22P on 24 June, was used for safety-critical handling of the BIO-2 experiments by Thomas Reiter during the Soyuz 13S visiting flight.

The large series of experiments successfully performed by Thomas Reiter during the 'Astrolab' mission covered the following scientific disciplines:

- molecular and cell biology: 3 experiments;
- integrative gravitational physiology: 6 experiments;
- non-gravitational physiology of spaceflight: 2 experiments;

Launch of the Maxus-7 sounding rocket on 2 May

- radiation physics: 2 experiments;
- fundamental physics (complex plasma): 1 experiment.

In addition, Thomas Reiter performed various educational activities, technological demonstrations, commercial experiments and further scientific experiments within both the US and Russian programmes.

During his 'Celsius' mission, Christer Fuglesang also performed some scientific experiments – ALTEA-CNSM and Chromosome-2 – in addition to his demanding ISS assembly tasks.

The Soyuz TMA-9 mission which lifted off from Baikonur in Kazakhstan on 18 September included the commercial fare-paying passenger Anousheh Ansari. She served as the test subject for four ESA medical experiments.

A total of four ESA Parabolic Flight campaigns were successfully conducted using the Airbus A300 aircraft in March and October/November.

A total of five experiment campaigns were conducted in the Zarm Institute's drop tower in Bremen (D), addressing soot formation in flames.

The development of the large payload for the Russian Foton-M3 capsule mission reached the experiment acceptance stage, with flight-payload integration scheduled to start in late spring 2007. The launch from Baikonur of the 12-day orbital flight is planned for September 2007.

The Maxus-7 sounding rocket carrying a complement of five ESA-funded modules for life and physical sciences experiments, was successfully launched from Esrange (S) on 2 May. On 11 May, the Texus-43 sounding rocket carrying three ESA-funded experiment modules was also launched successfully.

Exploration

At the ESA Ministerial Conference in Berlin in December 2005, the European space-exploration programme 'Aurora' was presented as a fully fledged optional programme made up of two elements: the robotic mission elements (and its first mission ExoMars) and the core element. Subscriptions to the core element amounted to 73.2 MEuro for the period 2006-2009 and 650.8 MEuro for the ExoMars mission for the period 2006-2013. Subscriptions to the ExoMars component of the Exploration Programme exceeded the proposed envelope.

ExoMars would be the first European mission to land and deploy a rover on the Martian surface with an exobiology payload. The mission will look for traces of life and characterise the Martian environment also from a biological point of view to identify potential hazards for future human explorers. With ExoMars, Europe aims at mastering key technologies for exploration, such as entry, descent and landing and surface robotic operations, as well as contributing to increased knowledge about Mars. The drill that the rover will carry will be a 'first' in Mars exploration as it will allow the retrieval of soil samples from up to 2 metres below the surface, where traces of life may have been preserved.

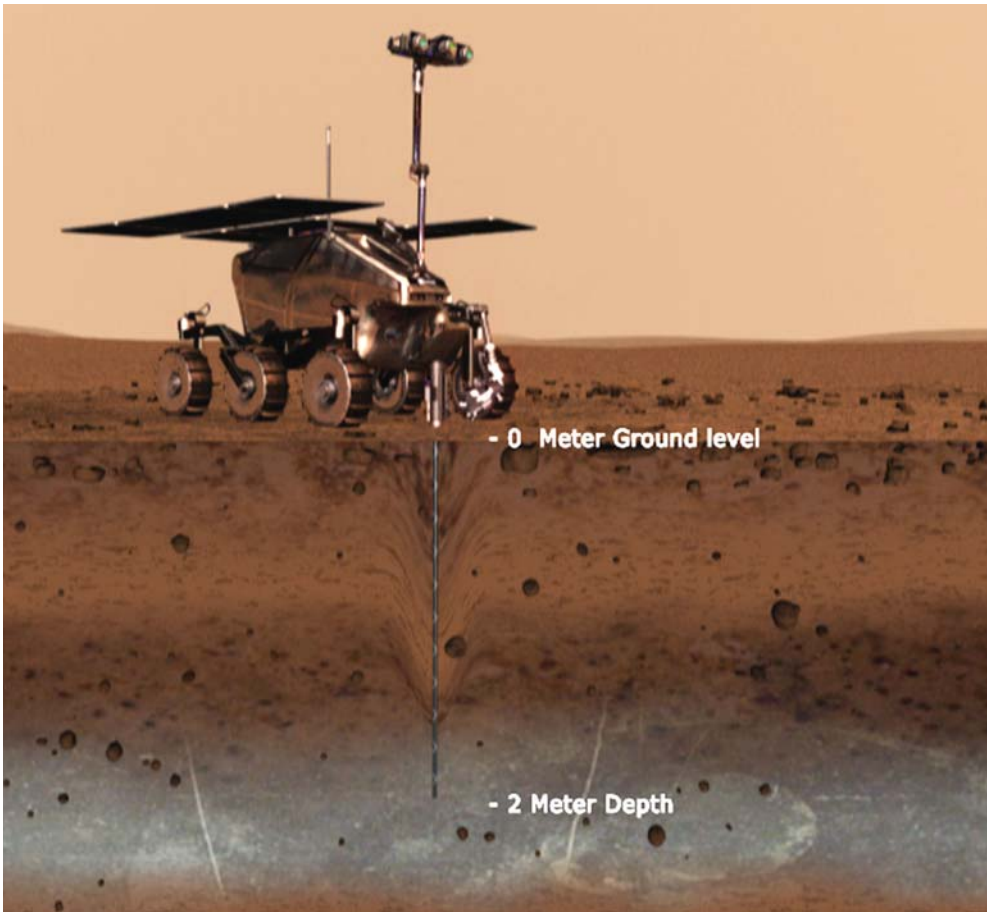
The Phase B-1 contract with the ExoMars mission prime contractor Alcatel Alenia Space (I), initiated in October 2005, had to be redirected to take into account the new contribution scale. The selection process for the second-level contractors then continued with the issue, in early August, of the Invitations to Tender (ITTs) for the Entry, Descent and Landing System (EDLS), Descent Module Support Structure and Rover Egress System (SES) and the Carrier/Orbiter. The Request for Quotation for the rover vehicle was also released.

At the end of August, the Planetary Protection support contract was kicked-off with SEA/Open University (UK). This completed the selection of the companies working directly with the mission prime for mission design (DEIMOS), entry descent and landing (DEIMOS), aerodynamics-aerothermal analysis (FGE) and the analytical integration of the Pasteur instruments and the GEP (Geophysical and Environmental Instrument Package with Kayser Threde) by Galileo Avionica.

The setting up of the industrial team continued with industrial activities started in early September with Galileo Avionica, including the drill and the Sample Preparation and Distribution System (SPDS) design and breadboarding, and with Aerosekur for the airbag design and breadboarding.

In November, Astrium UK was selected as the rover-vehicle lead, system design and AIV contractor, and Sener (E) as the structure and rover egress system design contractor.

Work has progressed on both the baseline mission, based on a Soyuz launcher and relying on a NASA



Artist's impression of the ExoMars Rover, showing the Pasteur drilling instrument

telecommunications orbiter, and on an enhanced option based on an Ariane-5 launcher. The latter option would provide the opportunity to conduct Mars orbital science as a continuation of the Mars Express studies. A careful assessment showed the proposed launch date of 2011 to be very tight, while a launch in 2013 would provide a robust schedule with several months of contingency.

On the ExoMars payload side, attention focused on the Pasteur instruments and the Geophysics and Environment Package (GEP). A preliminary meeting took place with Roscosmos to discuss the procurement of Radioisotope Heater Units (RHUs). A follow-up technical meeting with BIAPOS, which developed and manufactured these devices for the Mars 96 mission, took place in early September, with positive results.

As part of the Aurora core element, a one-year Mars Sample Return Phase-A2 study was kicked off with Alcatel Alenia Space (I) in the autumn. Four tenders for approved planetary protection/RHU units/radiation activities for the core programme were issued.

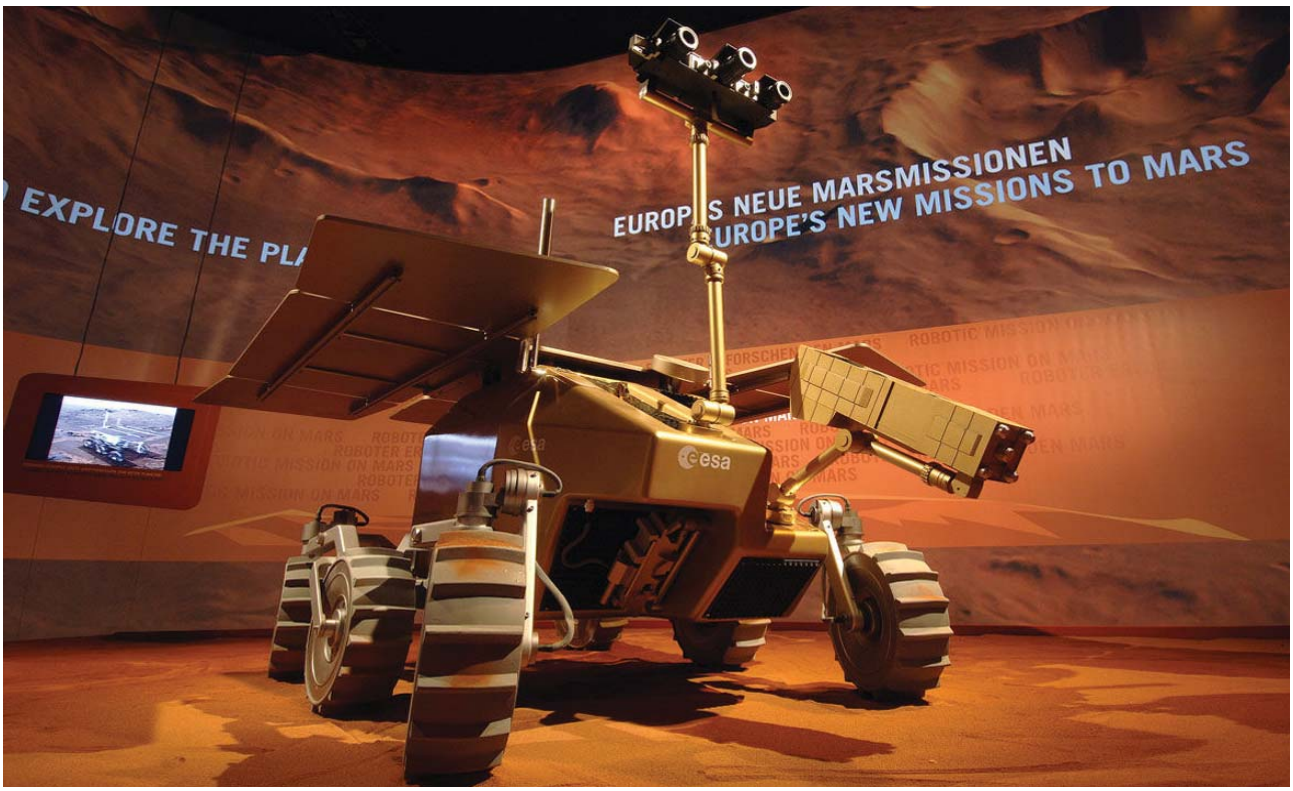
A work plan for the core programme component of the Exploration Programme is under development following the overall logic for consolidation of an integrated European Strategy for Human Spaceflight, Microgravity and Exploration.

As a follow-up to the proposal on the Clipper Preparatory Programme that was submitted to the Ministerial Council in December 2005, a special meeting was held in May. The result of the discussions was a common understanding with Roscosmos regarding the mission, system concept and programmatic aspects of an advanced crew transportation system. An updated programme has been proposed.

The Programme Declaration for the preparatory programme of the Crew Space Transportation System (CSTS), together with an accompanying document recording statements by Participating States and the Director General, in conjunction with subscriptions, was finalised in September.

A Second ESA/ASI Workshop on International Cooperation for Sustainable Space Exploration, held at Abbazia di Spineto (I) in May, was attended by more than sixty participants representing space agencies from Europe, North America and Asia. It was one of a series of international workshops meant to facilitate the establishment of a global, international cooperation framework to support the space-exploration plans of various space-faring nations, including NASA's Vision and Europe's Aurora Programmes. With this series of workshops, and the work accomplished in between, Europe is projecting itself as a key player in the establishment of effective relations among nations with an interest in the exploration of the Solar System.

Technical and Quality Management



An ExoMars Rover preliminary design

Mechanical Engineering

Structures and Thermal Control

After years of successful application to fracture control for manned-spaceflight structures, pressure vessels, and other critical spaceflight hardware, the latest version (4.1.0) of the ESACRACK fatigue, crack initiation and growth software package was released for use by the space-structures community.

In the area of cryogenics, following the earlier successful MiniTherm (miniature two-phase heat transport devices) flight demonstration, flight demonstrations of a high-performance heat pipe (TEPLO) and a loop heat pipe were initiated.

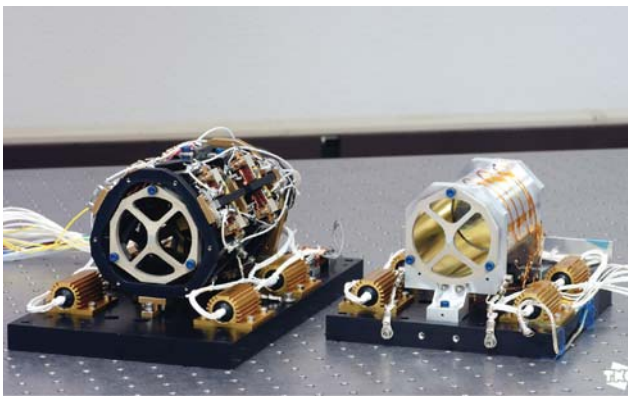
Mechatronics and Optics

Expertise in robotics underpinned the initiation of the ExoMars Phase-B1 rover-related industrial activities, and R&D activities on locomotion performance prediction and simulation tools for rover systems engineering. For planetary science, development of the 'Nanokhod' micro-rover and related geochemical instrument suite was pursued up to the qualification model stage. The flight model of the Erasmus Recording Binocular, a stereo camera used by ESA astronaut Thomas Reiter on the International Space Station (ISS), was developed and qualified as an in-house effort by the Automation and Robotics Section.

In the field of life- and physical-science instrumentation, the Scanning Probe Microscope could be converted into an Atomic Force Microscope, bringing atom-level resolution to space experimentation. In line with the focus on integrated countermeasures for the effects of long-term human stays in space, the Short-Arm Human Centrifuge for ground-based studies was completed and successfully tested, in support of the Directorate of Human Spaceflight, Microgravity and Exploration.

In the area of space mechanisms, much effort was devoted to the development of core technologies, such as large, medium and miniaturised actuators, position sensors, harmonic drives, and high-power slip rings. Space tribology was another area of intense investigation, e.g. to provide high-temperature lubricants for BepiColombo and cryogenic lubricants for the James Webb Space Telescope (JWST). Specific mechanical devices were prepared for the Aurora Exploration

The Nanokhod micro-rover



Optical delay line for the Darwin mission

An Si-hybrid APS detector array mounted on its front-end printed-circuit board

A MOEMS optical cross-bar switch

programme (e.g. moles, drills, seals) and for launchers (e.g. electro-mechanical thrust-vector control systems and valves, hold-down and low-shock release mechanisms for payload adaptors). The development of a new low-power solar-array drive mechanism was successfully completed, and it has been selected as the baseline for the Galileo IOV satellites.

In the opto-electronics domain, the main development effort was directed towards advancing the technology-readiness level of basic fibre-optic component building blocks for fibre-optic sensing, and high-speed and onboard optical data routing. Considerable progress was made, for instance, in the development of space-grade, vertical-cavity surface emitting laser/PIN diode transceiver modules, demonstrating high mechanical and thermal robustness, as well as resilience against radiation. A flight model of such a fibre-optic sensor demonstrator was developed and successfully tested for flight on Proba-2. In the area of detectors, a high-performance hybrid active pixel sensor (APS) was manufactured, combining the performance capability of state-of-art back-side thinned CCDs with the functional versatility of CMOS APSs. Similarly, a large-volume, high-light-output scintillator involving large (3-inch) cubed $LaBr_3$ and $LaCl_3$ crystals was developed for gamma-ray detection, as needed for the Mercury Gamma-Ray and Neutron Spectrometer (MGNS) instrument on BepiColombo.

The optical technology research effort concentrated, *inter alia*, on enabling technologies for future science missions like Darwin and XEUS. With the realisation of single-mode fibres and integrated optics devices operating in the infrared, technological breakthroughs were achieved to confirm the technical feasibility of the Darwin mission. Likewise, a high-precision optical delay line was developed, based on a two-mirror cat's-eye configuration, to demonstrate a sub-nanometre, optical path-length, control capability at cryogenic temperatures. Envisaging photonic payloads for the next generation of telecommunications satellites, an 8x8 non-blocking optical switch in a cross-bar architecture was designed and built based on silicon MOEMS (Micro-Opto-Electro-Mechanical System) technology.

Propulsion and Aerothermodynamics

The SMART-1 Hall-effect thruster (PPS1350) developed by Snecma has demonstrated the robustness of this technology for space applications. Ion engines have been qualified for the GOCE Earth Observation mission in 2007. The QinetiQ ion engine is being used for this spacecraft. FEEP technologies developed by Alta (I) and ARC (A) are currently being pursued for the LISA Pathfinder and Microscope missions, and this technology is essentially the enabling element for the realisation of such missions.

Significant progress has been made in the area of micro-propulsion development, especially regarding micro-turbo machinery, and now the focus is on improving the combustion of the propellants.

Electrical Engineering

Power Systems

In the photovoltaic-generation area, the focus of solar-cell R&D remains firmly on multijunction GaAs-based devices. Following the successful qualification of first-generation triple-junction devices (for Herschel, Aeolus, Pleiades and Proba-2) and the ongoing qualification of second-generation devices (for AlphaBus, Galileo and LISA Pathfinder), there is now a competitive source of fully European solar-cell technology for both scientific and commercial applications, thereby ensuring Europe's technological independence in this domain.

The need for reliability as a critical factor in achieving a cost-effective product has also been emphasised by the completion of a significant study of the performance of solar-cell bypass diodes.

Data Systems

The worldwide use of SpaceWire for onboard data links and networks, as defined by the European Cooperation for Space Standardization in ECSS-E-50-12A, picked up further momentum. The ESA-led SpaceWire Working Group concentrated on the definition of higher-level protocols for SpaceWire, in particular the Remote Memory Access Protocol (RMAP), with wide international participation from NASA, JAXA and Roscosmos, as well as universities and industry. The development of several SpaceWire-based ASICs also made significant progress, and they will be made available to project users via the ASIC manufacturer Atmel (F).

Control Systems

Vision-based navigation is playing an ever-increasing role in guidance, navigation and control (GNC) activities. Building upon several technological programmes devoted to optical relative navigation, planetary landing with hazard avoidance, and autonomous rendezvous, this key GNC technology has several distinct advantages as a navigation solution in terms of both performance and autonomy. Vigorous R&D efforts are currently being directed at demonstrating the performance and robustness of vision-based navigation and guidance systems in support of several Agency projects. This effort follows the successful demonstration of vision-based navigation systems up to elegant breadboard level and a first flight experiment on SMART-1. It will include the development of a multipurpose navigation camera that takes advantage of the commonalities between the rendezvous and landing applications.

The future of AOCS (Attitude and Orbit Control Systems) with the goals of improved competitiveness, robustness, and ease of system design and verification, has been further strengthened. In 2006, the first-generation APS star-sensor developments showed very impressive night-sky test results, and the feasibility of their large-scale functional integration was demonstrated with a low-cost mass sensor. European manufacturers are now among the World leaders in these key AOCS technology developments.

A new momentum was given to cooperation between the ESOC Flight Dynamics Division and the Dynamics and Mathematical Analysis Unit at ESTEC, by their joining forces in the trajectory and orbital mechanics domain to improve support to projects and initiate more R&D activities in Europe. The third International Workshop on Astrodynamics Tools and Techniques, co-organised with ESOC, CNES and DLR, attracted a large audience.

Radio Navigation

The Payload Systems Division heavily supported the in-orbit test campaign for GIOVE-A, launched in December 2005. This campaign confirmed the performances of the payload elements and secured the ITU-allocated frequency bands. It also helped in consolidating the Galileo signal-in-space Interface Control Document that will soon be made public.

Development of the radio-frequency metrology subsystem for formation flying was completed, allowing it to be used in the development of flight hardware to be embarked on the Swedish Prisma satellite.

The Third NAVITEC Workshop, held in December at ESTEC (NL), attracted some 250 experts from Europe, North America and Asia, and was a very fruitful forum for exchanges on radio-navigation techniques and technologies.

Communications

Technical support was provided to several ESA telecommunications missions, including the AlphaSat Phase-A and Hylas Phases-C/D. An internal study of a sample mission for security applications was undertaken in preparation for the Small GEO Programme.

Significant contributions were provided to recent telecommunications and TT&C standards, covering broadcasting to mobiles (DVB-SH), generic stream encapsulation over DVB-S2 (GSE protocol), and high-

data-rate applications for TT&C (CCSDS Orange Book).

The completion of the SMART-1 mission with its impact on the lunar surface also marked the end of the KATE experiment, which had allowed the demonstration of an X/Ka-band TT&C system under realistic operational conditions as a key spacecraft technology for future deep-space missions.

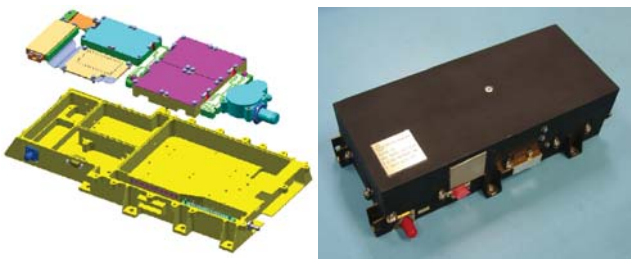
RF Technology

A contract was initiated with Alcatel Alenia Space (F) covering the investigation of state-of-the-art semiconductor power-transistor technologies for short- to mid-term onboard applications at L- and S-band frequencies (navigation, Earth observation and telecommunications). The study covers packaging issues, transistor optimisation, and a high-power-amplifier demonstrator using the European GaAs hetero-junction bipolar transistors from United Monolithic Semiconductors (UMS). This TRP activity has demonstrated a 76% efficiency at 2 dB compression, which is a new world record, outperforming the American and Japanese competition.

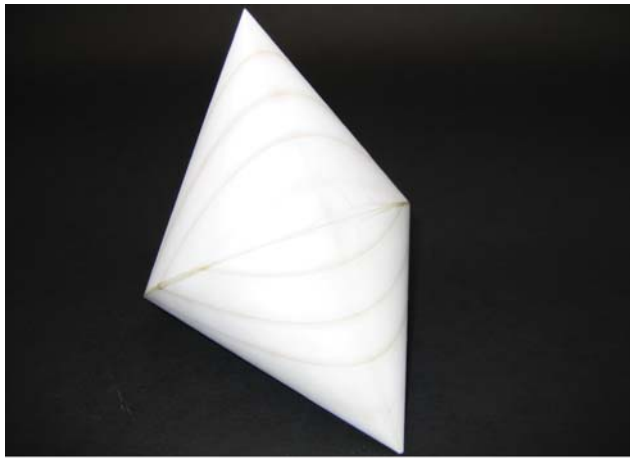
Within the framework of the Galileo Programme, Astrium UK and Alcatel Alenia Space (F) are developing the most powerful European Solid-State Power Amplifiers (SSPAs) to operate at L-band, with power levels exceeding 70 W with a modulated navigation signal. Each In-Orbit-Validation (IOV) satellite payload will carry seven SSPAs for the navigation channels, which will be enhanced evolutions of the GIOVE-B 50 W SSPAs developed by Galileo Avionica.

A Flexible Travelling-Wave-Tube Amplifier (Flex-TWTA), one of the key enabling technologies for flexible telecommunications payloads, has been developed and patented by ESA. It has been selected for the Hylas satellite, as its first flight opportunity.

IOV *GIOVE-B*



European Solid-State Power Amplifiers (SSPAs) for Galileo



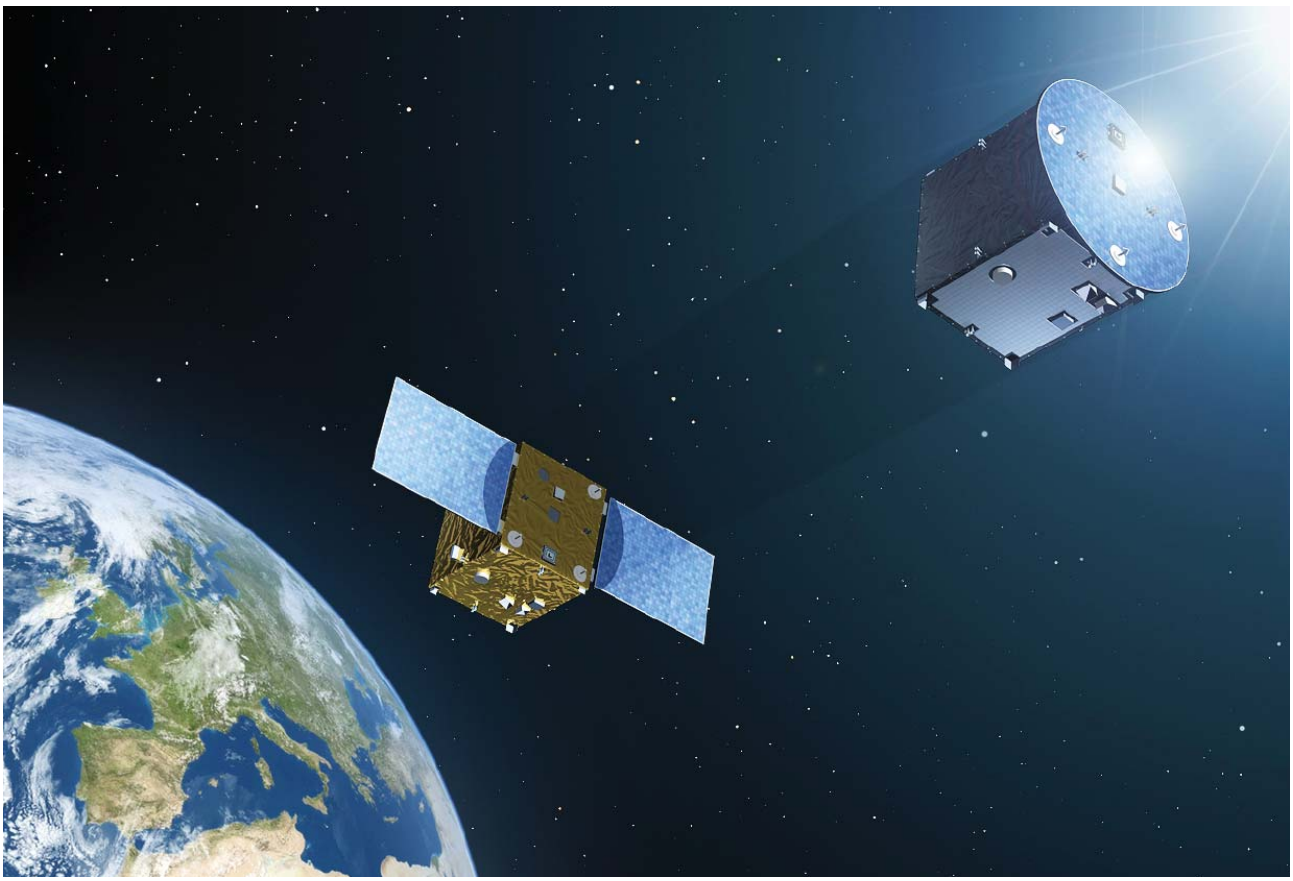
The prototype novel ultra-wideband lens antenna (Courtesy of TNO)

In the framework of ARTES 3, TESAT has developed a new generation of Ku- and Ka-band input multiplexers (IMUXs), thereby fostering the competitiveness of European Industry as equipment suppliers for telecommunications payloads.

