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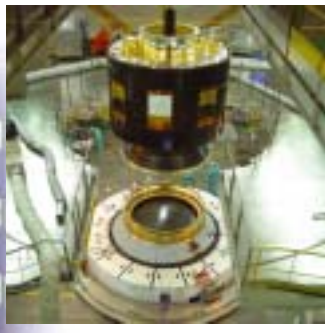

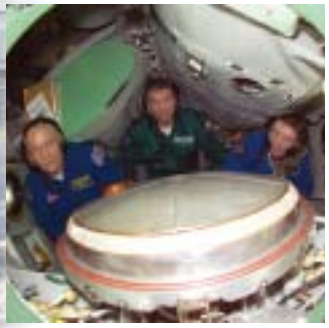

Annual Report 2005

European Space Agency
Agence spatiale européenne

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Foreword

2005 was an extraordinarily rich year for ESA and European space endeavours, and one that will be difficult to beat in the coming years. It started with the historic moment of the arrival of the Huygens probe on Saturn's moon Titan on 14 January. Huygens is an outstanding achievement for European science and technology, and a good example of successful partnership involving industry and scientists from all over Europe and the United States.

After two years of intense efforts to overcome the difficulties since the failure of its inaugural launch in December 2002, Ariane-5 ECA successfully returned to flight on 12 February, an event that was greeted with immense relief by the European space community. It was followed by a second successful flight in November. This modern and powerful launcher puts Arianespace in a stronger position in the global marketplace for launch services. With Ariane-5 ECA development behind it, Europe can now focus on the future.

On 27 February, following an eighteen-month journey, SMART-1 arrived in its operational orbit around the Moon. Rosetta, which is well on its way to Comet 67P/Churyumov-Gerasimenko, performed the closest ever Earth flyby by a spacecraft on 4 March.

Unfortunately, there were also some disappointments. CryoSat, the first spacecraft in the Earth Explorer series, was lost on 13 October following the failure of its Rockot launcher. The satellite, designed to investigate the status of the Earth's ice cover, is an essential mission with respect to our understanding of climate change, and the Agency is looking at ways of re-building and re-launching the mission in 2009.

On 9 November, Venus-Express was launched from Baikonur by a Soyuz-