Electromagnetics and Antennas

Under an ESA R&D Contract, TNO (NL) has developed a novel directive, non-dispersive and ultra-wideband lens antenna based on the leaky wave radiation mechanism of a slot printed between different homogeneous dielectrics. The prototype antenna operates in the frequency range 5-40 GHz in linear polarisation. This type of ultra-wideband antenna has applications not only in space, but also for terrestrial communications, wireless sensing and broadband measurements.

Under a contract with the Joint Institute for VLBI in Europe (JIVE, NL), the descent trajectory of the Huygens probe through the atmosphere of Titan was reconstructed using measurements taken by an Earth-based VLBI system consisting of 17 radio telescopes in Asia (Shanghai, China, and Kashima, Japan), Australia (CSIRO ATNF and University of Tasmania), and the United States (National Radio Astronomy Observatory). The data, processed at JIVE (the experiment coordinator) with participation by Helsinki University of Technology (Finland) and NASA's Goddard Space Flight Center (USA), provide a localisation accuracy of about 1 km, over the distance to Titan of about 8 Astronomical Units (1.25 billion km or 67 light-minutes). The VLBI techniques developed for this experiment are likely to find further application for pinpointing events of special interest during future deep-space missions.



Artist's impression of the Proba-3 mission

In-Orbit Technology Projects

Proba-1 celebrated its fifth birthday in orbit in October, with all primary subsystems still functioning. With more than 17 000 CHRIS (Compact High-Resolution Imaging Spectrometer) and 12 000 HRC (High-Resolution Camera) images having been taken, the spacecraft is still supporting an enthusiastic science community, embracing 98 projects in 26 countries. The space-environment experimenters are also benefiting from the extended period of data collection.

Proba-2 is a technology flight test bed similar to Proba-1, the guest payload comprising two solar-observation and two space-weather plasma experiments. The platform and payload subsystems progressed from breadboards to flight units. Testing is planned for the first half of 2007, ready for the shared launch with SMOS later in the year.

Proba-3 is a mission to demonstrate technologies and techniques for satellite formation flying. The Phase-A study reached the mid-term review, while technology pre-developments were still ongoing. There was strong interest from potential participants, which should result in full development being initiated soon.

The Instrument Acceptance Review for the European Technology Exposure Facility (EuTEF) was successfully concluded. The package of eight instruments should be carried to the International Space Station by the US Space Shuttle in late 2007.

Software Systems

The first version of the Virtual Spacecraft Reference Facility was installed in the Avionics System Laboratory. It will allow high-fidelity simulations of the complete avionics system, integrating software models and flight software together with real equipment. It will serve to demonstrate avionics technologies in a representative laboratory environment, thereby reaching a readiness level appropriate for their utilisation by projects.

The effort on advanced high-performance real-time simulation and visualisation tools paid off during the commissioning and routine operations of Venus Express. These tools allowed the Venus Express Mission Operations Centre to start planning the nominal mission very soon after the spacecraft's arrival at the planet.

Methodologies for increasing the reliability of critical onboard software by means of independent verification and validation were developed and are being demonstrated in pilot applications for the ADM-Aeolus and

LISA Pathfinder projects. This effort is expected to reduce the costs and increase the quality of independent software validation.

The ASSERT project, carried out for the European Commission by a consortium of 28 companies and institutes under ESA's leadership, successfully passed its second review. New concepts are being developed and demonstrated on real targets such as the LEON processor.

Product Assurance and Safety

European Component Initiative

Global trends in the Electrical, Electronic and Electromechanical (EEE) components industry over the past decade have resulted in the growing dependence of the European space user community on non-European components that are subject to export controls. Coordinated through ESA, the European Component Initiative (ECI) promotes the unrestricted availability of space-qualified components. Launched in 2004, it also involves national contributions from CNES (F) and DLR (D). It provides new European manufacturing capabilities for a wide range of space-qualified components, ranging from passive components to microprocessors. The first new components have already reached the market, with commercial orders being received in the autumn for fuses and double-balanced hybrid mixers. The ECI has also promoted the introduction of new space-component suppliers, including Small and Medium-size Enterprises (SMEs) with exposure to other specialist areas, such as the military, medical and offshore domains.

The European Space Component Coordination (ESCC) continued to provide the ideal forum for the European space community to establish the list of candidate components for the second phase of the ECI. The Initiative also paved the way for strategy papers related to the deep-submicron and gallium-nitride technologies presented to the Agency's Industrial Policy Committee (IPC) during the year, with the first activities to be kicked-off during 2007.

Cooperation with the Japan Aerospace Exploration Agency (JAXA) was widened in the area of space components, with JAXA being granted observer status in the ESCC. This cooperation will be further strengthened through an ESA/JAXA Agency-level agreement in the field of space components to be ratified in 2007.

EEE Components

The negative trend of an ever-diminishing number of suppliers on the ESCC Qualified Parts List has been halted, and the strong increase in evaluation and qualification activities under the Annual Qualification Plan (AQP), driven by ECI and ESA and national space agency technology programmes, will lead to an expansion of the European Preferred Parts List (EPPL) and Qualified Parts List (QPL) in 2007. A European Qualified Manufacturer List based on technology flow qualification has now been established. Significant progress was also made in the updating of ESCC specifications and component-related ECSS standards. The ESCC website and ESCIES (https://escies.org) remain the key communication tools for disseminating EEE component information to projects, manufacturers and users.

European Cooperation for Space Standardization (ECSS)

The ESA standardisation activities are a key element in executing Agency programmes effectively and improving the worldwide competitiveness of European industry. Two dedicated task forces were set up by the Steering Board to prepare for the next phase of ECSS, which should focus on the maintenance of ECSS standards based on feedback from the user community. The Steering Board also revitalised the ECSS definitions for standards, handbooks and technical memoranda, instigating an overhaul of the existing ECSS documents.

The routine work continued in parallel, leading in 2006 to a self-standing set of close to 115 documents covering European standards in the management, engineering and product-assurance disciplines for space-related activities. The level of maturity and completeness of the ECSS standards is such that all participants, and in particular European industry, are now requesting their systematic introduction into contractual space procurement documentation. In addition, several other space agencies, in the Ukraine, Russia, Japan, China, Brazil and Australia, have either decided to use or have expressed interest in using the ECSS documents.

At ECSS and ESA level, cooperation with other standards organisations continues to be pursued, ensuring consistent and closely aligned policies for space-related matters. In particular, ESA participation in 2006 in the Consultative Committee for Space Data Systems (CCSDS) facilitated the publication of a total of eight 'Blue Books'. The global and political implications of these standards for planetary protection and debris led to a decision to support their development as ISO standards.

Technology Harmonisation and Strategy

Technology development belongs to the class of enabling activities conducted by ESA. Without the timely availability of technology solidly anchored in the system concepts, projects suffer delays and cost overruns and industry loses competitive capacity.

This is a critical consideration at a time of constrained budgets, highly ambitious research missions and the expansion of service-oriented space systems to new areas in remote sensing (GMES), operational meteorology (Meteosat Third Generation and post-EPS), navigation (EGNOS and Galileo) and telecommunications, and the combination of systems for integrated applications, including human security. Alongside the need for new technologies for affordable European missions, there is also the need to compete on the world stage, especially in the context of export-control limitations and aggressive new players in the market.

Space Technology Strategy

The strategy for space technology is being adapted in light of the Resolution of the Ministerial Council held in Berlin in 2005, the preparation of the European Space Programme, and the analysis of the above challenges. In addition to meeting the needs of user programmes, including the anticipated needs of future applications, the strategy has to include the search for disruptive technologies, possibly by spinning-in non-space technologies. This should make space solutions more affordable and European industry more competitive. Attention has to be paid to the overall development cycle, from technology reference studies to strengthen the system–technology relationship, to demonstration in orbit as the means of providing confidence in the new technologies. It also has to foster European independence for key technologies and fit with industrial policies, as a healthy industrial base is a prerequisite for a strong technology portfolio.

Space Technology Harmonisation

The process of harmonising the technology needs and means of the European players continued, strongly supported by all stakeholders and recognised by the European Commission as a leading instrument for space technology in Europe. Operating in six-monthly cycles, the process has addressed more than 45 technologies since its inception, establishing dossiers and development roadmaps. It involves all ESA Member States, the European Commission and Industry, and some 800 professionals in more than 180 European space companies and research organisations.

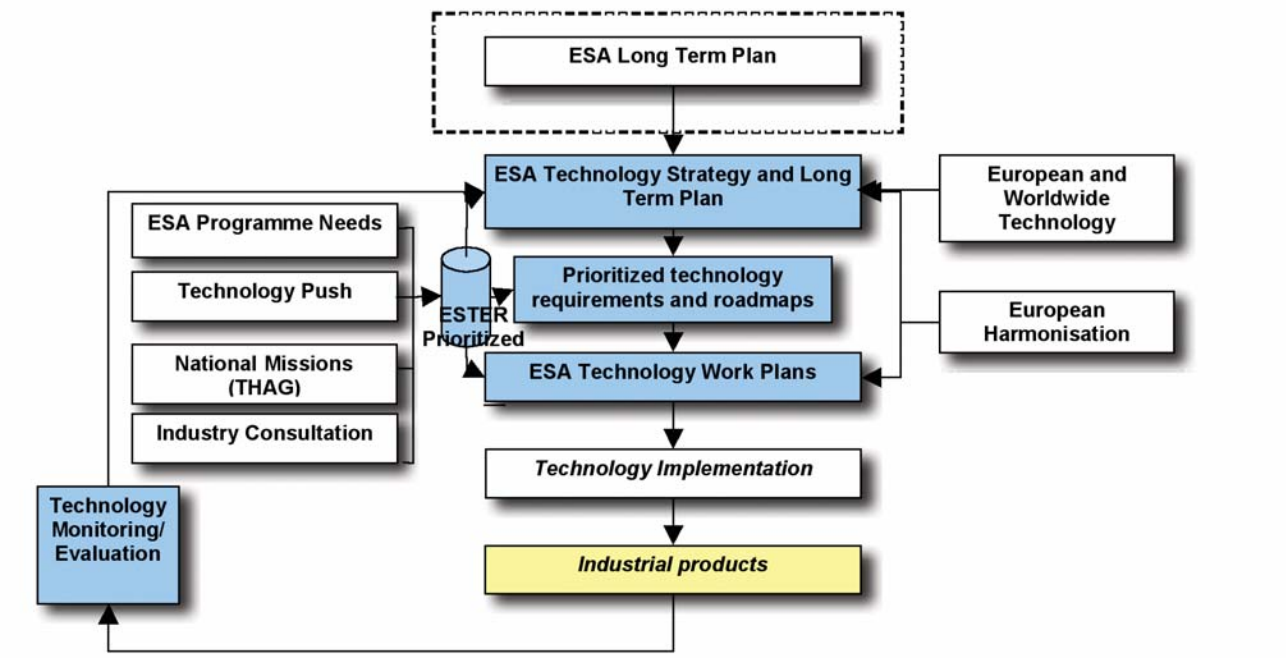
Significant steps were taken in 2006 to adapt the harmonisation process to the ESA Council Resolution of June 2004. An important milestone was achieved with the creation of a Technology Harmonisation Advisory Group (THAG) reporting to the Agency's Industrial Policy Committee (IPC). A harmonisation tracking system has been developed to monitor the implementation of the agreed roadmaps in ESA and national programmes.

The ESA Technology End-to-End Process

The process introduced in 2005 and revised in 2006 will be consolidated in 2007 to establish the new multi-year work plans for the technology programmes. The 2006 updates concerned the identification of programme needs and technology push and disruption, the identification of national missions via the THAG and of commercial missions via industry, the refinement of the derivation and prioritisation of requirements, the strengthening of the coordination between Agency corporate and domain-specific programmes, and the simplification of procedure-supporting tools.

European Space Technology Requirements Database: from Dossier 0 to ESTER

Essential for the proper implementation of the end-to-end process for the management of technology development is the availability of an enabling tool that is both user-friendly and comprehensive – this was the role of Dossier 0. It is now evolving into an even more user-friendly and complete database called 'ESTER' (European Space Technology Requirements). The new tool will be easier to maintain and will include new functionalities that allow requirements to be related to



The ESA end-to-end technology-management process

user-project milestones, as well as the approved technology-development activities that respond to those requirements. ESTER will be fully operational in 2007 and will be used to prepare future Agency technology development plans.

European Space Technology Master Plan (ESTMP)

The ESTMP is a key element of the overall European Space Technology Coordination and Harmonisation Process, as it provides the stakeholders with a comprehensive one-stop shop for information on space technology in Europe. The next issue of the ESTMP is planned for release in 2007.

Cooperation with the European Commission on Space Technology

A major achievement in 2006 was the establishment of the European Space Technology Platform (ESTP), building on the European space-technology harmonisation process and rounding-off a three-year effort. The ESTP includes over 110 European companies, representing more than 90% of the total turnover of the European space industry, as well as ESA, the national space agencies, 21 European countries and Canada.

The ESTP provides the vision for the deployment of space technologies in Europe for the next decade, reinforcing the coordination of efforts in the enlarged Europe so as to establish a sound, competitive and non-dependent space-technology base. The ESTP aims at facilitating interactions between the space sector and related non-space technology platforms and initiatives, supporting EU policies and enabling services to European citizens. The ESTP also supports the integration of new EU Member States working in the space sector, following agreed roadmaps.

In July, the ESTP issued its Strategic Research Agenda (SRA). It recommends that key technologies for European non-dependence be developed under the Seventh Framework Programme (FP7) of the European Commission, complementing the ESA and national efforts.

Technology Programmes

Basic Technology Research Programme (TRP)

The implementation of technology-development activities within approved plans of work continued, with the following main results. In 2006, the TRP placed 39 MEuro in industrial contracts. Management of the activities was improved considerably by the full implementation of the ACTIS management and monitoring tool, giving the technical and contract officers and line and programme managers an instantaneous view of the status of each activity and the upcoming milestones.

The plan of work for 2007 was derived from the existing three-year 2005–2007 plan, after thorough discussion with user programmes and consideration of generic needs. It was approved at the end of 2006.

Significant effort was devoted to beginning implementation of the strategy on space technology, as this pioneering role in the technology development cycle underpins the mandate of the TRP. The focus is on the development of disruptive technologies in the system context. Technology reference studies on future spacecraft concepts were proposed and approved. Dossiers on key items such as gallium-nitride and deep-submicron technologies were prepared and implementation started with actions in the work plan for 2007. Other dossiers are almost complete for micro/nano technologies, processors, embedded systems, onboard software, modelling and simulation, constituting essential inputs to the new TRP cycle and for NewPro.

The Innovation Triangle Initiative (ITI)

The aim of the TRP-funded ITI is to support the identification, validation and development of disruptive space innovations based on new ideas or concepts, giving preference to innovations coming originally from the non-space industrial or research sectors. A second ITI final-presentations day was held in 2006 giving both industry and researchers an opportunity to assess the achievements of recently concluded activities.

An evaluation of the ITI objectives, processes and results was conducted in 2006 by external experts. They confirmed the ITI's value and its role in the ESA R&D landscape and formulated recommendations that will be implemented in 2007. The next ITI call is planned for the first quarter of 2007, with additional attention being paid to the technology-adoption phase.

General Support Technology Programme (GSTP)

As for the TRP, the implementation of technology-development activities within approved plans of work continued, with the following main results. The GSTP placed 45 MEuro in industrial contracts, and these activities were also fully monitored using the ACTIS tool. New batches of activities were released for implementation as Delegations confirmed their support for the proposed plans of work. The GSTP also continued to support programmes such as the SMOS Earth-observation mission, the Expert re-entry experiment, and fundamental elements of the Vega small launcher.

An Announcement of Opportunity (AO) for close-to-market activities received significant support from Participating States and a massive response from industry. To respond faster to the latter's needs, a permanently open AO is being considered and a proposal will be presented in early 2007.

The key role of the GSTP in supporting not only the pre-development and qualification of space technologies required by ESA missions (support to Programmes), but also the competitiveness of European industry, is acknowledged by the fact that the financial envelope of GSTP-4, opened for subscription in June 2004, had reached 322 MEuro by the end of 2006.

NewPro

The implementation of the interim period of NewPro under GSTP-4 continued, including the preparation and approval by Member States of the first work plans for an amount of 11 MEuro. Confirmation of support is proceeding slowly as some major actions require prior actions in other programmes. The preparation of technology reference studies for space surveillance was completed and they should be released in early 2007.

The preparation of the actual NewPro programme has continued as requested at the ESA Ministerial Council in Berlin, spanning the complete scale of technology-readiness levels, from technology reference and impact studies to in-orbit demonstrations, with studies being conducted and dossiers prepared in support of the programme proposal.

Technology Transfer Programme (TTP)

The ESTEC Space Incubator selected five new companies whose ideas were found to have high potential for becoming commercial successes by an independent evaluation board made up of technical and commercial experts. The example of the ESTEC Incubator, supported by the Dutch Ministry of Economic Affairs, has been replicated by ESOC and ESRIN, where incubation facilities have also been started in cooperation with regional authorities.

The three ESA Incubators are now developing a common approach based on the underlying principle of the ESA technical centres using their expertise to facilitate the transfer of space-developed technologies to commercial applications. Internal coordination has been accompanied by a review of external relations in the context of the ESINET network of incubators.

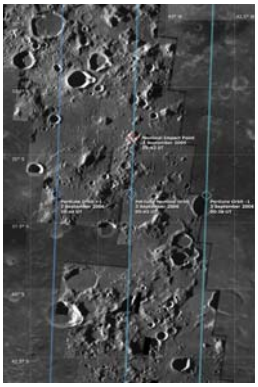
Operations and Infrastructure

The year was again punctuated with many highlights in terms of successful ESA mission operations, paving the way to 40 years of space operations excellence. These outstanding events drew exceptional public interest and created a positive image for European space activities.

The Columbus Control Centre during the Astrolab mission with ESA astronaut Thomas Reiter on board the ISS

Among the highlights was the controlled impact of the technology demonstration spacecraft SMART-1 on the Moon, marking an abrupt but successful end to Europe's first lunar mission. Also, Venus Express was gently manoeuvred, at a distance of 100 million kilometres from Earth, into an encounter with our closest planetary neighbour. With its hot temperatures and crushing surface pressure, this inhospitable planet hides behind a curtain of dense clouds of toxic gases, which Venus Express is now unveiling. Finally, MetOp-A, Europe's new flagship mission for weather forecasting and climate monitoring, experienced a smooth launch and early operations phase. It is the first of a series of polar-orbiting satellites developed and put into orbit by ESA for Europe's meteorological satellite operator Eumetsat.

A major step was taken in 2006 in strengthening the mission operations role of the Directorate when it assumed responsibility for ESA's human spaceflight and exploration mission operations. A first highlight in this context was the Astrolab ISS mission from July to December, the first long-duration mission with a European ISS crew member, German ESA astronaut Thomas Reiter. These new activities are managed by the Human Spaceflight and Exploration Operations Department, which is responsible for preparing and carrying out the ATV and Columbus missions and other ESA operations on the International Space Station. It is also preparing for and operating ESA's Exploration missions, in particular ExoMars, managing the operations services for external customers, studying



SMART-1 and its lunar impact area

advanced operations concepts and technologies, and coordinating the Directorate's role in the Network of Centres initiative.

This creates a truly unique portfolio of competences in Mission Operations and Ground Systems Engineering, both for manned and unmanned missions, geared for synergies and heading for growth. The delivery of the Columbus module to the ISS, the maiden flight of the ATV 'Jules Verne', the preparations for ESA's upcoming Space and Earth Science missions and the Galileo and GMES programmes will offer welcome opportunities to further demonstrate the Directorate's well-proven abilities.

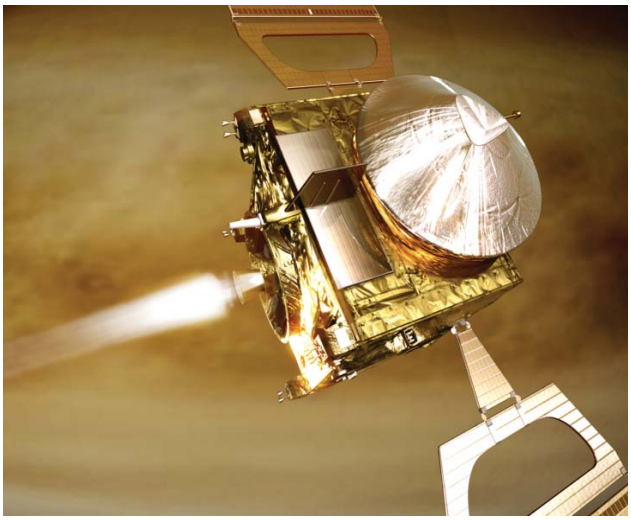
Another prime objective for the Directorate is to further improve the value of services delivered to its customers. The new ESA Informatics and Site Management Department, formed in mid-2006, is providing a stronger, but also more cost-effective organisation at each ESA site. These measures go hand-in-hand with a restructuring of the IT service portfolio. As one of the ESA reforms, work has started on the definition of a new corporate IT strategy embracing a modern set of common applications for the Agency. In addition, improved charging models for operational support and site-management services have been developed to increase transparency of the prices for services rendered to the Directorate's customers, and efforts in this direction will continue in 2007.

In the context of the Network of Centres, the Directorate and its partners also worked on the preliminary definition of elements for the Galileo In-Orbit Validation, demonstrated the feasibility of an operations concept for Galileo, and continued the harmonisation efforts for the flight operations infrastructure, in particular for ground-station cross-support, flight-dynamics systems and ground-system software.

Ongoing Missions

Venus Express

At the end of a five-month cruise phase, the spacecraft was successfully injected into orbit around Venus on 11 April. The perfect execution of this orbit insertion confirmed once again, after Mars Express in December 2003, ESA's competence in interplanetary flight dynamics, navigation and operations. After a series of orbit-correction manoeuvres, during which the first spectacular pictures of the planet's pole were taken, and an intense period of payload commissioning, the



Artist's impression of Venus Express

Congratulations from ESA's Director General Jean-Jacques Dordain (left) after the successful Venus Express orbit insertion

scientific mission commenced on 4 June. Routine science operations have proceeded smoothly since then, achieving all of the scientific objectives set.

SMART-1

The spacecraft continued its lunar observation mission until 3 September, when orbit degradation resulted in the planned impact with the Moon's surface. The final weeks of the mission were characterised by a number of minor trajectory corrections to ensure that the impact would occur during the chosen orbit and at the predicted time. The last radio signal was received at 05:42:22, which was within 1 second of the predicted moment of impact. Images could be taken and downloaded throughout the last orbit, including the last 20 minutes of flight, via the New Norcia (Aus.) ground station. Images of the impact flash on the Moon's surface were also captured by ground-based observatories, whose scientific measurements contributed to the success of this exciting mission.

Astrolab

Astrolab was the first long-duration mission performed by an ESA astronaut on board the ISS. During the Shuttle-launched mission, ESA astronaut Thomas Reiter performed a wide range of operational tasks and a full scientific, commercial and educational utilisation programme. The Columbus Control Centre, operated round-the-clock by an integrated team of ESA, DLR and space industry staff, was used to coordinate the European facilities and experiments, as well as to monitor the astronaut's activities. The mission provided the operations and engineering teams with a wealth of valuable experience in preparation for the launch of the Columbus laboratory in 2007.

Rosetta

The spacecraft was configured for a quiet cruise for the first half of the year, with weekly ground contact. From March to May, the first solar conjunction of the mission was used to characterise the radio-frequency link performance at close angular separation from the Sun and to perform solar-corona sounding measurements. A trajectory correction and a trim manoeuvre were performed in the second half of the year. By the end of November, the first payload active checkout had been carried out, consisting of a month of intense activity that included onboard software maintenance, and pointing and calibration operations for all scientific instruments and the lander.

SMART-1 mission controllers in the Main Control Room at ESOC

Mars Express

Routine scientific data production continued during the first half of the year. From August onwards the spacecraft had to be configured in a special low-activity/low-power-consumption mode to cope with the extreme limitations induced by the eclipse environment close to aphelion. When this critical phase had been successfully completed at the end of September, the spacecraft entered a period of solar conjunction until the end of October, when normal scientific operations were resumed. The performances of the spacecraft and the ground segment are excellent, and the spacecraft is in perfect health even after more than 3 years at Mars.

Ulysses

6 October marked the 16th anniversary of the Ulysses launch. After several mission extensions, Ulysses is now in its third orbit over the poles of the Sun and continues to deliver first-class scientific data from this unique vantage point. In the last months of the year, preparations began for the next nutation phase - an anomaly of about 12 months which occurs once per 6.2 year orbit around perihelion and is predicted to start in February 2007 - with intense planning and negotiation activities to obtain the required ground-station coverage to maintain the spacecraft's nutation level under ground control and within acceptable safety limits. The third south solar polar pass started on 17 November when the spacecraft reached 70° heliographic latitude.

Cluster II

The Cluster fleet continued its successful scientific

Hokkaido, the northernmost main island of Japan, imaged on 26 September 2006 by Envisat's MERIS (Medium Resolution Imaging Spectrometer) instrument

operations phase, which has already lasted more than 6 years. In June, the 10 000 km large-scale tetrahedron constellation was successfully reoriented by phasing manoeuvres to optimise the study of the magnetotail in September. A very critical long-eclipse season was successfully sustained in September. Due to degradation of the batteries, especially on one spacecraft, special power-reduction configurations and procedures were applied, and at eclipse start and exit real-time commanding without monitoring capabilities was required. All operations were successful and the spacecraft reacted as expected. In November, the tetrahedron constellation was changed to a multi-scale constellation with three spacecraft forming a 10 000 km triangle and two spacecraft 500 km apart.

XMM-Newton

XMM-Newton, launched in December 1999, will complete its 1296th orbit on 1 January 2007. The platform and instruments have performed nominally and none of the redundant components has had to be used. An unusual and challenging operation to survey part of the galactic plane was conducted successfully. With only 5 kg of fuel used in 2006, 95 kg are still available to continue operations well beyond the present mission extension to March 2010. The scientific data gathering continued to meet with the full satisfaction of the X-ray science community.

Integral

Integral, launched in October 2002, is in its first mission extension. The operational highlight in 2006 was the Earth Observation campaign at the beginning of the year. Apart from this, mainly routine scientific observations were performed, providing the gamma-ray science community with a far better data return than specified. The remaining onboard power and fuel resources are sufficient for several more years of operations.

Envisat

In December Envisat completed 25 000 orbits and it continues to deliver excellent results. The scientific data return remains high for all instruments and could even be improved on in a few cases by optimising operational strategies and reactions to known payload features. A few platform and data-transmission hardware-related anomalies were successfully corrected, ensuring fast and safe resumption of operations in all cases. An Inter-Operability Technology Test was successfully performed in September to demonstrate the feasibility of Ka-band inter-satellite communication between Envisat and JAXA's Data Relay Test Satellite (DRTS). It included a full end-to-end test from Envisat data transmission through to data storage and post-processing on the ground.

ERS-2

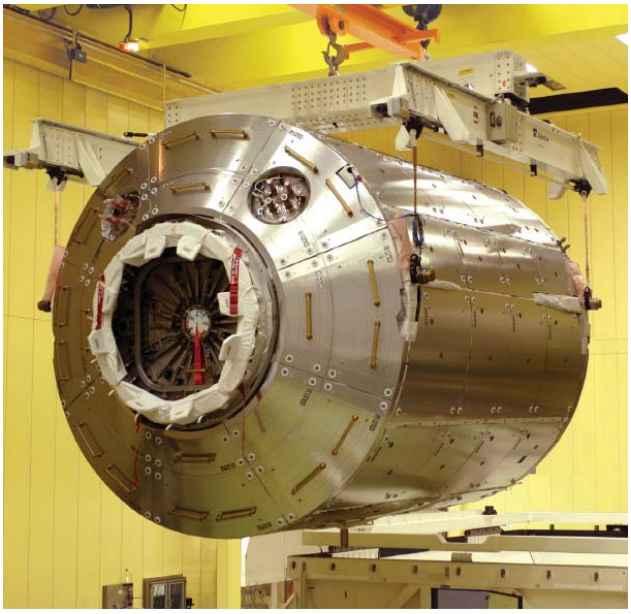
The spacecraft continued in zero-gyro mode and with no onboard data storage, such that science data is now downloaded in real time through a global ground-station network. No major anomalies or further degradation of the mission occurred. The real-time X-band ground-station network was increased from 12 to 13 stations with the inclusion of Singapore, bringing global coverage to around 55%. SAR data return is now at an all-time high, with 25 000 products having already been distributed. Further ground-station additions are foreseen for 2007, with the downlink strategy being fine-tuned to accommodate the increased science return within available onboard resources.

Missions in Preparation

ATV

The flight in 2007 of the first Automated Transfer Vehicle (ATV), named 'Jules Verne', to the ISS and at least four subsequent ATV flights will be operated and controlled by the ATV Control Centre, located at CNES Toulouse (F). Most of the operations products required

ATV in the ESTEC test facilities



The Columbus laboratory

to conduct the ATV mission have already been developed and the Operations Products Verification Readiness Review was successfully completed, thereby allowing the start of the formal simulation and training campaign. The cargo for the first ATV has been agreed with NASA and its analytical integration for launch is at an advanced stage.

Columbus

The Columbus laboratory's launch to the ISS is currently planned for late 2007. It will host experiments in many disciplines, including materials science, medicine, biology and fluid physics. Development of the operations products is well advanced and training and certification of the operations teams via standalone and integrated simulations progressed according to schedule. The Columbus Flight Operations Readiness Review was successfully carried out in December, confirming that preparations for the mission are on track.

BepiColombo/Solar Orbiter

The selection of the BepiColombo industrial prime contractor was supported by ESOC, including participation in the technical panels in the spring and in the negotiation discussions in November. The first ESA/JAXA operations meeting took place at ESOC in October, establishing the first cross-agency operations contacts. Support was also provided to the Solar Orbiter Assessment Team.

Herschel-Planck

The implementation of the Herschel-Planck operational ground segment and the interfaces to the science ground segment is proceeding well, as indicated by the successful completion of the first Ground Segment Implementation Review. Procurement of the hardware facilities for the Mission Operations Centre is almost complete and there have been major deliveries for the mission control, simulator and flight-dynamics systems.

Artist's impression of the Planck satellite and telescope

Compatibility of the spacecraft and ground radio-frequency systems was successfully demonstrated, and the first test of the mission control and flight-dynamics systems with the Herschel flight model was a complete success.

LISA Pathfinder

The LISA Pathfinder Ground Segment Preliminary Design Review was completed towards the end of the year, paving the way for the release of the Invitations to Tender (ITTs) for the Mission Control System and Simulator to Industry early in 2007. The current focus is on the interface and interaction between the Science and Operational Ground Segments.

Gaia

Gaia satellite development has been kicked off and was closely followed by the Directorate's engineering and operations teams. The strong dependence of the mission design on the data recovery resulted in the examination of a number of scenarios for data production onboard, and optimal occupancy of the downlink capacity and ground-station usage. The Mission Operations Centre requirements definition phase has started.

ADM-Aeolus

Preparation of the flight-operations segment progressed according to plan. Important milestones were the successful closure of the Ground Segment Design Review and the delivery of the first versions of the ADM-Aeolus spacecraft simulator and mission-control system. The last quarter of the year saw the start of preparations for the first system validation test, scheduled for May 2007.

GMES/Sentinels

The Directorate's operations teams participated in the System Requirements Review for the Sentinel-1, 2 and 3 spacecraft, marking the end of Phase-A and the start of the development phase. The preparation of the industrial Invitation to Tender (ITT), planned for release early in 2007, was also supported.

CryoSat-2

Following the failure of the CryoSat-1 launch vehicle, a replacement mission with a 2009 launch was agreed by the ESA Council. The Request for Quotation, the proposal, and all technical and contractual discussions were completed during the first half of the year, allowing Industry to start the procurement of subsystem elements. The sub-contractor delta Critical Design Reviews were completed for almost all items by the end of the year and the System delta Critical Design Review commenced. The Flight Operations System delta Requirements Review will be held in mid-2007.

EarthCare

The Phase-A extension was completed with Directorate support for the final presentations. The Flight Operations System documents for the Invitation to Tender (ITT) were generated and support provided to the review of other ITT-applicable documentation. EarthCare Phase-B will commence with the selection of the prime contractor in early 2007.

GOCE

The flight operations segment testing progressed as planned during the year. Important milestones were the execution of three System Validation Tests with the spacecraft, exercising all unit-level operations. Other important activities were the work on the Flight Operations Plan, including unit-level procedures, and participation in the Ground Segment Overall Validation.

SWARM

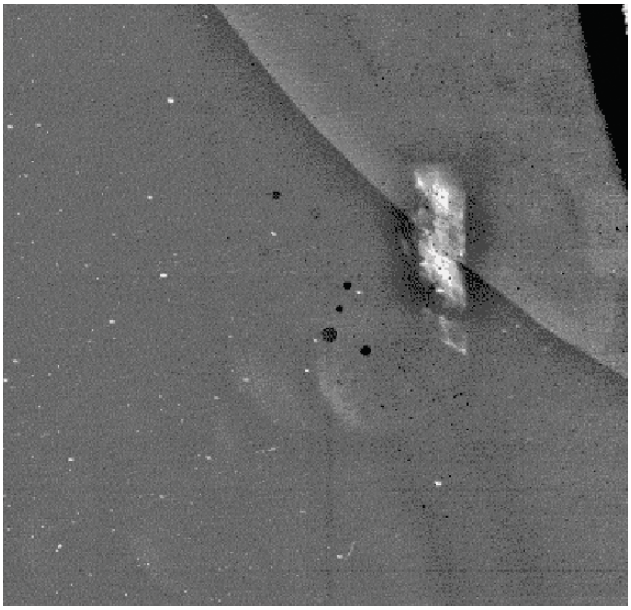
During the year, support was provided to the satellite Phase-B activities, in particular to the System Requirements Review and the Mission Analysis and Constellation Operations aspects. In the last quarter the detailed work to define the Ground Segment Architecture started.

ExoMars

Phase-B1 activities were supported by the provision of mission analyses, the development of operations concepts and requirements, as well as inputs to the industrial Invitations to Tender (ITTs).

Flight Dynamics and Mission Analysis

After a flight of five months, Venus Express arrived at Venus and was manoeuvred into a planetary orbit with an accuracy of just 100 metres at a distance of 100 million kilometres. SMART-1 became the first space-



The lunar impact of SMART-1 precisely controlled right up to the end

craft to make a controlled impact on the visible side of the Moon. The fact that the impact took place within 1 second of the predicted time again demonstrated Europe's outstanding ability to perform complex interplanetary missions and manoeuvres. MetOp-A, the first of a new generation of European weather satellites, had to face several launch delays, challenging the dedication and flexibility of the flight dynamics team, until it was finally put into a perfect polar orbit at the sixth launch attempt.

Space Debris

In support of satellite operations, the Space Debris Office monitored more than a dozen high-risk fly-bys of Envisat and ERS-2 with catalogued objects. On 20 June, a collision-avoidance manoeuvre had to be performed with Envisat to increase its distance from a 2.4 ton Soyuz upper stage.

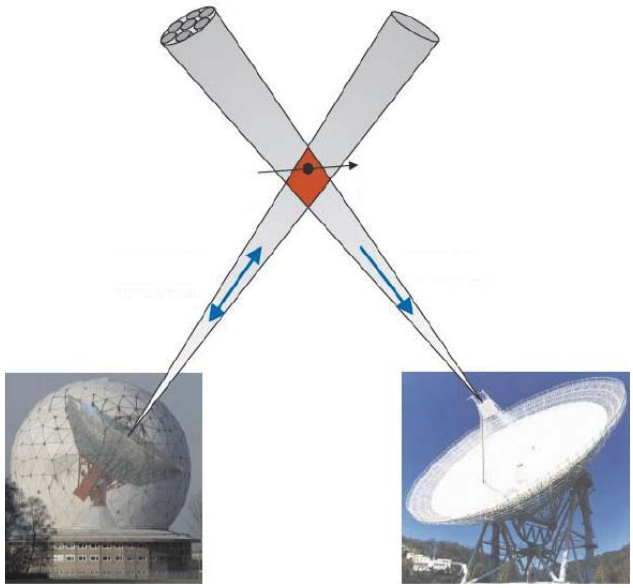
The 1 m ESA telescope on the Canary Islands (E) continues to provide information on objects as small as 15 cm near the geostationary ring. In addition, a first high-sensitivity space-debris observation campaign was initiated, using the German high-power 34 m TIRA radar as the transmitter and primary receiver and a new 7-horn receiver at the 100 m Effelsberg radio telescope 21 km away as the secondary receiver. It can detect objects smaller than 1 cm at a range of 1000 km.

During 2006, the European Network of Centres on Space Debris submitted their final report on 'Space Surveillance for Europe' and the Space Debris Office contributed to high-level UN Space Debris Mitigation Guidelines, to ISO Standards for the implementation of debris-mitigation measures, and to a European 'Code of Conduct' on space-debris mitigation, which was subsequently ratified by all major space agencies in Europe. The translation of this Code of Conduct into a set of applicable requirements for ESA projects is in progress.

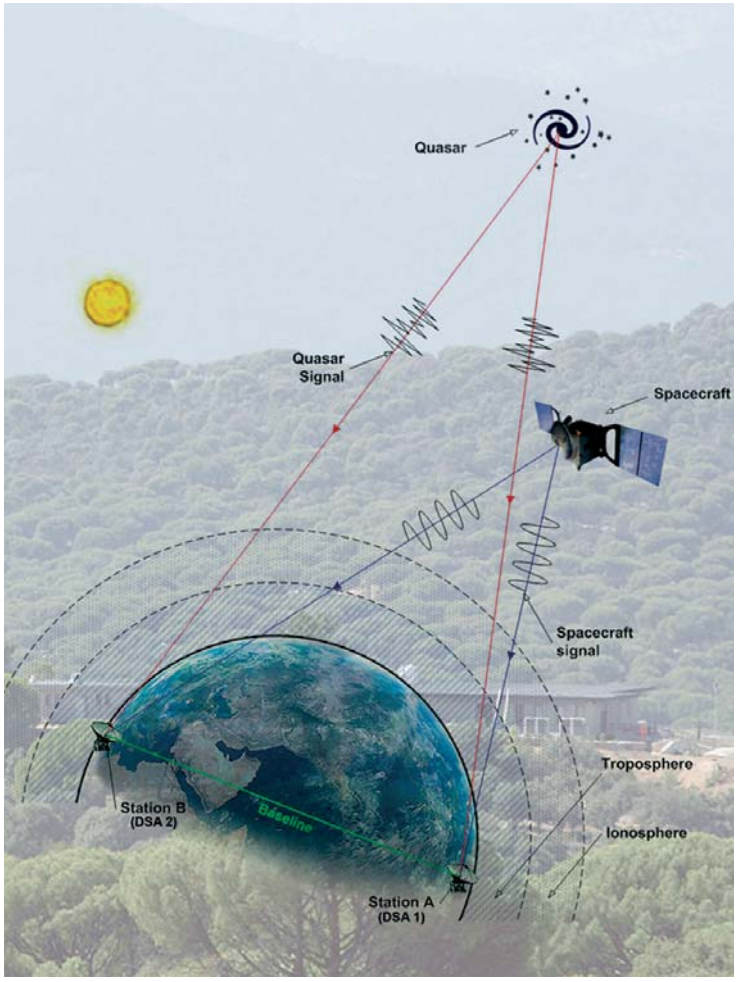
Ground-Station Engineering

The construction and upgrading of the ESTRACK tracking network and the development of specialised communication and ranging equipment continued. In support of the Launcher Directorate, the procurement of a new S/X-band ground station in the Azores and the upgrading of the Perth (Aus.) ground station were started. These enhancements will provide important new functionality in strategically located areas.

Novel engineering work is in progress to upgrade the Cebreros ground station in Spain with new Ka-band uplink functionality, covering the servo-mechanics of the beam waveguide movable mirror as well as dichroic mirrors, which will allow transmissions at two different wavelengths, and Ka-band 1 kW uplink feeds. This upgrading is required for the BepiColombo mission, but will also be used in future cross-support activities with NASA/JPL.



The TIRA-Effelsberg multi-beam radar experiment



The Delta-DOR measurement principle

With the launch of Venus Express, ESA faced new requirements for providing very precise navigation and orbital insertion support. Complementary means to validate and refine orbital solutions are mandatory for accurate orbit determination prior to critical manoeuvres like planetary flybys or orbit insertions. The new ESA Delta-DOR method makes use of the very large baseline for measurements between two distant ground stations, and uses quasar measurements to synchronise and calibrate the signals coming from both stations. Operational Delta-DOR measurements performed with Venus Express for the Venus Orbit Insertion, using both ESA and NASA/JPL deep-space stations, gave excellent results. The Rosetta spacecraft is also benefiting from the use of such measurements prior to its critical Mars flyby, planned for 25 February 2007.

Navigation Support

The highlight here was the successful completion and initial operation of the GRAS Ground Support Network for Eumetsat. GRAS, the GNSS Receiver for Atmospheric Sounding, is a GPS payload on the MetOp spacecraft. The necessary high-precision orbit and time corrections are generated in the ESOC Navigation Facility, using data from a worldwide network of GPS sensor stations, and are provided to Eumetsat in near-real-time.

The Navigation Support Office continued to be active in the governance and operations of the International GNSS Service (IGS). More than 140 participants from about 25 countries attended the IGS Workshop at ESOC

in May, titled 'The International GNSS Service (IGS): Perspectives and Visions for 2010 and Beyond'.

During 2006, the Navigation Support Office managed the establishment of five of the 13 Galileo Experimental Sensor Stations required to support the GIOVE-A mission and provided consultancy and operational support for two others. The data from this network are now contributing to early validation of the Galileo space and ground segments in a number of key areas.

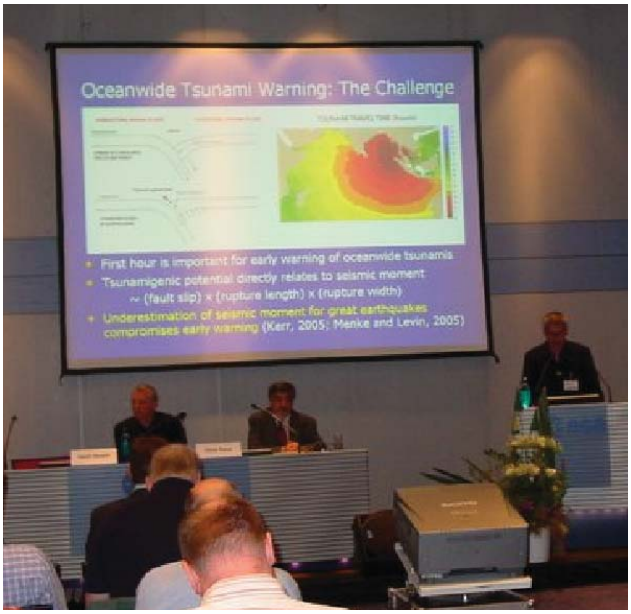
Software Infrastructure Systems

Substantial effort to support the European Technology Harmonisation initiative in the field of ground-segment software continued. EGOS, the ESA Ground Operation System, is attracting considerable attention from other centres and European Industry. It encompasses a general architecture for all ground-segment data subsystems, designed to achieve maximum synergy and interoperability between software elements coming from different application areas and developers. It should make the development, operation and maintenance of software products for the ground-segment area more efficient. The Low-Level Components Requirements Engineering Phase was completed in 2006 and the Architectural Phase started in October. An EGOS User Desktop implementation was started in November.

ESA's operational software including SCOS-2000, SIMULUS, PSS, and TMTCS continues to be used by a number of ESA missions, including the Vega launcher programme, the Galileo GSTB V2 and In-Orbit Validation and many other space programmes, such as DLR's Radarsat, Eutelsat, ASI's Cosmos Skymed, Astra 1M, and Arabsat. All of these projects are integrating and validating their new control centres based on SCOS-2000. More than 70 licences have already been granted within Europe. The use of SCOS-2000 as satellite and/or instrument EGSE by different projects is also demonstrating its capability as a Common Electrical Ground Support Equipment and Mission Control System. Its use for the Vega programme also underlines its potential in the launcher domain.

Mission Data Systems

In 2006, over 20 systems for missions in orbit were supported, while the development of some 10 systems for missions in preparation continued, as well as the provision of support to missions in an early phase, such as BepiColombo, Gaia and GMES Sentinel-1. In particular, the mission control system for MetOp-A's Launch and Early Orbit Phase (LEOP) was provided and the LEOP itself successfully supported. In the frame of the Herschel-Planck project, a Linux-based version of the mission control system was delivered, which helped to confirm the feasibility of Linux as the future platform for mission data systems.



The IGS 2006 Workshop at ESOC in May

The development of mission data systems for GOCE, Aeolus, Lisa Pathfinder and SWARM continued as planned. Support was also provided to Navigation programmes, in particular Galileo and EGNOS, both as functional support to the Galileo Project and in the Network of Centres framework. The ESOC Secure Mission Operations Project was supported, in particular in preparing the migration of systems to the new split data centres, which will take place in 2007. Further activities covered the area of standardisation, mainly in the ECSS and CCSDS domains, with ESOC playing a key role in a number of instances.

Third-Party Support

About 15 ground-segment Phase-A/feasibility studies were conducted in support of ESA's Science and Earth Observation Programmes, along with the provision of functional and integrated support to the GalileoSat In-Orbit Validation (IOV) project.

Successful execution of the Launch and Early Orbit Phase (LEOP) operations for MetOp-A was a highlight of the year. Work also started on preparing the LEOP operations for the four Galileo IOV satellites, due for launch by 2008/09. This is a joint venture with CNES as part of the Network of Centres provision of a complete operational service for the Galileo IOV phase, led by DLR. In the area of technology for operations, several prototype tools have matured into operational systems supporting the current operations of, for example, Mars Express, Venus Express and Envisat. Within the more research-oriented study work, there was a significant increase in cooperation with university groups during the year.

There was a steady stream of external enquiries for operations support and services. Some 38 enquiries led to the production of seven proposals and to the award of five contracts, including one from Eumetsat (subject to successful negotiation) for the LEOP operations of the MSG-3 and MSG-4 meteorological satellites, due for launch in 2010 and 2013, respectively.

Network of Centres Initiative

The Network of Centres partners for the Galileo In-Orbit Validation (IOV) Operations Services carried out preliminary definition work for the launch and early operations, in-orbit testing, routine operations and logistics services for the IOV programme. The partners, led by DLR, include AENA, CNES, ESOC, Hispasat, KSAT, Inmarsat, SSC and Telespazio. Based upon this preliminary work, a proposal for the complete package of work in these four areas is in preparation. This Network of Centres effort has demonstrated the practicality of producing a solution for Galileo operations, and has thereby also established the mechanism for providing Network of Centres solutions for other future European space missions.

Flight operations infrastructure harmonisation has continued between ESA, CNES and DLR in the areas of network/ground-station cross-support, flight dynamics system evolution and ground-system software. Cross-support for operational missions is already provided on a routine basis. The drive towards the further harmonisation of study work, R&D activities and operations technology is still on-going.

ESA Corporate Informatics and Site Management

The first year has been very challenging for the newly created Department, which merged the former Site Management and Information Systems Departments into a single unit. The new management team was in place by July and a budget scrutiny exercise was conducted to ensure harmonisation of the planning processes and budgets. An action plan was established to resolve some apparent shortcomings by early 2007. During the year, additional services were offered and the cost of services to customers, in the form of recharges, continued to decrease.

MetOp-A

Corporate Informatics

The Department collaborated with the Agency Reform working groups in the creation of a new Corporate Informatics Policy and proposed a related ESA-wide governance process. The Management Information Systems Division actively supported the relevant inter-Directorate reform working groups in selecting and

adapting existing tools to the new corporate needs. This experience enabled the establishment of stronger ties and greater trust between the relevant entities across the Agency.

Financial processes continued to be executed in AWARDS, duly improved in performance and enriched in functionality, to support the in-year flexibility budgetary planning and factoring. Procurements benefited from the introduction of an electronic workflow for commitment of funds and advanced functions offered to bidding industries and auditors. Invoice-payment processes logged a considerable increase in usage, while customer satisfaction surveys reported remarkably high scores.

Support to Human Resources processes included the introduction of a new staff annual assessment procedure, and the preparation of a 'recruitment module' due to become operational in 2007. The facility management system was also upgraded to better match today's site management processes.

The outsourcing contract for the provision of ESA's Corporate Information Communication Technology infrastructure and related services was signed with the company Electronic Data Systems. As the overall service provider, EDS will be responsible for the service desk, desktop computing, e-mail, local- and wide-area networks, mobility, ICT security and applications infrastructure, and will initiate migration of these services to the target configuration in 2007.

Site Management

It was a year of intense site management activity at ESTEC in particular. The construction of a major new office building and a laboratory complex proceeded on schedule and within budget. Other significant areas of the site contaminated by asbestos were the subject of extensive engineering work, such that the overall end-date of 2008 for the asbestos removal programme should be achievable. The drafting of a new environmental permit for ESTEC entailed extensive cooperation with the local authorities. The year finished with the formal transfer to ESA of 4.5 hectares of land that will be available for future development adjacent to the main site.

Major activities at ESA Headquarters included the refurbishment of the facade of the main building, the finalisation of the building management system and the video/intrusion control system. In the course of the year, the team supported 2800 meetings and 660 video conferences, produced 8.9 million pages of documents to support the Delegations, and served 66 200 meals.

At ESRIN, refurbishment of the main access gate and the building 8 electrical cabin was completed. A general review of office accommodation after the reorganisation of the Earth Observation and the Operations teams resulted in some 220 planned office moves, half of which were completed before the end of the year.

Substantial work was also undertaken on the building infrastructure at ESAC, with the refurbishment and extension of the OPS-1 building, the refurbishment and extension of the canteen building, and the design and construction of the brand new OPS-3 building. The on-site facilities have thereby been aligned with the ongoing evolution in the Centre's activities.

Industrial Relations and Procurement

The year was mainly dedicated to the implementation of the FINPOL reform on the hierarchy of return rules and to the assessment of the industrial policy for the years to come.

Industrial Policy

On the hierarchy of return rules, it is to be noted that the new programmes approved at the 2005 Council at Ministerial Level all feature provisions complying with the reform. Particular attention has been paid to the issue of contributions to Optional Programmes matching (or not) industrial capabilities: the results were brought to the attention of the Heads of Delegation in the autumn, and will require further discussions. An important aspect of the reform is the proactive management of return matters, which is being applied more and more throughout all ESA programmes.

Future industrial policy to be developed and implemented will place emphasis on the maintaining of industrial capabilities and on the continuing pursuit of European industrial competitiveness for all types of industrial firms, including Small and Medium-sized Enterprises (SMEs) and value-adding companies.

Industrial Relations

Efforts were pursued to improve communication and interaction between ESA and European Space Industry. In particular, the three-day '2006 Industry Space Days' event focussed specifically this year on cross-sectorial synergies for technology activities and new actions in support of SMEs, to help them to improve their skills, to lower their entry barrier to space and to foster their competitiveness in the space and non-space markets. This event was a significant success with more than 650 participants and more than 6100 'face-to-face' meetings, allowing numerous European companies to liaise, renew contacts or assess potential business opportunities.

A survey was conducted, and consultation workshops were organised, to appreciate the perceived importance of, and likely level of demand for access by SMEs who are currently or potentially active in the space sector, to various types of expertise, support, training, facilities and services.

A new web portal was developed and released consolidating into a single focal point a very large amount of practical information targeting SMEs wishing to contribute to ESA programmes.

Seeking to improve future ESA strategy and potential industrial policies, a review of downstream added-value services and related industries was performed.

Assessments were performed of European industry restructuring or changes in its worldwide context and these supported various ESA actions and communications involving ESA boards. A feasibility study was performed on possible ways to improve market-size estimations for European industry in different domains and technologies. Various databases related to European industry and research organisations were updated.

The new online registration process used by industry to obtain access to EMITS (Electronic Invitation to Tender System) was launched and allowed a cleanup of the industry EMITS access codes to begin.

Industrial Policy measures for non-Large System Integrators and SMEs were applied 90 times to R&D programmes. A consultation process, involving industrialists and Member States, took place in order to reflect on the evolution of this policy. The Industrial Policy Committee (IPC) approved the new proposed guidelines for implementation and the continuation of these measures until the next Ministerial Conference in 2008.

Support to the Technology Harmonisation process was provided, identifying future market size and providing inputs for the identification of potential players involved in the technologies reviewed.

The SME Initiative continued to support SMEs through its specific tools. An Announcement of Opportunity (AO) covering 'Leading Edge Technologies for SMEs (LET-SME)' was generated and eight proposals were selected and the relevant contracts awarded.

Procurement

Procurement Auditing

A large number of company audits were performed in 2006, all of which were based upon the purchasing-power dossier framework as endorsed by Council in 2004. In addressing possible improvements to the procurement process, various meetings took place with industry on contractual and financial issues. In addition, national audit agencies have been approached to review the options for increased coordination. Finally, under the mandate received from the Launcher Directorate, nearly 60 company audits took place in the framework of the EGAS Programme, in order to provide Member States with an updated view of the situation (Phase 3) regarding the industrial return associated with batch PA production.

Procurement Activities

600 Invitations to Tender (ITTs) were sent to industry in 2006:

- 258 in open competition
- 10 in restricted competition
- 332 in direct negotiation.

ESA also initiated 3765 contract actions:

- 878 main contracts
- 134 riders
- 379 work orders
- 2374 Contract Change Notices (CCNs).

The ESA Adjudication Committee (AC) and Industrial Policy Committee (IPC) were involved as follows:

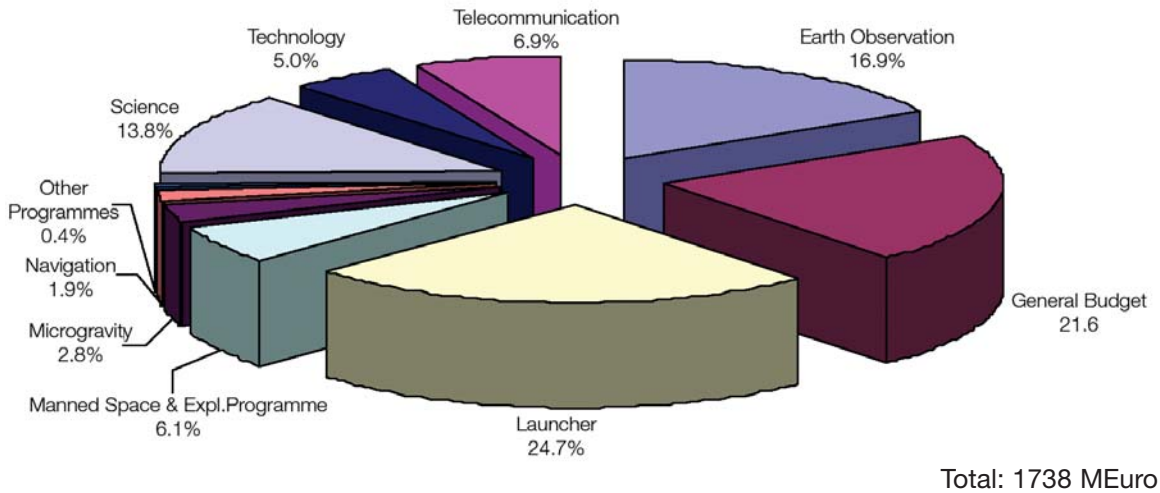
- 123 procurement proposals were submitted to the AC, of which 66 were presented to the IPC
- 53 contract proposals were submitted to the AC, of which 20 were submitted to the IPC.

The value of the contracts and procurement proposals submitted to the AC was 2558 MEuro. Of these, 71 MEuro were finalised at AC level, and the remainder, worth 2487 MEuro, were passed on to the IPC for a final decision.

Industrial Activity and Evolution of Industrial Return

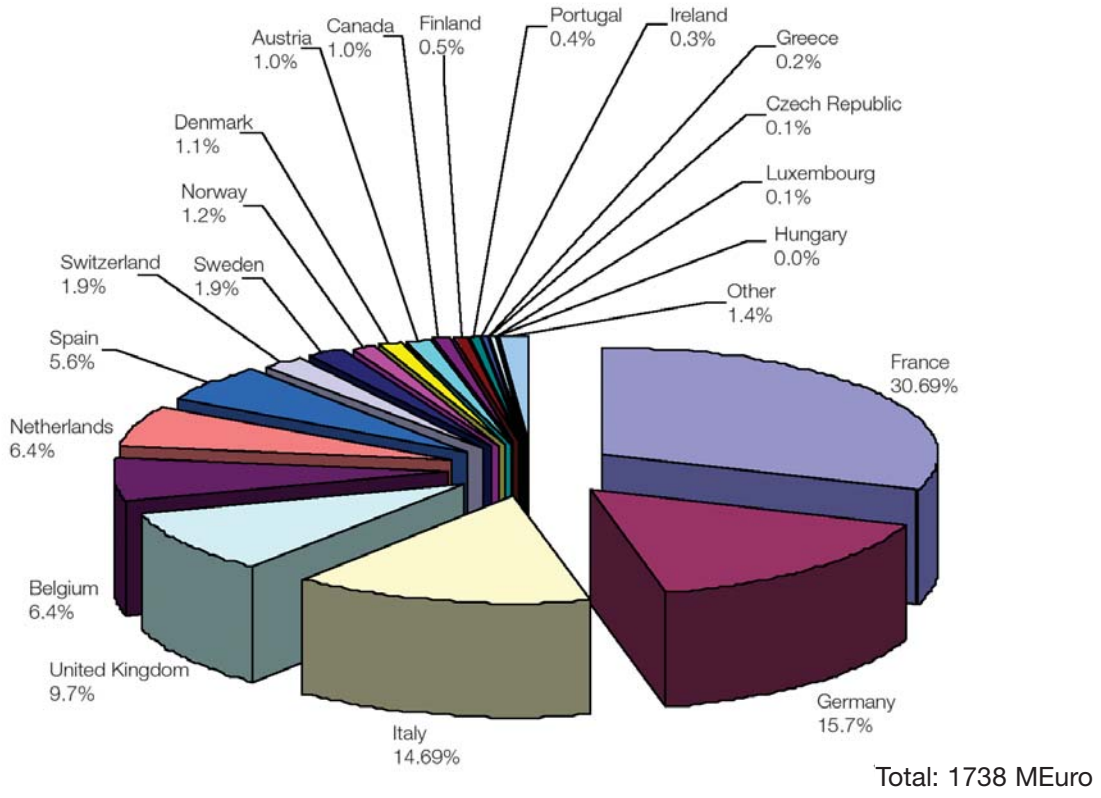
Industrial activity was maintained at a sound level, with some 1738 MEuro[1] of contracts committed with industry (1714 MEuro of which were with European and Canadian space industry) during the year. The accompanying pie charts show the distribution of activities per programme and per state. Application Programmes (Telecommunications, Navigation and Earth Observation) accounted for about 26% of the total committed value. About 25% was related to Launchers, 9% to the Human Spaceflight, Microgravity and Exploration Programme, around 14% to the Scientific

[1] About 283 MEuro committed with Industry during 2006 were not yet included in the return statistics at end-2006, pending finalisation of the relevant subcontracts or in the case of Galileo IOV inclusion in the return statistics on completion of the Galileo IOV programme.



Total: 1738 MEuro

Commitments made to industry in 2006, per programme



Commitments made to industry in 2006, per state

Programme, and 5% to Technology, with the remaining 22% relating to the General Budget (this high percentage being mainly due to the ESA Information Systems Infrastructure & Users Support Services frame contract renewal, worth 87 MEuro).

In the field of Launchers, the contract with CNES related to maintaining the CSG Launch Range in operational condition was concluded.

Other substantial procurement actions were initiated in relation to the Vega (VERTA), Ariane development (ARTA, ACEP, and Slice 10) and FLPP Programmes.

In the Human Spaceflight field, procurement activities were directed to either consolidating existing Programmes (ISS Exploitation and Utilisation) or establish funding for new endeavours (ExoMars).

For the new type of large ARTES telecommunication programmes which are characterised by a major ESA development contribution to a fully commercial programme, e.g. Hylas and in particular Alphasat, new procurement approaches have been developed in order to cope with the peculiarities of these projects to be implemented together with leading European operators. Both the selection process and the contractual approach have been mainly driven by the critical impact of such large ESA contributions to commercial operators in a highly competitive environment. The resulting approaches, e.g. organising the selection contest before formal tender actions and developing contract provisions based on partnership concepts, will increasingly be used for further projects with commercial partners.

The preparation and issuing of Phase-B2/C/D tenders and their subsequent evaluation for two large Science missions in very close proximity during 2006 was a major achievement, particularly in the light of the difficult industrial policy situation and the implementation of best practices for subcontractor selection.

Support to Third Party Activities (ESOC)

In addition to procurements to meet the Agency's own requirements, support was also given to activities undertaken by third parties. This involved limited use of the Agency's expertise, facilities, services or products, and the costs incurred were fully charged to those customers, primarily in the ESA Member States. That kind of support should not to be confused with activities performed under Cooperation Agreements signed for dedicated projects involving complementary activities, with or without an exchange of funds.

In 2006, seven proposals were prepared:
- Galileo LEOP to DLR
- JAXA - Astro-F Additional TT&C
- Eumetsat: MSG-3/4 Support
- Eumetsat: Disposal of LBT in Kourou
- SES Astra: IOT Support for Astro KR
- SciSys: MUST
- EC 6th Framework Programme: Astronet

and two contracts were awarded.

The value of orders received in 2006 for ESOC's support amounted to 4.7 MEuro, of the total of 11.5 MEuro invoiced.

Other Support Activities

ESA also performed, through ESTEC, a considerable number of smaller activities in the areas of general technical support, individual consultancies and testing.

The External Customers desk handled 75 enquiries (17 of which were carried forward from previous years and 58 were newly received in 2006) concerning services performed at ESTEC. This resulted in the receipt of 47 contracts with a total value of 647 kEuro, broken down as follows:

ESTEC Laboratories	46	620 kEuro
Consultancy	1	9 kEuro
Software/Product Licensing + Support	31	18 kEuro

Major clients included EADS (D), SAFT (F) and Oerlikon Contraves (I).

ETS (NL), the contractor currently responsible for the management, operation, maintenance and marketing of the ESTEC Test Facilities, performed 14 tests for external customers. It paid ESA 397 kEuro for the rental of additional offices and a turnover fee for the previous year.

15 of the 22 tenancy agreements for office accommodation and services in the European Space Incubator (ESI) were signed in 2006.

Reform of Internal Operations

ESA must constantly strive to keep pace with the evolution and trends both within Europe and internationally and to adapt, as necessary, to the demands that these place upon it. It must respond quickly and effectively to demands coming from the ESA Council of Ministers, from ESA Member State Delegations, from industry and from its various partners, and it has to stay at the forefront of modern management practices.

The Ministerial Council in Berlin in December 2005 passed a Resolution calling on the Agency to further strengthen the management of its internal operations. In response to this Resolution and to the targets set by the Director General in his Agenda 2007 and Agenda 2011, as well as to other internal and external factors, ESA has undertaken and successfully completed in 2006 the Inter-Directorate Reform of Corporate and Risk Management. The reform has contributed to improved management of the Agency's internal operations by engaging all internal stakeholders in a common objective, by introducing improvements to planning and management methods, by elaborating consolidated information structures and tools, by contributing to enhanced transparency and accountability, and by providing new qualified policies, processes and tools.

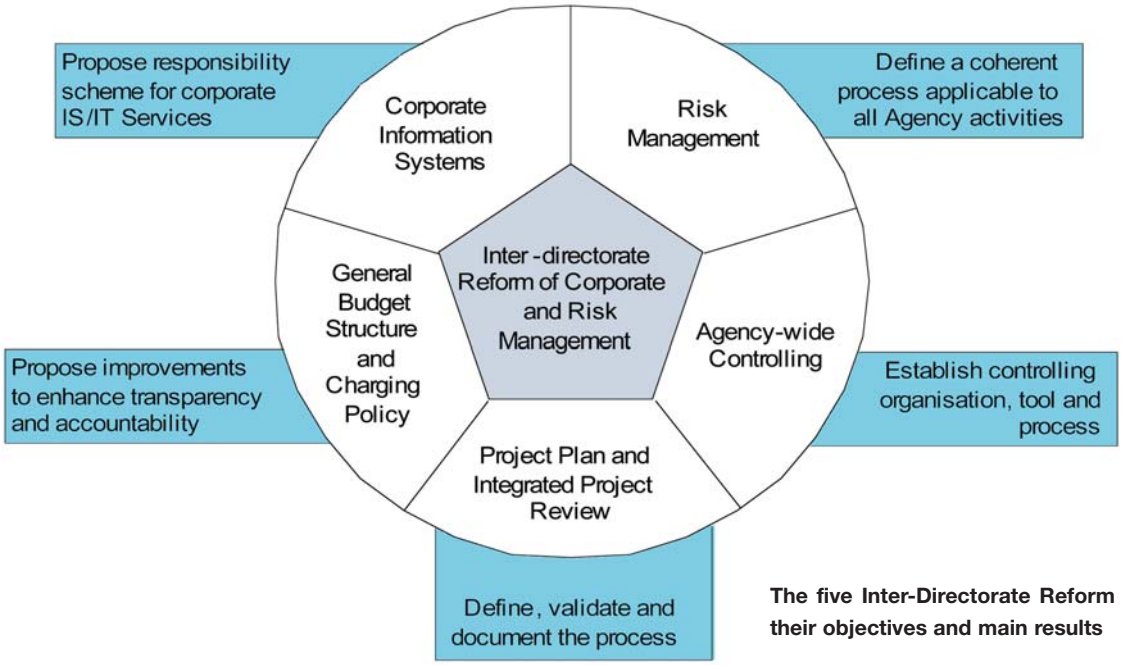
The Inter-Directorate Reform of Corporate and Risk Management

The Inter-Directorate Reform of Corporate and Risk Management, led by the specially appointed Director of Reforms, encompassed five dedicated projects (see accompanying illustration) covering: Risk Management; Agency-Wide Controlling System; Project Plan and Integrated Project Review; General Budget Structure and Charging Policy; and Corporate Information Systems. These projects were aimed at improving internal working methods at ESA and therefore involved all Directorates. The Director of Reforms, together with his project managers and with support from specialists in all Directorates, led each project through to the full qualification of a new or revised policy and process, and then handed it over to the relevant Directorate for implementation.

The major result of the *Risk Management* project was the elaboration of an updated Agency risk-management policy accompanied by a detailed process description for practical risk-management in projects and activities. The updated policy and the newly established process are designed to support the coherent flow of critical information provided and required by the various management layers, whilst highlighting the role and responsibilities of the managers in achieving their objectives. A further significant improvement has been made in risk management at the Agency level. The risk information is now consolidated at Agency level and supports the decision-making, for both strategic risks at the executive level and those related to projects or activities that concern the Agency as a whole.

The major aim of the *Agency-Wide Controlling System* project was to define and implement a corporate system for integrated planning, monitoring and reporting of the progress, financial commitments and expenditures, workforce, schedule, risks and geographical return of all Agency activities. The project achieved the setting-up of an Agency-wide system with a Corporate Controller responsible for the consolidation of information at overall Agency level, and Business Unit Controllers responsible for the provision of data within the Directorates. Other significant achievements include the implementation of a monthly reporting system (status and forecasts) to the Director General and the Directors' Committee, and the establishment of a common database, the Multi-Year Plan, incorporating short-, medium- and long-term planning data. This corporate tool is already fully supporting the monthly reports and will be continuously enhanced for use as a corporate database for the Long-Term Plan (LTP), the Quarterly Report to Council (QRC), Budget Planning and other internal and external reporting elements.

The main result of the *Project Plan and Integrated Project Review (IPRev)* project is a fully qualified policy



The five Inter-Directorate Reform projects, their objectives and main results

and process for the establishment of Project Plans and Integrated Project Reviews. The Project Plan is a new internal standard tool that defines an ESA project through its key parameters in all phases of a project or major activities. The Integrated Project Review is a versatile optional tool for clearing Project Plans for authorisation or to assess the status or risks of projects. IPRevs are chaired by the Director General and attended by the key Directors involved in the project, and may be supported through an independent assessment by a small team of ESA experts from other Directorates. The new policy and process have already been successfully applied for the definition of 16 Project Plans, the conduct of 14 IPRevs and the performance of 9 independent assessments. The Project Plan and Integrated Project Review is an essential tool for the preparation of all new programme proposals for submission to ESA Member States, particularly in the context of the next ESA Ministerial Council in 2008.

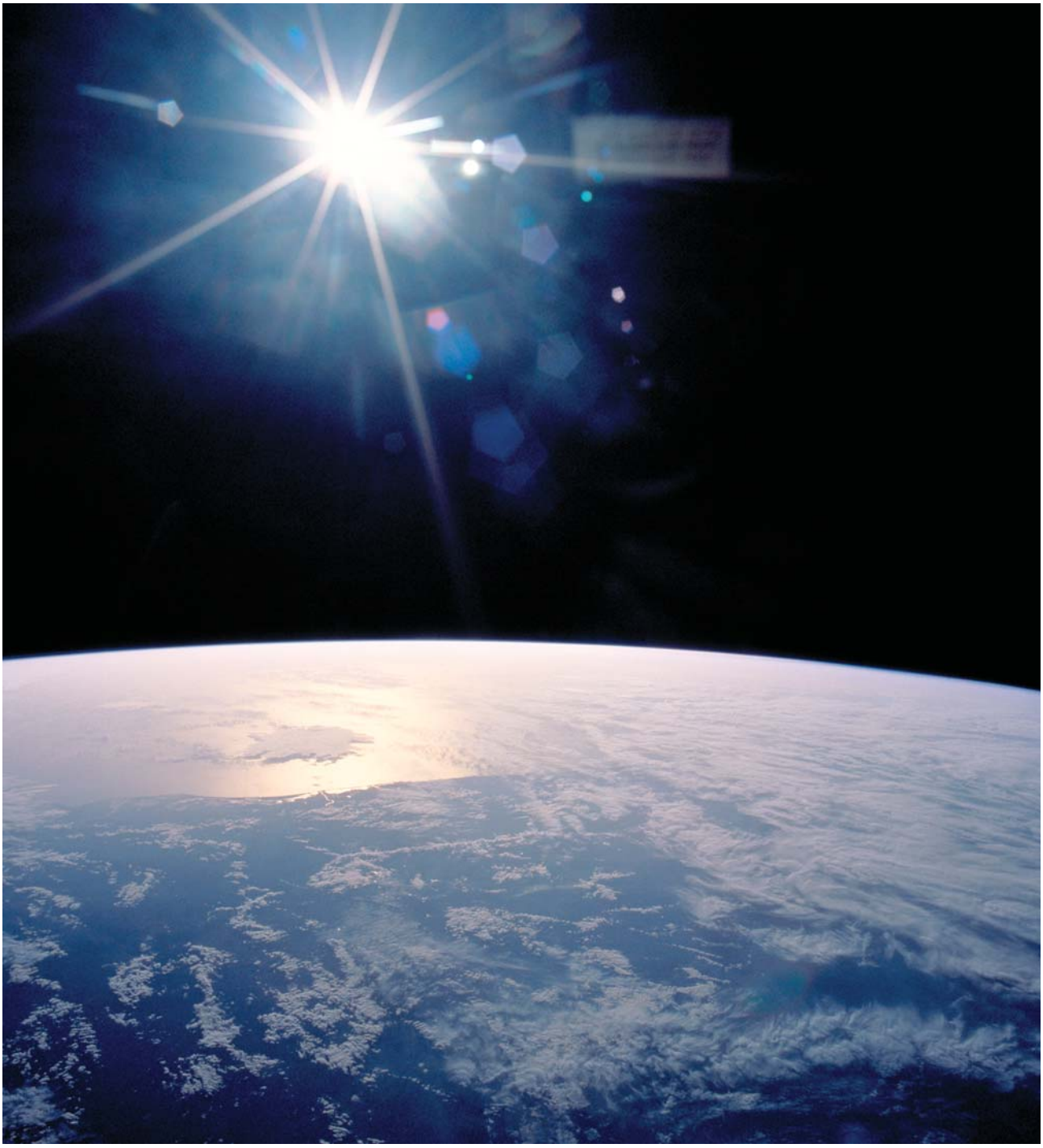
The *General Budget Structure and Charging Policy* project has elaborated a proposal for a revised General Budget structure and charging policy, leading to greater transparency and accountability of the various services and activities performed within this budget. Particular emphasis was put on achieving improved definition of end-to-end functions and their cost charging for the various activities and services, and increased user orientation of administrative and support services. For this purpose, a clear grouping has been established with 'basic activities' to be funded by the Level of Resources, and 'support activities' to be funded through a charging process. All of this should lead to a more direct costing of services to programmes, a redistribution of indirect recharges and, last but not least, greater responsibility and accountability of service suppliers and thereby a more user-oriented and stable General Budget. The results of this project will be incorporated into the Financial Reform.

The main objective of the *Corporate Information Systems* project was to establish the framework for providing adequate corporate information systems support to users throughout ESA. The project has established a policy outlining the guiding principles for developing and maintaining efficient and effective information systems and tools at corporate level supporting users Agency-wide. The policy also identifies the roles and responsibilities governing the management of corporate information systems services, and introduces key features, like the technology and application architecture and common data structures. Furthermore, the project succeeded in delivering for the Corporate Controlling domain an operational tool using existing data structures and supporting users in all Directorates. The establishment of this common tool engaged all stakeholders in a common dialogue and thereby also benefited from the existing solutions in the Agency. The policy framework established in parallel aims to ensure that such synergies are also pursued in other undertakings in the future.

The Inter-Directorate Reform effort was completed by the end of 2006 with definitive proposals for new policies and processes that should improve the Agency's managerial effectiveness. The challenge is now to put them into effect for the benefit of ESA, its managers and projects, programmes and activities. The achievement of these results was possible only due to the strong support of participants in all Directorates, working together towards common goals and seeking to improve the way in which we manage our various activities and ESA as a whole.

International Relations

During the year, delegations from Cyprus, Estonia, Slovenia, Lithuania and Bulgaria expressed interest in ESA's programmes and visited its centres. Estonia has already formally requested to conclude an Agreement with the Agency.



New European Union Member States

Hungary has officially applied to become an ESA Member State and negotiations will start soon. There are around 27 PECS (Plan for European Cooperating States) projects running in Hungary, and 15 in the Czech Republic. The Czech Republic also expressed its intention to begin negotiations for accession in the near future.

Romania and ESA signed an ECS (European Cooperating State) Agreement on 17 February in Bucharest. The selection of projects under the PECS Charter has been concluded and is awaiting final approval. The discussions on the ECS Agreement with the Polish authorities have almost been finalised.

Signature of Romania's European Cooperating State (ECS) Agreement in Bucharest on 17 February

Space-faring Nations

Canada

The most recent Cooperation Agreement between ESA and Canada came into force on 1 January 2000 for a period of 10 years. A formal mid-term review of this cooperation took place during a visit by the ESA Executive to the Canadian Space Agency on 3/4 May. In fact, a 'space bridge' has spanned the Atlantic since 1979, when Canada and ESA signed their first Cooperation Agreement. Canada's involvement in a number of ESA programmes remains mutually beneficial, helping European and Canadian firms to get to know each other better and encouraging cooperation between them.

Canada and Europe have worked together on a range of leading-edge satellite-communication technologies and practical applications, as well as on Earth observation technology, developing radar satellites and commercial applications for satellite data.

Wishing this cooperative relationship to continue, ESA and Canada will work closely together to prepare for the renewal of the Agreement.

United States

ESA and its international partners reached agreement on a revised configuration, assembly sequence and transportation strategy for the International Space Station (ISS). Assembly activities resumed in earnest with three Shuttle flights, and the ISS crew size was increased to three.

Development of a space exploration strategy for future robotic and human missions was initiated, integrating the common interests and objectives of the 14 participating space agencies into a comprehensive vision for a globally coordinated exploration of the Moon, Mars and beyond.

The adjustments in the NASA science programme to fit with its budget and the focus on exploration have not directly affected any ESA/NASA cooperative space science projects, and preparations for future missions such as the James Webb Space Telescope, LISA, and Herschel-Planck are proceeding.

Russian Federation

Cooperation with Russia was further strengthened during the year with the creation of a common space dialogue between ESA, Roskosmos and the European Commission. The three Director Generals, Messrs Dordain, Perminov and Zourek, met in Brussels on 10 March and committed to strengthening Euro-Russian space relations. They agreed to set up joint working groups dedicated to the areas of: Earth observation, satellite navigation, satellite communications, launch systems, space ships, fundamental space sciences and applied space sciences and technologies.

The Astrolab mission, involving a long-duration visit by ESA astronaut Thomas Reiter to the ISS, began in July and ended in December. With his arrival at the Station,

the permanent crew was increased to three. He took on the role of a Russian flight engineer, performing ISS system activities as well as executing a challenging ESA scientific programme.

ESA and Roskosmos began discussions in 2006 on the possibilities for developing a common Crew Space Transportation System, and agreed to undertake a preparatory programme.

Japan

The Agency continued to hold regular meetings with Japan. In addition to their traditional cooperation in the framework of the ISS, ESA and the Japan Aerospace Exploration Agency (JAXA) cooperate actively in the fields of mission operations and product assurance and safety. At the beginning of the year, ESA and JAXA established a new cooperation in the space-components domain.

In the field of Earth observation, after the successful launch on 24 January of ALOS (Advanced Land Observing Satellite), Japan's latest Earth-observation satellite, ESA and JAXA were able to implement their Memorandum of Understanding (MoU) on the ALOS Data Node. ESA is supporting ALOS as a 'Third Party Mission', which means that the Agency will use its multi-mission ground systems, involving existing national and industrial facilities and expertise, to acquire, process and distribute data from the satellite. ESA is hosting the ALOS European Data Node (ADEN), delivering both near-real-time and offline data to scientific and operational users across Europe, and also Africa.

In the field of space science, ESA and JAXA pursued their strong cooperation on various missions. In July, they signed an MoU on cooperation on Solar-B. It enables JAXA to use the Svalbard Ground station in Norway, while ESA gets immediate access free-of-charge to all scientific data from the mission. After the successful launch of Astro-F on 22 February, ESA and JAXA were able to implement their cooperation on the 18-month mission, which delivered its first images in April. ESA and JAXA have also finalised the text of an MoU regarding cooperation on the ESA BepiColombo mission to Mercury, for which JAXA will provide the Magnetospheric Orbiter (MMO).

In the framework of the existing Staff Exchange Programme, ESA and JAXA pursued the exchange of astronaut training instructors for three-month periods.

China

ESA/China cooperation in the field of Earth-observation application development continued during the year. The third Dragon Symposium, held at Lijiang in Yunnan province in July, attracted more than 170 participants from China, Europe and beyond. The programme is advancing satisfactorily.

Cooperation with China on Galileo is based on the Agreement between the National Remote Sensing Centre of China and the Galileo Joint Undertaking. Chinese industry is well advanced in the development work related to the Chinese contributions to the In-Orbit Validation (IOV) Phase.

In the area of space science, ESA and the China National Space Administration held their third annual meeting, at which the two sides presented their respective programme plans and addressed possible opportunities for cooperation.

India

On 15 June, ESA's Director General Jean-Jacques Dordain met with Dr G. Madhavan Nair, the Chairman of ISRO, on the occasion of the 25th anniversary of the launch of India's Apple spacecraft by an Ariane vehicle. Both parties proposed to increase cooperation between the two agencies over the next five years, particularly in the fields of Earth and space sciences.

Good collaboration has been established between ISRO and Europe on Chandrayaan-1, India's first lunar mission, expected to be launched in 2008. The plan is to fly three European instruments on board. Other ESA contributions to Chandrayaan-1 concern the flight dynamics and mission analysis.

There were ongoing discussions between ESA and ISRO during the last half of 2006 to formally extend the current agreement, signed in January 2002, for a further period of five years via an Exchange of Letters. Such an extension was approved by both the ESA Council and ISRO.

Others

Asia-Pacific region

The Asia-Pacific region is seeing a rapid growth in space activities. The Republic of Korea, for example, successfully launched the Kompsat-2 remote-sensing satellite. ESA focused its activities in the region mainly on support to Agency programmes:

- contact with New Zealand regarding the installation of a mobile ground station to track Ariane-5 during the first ATV launch (Jules Verne mission);

- maintenance of close relations with the Department of Education, Science and Technology of Australia's Federal Government for optimal use of the ESA deep-space antenna in Western Australia and for the temporary installation of a mobile tracking station at the University of Adelaide for the first ATV mission. Bilateral discussions continued regarding the eventual extension of ESA/Australia cooperation to include space applications, such as Earth observation, telecommunications and navigation;

- identification of possibilities for scientific cooperation with ANGKASA (Malaysia's National Space Agency) in the context of ESA's microgravity programmes in the life and physical sciences for the flight of the first Malaysian astronaut to the ISS on a 10-day Soyuz mission in September 2007;

- contact with MONRE (Ministry of Natural Resources and the Environment) in Vietnam regarding institutional support to EADS for the installation in 2007 of an Earth-observation ground receiving station (Spot and Landsat) at the National Center for Remote Sensing in Hanoi;

- successful installation of an ASAR transponder (calibration station) in Kalimantan, Indonesia, for the remainder of Envisat's operational lifetime - it will be used as a precision target for calibrating of the spacecraft's ASAR instrument.

Africa
The European Union's Strategy for Africa adopted in 2005 in response to the World Summit for Sustainable Development and the UN Millennium Goals recognises the need for timely access to accurate and reliable information, including satellite-based data. The Tiger initiative is ESA's response to the challenge of water-resource management; its expansion into Africa will be enhanced through the setting up and local staffing of the Executive Bureau. ESA's support for the search for funding for extending EGNOS operational services over the African continent will drive improvements in air-traffic management and safety.

Turkey
The Framework Cooperation Agreement between ESA and the Government of Turkey concerning Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes was unanimously ratified by the Turkish Parliament, thereby triggering the investigation of potential cooperative activities, mostly in the areas of space science, Earth observation and education.

Argentina
ESA and Argentina have pursued their cooperation through the implementation of the Cooperation Agreement between ESA and the Government of the Argentine Republic signed on 11 March 2002. ESA experts participated in training courses organised by CONAE.

Brazil
ESA and Brazil pursued their cooperation on the use of the Natal tracking station. In the framework of the Cooperation Agreement between ESA and the Government of the Federative Republic of Brazil concerning Space Cooperation for Peaceful Purposes, signed in Paris in 2002, ESA has financially supported two years of training for a Brazilian expert in the analysis of Cassini-Huygens mission data.

International Organisations

United Nations
As an observer to the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS), ESA pursued its coordinating role to achieve common European positions within COPUOS as well as its subsidiary bodies. In 2006, ESA renewed its support to the series of workshops and training courses organised by the UN Office of Outer Space Affairs (OOSA) within the framework of the UN Programme on Space Applications.

GEO (Group on Earth Observation)
ESA continued to play an active role in GEO, where member states and international organisations are working together to establish a Global Earth Observation System of Systems (GEOSS). The Third Plenary Session of the GEO took place in Bonn, Germany, on 28/ 29 November.

Communication

Jubilant Venus Express team members and Communications staff at ESOC in April, together with the Director General

It was another outstanding year for Communication, with highly successful ESA missions to Venus and the Moon, with two missions carrying ESA astronauts that drastically increased public awareness of space in many Member States, and with the successful launch of MetOp.

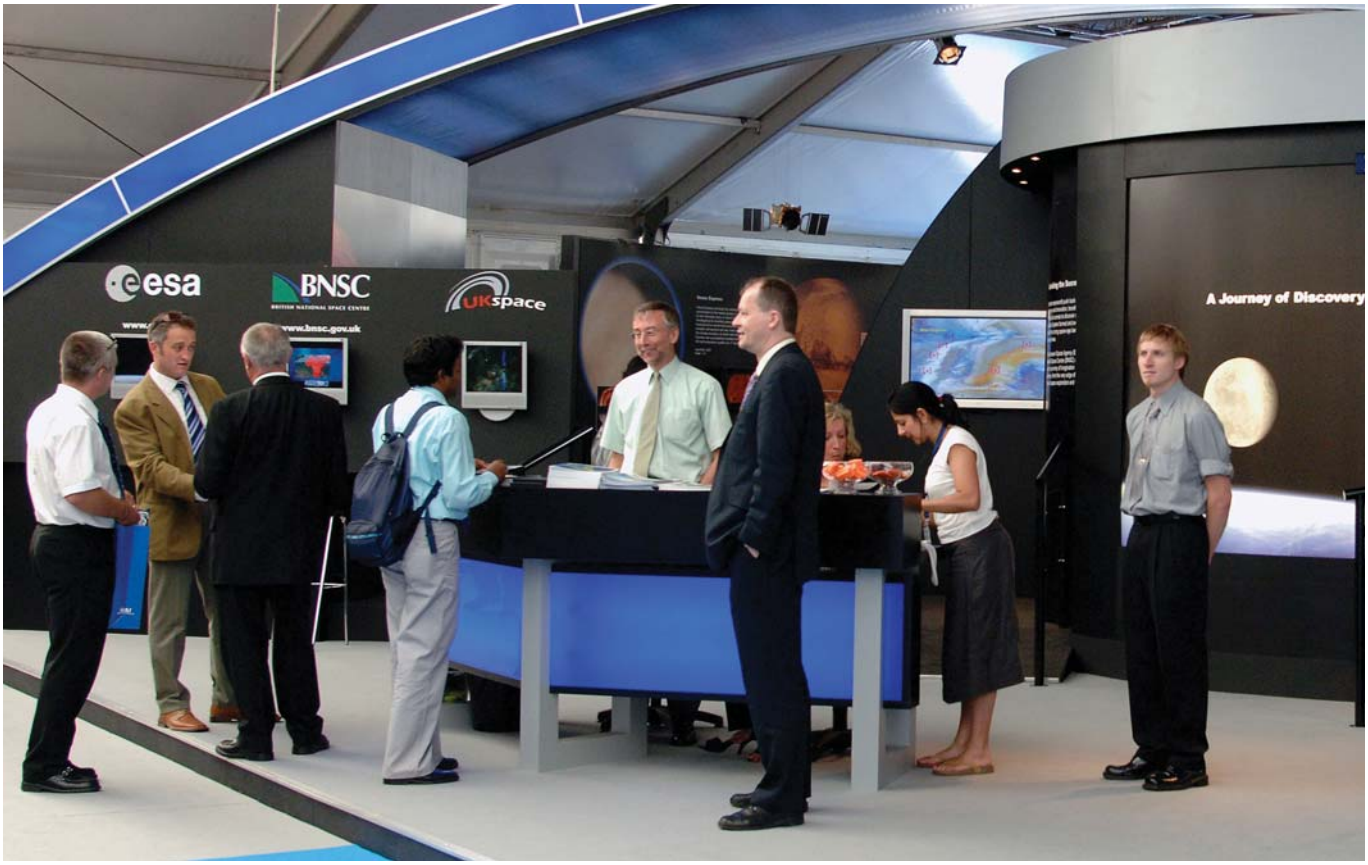
Communication Campaigns

In addition, the ESA Establishments received high-profile visits from very important politicians and national authorities, showing the increasing relevance that space is acquiring in Europe.

The relevant campaigns were conducted by the Communication Department in close cooperation with the respective ESA Programme Directorates and Member State Delegations.

Venus Express

The spectacular entry of Venus Express into orbit around the planet in April was one of the main events in the area of space science. Interest was high and the media coverage was excellent with a large media attendance at the ESA Establishments, in addition to the 98 media representatives who watched the event live at ESOC. When the first Venus image was published on the web, two days after orbit insertion, around 200 000 pages were downloaded. More than 444 TV reports were broadcast and 150 press



The joint ESA/BNSC/UK Space stand at the Farnborough International (UK) airshow in July

clippings collected, demonstrating the public's interest in planetary missions.

Columbus

To mark the delivery of the Columbus laboratory and to allow a viewing opportunity prior to its shipment to Kennedy Space Center (KSC) in May, a Columbus Media Day was organised in Bremen (D), in coordination with EADS and Alenia, for prominent decision makers, national and international media representatives, as well as the general public. The German Chancellor, Mrs Angela Merkel, participated and made a key speech in support of space.

Vega

Communication activities in the framework of the small launcher programme included a press trip for European journalists to the Z23 firing test in Sardinia (I) in June, and to witness the P80 engine test activities in Kourou in November (organised jointly with CNES). A special feature on Vega was produced with EuroNews.

Astrolab

The 'Astrolab' mission, from July to December, with ESA German astronaut Thomas Reiter and the first ESA long-duration mission onboard the International Space Station (ISS), attracted record interest from target audiences in all Member States. Media coverage was very high in Germany, where the launch was televised live during half-time in the World Cup football semi-final hosted by Germany, thereby reaching an audience of 20 million viewers. In addition to regular reporting on the ESA web portal, some new initiatives such as a 'blog' during Reiter's spacewalk (EVA) and 'vodcasting' were introduced. An unprecedented number of in-flight calls with the ISS allowed 44 events to be organised in Germany and other Member States, 22 of which were live links with Thomas Reiter in orbit. A rich variety of associated events were also organised, including interviews with high-ranking politicians, prime-time TV appearances, and educational activities.

Celsius

In December, ESA astronaut Christer Fuglesang became

the first Nordic astronaut in space, with the 'Celsius' mission to the ISS. The communication campaign generated overwhelming interest in the mission itself and space in general amongst the public, the media and politicians in the Nordic countries, especially Sweden.

The 'Europe in Space/Sverige i Rymden' exhibition in Stockholm (S) during Christer Fuglesang's Celsius mission to the ISS, organised together with the City of Stockholm and the Swedish National Space Board, attracted around 60 000 visitors, including high-ranking politicians and personalities.

A live in-flight call from the ISS, during which Christer Fuglesang talked to the Swedish Crown Princess Victoria and Vice Prime Minister Maud Olofsson, was watched by 1.3 million viewers. Christer Fuglesang participated in three of the four spacewalks (EVAs) to work on the construction of the ISS, including one unforeseen but very successful EVA to solve a problem with a retractable solar array.

SMART-1

The impact of the SMART-1 spacecraft on the Moon in September received extensive coverage from the international media as a positive contribution by Europe to exploration and advanced technology. Positive reporting was achieved through a mixture of extensive web coverage with articles and photographs of the Moon and scores of interviews given by ESA specialists. The popularity of planetary missions with the general public was underlined by ESA web portal visitor figures and the extent of worldwide TV coverage of the subject. A competition on 30 radio stations and in several European magazines also contributed to the success of the communication campaign.

MetOp

A joint ESA/Eumetsat communication campaign covered the mission during the run-up to the successful launch of the satellite in October. It included a joint press trip for European journalists to Toulouse (F) prior to the shipment of MetOp to Baikonur from EADS Astrium, a joint pre-launch press trip to Baikonur, and press activities around the launch event. A special mini-site was set up on the ESA web portal with articles, in-depth interviews with the various partners in the mission, a launch campaign diary and streaming of the launch. Despite repeated delays, the launch itself received good coverage from the written media and TV broadcasters.

The ESA stand at the IAC in Valencia (E) in October

Media Relations

More than 500 interviews were handled through Headquarters alone, as well as several hundred others throughout the various establishments, involving ESA senior management and specialists in the various space disciplines.

51 corporate Press Releases and Information Notes were issued and distributed to the written media, radio and TV stations throughout Europe and beyond, and posted on the ESA home page on the web portal.

Media Relations also organised 12 press trips and invited international journalists to 11 press conferences, working with some 300 media representatives from ESA Member States who regularly follow the Agency's activities.

As a result, more than 2800 articles were published in main European print media, with a potential audience of more than 345 million readers, a 10% increase on previous years.

The ESA TV Service produced 76 videos, 12% more than in 2005, and distributed them via satellite to the television networks. These covered all ESA programmes and main events and were also made available on videotape to professional users. Most were also released

as podcasts on the ESA web portal. Preparations were also started to make them available free-of-charge in DVD-quality via the internet. This new service will be rolled out early in 2007.

Live transmissions were set up enabling broadcasters and the public to follow key events at ESOC (SMART, Venus Express), the launches of MetOp (with Eumetsat) and COROT (with CNES), and numerous events involving ESA astronauts, such as Thomas Reiter talking to German Chancellor Angela Merkel and Christer Fuglesang talking with Swedish Crown Princess Victoria and Vice Prime Minister Maud Olofsson.

2215 subscribers now receive e-mails notifying them of the availability of new TV material, a 15% increase with respect to 2005. To strengthen relations with larger independent producers and editors, ESA participated in MIP-TV 2006, the world's biggest audiovisual programme market, via an invitation from the European Commission to join its pavilion.

The contract with EuroNews for a bi-weekly Space Magazine continued in 2006 and 20 such programmes were produced, each of which was transmitted 21 times. EuroNews offers each story to public broadcasters in Europe via the European Broadcasting Union (EBU). The European Commission, which has a similar arrangement with EuroNews, estimates that it reaches 15 million viewers, directly and indirectly, with every magazine programme. Important synergies with the EBU were also exploited in covering the STS-121 and STS-116 launches, generating many interviews with ESA spokespersons during Shuttle launch coverage.

2006 saw the start of use of the High-Definition Television (HDTV) format and the first productions will be rolled out in 2007 for ESA events and exhibitions, and for the HDTV cable channels.

Exhibitions and Events

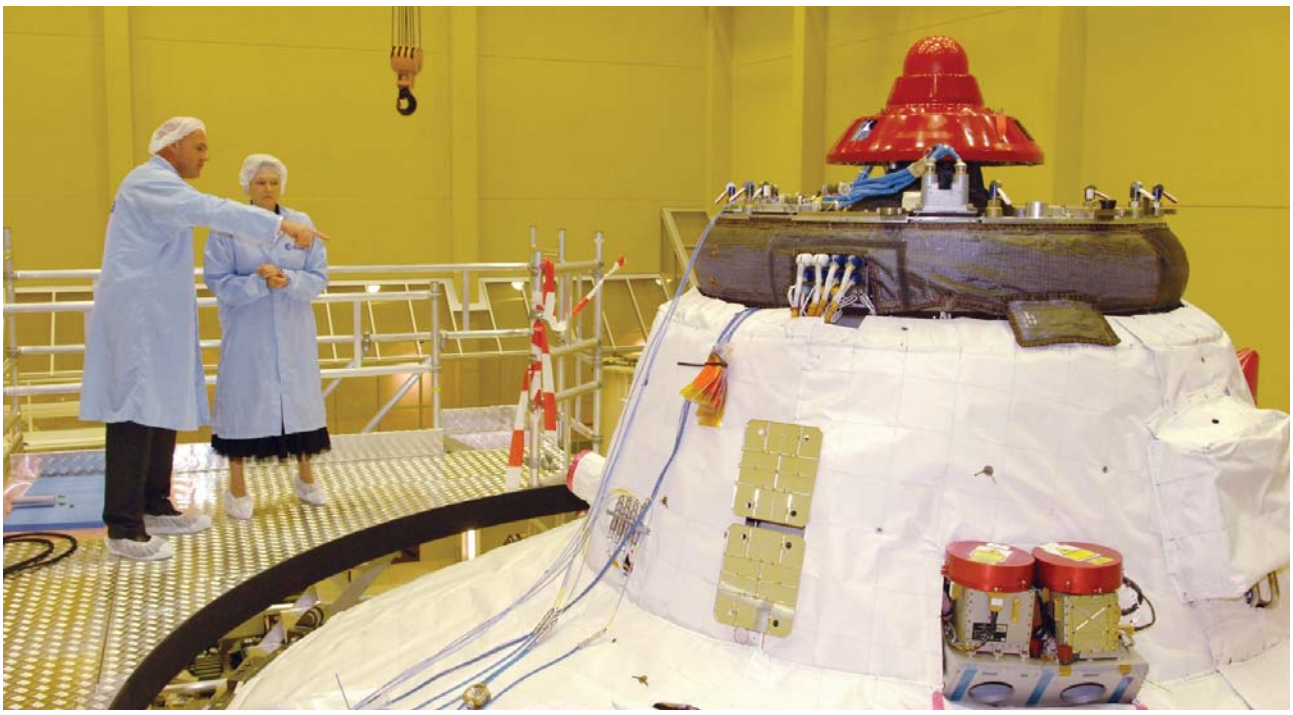
Amongst the many exhibitions organised in the Member States throughout the year, one of the highlights was undoubtedly the joint ESA/DLR/BDLI pavilion at the International Air and Space Show (ILA) in Berlin in May. It was visited by more than 50 000 members of the general public and numerous high-ranking parliamentarians and VIP guests. ESA also participated at the other main international airshow, Farnborough International, in July, presenting 'A Journey of Discovery' together with BNSC and UK space industry in an international space pavilion. The 'Space Day' provided a platform for the heads of international space agencies, the UK Minister and industry figureheads to meet, network and discuss the international space industry's future.

The ESA exhibition stand at the International and Astronautical Congress (IAC) in Valencia (E) in October provided a forum for ESA staff to discuss programmes in detail with conference delegates. Informal sessions with young professionals were highly valued and well-attended.

Continued cooperation with various science and space museums and other institutions organising exhibitions for the general public allowed further promotion of ESA's programmes.

Online Communication

The success of the ESA web portal has continued with ever-increasing content and multimedia feature enhancement. Daily updates on all aspects of ESA's activities were delivered at a rate of at least one new story per working day, and special web coverage was given to all major events, producing visitor peaks around the SMART-1 lunar impact in September (7 million page views) and the return of ESA astronauts Thomas Reiter and Christer



Dutch Minister Maria van der Hoeven being shown the ATV during her visit to the ESTEC Test Centre in July

Fuglesang from the ISS in December (more than 6 million page views). The portal was further enriched with the launch of a new Earth Observation mini-site known as 'MIRAVI', which provides users with near-real-time images taken by Envisat.

The portal has evolved in line with the latest web communication trends. The addition of ESApods (audio and video podcasts) has transformed it into a 'live' communication tool. ESA news can now be received by mobile media users on devices such as the iPod. With the introduction of RSS feeds, journalists and other media representatives can follow updates delivered directly to their desktops, without having to surf the internet. It is worth noting that the ESA 'vodcasts', newly introduced in 2006, are already globally recognised by the specialist sites.

Analysis of the Agency's present corporate identity was commenced in 2006 not only with the goal of Agency-wide harmonisation but, more broadly, to safeguard ESA's corporate identity and ESA logo. Harmonisation of the design of a large number of technical sites on the ESA web portal was a significant achievement.

A key activity in the last quarter was concept definition for a new ESA Intranet, which will provide more information to, and better communication with, the internal audience.

Internal Communication

Internal communication provided information to staff members throughout the year via: two publications, the house journal 'ESA Today' and 'On the Move', a newsletter published in cooperation with the Human Resources Department to report on staff movements; online communication in the form of 'Internal News' messages disseminated via Lotus Notes; and staff events organised around video transmissions of the main ESA missions, during which presentations are made by key project personnel.

ESTEC

Amongst the many VIP guests to visit ESTEC were six Ministers, from Germany, Russia and The Netherlands, a Chinese astronaut and many decision-makers. On 6 July, ESTEC hosted a meeting of the Innovation Platform, a high-level event attended by the Dutch Minister of Education Maria van der Hoeven and a large group of Dutch captains of industry.

In April, ESTEC co-hosted the ERA Media Day along with Dutch Space, the Dutch industrial contractor, to allow journalists to view the impressive European Robotic Arm (ERA) before its shipment to Russia for launch, and to meet the people behind it.

During the year, some 141 journalists visited ESTEC to interview ESA specialists, and 44 television crews made use of the excellent on-site filming locations, namely the Test Centre, the Erasmus User Centre and Space Expo. ESTEC also received 48 groups of communication-activity-related visitors, mostly university students. Some 11 000 members of the general public took the 'Space Train' from Space Expo for the 'ESTEC experience'. Space Expo itself received 70 000 visitors in 2006.

German Chancellor Angela Merkel during her telephone call from ESOC to ESA astronaut Thomas Reiter onboard the International Space Station

As part of ESTEC's role to provide a 'Country Desk' service to ESA's Nordic Member States, three special events were organised. The main activity of the year, however, for the Nordic countries centred around Christer Fuglesang's visit to the ISS and the ensuing programme of events and media activity. An awareness survey conducted in December by the Swedish Delegation showed new record statistics, with 85% of the Swedish population having heard of Fuglesang and 56% of ESA.

ESOC

Communications highlights for ESOC in 2006 included the successful mission operations around Venus with Venus Express and around the Moon with SMART-1, paving the way to 40 years of operations excellence and much fascination with space in the Darmstadt area.

In April, Venus Express had been gently manoeuvred by ESOC, at a distance of 100 million km, into orbit around Venus. By contrast, the controlled impact of SMART-1 on the lunar surface in September marked an abrupt but successful end to Europe's first mission to the Moon. The dissemination of regular information via the web, complemented by a special media event on 2 September, led to worldwide coverage of ESA's first lunar mission. Both operations scenarios were accompanied by well-prepared corporate communication campaigns, including the fully fledged 'ESA live space event' package in Darmstadt with VIP events, live TV transmissions, event-related media partnerships, etc. Each space event produced around 1000 media reports throughout the ESA Member States, and many more in North America and Asia.

The six-month trip to the ISS by German ESA astronaut Thomas Reiter also clearly helped in achieving another historic peak in interest in space in Germany.

Several high-ranking politicians visited ESOC during the year, the most prominent being the German Chancellor Angela Merkel and Hessen Prime Minister Roland Koch who visited the Establishment in July. A live in-flight call with locally born Thomas Reiter on the ISS was arranged to mark the occasion.

Some 500 media interviews were conducted from ESOC in 2006, and thousands of media reports published not only in Germany, but also in Austria and Switzerland, secured international coverage. Such events again created exceptional public awareness and a positive image for ESA and for space in general. A TNS-Emnid survey conducted at the end of the year showed new records, with 86% of Germans have heard of Thomas Reiter and 76% of ESA. As further confirmation of this continuously rising trend in interest, ESOC hosted 13 000 visits by the general public, and 1000 VIP guests (from politics/industry/science).

ESRIN and ESAC

The Communication Office managed all ESRIN- and ESAC-related communication activities in Italy, Spain and Portugal in 2006. Activities at ESRIN included

launch retransmission events for all ESA missions, in particular the Venus Express orbit insertion in April and the MetOp launch in October. Numerous Press activities were organised in Spain for Spanish ESA astronaut Pedro Duque, and a Press Conference was arranged jointly with ASI in Rome in June to announce the mission of Paolo Nespoli.

Open Days were organised both at ESRIN and ESAC in conjunction with the Science Week. A European Researchers' Night was organised at ESRIN, together with other research centres in the Frascati (I) area.

ESA managed numerous communication events in Italy, Spain and Portugal. A conference with student involvement was organised in Rome (I) in February with the Provincia di Roma and the Chairman of the Italian Parliament. Support was given to local exhibitions as well as those at IDIS in Naples (I) and Scienza Orienta at Tor Vergata University for Astronomy Week.

In Spain, ESA managed an exhibit about Mars at the Madrid Planetarium in April, which coincided also with the announcement of the City of Madrid as the new Member of the Cités des Villes Ariane. ESA also participated in the 'Madrid por la Ciencia' exhibition devoted to science and education, which was visited by over 100 000 people and included conferences and media activities.

In Portugal, a special event was organised at the Ciencia Viva in Lisbon to mark the orbit insertion of Venus Express. ESA also participated in a conference on communication and education in space at the Multimedia Centre in Esphinho.

EAC

There were more than 497 requests for public appearances by ESA astronauts in 2006, 40% of which came from the media.

As the home base of the ESA astronaut corps, the European Astronaut Centre (EAC) is committed to organising events related to specific astronaut missions. During the final phase of ESA astronaut Thomas Reiter's training at EAC, a press conference was arranged to give the media the opportunity to meet him. A live retransmission of his launch was jointly organised with DLR at the Columbus Control Centre in Oberpfaffenhofen (D).

EAC also promoted ESA activities in general via a 'Night of the Astronauts' event in Barcelona (E) in March, co-organised with Barcelona City Council and CDTI. 3400 members of the public attended this spectacular event.

As part of the ongoing effort to increase the visibility of ESA, EAC and human spaceflight activities, new promotional material was produced, including photographic and video material shot during actual missions and mission training.

Visitors to ESRIN's virtual-reality theatre during the centre's Open Day in March

The 'Night of the Astronauts' in Barcelona (E) in March

EAC welcomed more than 7500 visitors through its doors in 2006.

Publications

The output of ESA Publications Division in 2006 included the Agency's *Annual Report* to Council, ESA's Report to the 36th COSPAR Meeting in Beijing, 4 issues of the *ESA Bulletin*, 15 scientific/technical monographs and reports, 12 brochures, 6 newsletters, 2 training manuals, 2 ESA History Reports, 3 ESA/European Technical Standards, 25 proceedings of ESA conferences and symposia, 7 workshop proceedings, and 70 contractor reports.

As usual, requests for the Division's support and services were received from Divisions and Departments within all of the ESA Directorates and from all of the ESA establishments. The products needed ranged from a simple four-page folder to promote a particular programme or event, to the editing and production of a highly technical 550-page volume for the EGNOS project. Several of the publications requested by Directorates in 2006 were a direct consequence of the deliberations at, and outcome of the ESA Ministerial Council in Berlin in December 2005.

As always, the goal was the provision of a quick high-added-value editing/writing/design and production service resulting in high-quality publications at minimum cost.

A full listing of all of the latest publications can be found in each quarterly issue of the *ESA Bulletin* and on the frequently updated ESA Publications web site on the ESA portal.

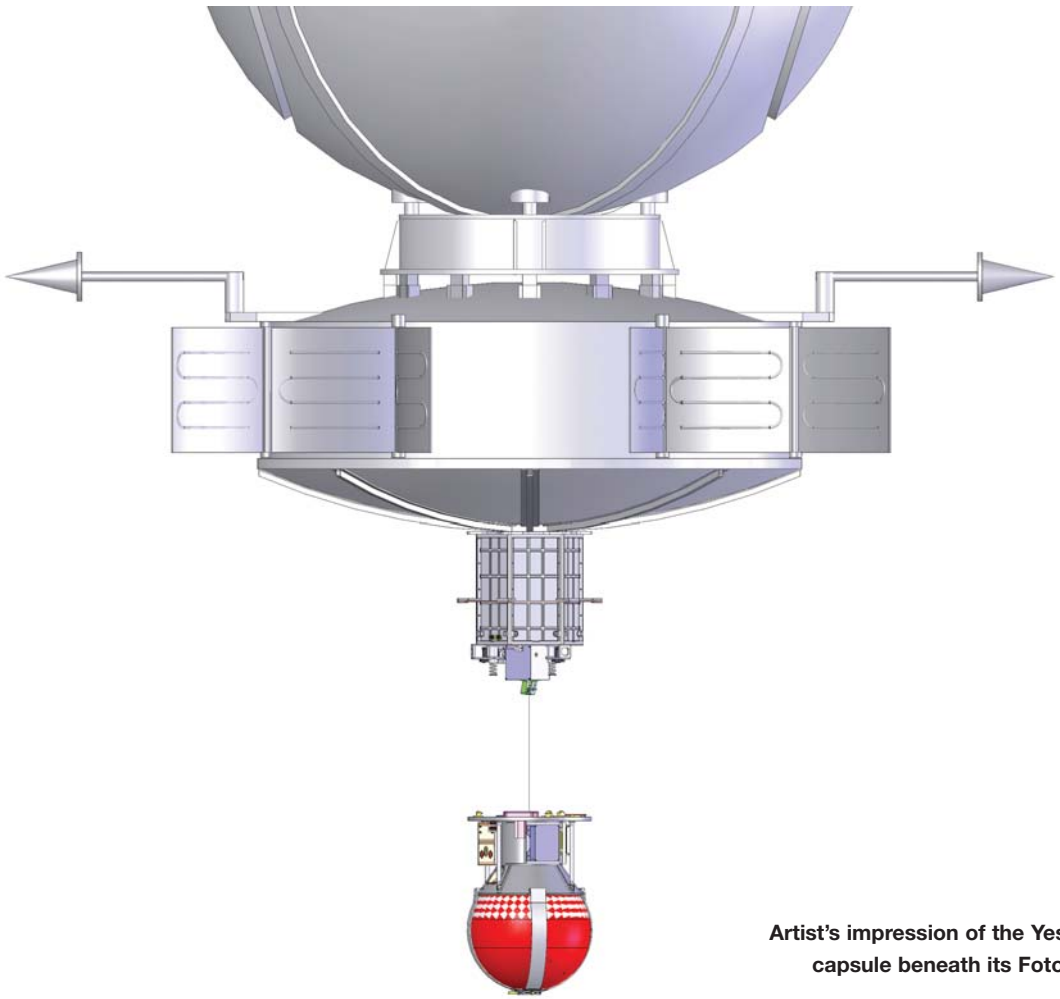
The team's reputation for quick service and high-quality products again resulted in requests to ESA from several national space organisations for Publications support, including the International Space Science Institute (ISSI) in Bern (CH) and the International Space University (ISU) in Strasbourg (F).

Education

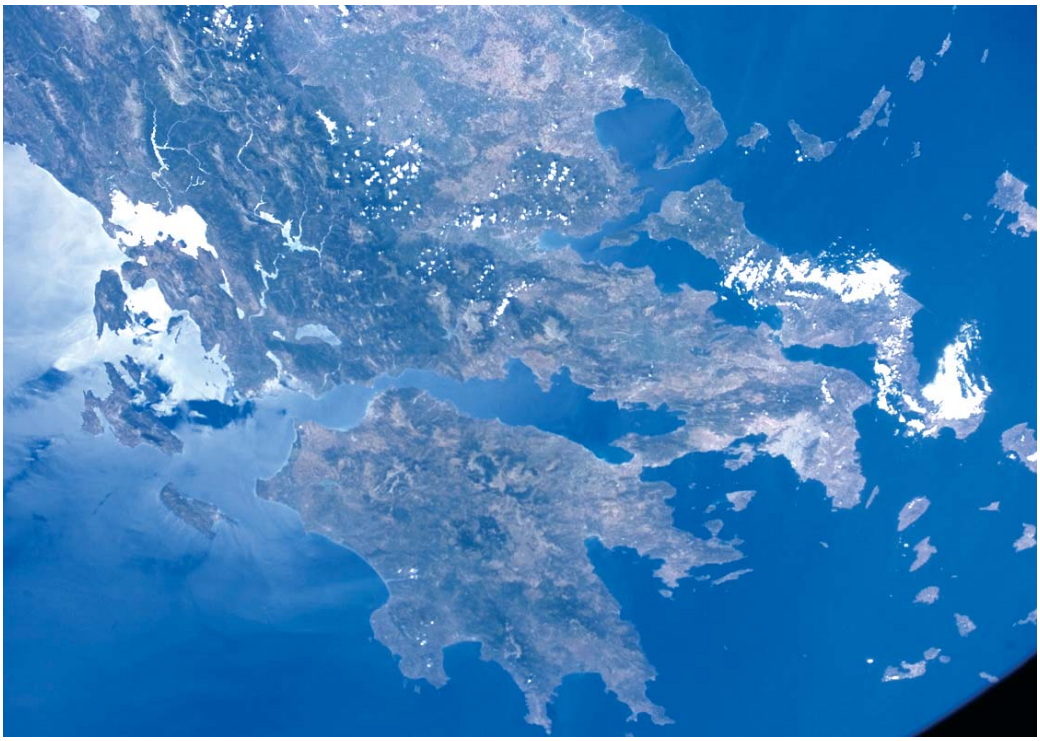
ESA's educational hands-on projects are intended to provide university students with practical experience in real space projects and to enhance their motivation to pursue a career in the fields of space technology and science, thus helping to ensure the availability of a suitable and talented workforce in the future.

Hands-on Projects

High levels of academic expertise in specific space-related fields exist throughout European universities. However, these units currently operate independently of each other. The hands-on projects of the Education Department have the potential to combine these isolated centres of expertise, offering students access to a powerful network, capable of designing, developing, integrating, testing, launching, and operating intricate and technologically challenging student spacecraft and payloads. Student hands-on projects include the development and operation of small satellites, provision of payloads for satellites, parabolic-flight campaigns, sounding-rocket and stratospheric balloon-flight campaigns, and student mission-design workshops. It is estimated that over a period of 10 years about 5000 students have been involved in these hands-on projects and that more than 100 Masters and PhD theses will result from them.



Artist's impression of the Yes 2 'Fotino' capsule beneath its Foton-M3 host



Greece photographed by ESA astronaut Thomas Reiter from the International Space Station during his radio contact with students at the ESA Space Camp in Patras

Satellite Projects

The Student Space Exploration and Technology Initiative (SSETI) consists of a series of micro-satellites the first of which, a 62 kg satellite called 'Express', was successfully launched on 27 October 2005 by a COSMOS-3M from Plesetsk (Russia) into a low-Earth, Sun-synchronous orbit.

These micro-satellites are designed and built entirely by student teams. The ESA Education Department provides network facilities for the exchange of information and discussion of problems and solutions, identifies a suitable launch vehicle and covers the launch costs, provides technical and management coordination, organises and sponsors regular workshops at ESTEC during which the student teams agree on their interfaces and can receive advice from ESA experts, manages the integration and testing of the spacecraft, including the provision of the test facilities, and manages the launch campaign.

Another series of micro-satellites is the Young Engineers' Satellite (YES) programme. YES 2 is currently being prepared for launch from Baikonur into a low-Earth orbit (280 km altitude) on 14 September 2007, together with the Russian Foton-M3 capsule carrying a microgravity payload primarily provided by ESA. YES 2 consists of three elements, two of which will be lowered from Foton-M3 on 25 September using a 30 km long tether to reduce orbital energy. Once fully unreeled, the tether will be cut and a fully instrumented small spherical capsule, called 'Fotino', will re-enter the Earth's atmosphere and land in Russia. A Call for Mission Proposals for YES 3 was issued in August. Twenty proposals were received from European student teams in response to this call, of which six were short-listed for further study. The final selection will be made in November 2007.

It has also been agreed that there will be an Education Payload on the maiden flight of Vega, Europe's new launch vehicle. This payload will consist of six university CubeSat pico-satellites that will be deployed in orbit, and potentially a number of small components that will remain fixed to the main test spacecraft. An Announcement of Opportunity for this project will be made in mid-2007, and will be open to all European educational institutes.

Student Parabolic Flight Campaigns

The 9th campaign took place from 28 August to 15 September in Bordeaux. A total of 170 students participated, 142 of them flying on board the Airbus 300 – Zero G. During the campaign, 35 experiments were performed under microgravity conditions in the fields of physics, chemistry, biology and life sciences. Twenty-eight experiments were selected by the Education Department, six by the Belgian authorities, and one by the Italian space agency (ASI). During five flights, the Airbus flew 138 parabolas offering a total of nearly one hour of microgravity time. Between the first and the second flights the aircraft stayed overnight in Brussels.

Sounding Rocket Campaigns

Exploratory discussions are being held with representatives from the Swedish National Space Board to provide a regular possibility for European students to fly small

payloads (typically 30 kg) on sounding rockets to an altitude of 100 km on a regular basis. The Swedish campaign is called REXUS (Rocket EXperiments for University Students) with launches from Esrange in Kiruna. The first launch carrying an experiment selected by the ESA Education Department took place from Kiruna on 5 April 2006.

STRAPLEX

The STRAtospheric PLatform EXperiment is a collaboration between the University of Porto and the ESA Education Department which began in 2005. STRAPLEX offers European students the possibility to send experiments into the stratosphere using balloons filled with helium. The balloons are launched from Evora (Portugal) and can reach an altitude of up to 35 km with a 3.5 kg payload. The first qualification flight took place on 20 December 2005, the second on 23 April 2006. Starting in 2007, one campaign is foreseen every year in September, involving 10 balloon launches. The experiments are provided by student teams working in the fields of engineering, physics, chemistry and biology.

International Activities under the Auspices of the ISEB

The International Space Education Board (ISEB) was created during the 56th IAC in Fukuoka (Japan). The member space agencies are ESA, NASA, JAXA, CSA and CNES. Under ESA's chairmanship in 2006, the ISEB adopted two projects: the Global Educational Network for Satellite Operations (GENSO) and a global CanSat competition. In its fully fledged operational phase (starting in 2008), GENSO will involve more than 100 ground stations, providing vastly improved coverage for all educational and radio-amateur satellites in low-Earth orbit. A CanSat is a satellite in a can, more specifically all the subsystems of a pico-satellite accommodated within the volume of a 330 ml soft-drink can. The CanSats from participating countries will be launched by amateur rockets to an altitude of 4 km. Regional competitions and demonstration events are already taking place.

Student Mission Design Workshops

In the Concurrent Design Facility (CDF) at ESTEC, students have access to a state-of-the-art infrastructure and design tools for spacecraft system/payload design and mission analysis.

Student Participation at Conferences

Presentation of the results obtained by the students is considered an integral part of the hands-on projects. For the 57th IAC in Valencia (Spain) on 2-6 October, 80 students were selected from almost 400 applicants and their attendance sponsored by ESA. In 2006, ESA also sponsored the participation of: 67 students at the annual Student Technology Education Conference (STEC) on 9-12 May in Braunschweig (D), 22 students at the 36th COSPAR Scientific Assembly on 16-23 July in Beijing (China), and 65 students at the 1st Hellenic-European Student Space Science and Technology Symposium on 9-11 October in Patras (Gr). It also contributed to the annual Alpbach Summer School in Austria.

European Space Education Resource Office (ESERO)

The implementation of the ESERO (European Space Education Resources Office) pilot project is now well underway in The Netherlands, Spain, Belgium and the United Kingdom. The project is meant, through 'contact points' located in ESA Member States, to support the national education community, to respond to their specific educational needs and to provide easy access to the already existing national networks.

The office in the Netherlands is located at NEMO, the National Centre for Science and Technology, in Amsterdam. It was officially inaugurated in April in the presence of the Dutch Minister for Education, Science and Culture and senior ESA representatives. A comprehensive study report has demonstrated the need for such offices that can act as a 'one-stop-shop' for the development, promotion and distribution of space-related educational materials.

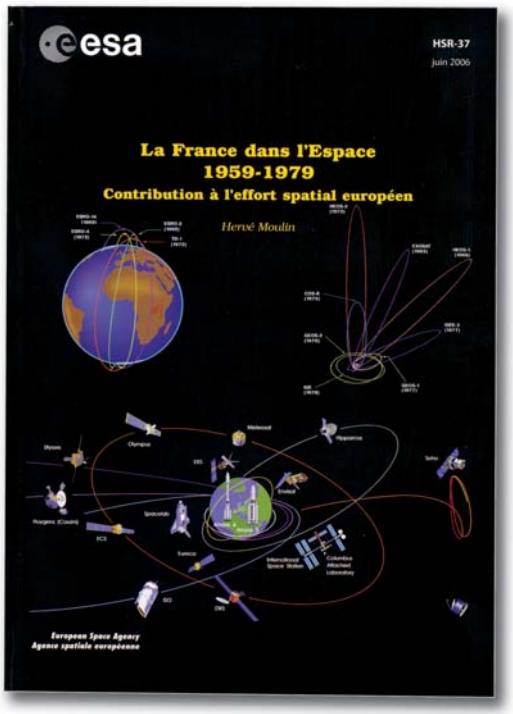
The office in Spain will be located at the science centre 'La CosmoCaixa in Barcelona, whilst that for Belgium will be situated at the Planetarium in Brussels. Inauguration of these two offices is planned for the first quarter of 2007.

The United Kingdom, via 'Yorkshire Forward', a regional development agency, had demonstrated a strong interest in the project. In collaboration with BNSC, ESA has invited 'Yorkshire Forward' to administer a research and consultative phase to establish the pattern for distributed 'ESERO contact points' in the United Kingdom. The results of this study are expected in late March 2007.

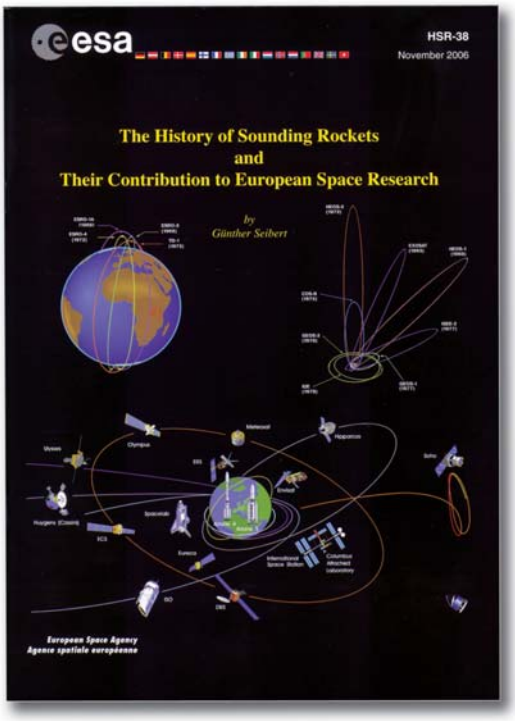
History Project

In the framework of the extended ESA History Project, HSR-37 titled 'La France dans l'Espace 1959-1979, Contribution à l'effort spatial européen', written by Hervé Moulin, and HSR-38 dedicated to 'The History of Sounding Rockets and Their Contribution to European Space Research', written by Günther Seibert, were published in 2006. A short history of the Swedish space programme is in preparation. The accompanying panel provides an overview of the short histories published so far.

In collaboration with Prof. Robert Halleux from the University of Liège, the International Academy of the History of Science is planning to publish eight longer studies in a new collection entitled 'Explorations. Studies in Modern History of Science' in the course of 2007.



HSR-37



HSR-38

ESA History Study Reports

HSR-#	Date	Title	Author
1	July 1992	The Prehistory of ESRO 1959/60	J. Krige
2	October 1992	ESRO's First Scientific Satellite Programme 1961-1966	A. Russo
3	November 1992	Choosing ESRO's First Scientific Satellites	A. Russo
4	January 1993	The Early Activities of the COPERS and the Drafting of the ESRO Convention (1961/62)	J. Krige
5	March 1993	Europe in Space: Edoardo Amaldi and the Inception of ESRO	M. de Maria
6	March 1993	The Definition of a Scientific Policy: ESRO's Satellite Programme in 1969-1973	A. Russo
7	March 1993	The Launch of ELDO	J. Krige
8	May 1993	Europe into Space: The Auger Years (1959-1967)	J. Krige
9	May 1993	The Early Development of the Telecommunications Satellite Programme in ESRO (1965-1971)	A. Russo
10	September 1993	The History of ELDO Part 1: 1961-1964	M. de Maria
11	January 1994	Reflections on Europe in Space	J. Krige & A. Russo
12	January 1994	The Origins of the Federal Republic of Germany's Space Policy 1959-1965 — European and National Dimensions	P. Fischer
13	February 1994	ESRO's Telecommunications Programme and the OTS Project (1970-1974)	A. Russo
14	July 1994	United States–European Cooperation in Space During the Sixties	L. Sebesta
15	February 1995	United States– European Cooperation in the Post-Apollo Programme	L. Sebesta
16	February 1995	The Scientific Programme Between ESRO and ESA: Choosing New Projects (1973-1977)	A. Russo
17	February 1996	The Aeronautical Satellite System: An Example of International Bargaining	L. Sebesta
18	September 1996	The Availability of European Launchers and Europe's Decision 'To Go It Alone'	L. Sebesta
19	August 1997	Big Technology, Little Science The European Use of Spacelab	A. Russo
20	September 1997	The Definition of ESA's Scientific Programme for the 1980s	A. Russo
21	October 1997	Spacelab in Context	L. Sebesta
22	March 1998	The European Meteorological Satellite Programme	J. Krige
23	September 1998	The Third Phase of the Telecommunications Programme ECS, Marecs and Olympus	A. Russo
24	May 1999	ESA's Scientific Programme Towards the Turn of the Century	A. Russo
25	May 2002	Canada and ESA – Three decades of cooperation	L. Dotto
26	August 2002	Spain in Space	J. M. Dorado et al.
27	November 2002	An Overview of Space Activities in the Netherlands	J. van Kasteren
28	December 2002	The 'Triple Helix' of Space – German Space Activities in a European Perspective	H. Trischler
29	February 2003	Belgium's Participation in the European Space Adventure	D. Laureys
30	March 2003	Italy in Space, 1946-1988	M. de Maria L. Orlando F. Pigliacelli
31	March 2003	Switzerland and Space	P. Creola
32	April 2003	Finland and the Space Era	I. Seppinen
33	September 2003	ESRO/ESA and Denmark	P. Gudmandsen
34	January 2004	Austria's History in Space	B. Besser
35	October 2004	Norwegian Space Activities 1958-2003, An Historical Overview	O.A. Røberg & J.P. Collett
36	April 2005	An Overview of United Kingdom Space Activity 1957-1987	D. Millard
37	June 2006	La France dans l'Espace 1959-1979, Contribution à l'effort spatial européen	H. Moulin
38	November 2006	The History of Sounding Rockets and Their Contribution to European Space Research	G. Seibert

Facilities

ESTEC

ESTEC was extremely busy, with the simultaneous system and verification testing of several ESA spacecraft. In addition to the newly arrived Herschel Payload Module structural model, testing of the Automated Transfer Vehicle (ATV), the Herschel structural model and the Planck telescope continued, resulting in a very high workload for the Centre. In view of the ATV's 2007 launch, astronaut training was also performed for late access to space-vehicle parts.

ESTEC Test Centre

Elements of the Vega small launcher were also tested. The payload mechanical dummy and the upper-composite mechanical model underwent vibration testing from June to August, and the latter, including the fairing, underwent acoustic tests in the Large European Acoustic Facility (LEAF) in October.

In parallel with the spacecraft and subsystem testing, the continuous replacement and updating of ageing test equipment continued with the replacement of the mass-property measurement facility, acquired from APCO Switzerland, which came into operation at the end of February. Successful refurbishments were also performed on the control/command and motion systems of the Large Space Simulator (LSS).

Transient vibration tests were conducted on an Airbus A380 luggage pallet using the Hydra (hydraulic shaker) in July. The novel aspect of this test was the simultaneous introduction in six degrees of freedom of transient test excitations that have been measured during flight, for verification of the loaded pallet. The use of this type of aeronautical testing for the verification of satellite hardware will now be considered.

Engineering Laboratories

Power Laboratory
Several ideas and concepts developed within the power-systems and power-conditioning laboratories at ESTEC generated patent applications both in Europe and in the USA. Following up a previous application in France, a US patent was filed for 'Segregated maximum power-point tracking based on step-up regulation', an idea that has been further developed and breadboarded and

which might be used in the power system for BepiColombo. Another new patent application was filed in France for the 'Single-point failure-free S4R concept with respect to battery overcharge', which can preclude single-point failures causing battery overcharging and can be applied, for instance, in the Galileo IOV power system currently under development. Another ESA patent, on 'Zero voltage switching – zero current switching push-pull with regulation', was issued by the French Patent Office in December.

Battery Test Centre

In view of future ESA planetary exploration missions requiring high battery specific energies, a test campaign on new low-temperature lithium-ion cells was initiated in the European Space Battery Test Centre with cells provided by two leading European space battery suppliers. Based on a preliminary mission profile for a Mars rover in the framework of the ExoMars project, a test profile covering descent, landing and operations on the Martian surface was elaborated in cooperation with the cell suppliers. The results will provide a sound basis for the selection of low-temperature lithium-ion cell technology for ExoMars and other future ESA planetary exploration missions.

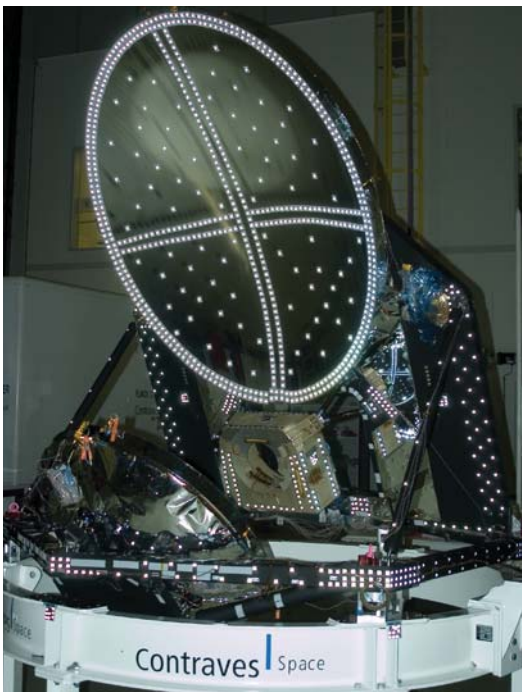
Concurrent Engineering

ESA continued its use of concurrent engineering for space applications and further enhanced the Concurrent Design Facility (CDF) at ESTEC (NL). The latter was used for studies at various levels, such as mission-system, instrument-concept and technology-reference studies, for a wide range of ESA programmes. Studies were also carried out to analyse the potential of disruptive technologies. The CDF concurrent-engineering methodology was applied to the reviews of industrial studies for several programmes. The work of the Herschel-Planck 'Tiger Team' deserves a special mention in this context, whereby a group of European and other experts, scientists and engineers worked together in the CDF to address a complex problem on the Herschel telescope.

Work continued on developing a robust open-source-design server to enable collaborative, concurrent and distributed engineering of space systems based on standard definitions.

The CDF also supported ESA's Education activities through the European Students Moon Orbiter project, involving a large student community, and with training in the context of the ESA Internal University.

The Herschel structural model on the Hydra test facility at ESTEC (NL)



The Planck telescope with videogrammetry targets mounted

The Herschel telescope

ESOC and the Stations

ESOC continued to respond to the immense public interest in space in Germany by maintaining a high level of visibility throughout the year.

The Establishment

The Centre hosted three major space-operations events, associated with the Venus Express orbit insertion, SMART-1's controlled impact on the Moon and the MetOp launch, attended by a total of around 700 invited guests. With some 13 000 visitors, tours of the Control Centre were again at an all-time record. The support given to a number of well-attended space exhibitions in Germany provided an additional window on ESA activities and successfully raised the public's space awareness.

In July, ESA's Director General Jean-Jacques Dordain and ESOC's Head of Establishment Gaele Winters hosted a visit by the new German Chancellor, Angela Merkel, and Roland Koch, Prime Minister of ESOC's host region Hessen. A live call was made to the Hessen-born ESA astronaut Thomas Reiter, as the first of a series of in-flight calls during his six-month stay on the International Space Station.

The Business Incubator Initiative, an ESA Technology Transfer Programme activity already operating successfully at ESTEC, was extended to ESOC in 2006. In close cooperation with and co-financed by the State of Hessen, it was joined by leading industries and research institutions in the region. With a special focus on supporting start-up companies developing innovative satellite-navigation applications, it attracted significant interest from throughout the region. The start-up companies will be hosted by the Technology and Innovation Centre of the Technical University of Darmstadt, located in the immediate vicinity of ESOC.

A number of high-calibre conferences and meetings were hosted at ESOC, involving some 1000 participants drawn from the international scientific, political and industrial communities. They included the second Galileo User Congress organised by the German Government.

German Chancellor Angela Merkel in the Main Control Room at ESOC with Hessen's Prime Minister Roland Koch (centre) and ESA's Director General Jean-Jacques Dordain

The Control Centres

Automated operations for ESA's Deep-Space Ground Stations were introduced at the ESOC Operations Control Centre, marking a further step towards reliable and cost-efficient ground operations. Two of the multi-mission operations facilities at the Centre, the Project Support Room and the Software Support Room, were refurbished and the installations modernised to support upcoming critical mission-operations phases.

The Columbus laboratory will be operated and controlled by the Columbus Control Centre located at DLR in Oberpfaffenhofen (D). The qualification and acceptance of this Control Centre were successfully completed and extensive end-to-end system-validation tests were conducted with the Columbus flight unit and various simulators.

The Automated Transfer Vehicle (ATV) will be operated and controlled by the ATV Control Centre, located at CNES in Toulouse (F). This Control Centre has achieved preliminary acceptance by ESA and an extensive series of system-validation tests were carried out to ensure that the ATV and the Control Centre can communicate properly. The ATV simulators, for crew training at EAC in Cologne and Star City near Moscow and for ground personnel training at the ATV Control Centre, were delivered and are operational.

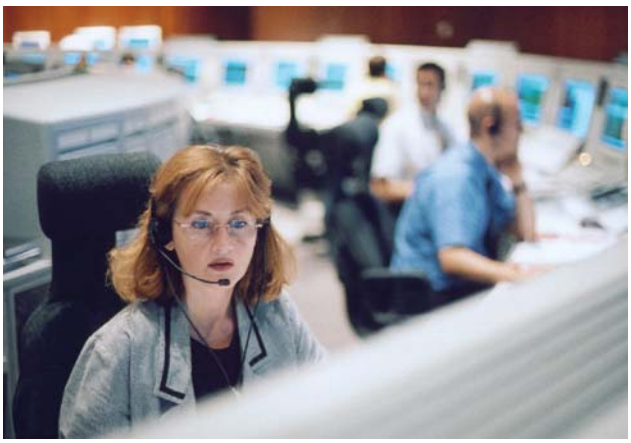
The ATV Control Centre in Toulouse

Mission Operations Infrastructure

The Secure Mission Operations Project will provide mission data systems at ESOC with a second data centre. In the future, missions will be able to distribute their computer systems infrastructure across two physically separated locations, thereby improving the overall resilience of the ground segment. Civil works for the new data centre were completed during 2006 and the essential communications and computer-system services will be installed early in 2007.

A new communications solution for high-volume Delta-DOR data transfers from the deep-space antennas

The Main Control Room at ESOC



was very successfully exploited for the Venus Express orbit insertion.

The Stations

The ESTRACK core network, comprising Cebreros, Villafranca and Maspalomas in Spain, Redu in Belgium, Salmijaervi/Kiruna in Sweden, Perth and New Norcia in Western Australia and Kourou in French Guiana, successfully completed more than 56 000 hours of spacecraft tracking for the various classes of missions:

- for the deep-space missions like Mars Express, Rosetta and Venus Express from the two 35 m deep-space antennas at New Norcia (Australia) and Cebreros (Spain);
- for the near-Earth scientific missions like XMM-Newton, Clusters 1-4, Integral and SMART-1 with classical Telemetry, Telecommand and Tracking (TT&C) antennas in the 15 m range from Kourou (Fr. Guiana), Maspalomas and Villafranca Terminal-2 (Spain), Perth (Australia) and Redu (Belgium);
- for the low-Earth-orbit Earth Observation missions like ERS-2 and Envisat from the Kiruna station (Sweden).

The 35 m ground station at Cebreros, ESA's second deep-space station, successfully supported the Venus Express mission and will be used for ESA's future missions such as LISA Pathfinder, Gaia and Bepi Colombo.

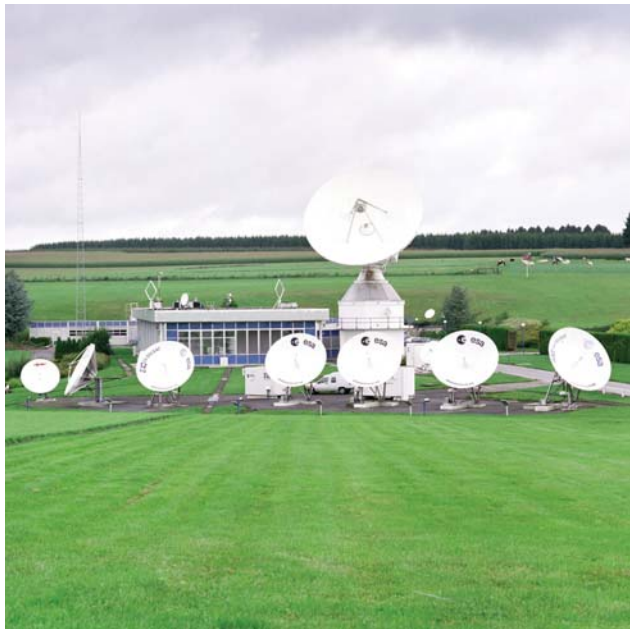
The Redu ground station successfully supported the Proba-1 technology-demonstration mission and is now preparing for Proba-2. An Announcement of Opportunity for the exploitation of the facilities was released and promising opportunities for securing and strengthening Redu's future role were identified.

International Cooperation

ESA benefits from long-term leasing arrangements with Member State countries hosting its ground stations. To support the ESA launcher programme, new ground stations are being built at Santa Maria in the Azores (P), and those in Perth (W. Australia) are being upgraded.

Ground-station support was prepared for the Chinese Chang'E 1 lunar mission during its transfer and orbit-insertion phases. Support to the Chinese Double Star and the Japanese ASTRO-F missions continued successfully.

ESA's deep-space ground station at Cebreros in Spain



ESA's ground station at Redu in Belgium

ESAC

The European Space Astronomy Centre (ESAC), located at Villanueva de la Cañada near Madrid, is a relatively new arrival to the ESA scene. The new facility occupies the grounds of the Villafranca Satellite Tracking Station (VILSPA) and it hosts the scientific operations for ESA's astronomy and planetary missions, as well as their scientific archives.

In the future ESAC, building on the experience of ESA's present suite of planetary missions, is expected to host activities related to the Exploration Programme. Another synergistic activity is that the data processing of the Earth Observation SMOS (Soil Moisture and Ocean Salinity) mission will be located there. Further expansion is expected by it taking an important role in the future Space Surveillance Network. VILSPA also continues as a ground station site, but with a reduced activity level. Since October 2006, ESAC has been managed under the ESA Science Directorate.

2006 was marked by major activities towards developing the site. Extensive refurbishment and a new construction project were undertaken as the site is prepared for a growing number of staff. The site is also being brought up to standard to be able offer the same level of services as ESA establishments (ESTEC, ESOC, HQ and ESRIN). In particular, the IT network has been enhanced and brought up to date using the latest technology to cope with today's high demand for fast and stable high-volume data exchange as the site becomes a central node for European space science data. The host country has played a major part in the development plan that commenced in 2005.

Science

ESAC is now the default location for science operations and archiving activities for all future missions undertaken in the Science Directorate. Over the year there has been a steady expansion of the operational archives for the astronomy missions Infrared Space Observatory (ISO), the XMM-Newton X-ray observatory and the Integral gamma-ray observatory. However, 2006 also marked the arrival of and the first developments for the planetary sciences at ESAC. The missions concerned are: Mars Express, SMART-1, Giotto, Huygens and Rosetta. One highlight here was the release of a map-based interface to the Mars Express data. At the same time, developments in preparation for missions not yet launched continued. In particular, the build-up of the Herschel team began in earnest.

As Herschel work built up, the year marked the official end of the post-operational phase of ISO. ISO was the world's first observatory-class spacecraft working in the infrared band and its archiving was a very important task. The final milestone, making available final data products of the long-term archive, was marked by a well-attended celebratory colloquium in December, during which the many technical and scientific achievements of the mission were reviewed.

Work with XMM-Newton continues apace, with nearly 2000 astronomers worldwide being involved in its Calls for Proposals. The XMM-Newton Science Workshop on 'Variable and Broad Iron Lines around Black Holes' took place at ESAC 26–28 June. The meeting concentrated on bringing together the many discoveries from the European XMM-Newton, US Chandra and Japanese Suzaku missions.

Following its successful move to ESAC in 2005, the Integral Science Operations Centre (SOC) consolidated its operations in Spain during the year. Major highlights included measurements of the high-energy cosmic background radiation using the Earth as an occulting source, and the introduction of 'Key Programmes' as a method of further expanding its use by the community.

The Japanese Akari mission was launched in February and embarked on its all-sky survey at infrared wavelengths. ESA's cooperation with the Japanese agency JAXA in Akari acts as a scientific bridge for the European community between ISO and Herschel missions. As well as the distribution of observing time to European observers, ESAC mission activities included

the production and use of a system to accurately determine where the telescope is pointing at all times.

As launch approaches in 2008, the development of the Herschel Science Centre at ESAC has picked up speed, with particularly significant expansions of data-processing system development and preparations for the initial Herschel Calls for Key Programme observing proposals. In parallel, the Planck Science Office was transferred from ESTEC to ESAC. Although the Herschel and Planck spacecraft are being developed in parallel, their science facilitation through ESAC is very different. In 2006, the Planck team focused on the coordination of science ground-segment development and testing, and on the development of software tools for the operational phase.

The start of industrial work in ESTEC on the Gaia mission, a mission to map up to a billion stars in our galaxy, marked also the kick-off for buildup of the Gaia SOC. Once again, ESAC's role is to be mission-specific and here the enormous scale of the data analysis required is the central issue. The first significant accomplishment was in demonstrating the feasibility of the astrometric global iterative solution for a Gaia-like dataset containing 1 million objects and 5 years of observations.

The year also saw the start of the planned transfer of solar-system science operations to ESAC with the arrival of the first staff and contractors; the main buildup is foreseen for 2007.

Operations

The main TT&C activities were performed using the VIL-2 terminal supporting the cooperative ESA-CNSA DSP mission. VILSPA continued to serve a back-up role for several ESA missions, including XMM-Newton, SMART-1, Cluster and Integral.

Communication and Education

The new ESAC is working to integrate with the surrounding community and to bring the European space endeavour to the attention of the wider community. ESAC welcomed about 3000 visitors in 2006 during numerous scientific and general public events, opening its doors to guests and the international press for ESA launches and other key events like the Venus Orbit Insertion in April. Several media days were also organised with the Spanish ESA astronaut Pedro Duque, in response to press requests. ESAC hosted a Science Week in May and another in November, which were attended by a total of about 1500 students and also the general public, helping to increase awareness of ESA and its scientific missions, and the activities of ESAC. A major event in June hosted several VIP visits and a special visit by 80 prize-winning students sponsored by the Spanish Ministry of Education and the Instituto Nacional de Técnica Aeroespacial.

In addition over 200 interviews were managed by ESAC Communications Office during the year, as well as a special Euronews TV feature. A new dedicated ESAC website was also launched.

Resource Management

During 2006 the ESAC Administration was reinforced with the creation of a local Human Resources Service and the harmonisation of local administrative procedures to bring them fully in line with the other ESA sites.

Aerial view of ESAC

ESRIN

ESA's centre for Earth observation in Frascati (I) hosted numerous scientific conferences, high-level scientific workshops, industrial meetings and reviews, as well as VIP visits and events for the general public during the year.

They included the European Advisory Working Group on the European Strategy for Earth Observation in February, the CEOS-SIT (Strategic Implementation Team) Meeting, the Executive Board Meeting of the International Charter on Space and Major Disasters. An Atmospheric Chemistry Science Conference and the MIPAS Workshop attracted many scientists. The EPS/MetOp RAO Workshop involved the meteorological community, while the Global Wetlands Symposium and the DUE Epidemio Workshop attracted the service industry active in these EO application areas. A special workshop was organised in April on the GMES space component to present progress in the programme. Another special workshop in November involved all of the international GOCE scientific community in preparing for the mission. A symposium was also organised at ESRIN on the Proba mission.

There were more than 25 000 visitors to ESRIN in 2006. The Open Day in March attracted the general public in large numbers, including more than 1000 students, as also did the Science Week and the European Researchers' Night organised jointly with all of the other research centres in the Frascati area.

Many media representatives were welcomed to the site for ESA launch-related events and for specially organised media days. One of the highlights was an in-flight call to the International Space Station during the stay of ESA astronaut Thomas Reiter in November.

Visit to ESRIN by representatives of the Japanese space agency JAXA in November

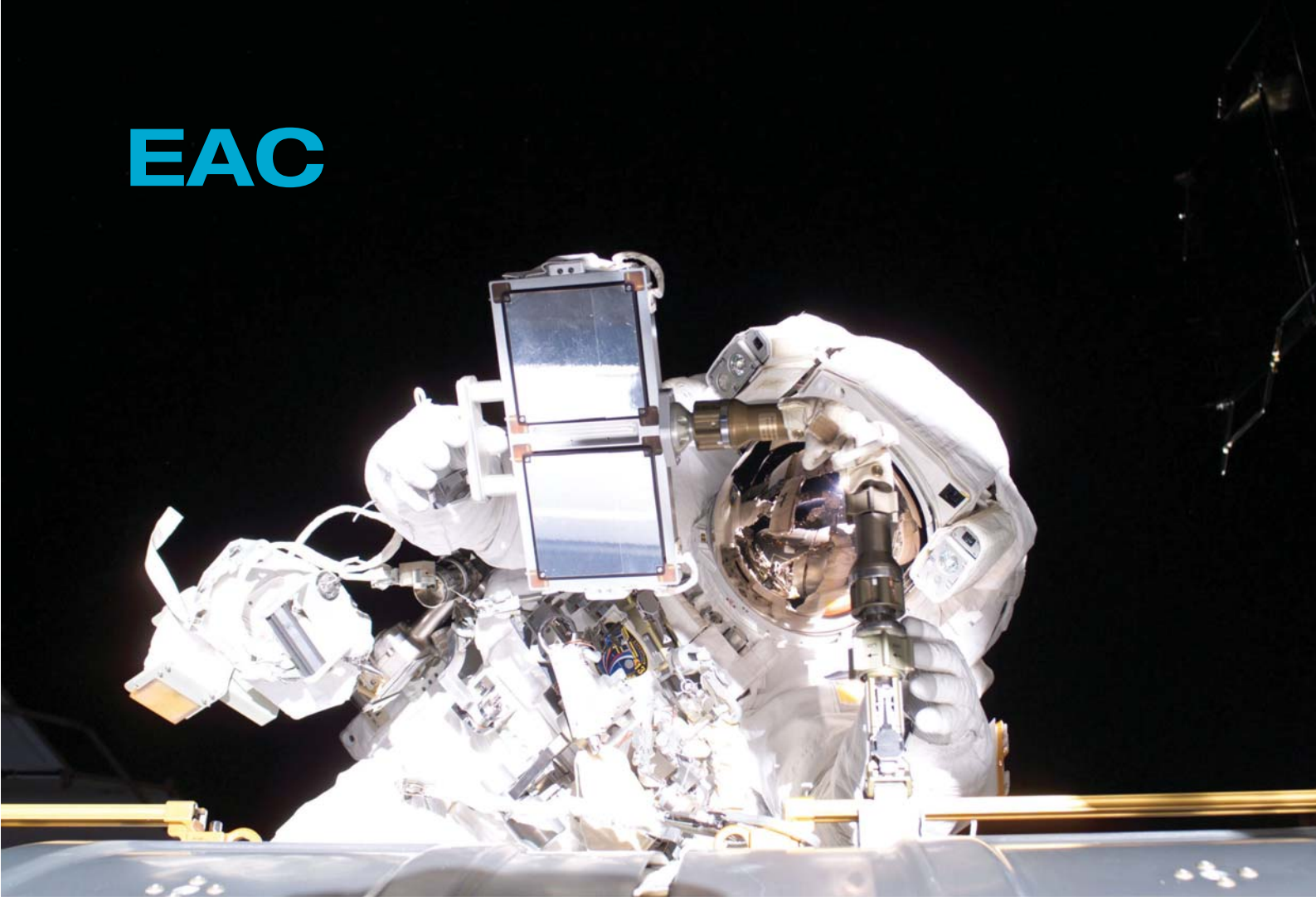
ESRIN also hosted numerous VIP visits, including that of the Austrian Secretary of State for Research, a delegation from the German Aerospace Centre (DLR), a delegation from Luxembourg, a group from the United Space Alliance, a delegation from Korea, and a delegation from the French Parliament, the European Commission and Eumetsat.

Last but not least, the establishment played host for various educational activities designed to attract and train the next generation of space engineers and scientists, including: a Delft University of Technology session, the Masters Courses of Roma Sapienza University, and the traditional Envisat Summer School. There were over 70 school and university student visits, giving hundreds of young people the chance learn about an ESA establishment from the inside.

Some 10 so-called 'pre-incubation activities' were also developed at ESRIN in 2006 within the framework of the agreement between ESA and the Business Innovation Centre (BIC) of the Lazio Region of Italy.

Visit by the Austrian Secretary of State for Transport, Innovation and Technology, Eduard Mainoni (front centre) in July

EAC



Thomas Reiter during his first EVA from the ISS on 3 August

The year was dominated by the two very successful 'Astrolab' and 'Celsius' missions carried out by ESA astronauts Thomas Reiter and Christer Fuglesang, respectively.

Having received training both at Johnson Space Center and at the Gagarin Cosmonaut Training Centre, Thomas Reiter and his backup Leopold Eyharts completed their training for the long-duration 'Astrolab' mission at EAC in May. Frank De Winne supported the mission as Mission Manager Advisor.

On 4 July, Space Shuttle 'Discovery' (STS-121) lifted off from Kennedy Space Center carrying Thomas Reiter on his journey to the International Space Station (ISS). On 6 July Reiter joined his fellow crew members, Russian Pavel Vinogradov and American Jeff Williams, and took up his duties onboard as flight engineer. During his 'Astrolab' mission, he carried out numerous operational and maintenance activities for both the US and Russian segments of the ISS. Reiter is the first non-American and non-Russian astronaut to serve as a 'permanent' ISS crew member. As the flight engineer, he was in charge of vital tasks associated with the Station's guidance, control and life-support systems, power control and communications, crew health and safety and extravehicular activities (EVAs).

Following a successful spacewalk by ISS commander Pavel Vinogradov and NASA science officer Jeff Williams, on 3 August Reiter became the first ESA astronaut to perform a spacewalk from the ISS. Here too he had considerable experience to draw upon, having performed two EVAs during his six-month EuroMir mission in 1995.

During their 6½-hour EVA, Reiter and Williams set up external hardware including the Floating Potential Measurement Unit, designed to monitor ISS electrical charging and improve rendezvous and docking and EVA safety, and two Materials International Space Station Experiments (MISSE-3 and 4). They also prepared Station truss components for future assembly work, by

EVA familiarisation training in the Neutral Buoyancy Facility at EAC

installing a motor controller on the thermal radiator rotary joint and deploying the new EVA infrared camera to monitor the condition of critical reinforced carbon-carbon materials.

In September, Vinogradov and Williams returned to Earth to be replaced by NASA commander Michael Lopez-Alegria and Russian flight engineer Mikhail Tyurin, with whom Reiter continued his 171-day mission.

Reiter operated ESA, NASA and Russian research facilities in support of international science experiments and conducted a programme of European experiments in the fields of human physiology and psychology, microbiology and plasma physics. He also performed technology demonstrations as well as industrial and educational experiments for universities and primary/secondary schools. This was the first long-duration mission for an ESA astronaut on the ISS and it provided highly valuable experience.

The ESA medical support team continuously monitored the ESA astronaut's health from the Medical Control Centre at EAC and coordinated all health-related issues with the Columbus Control Centre in Munich (D) and the partners' control centres in Moscow and Houston. The 'Astrolab' mission served as the final verification of the EAC medical team's readiness to support future long-duration missions.

On 9 December, Space Shuttle 'Discovery' (STS-116) lifted off at 02:47 CET from Cape Canaveral, the first night launch in four years. It carried ESA astronaut

Christer Fuglesang during his unscheduled EVA to free a jammed solar array

Christer Fuglesang, the first Swede to go into space, as a mission specialist to the ISS. During his stay on board, Fuglesang participated in two EVAs to attach new hardware to the Station and to reconfigure its electrical power system. He later participated in an extra, unscheduled, spacewalk to help free a solar array that had become jammed during retraction. He spent a total of 18 hours 14 minutes outside the Station. Reiter and Fuglesang returned to Earth together on Space Shuttle 'Discovery' on 22 December.

The first ESA Automated Transfer Vehicle (ATV) training was provided to the ISS Expedition-15 crew in September and December, when the Russian prime and backup crew members received 'ATV Part-1 Training' at EAC. Earlier in the year, the International Partners (IP) pool astronauts, with the exception of Thomas Reiter,

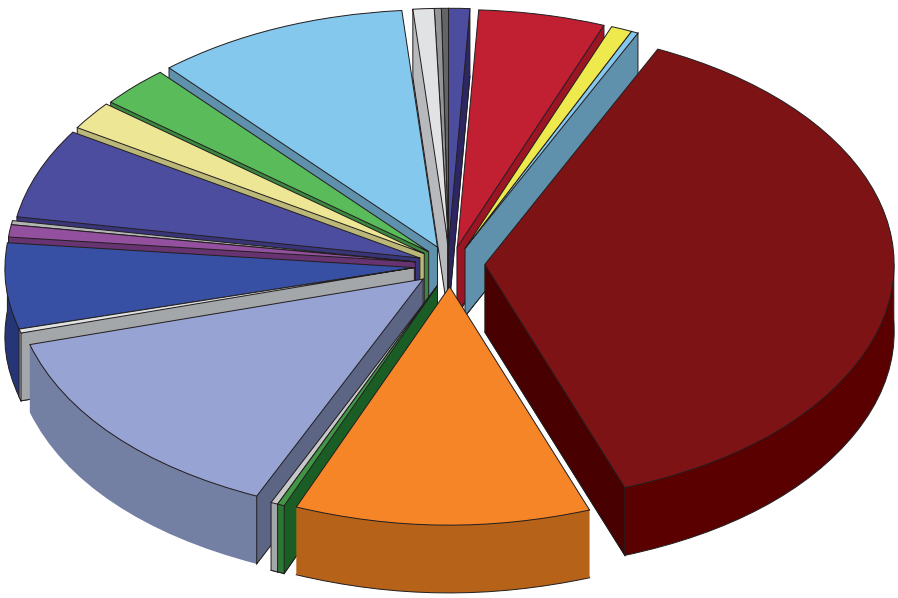
Expedition-15 crew members Oleg Kotov and Fjodor Yurchikin during ATV rendezvous and docking training at EAC

Leopold Eyharts and Christer Fuglesang, had undergone the same training. Final ATV refresher training has taken place at the Gagarin Cosmonaut Training Centre and the Expedition-15 crew have been formally certified for onboard ATV operations. Expedition-16 crew members from NASA, Roskosmos (RKA) and ESA began their Columbus laboratory and payload training at EAC in December.

Columbus flight control team training and simulations for the 1E and Expedition-16 teams conducted under EAC's responsibility are progressing according to schedule. In December, the first joint NASA/ESA simulations, involving the Columbus Control Centre and Houston Mission Control Centre flight control teams were successfully conducted.

ESA astronaut Paolo Nespoli has been assigned to the crew of Space Shuttle flight STS-120 to the ISS, due for launch in autumn 2007. This flight will carry Node-2, the interconnecting module built in Europe for NASA as part of the Columbus launch barter agreement. Hans Schlegel has been selected as a member of the crew for Columbus/Shuttle flight 1E at the end of 2007.

Resources Management



Finance and Corporate Control

Expenditure

The Agency's total expenditure in 2006 amounted to:

- 2824 MEuro in Contract Authority and
- 2582 MEuro in Payment Appropriations.

The Agency's Mandatory Activities represented 28% of the total expenditure (734 MEuro) in Payment Appropriations, whereas 69% was spent by Optional Programmes (1780 MEuro) and 3% by Programmes financed by Third Parties (68 MEuro).

The core elements of the Agency's Mandatory Activities are the Science Programme, the Technological Research Programme and the technical and operational infrastructure. In 2006, the Science Programme benefited from a rescheduling of the loan reimbursement, allowing the start of the development of the Gaia mission while continuing the implementation of the Herschel, Plank and LISA Pathfinder projects. The Science Programme also funded the operation of nine satellites in orbit and contributed to the operating costs of eight spacecraft in orbit in the framework of international cooperation.

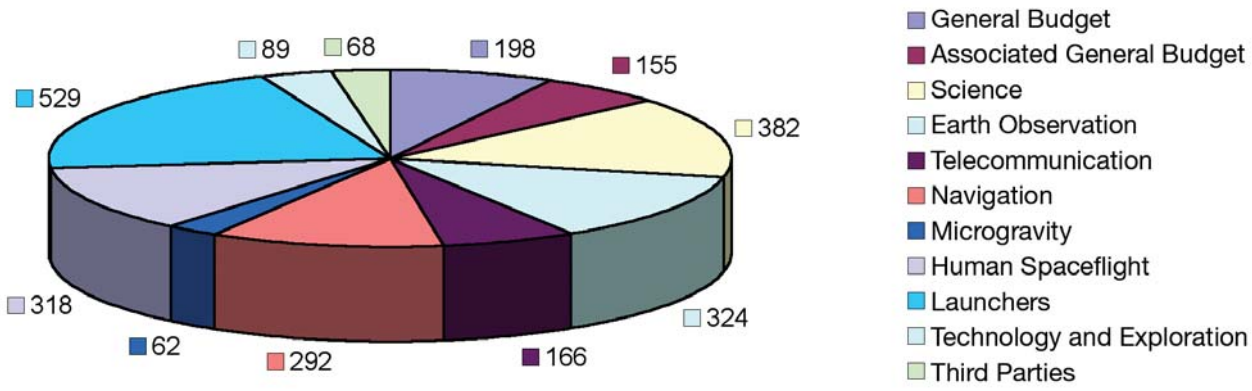
The expenditure associated with the General Budget increased by 10% in 2006. The main emphasis was on reinforcing the Technological Research activities, in preparation for future missions, and the general strengthening of the Agency's technical capabilities, including enhancements to the common technical and operational infrastructure.

The development of applications is provided via the Agency's Optional Programmes, to which Participating States declare a voluntary subscription. In 2006, the expenditure on Optional Programmes decreased by 18% compared with 2005. Following the Ministerial Council in December 2005 in Berlin, several new programmes were initiated, including ExoMars and the GMES programme. Expenditures for these new programmes will pick up in later years based on the specific frameworks of these initiatives.

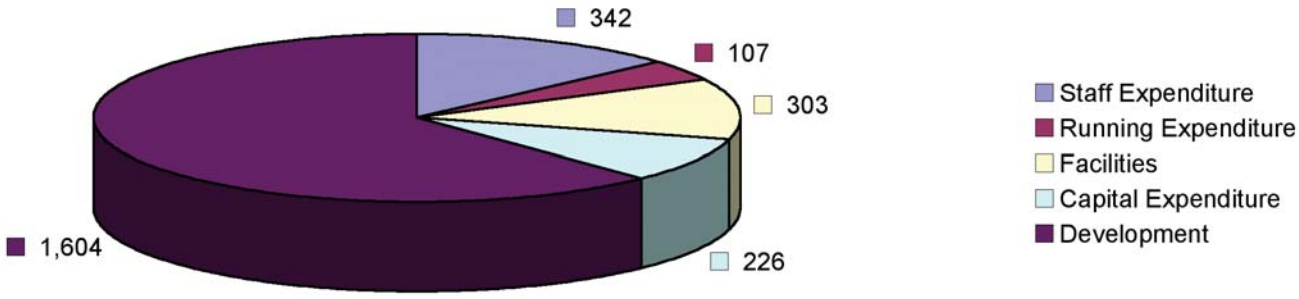
In 2006, 523 MEuro or 20% of the total ESA budget was spent on the Launchers Programme. The construction of the Soyuz launch facilities in Kourou, the development of the small launcher (Vega), and the programme supporting European Guaranteed Access to Space (EGAS) represent the main areas of expenditure in the launchers domain.

13% of ESA's 2006 expenditure was devoted to the Earth Observation Programme, with the development of the family of Explorer missions accounting for the majority of that expenditure. A smaller than originally planned amount was spent on the new Global Monitoring for Environment and Security (GMES) Programme.

The Navigation Programme increased its share of ESA's total expenditure from 8% in 2005 to 11% in 2006. The main area of expenditure was Galileo, on which a total of 249 MEuro was spent.



Expenditure per Programme domain (MEuro)



Expenditure per function (MEuro)

The solid recovery of the Telecommunications Programme in 2005 continued in 2006, with expenditure amounting to 165 MEuro. In particular, the Artes-8 programme (Alphabus, Alphasat) benefited from the renewed interest of the Participating States in space-based telecommunications.

Expenditures for the Human Spaceflight and Microgravity Programmes, which account for 15% of ESA's total expenditure, were substantially reduced as a consequence of the delayed Space Shuttle return to flight, following the Columbia accident in 2003.

Similar to previous years, around 83% of the Agency's 2006 budget was spent on contracts in the Member States for research or project-related activities, the running of technical or operational facilities, and the financing of capital expenditure and industrial development.

Financial Management Evolution

In 2006, the Director General and ESA staff pursued the ongoing efforts to increase internal operating efficiency. In this context, the financial operations processes and procedures have been simplified wherever possible and the organisation has been rationalised by regrouping the services in the Establishments. In parallel, the financial systems have been enhanced to introduce an electronic workflow wherever possible, such as for the invoice registration process (90% of invoices are now submitted electronically by industry). In 2007, it will be extended to include the invoice approval process and travel-expenditure management.

In parallel and following the Ministerial Council decision, a more ambitious project is ongoing, namely the Financial Management Reform. The aim of that reform is to introduce a new financial-management model, which will provide financial information allowing continuous optimisation of the use of available resources and the attraction of new ones. In 2006, the Director General outlined the main features of this new model, taking due account of the best practices identified in a benchmarking exercise with comparable organisations. In particular, the new model will re-focus performance measurement on activities and costs rather than on budget and expenditure. The project is currently in a definition phase, with the final decision on its implementation planned for March 2008.

Funding of ESA Programmes

The ESA Mandatory Activities (which include the General Budget, the Associated General Budget and the Science Programme) are financed by Member State and Cooperating State contributions. The ESA Convention dictates that the Agency's Mandatory Programme be financed using a contribution scale based on the national incomes of the Member States over the last three years for which statistics are available. The ESA Council adopted a new scale for the period 2006-2008 in October 2005.

Contributions to Mandatory Activities (%)		Contributions to Optional Programmes (%)*	
AUSTRIA	2.24	AUSTRIA	1.08
BELGIUM	2.74	BELGIUM	7.36
DENMARK	1.76	DENMARK	0.79
FINLAND	1.40	FINLAND	0.52
FRANCE	15.50	FRANCE	34.08
GERMANY	21.85	GERMANY	22.56
GREECE	1.57	GREECE	0.06
IRELAND	1.11	IRELAND	0.28
ITALY	12.85	ITALY	14.00
LUXEMBOURG	0.21	LUXEMBOURG	0.25
NETHERLANDS	4.48	NETHERLANDS	1.92
NORWAY	2.06	NORWAY	0.81
PORTUGAL	1.20	PORTUGAL	0.25
SPAIN	7.33	SPAIN	4.42
SWEDEN	2.58	SWEDEN	1.83
SWITZERLAND	3.42	SWITZERLAND	3.58
UNITED KINGDOM	17.70	UNITED KINGDOM	5.11
TOTAL MEMBER STATES	**100.00**	**TOTAL MEMBER STATES**	**98.90**
CANADA	3.64	CANADA	0.98
CZECH REPUBLIC	-	CZECH REPUBLIC	0.06
HUNGARY	-	HUNGARY	0.06
TOTAL Cooperating States**	3.64	TOTAL Cooperating States**	1.10
TOTAL ESA	**-**	**TOTAL ESA**	**100.0**

* Including contributions of National Aviation Agencies to ARTES-9 GNSS IP (ATMSP)
** Participating non-Member States linked to ESA by a Cooperation Agreement

The ESA Optional Programmes are financed by Member and Cooperating State contributions and by third parties, which include the European Union. The Participating States declare a voluntary subscription on a multi-annual basis.

The Third-Party Programmes are managed by ESA, but are totally financed by third parties. In 2006, they represented 3% of ESA activities.

The contributions from Member and Cooperating States to the Agency's Mandatory Activities and Optional Programmes in 2006 are shown in the above table.

Annual Accounts

In recent years, modernisation of the Agency's accounting methods has been initiated to better align them with International Public Sector Accounting Standards issued by the International Federation of Accountants (IPSAS), particularly through the introduction of full 'Accrual Accounting' in a phased manner, as decided by Member States in order not to disrupt operations unduly.

The Agency's Financial Statements for 2006 are presented in the following pages.

Notes to the Financial Statements

The Agency's Annual Accounts are summarised in four main financial statements presented herewith (unaudited at the time of this publication), including comparative information for 2005.

Among the assets, the 908 MEuro balance under Cash and Banks does not include the funds managed for the Pension Scheme. The latter represent the financed portion of the scheme, invested in the so-called 'Buffer Fund', and are presented as non-current assets. Since the total obligation of the Pension Scheme towards the active and retired staff of the Agency is valued 771 MEuro, the not yet financed portion is shown as a receivable amount.

One of the main current assets is represented by 227 MEuro of advance payments to suppliers, made across the on-going programmes of the Agency. Until the relevant services are tested and accepted, these payments are considered as a claim towards the contractor companies.

Among the liabilities, the Prepaid Contributions and the funds available in the Regulation Fund represent balances due to Member States, whereas Accrued Payables are obligations towards suppliers for invoices received but not yet paid, or costs incurred in 2006 but not yet invoiced.

The provision for Untaken Staff Leave represents the value of the number of days of leave accrued by staff members but not yet taken at year's end.

The net effect of provisions and accruals is reflected in the item 'Reserve for Accruals and Provisions'. The 151 MEuro credit balance in 2006 can be considered as the net accumulated excess of assets over liabilities recognised in the accounts.

Provisions and accruals are included in the Statement of Assets and Liabilities in order to provide a comprehensive picture of all claims, entitlements and obligations of the Agency, but at this stage of the transition to Accrual Accounting they are not financed. Therefore, the net effect of reversed accruals of the previous year and new accruals is identified in a separate line of the Statement of Income and Expenditure, which adjusts the year's expenditure to show the total cost incurred. In 2006, this balance amounted to a 244 MEuro net increase in restated prior-year accruals.

The Statement of Changes in Net Assets/Equity illustrates the allocation of the Surplus in the following year, part of which is represented by the net effect of accruals and provisions. This part is consolidated in the Reserve for Accruals and Provisions.

The 2006 Surplus amounts to 508 MEuro, including 677 MEuro of underspending of the budget allocations, 75 MEuro of excess actual income over the budget, with other minor balances, and the 244 MEuro net increase in restated prior-year accruals.

1. Income and Expenditure for the year ended 31 December

(in kEuro)

	2006		2005		Increase/ Decrease
OPERATING INCOME					
Contributions	2,758,817		2,854,432		-95,615
Other Income	427,434		264,878		162,556
		3,186,251		3,119,310	66,941
Third Party Programmes Income	118,460		169,580		-51,120
Plan for European Cooperating States	4,894		3,845		1,049
Management Outputs/Esrange Income	25,370		486		24,884
Suspense Output	2,669		2,794		-125
Internal Tax Income	111,736		103,332		8,404
Etraordinary Accrued Income	362		0		362
		263,491		280,037	-16,546
Total operating income		**3,449,742**		**3,399,347**	50,395
OPERATING EXPENDITURE					
General Budget	197,616		187,573		10,043
Scientific Programme	381,256		345,723		35,533
Earth Observation	323,701		362,810		-39,109
Telecom	165,242		159,312		5,930
Navigation	291,874		244,051		47,823
Manned Spaceflight	61,934		574,396		-512,462
Microgravity	317,287		81,036		236,251
Launchers	523,189		648,666		-125,477
Technology	88,719		85,025		3,694
CSG Kourou and other activities	90,169		82,711		7,458
Pensions	64,452		59,496		4,956
Total financed by contributions		2,505,439		2,830,799	-325,360
Third Party Programmes	68,283		145,796		-77,513
Plan for European Cooperating States	1,474		1,196		278
Management Outputs Expenditure	8,519		-24,880		33,399
Suspense Output	1,633		0		1,633
Esrange/Andøya special project	198		193		5
Internal Tax	111,736		103,332		8,404
Variation of accruals/provisions	244,783		-242,582		487,365
Restatement of expenditure to assets	0		-20,000		20,000
		436,626		-36,945	473,571
Total operating expenditure		**2,942,065**		**2,793,854**	148,211
NON-OPERATING CHARGES	0		0		0
Net Surplus for the Period		**507,677**		**605,493**	-97,816

REPRESENTED BY		
Bank and Cash	908,118	311,779
Other Assets	1,439,727	1,637,461
Prepaid Contributions, Other Liabilities	-1,644,948	-1,420,137
Reserves	-195,220	76,390
Net Surplus for the Period	**507,677**	**605,493**

2. Assets and Liabilities at 31 December

(in kEuro)

	2006		2005		Increase/ Decrease
ASSETS					
Current assets :					
BANKS AND CASH	908,118		311,779		596,339
AMOUNTS RECEIVABLE :					
Outstanding contributions	387,193		353,270		33,923
Other customers (net)	3,550		20,615		-17,065
Other amounts receivable	51,423		66,280		-14,857
PREPAYMENTS	226,561		396,296		-169,735
		1,576,845		**1,148,240**	**428,605**
Non-current assets :					
Investments in associates	0		40,000		-40,000
PENSION SCHEME to be financed	574,514		569,152		5,362
PENSION SCHEME Buffer Fund	196,486		191,848		4,638
		771,000		**801,000**	-30,000
Total assets		**2,347,845**		**1,949,240**	**398,605**
LIABILITIES					
Current liabilities:					
Prepaid Contributions and other payables to Member States	296,685		194,466		102,219
Regulation Fund	50,590		72,574		-21,984
ACCRUED PAYABLES	459,524		339,803		119,721
OTHER AMOUNTS PAYABLE	11,018		9,279		1,739
UNTAKEN STAFF LEAVE	56,131		43,015		13,116
		873,948		**659,137**	**214,811**
Non-current liabilities:					
PENSION SCHEME	771,000		761,000		10,000
		771,000		**761,000**	10,000
Total liabilities		**1,644,948**		**1,420,137**	**224,811**
NET ASSETS		**702,897**		**529,103**	**173,794**
NET ASSETS/ RESERVES					
RESERVES Telecom 3 bis, GNSS2, ARTES, PPF Envisat, Marecs, Exchange gains	43,663		34,635		9,028
Reserve for Accruals and Provisions	151,557		-111,025		262,582
SURPLUS	507,677		605,493		-97,816
		702,897		**529,103**	**173,794**

MEMORANDUM ACCOUNTS					
Property, plant and equipment	2,787,030		2,739,381		47,649
Fixed Assets in progress	284,615		217,945		66,670
INVENTORY OF FIXED ASSETS		**3,071,645**		**2,957,326**	**114,319**

3. Consolidated Cash Flow for the year ended 31 December

(in MEuro)

CASH FLOWS FROM OPERATING ACTIVITIES		
Receipts of Contributions		
2006 Called Contributions	2,554.7	
Increase in outstanding contributions	-33.9	
Increase in prepaid contributions	102.2	
Decrease in Regulation Fund	-21.9	
		2,601.1
Other Receipts		
Other Income ESA financed programmes	427.4	
Third Party Programmes	94.5	
Plan for European Cooperating States	2.2	
Other Receipts	0.3	
Decrease in other customers	17.8	
Decrease in other amonuts receivable	11.9	
Increase in other reserves	9.0	
		563.1
		3,164.2
Payments		
Expenses for ESA Programmes	-2,750.2	
Expenses for Third Party Programmes	-68.3	
Expenses for Plan for European Cooperating States	-1.5	
Other Expenses	-10.4	
Decrease in prepayments to suppliers	169.7	
Decrease in investments to associates	-40.0	
Increase in untaken staff leave	13.1	
Increase in accrued payables	119.7	
Increase in other amounts payable	1.7	
Reimbursement of contributions	-1.7	
		-2,567.9
Net cash flow from operating activities		596.3
CASH AND BANKS 31.12.2005		311.8
CASH AND BANKS 31.12.2006		908.1

4. Changes in Net Assets/Equity for the years 2005-2006

(in MEuro)

	SURPLUS	RESERVES	RESERVE FOR ACCRUALS AND PROVISIONS	TOTAL NET ASSETS
	(A)	(B)	(C)	(A+B+C)
Balance at 31 December 2005 ESA/AF(2006)1	605.5	34.6	-111.0	529.1
Allocation of Surplus 2005 to income 2006:				
- Programmes funded by contributions	-286.8			
- Plan for European Cooperating States	-2.7			
- Programmes funded by Third Parties	-24.0			
- Management and Suspense Outputs	-27.7			
Reimbursement to Participants	-1.7			
Allocation to exchange gains reserve	0.0			
Adjustments for accrued expenditure 2005	-262.6		262.6	262.6
Sub-total Allocation of Surplus 2005	-605.5			-605.5
Surplus 2006	507.7			507.7
Net movements in reserves		9.0		9.0
Balance 31 December 2006	**507.7**	**43.6**	**151.6**	**702.9**

Human Resources

The year was marked by a number of initiatives in the area of HR policy. These included measures that have been put into place aimed at reinforcing the management team, particularly at the A6 level. Following a review in 2004, the HR Department had also embarked on a project to introduce amendments to a number of HR Reform elements. This project was concluded in 2006.

Human Resources Policy

Through the recently introduced Agenda 2011, the Agency has also adopted a strengthened approach to HR, which foresees: (a) raising the profile and importance of human resources management in the Agency, (b) improving the clarity and transparency of HR processes, and (c) establishing the flow of information through managers (top-down and bottom-up).

Staff Training and Development

A wide range of training and development activities were made available to ESA staff members. These included activities centrally driven by the Internal University to serve corporate needs and priorities and those instigated locally in each Establishment in response to the job needs ientified by staff members and their managers. Activities covered a broad spectrum, from courses/seminars designed to ESA specifications, to the financing of staff members' participation in external professional or academic programmes.

In 2006, the Internal University offered about 15 programmes responding to different corporate priorities, and introduced in particular new seminars to reinforce management and leadership skills, and to promote harmonisation of practice and exchange of expertise.

To evaluate the impact of Leadership Development Programmes on ESA managers and on the organisation itself after five years, a survey was conducted in summer 2006, the outcome of which was positive and encouraging.

External Training

Almost 1850 applications for the 2006 Young Graduate Trainee (YGT) programme resulted in the successful recruitment of highly motivated recent graduates contributing to the total of 170 YGTs (totalling 93 man-years) working at ESA in 2006. The YGTs gained valuable 'hands-on' work experience preparing them for future employment in space industry or research.

The Internal Research Fellow Programme provided 50 Postdoctoral candidates (totalling 29 man-years) with the opportunity to carry out research in a variety of disciplines, mainly related to space science, space applications or space technology, under the supervision of ESA scientists and engineers.

Two new groups of 14 Spanish and 8 Portuguese graduates started a traineeship at ESA within the framework of bilateral agreements with these two countries. The graduates will benefit by gaining practical experience in engineering and scientific disciplines related to space applications.

Equal Opportunity and Diversity Policy (EOD)

The end of 2005 marked the completion of the EOD first phase, with all of the instruments defined in the 2002 Action Plan being implemented. The 2nd phase started in 2006 with four main objectives to be focused on: increased female representation with the support of the NOW programme and ESA's database; career development with specific training in female leadership and self communication, in close cooperation with the Internal University; managerial commitment to EOD through

the Directorate Specific Action Plan, a key issue in getting the support of mid-managers for EOD objectives; external visibility by developing role models, and partnership with the public and private sector, bringing opportunities for good-practices exchange and benchmarking in the field of EOD.

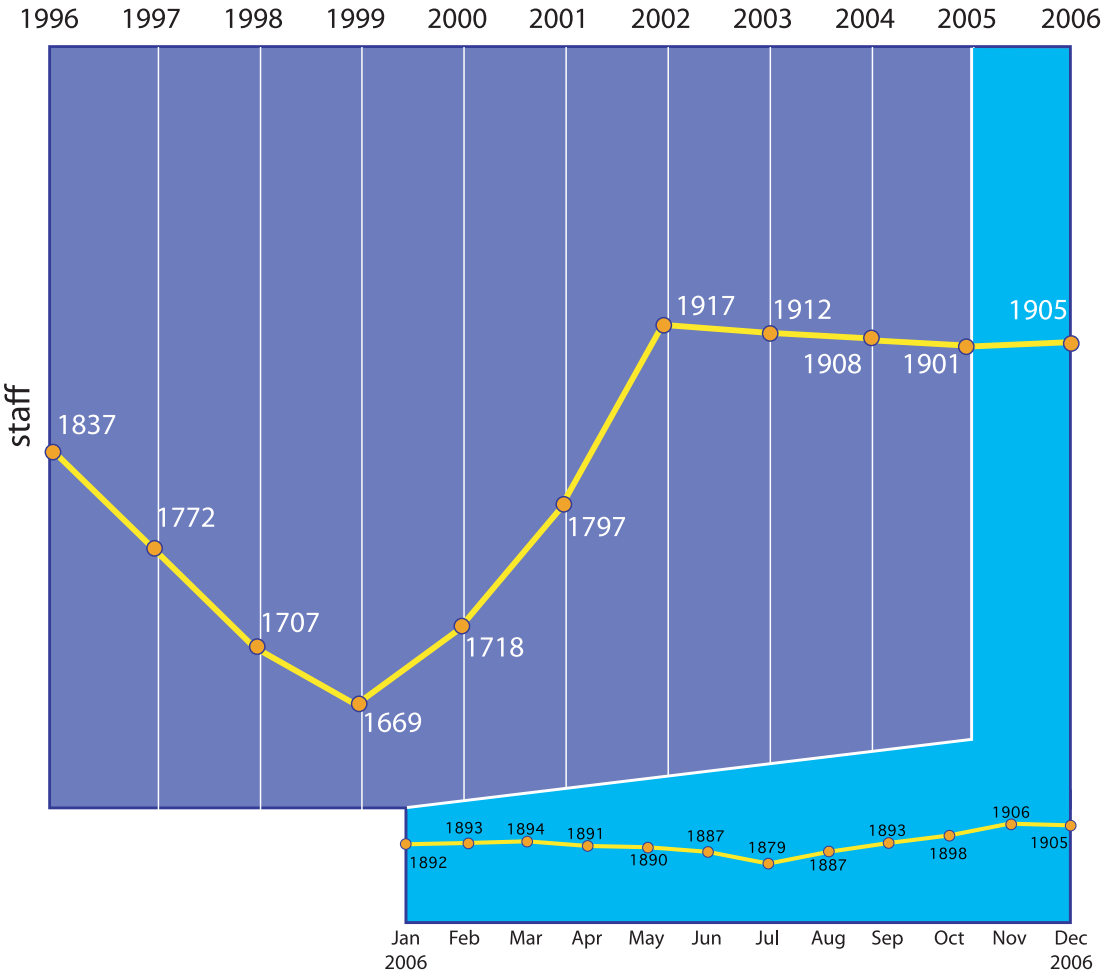
Indicators show an encouraging increase in overall A-grade female representation from 8% to 14% between 2001 and 2006, reflecting real progress in female representation in grades A2 to A4, but also a clear improvement at A5 level, up from 2.1% in 2001 to 6.6% in 2006. These figures show that the 'glass ceiling' is not an inevitability at ESA if it maintains the current proactive approach. However, benchmarking reveals that the Agency is still quite far behind its partners in terms of female representation in managerial and engineering positions.

Coordination

The Coordinating Committee on Remuneration (CCR) finalised a recommendation on a new salary adjustment method, as the previous one was due to come to an end by December 2006. The Administrative and Finance Committee (AFC) adopted this new method, which will be valid for 6 years, in September. The AFC also approved the new set of Education Allowance rules, on the basis of the proposal made by the Coordinating Committee on Remuneration (CCR) in 2005.

Workforce Management

A workforce-management system project was initiated in 2006, aimed at supporting the optimisation of the ESA workforce – staff and contractors – taking into account a



Evolution in staffing from 1996 to 2006; inset, the evolution during 2006

	Hors Classe	A	L	B	C	Total Staff
I Member States						
Austria		29		3		32
Belgium	1	71		12		84
Denmark		26		2		28
Finland		12		4		16
France	3	347	10	94	9	463
Germany	3	296	4	62		365
Greece		3				3
Ireland		12		8		20
Italy	2	304		34	1	341
The Netherlands	1	57		40		98
Norway		20		2		22
Portugal		9		3		12
Spain		134		9		143
Sweden		42		4		46
Switzerland		25		3		28
United Kingdom	1	140	3	34		178
Total	**11**	**1527**	**17**	**314**	**10**	**1879**
II Non-Member States						
Canada	-	23		3		26
Total	-	**23**		**3**		**26**
Grand Total	**11**	**1550**	**17**	**317**	**10**	**1905**

ESA staffing per December 2006

variety of budgetary constraints and the necessary evolution in competences to cope with new challenges. This system encompasses a set of coherent and inter-linked modules such as:

- Mapping/apportionment of the workforce (staff and contractors) per competence and activity
- Workload planning with a 3 to 5 year horizon
- Anticipation of short-term staff movements
- Rationalisation of the human-resources allocation process within an overall integrated process including budget
- Implementation of an information system able to consolidate the workforce data
- Definition and implementation of reporting tools

Review of HR Processes

A review of HR processes is being conducted via a project with the following objectives:

- To enforce harmonisation of practices ESA-wide
- To increase efficiency, i.e. maximisation of results with available resources (manpower, systems)
- To compress processing time through simplification and the delegation of decision authority to local/subordinate level

Pensions

At the end of 2006, there were 1011 pension recipients, compared with 959 at the end of 2005. An actuarial study conducted in 2006 in conformity with the established procedure resulted in an increase in the pension contribution rate as of 1 July 2006.

Staff

At the end of 2006, the Agency had 1905 staff in post, compared with 1901 at the end of 2005.

Annexes

Chairs of Council, Programme Boards and Other Delegate Bodies

Council

Chairman	Sigmar Wittig (G)
Vice-Chairs	Per Tegnér (S) Marc Bertschi (CH)

Programme Boards

Communication Satellite Programmes	Heikki Hannula (FIN)
Satellite Navigation Programme	Frank Udnaes (N)
Earth Observation Programme	Jorge Lomba (E)
Ariane Launcher Programme	Christoph Hohage (D)
Human Spaceflight, Microgravity and Exploration Programme	Simonetta Di Pippo (I)

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Security Committee	Albert Le Goué (F)

Statutory Bodies

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UNITED KINGDOM
David Williams
Paula Freedman
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CANADA
Carole Lacombe
Virendra Jha
Hugues Gilbert

Agreements Signed

Agreement between the European Space Agency and the European Organisation for the Exploitation of Meteorological Satellites concerning Cooperation on the MetOp Satellites series, signed in Paris on 22 February 2006 by Mr Jean-Jacques Dordain, ESA's Director General, and Mr Lars Prahm, Director General of Eumetsat.
(ESA/LEG/304)

European Cooperating State (ECS) Agreement between the European Space Agency and the Government of Romania, signed in Bucharest (Romania) on 17 February 2006 by Mr Jean-Jacques Dordain, ESA's Director General, and Mr Marius-Ioan Piso, President of the Romanian Space Agency.
(ESA/LEG/305)

Agreement between the European Space Agency and CNES relating to cooperation on large platforms for telecommunication, signed on 15 March 2006 by Mr Jean-Jacques Dordain, ESA's Director General, and Mr Yannick d'Escatha, President of CNES.
(ESA/LEG/306)

Memorandum of Understanding between ESA and the Japan Aerospace Exploration Agency (JAXA) concerning the ALOS Data Node cooperation, signed in Paris on 19 May 2006 by Mr Jean-Jacques Dordain, ESA's Director General, and in Tokyo (Japan) on 14 June 2006 by Dr Keiji Tachikawa, President of JAXA.
(ESA/LEG/307)

Amended Agreement between ESA and the Galileo Joint Undertaking (GJU), signed on 16 June 2006 by Mr Jean-Jacques Dordain, ESA's Director General, and on 6 July 2006 by Mr Olivier Meert (for Mr Rainer Grohe), Head of Administrative and Finance Division of the Galileo Joint Undertaking.
(ESA/LEG/308)

Arrangement concerning the participation of Canada in the European Programme for Life and Physical Sciences and Applications in Space (ELIPS), signed in Paris on 22 June 2006 by Mr Jean-Jacques Dordain, ESA's Director General, and for the Government of Canada by Mr Virendra Jha, Vice President Science, Technology and Programs of the Canadian Space Agency.
(ESA/LEG/309)

Arrangement concerning the participation of Canada in the GMES Space Component Programme, signed in Paris on 22 June 2006 by Mr Jean-Jacques Dordain, ESA's Director General, and for the Government of Canada by Mr Virendra Jha, Vice President Science, Technology and Programs of the Canadian Space Agency.
(ESA/LEG/310)

Memorandum of Understanding between the European Space Agency and the Japan Aerospace Exploration Agency (JAXA) concerning cooperation on SOLAR-B, signed in Paris on 11 July 2006 by Mr Jean-Jacques Dordain, ESA's Director General, and in Tokyo (Japan) on 20 July 2006 by Dr Keiji Tachikawa, President of JAXA.
(ESA/LEG/311)

Signing of the Alphabus co-operation agreement between ESA and CNES, 15 March

Jean-Jacques Dordain, ESA Director General, and Marius-Ioan Piso, President and CEO of the Romanian Space Agency, signed the European Cooperating State Agreement, 17 February in Bucharest, Romania

Agreement between the European Space Agency and the Agenzia Spaziale Italiana (ASI) on the termination of the Arrangement between ESA and ASI on the Management, Execution and Funding of the Node 2/Node 3 Project for the International Space Station, signed on 10 August 2006 by Prof. Sergio Vetrella, President of ASI, and on 1 September 2006 by Mr Jean-Jacques Dordain, ESA's Director General.
(ESA/LEG/312)

Rider to the Convention between the European Space Agency and Arianespace concerning the Vega Small Launcher Development programme (Rider 5.4), signed in Paris on 22 November 2006 by Mr Antonio Fabrizi, Director of Launchers, and Mr Jean-Yves Le Gall, Chief Executive Officer of Arianespace.
(ESA/LEG/313)

Protocol amending the Agreement between the French Government and the European Space Agency on the Guiana Space Centre (CSG), signed in Paris on 12 December 2006 by Mr Jean-Jacques Dordain, ESA's Director General, and Mr Yannick d'Escatha, President of CNES.
(ESA/LEG/314)

Arrangement between CNES, the Belgian Federal Science Policy Office and the European Space Agency concerning the development and exploitation of the Picard Scientific Mission Centre, signed in Paris on 22 November 2006 by Mr Yannick d'Escatha, President of CNES, in Brussels on 30 November 2006 by Mr Philippe Mettens, Chairman of the Directing Board of the Federal Science Policy Office, and in Paris in 15 December 2006 by Mr Jean-Jacques Dordain, ESA's Director General.
(ESA/LEG/315)

Patents

PAT 509 A METHOD OF PACKET MODE DIGITAL COMMUNICATION OVER A TRANSMISSION CHANNEL SHARED BY A PLURALITY OF USERS

US Application	11/342,980
European Application	06290178.0
Israeli Application	173147
Filed	29 & 30 January 2006
Applicant	ESA
Inventors	E. Casini, O. Del Rio Herrero & R. De Gaudenzi
Other Applications	France

PAT 510 DEVICE AND METHOD FOR REDUCING THE NONSTEADY SIDE LOADS ACTING ON A NOZZLE OF A ROCKET ENGINE

French Application	06 01371
US Application	11/359,692
Chinese Application	20060008900.6
Eurasian Application	200600289
Filed	21 & 22 February 2006
Applicant	ESA
Inventor	C. Dujarric
Other Applications	France

PAT 511 METHOD FOR ESTABLISHING CARTOGRAPHIC IMAGES OF VELOCITY VECTORS OF MARINE SURFACE CURRENTS AND SYSTEM OF A RADAR ALTIMETER IMPLEMENTING SAID METHOD

US Application	11/435,642
Filed	17 May 2006
Applicant	ESA
Inventor	C. Buck
Other Applications	France

PAT 513 MICROWAVE FILTER FOR OUTPUT MULTIPLEXER

US Application	11/492,883
Filed	26 July 2006
Applicant	ESA
Inventors	N. Ortiz, M. Sorolla, D. Schmitt, M. Guglielmi & J. Gil
Other Applications	France

PAT 514 SET-UP FOR TEMPERATURE MEASUREMENT WITHOUT CONTACT TO THE SAMPLE UNDER VACCUUM

International Application	PCT/FR 2006/001305
Filed	7 June 2006
Applicant	ESA
Inventors	C. Semprimoschnig, S. Hetzel & M. van Eesbeek
Other Applications	France

PAT 515 HIGH-EFFICIENCY ZERO-VOLTAGE ZERO-CURRENT SWITCHING REGULATED CONVERTER

US Application	11/472,062
Filed	21 June 2006
Applicant	ESA
Inventor	S. Weinberg
Other Applications	France

PAT 516 AUTOMATIC AUTOPILOT OF A SAILING BOAT FOR NAVIGATION IN THE PRESENCE OF WAVES

International Application	PCT/FR 2006/001240
Filed	1 June 2006
Applicant	ESA
Inventor	M. Lopriore
Other Applications	France

PAT 517 SEGREGATED MAXIMUM POWER POINT TRACKING BASED ON STEP-UP REGULATION

US Application	11/415,827
Filed	2 May 2006
Applicant	ESA
Inventor	P. Rueda Boldó
Other Applications	France

PAT 519 MULTIBEAM ANTENNA

French Application	06 01585
Filed	23 February 2006
Applicant	ESA
Inventors	P. Balling, A. Roederer & C. Mangenot

PAT 520 MICROWAVE WAVEGUIDE FILTER WITH NON-PARALLEL WALLS

International Application	PCT/FR 2006/002087
Filed	12 September 2006
Applicant	ESA
Inventors	J. Hueso Gonzalez, D. Raboso & D. Schmitt
Other Applications	France

PAT 522 DEVICE AND METHOD FOR MATERIAL TESTING

US Application	11/544,659
Filed	10 October 2006
Applicant	ESA
Inventor	G. Bussu
Other Applications	France

PAT 525 METHOD OF PROCESSING POSITIONING SIGNALS, IN PARTICULAR FOR INDOOR APPLICATIONS

International Application	PCT/EP 2006/002581
Filed	3 March 2006
Applicant	ESA
Inventors	G. Lopez-Risueno & G. Seco-Granados

PAT 526 INTERFEROMETRIC RADIOMETER

French Application	06 05371
Filed	16 June 2006
Applicant	ESA
Inventors	P. de Maagt, J. Christensen, A. Carlström, A. Emrich & S. Andersson

PAT 527 SPHERICAL PARALLEL MECHANISM WITH TWO DEGREES OF FREEDOM

French Application	06 04744
Filed	24 May 2006
Applicant	ESA
Inventors	C. Menon, R. Vertechy & V. Parenti Castelli

PAT 530 CONTROL APPARATUS FOR VOLTAGE REGULATION OF A POWER BUS

French Application	06 10059
Filed	17 November 2006
Applicant	ESA
Inventor	F. Tonicello

PAT 532 ELECTRICAL POWER GENERATION SYSTEM WITH MAXIMUM POWER POINT TRACKING

French Application	06 11007
Filed	18 December 2006
Applicant	ESA
Inventor	P. Perol

GAL PAT 006 A RECEIVER AND TRANSMITTER FOR USE IN A SATELLITE NAVIGATION SYSTEM

International Application	PCT/EP 2006/002497
Filed	9 March 2006
Applicant	ESA
Inventors	M. Hollreiser & R. Weigand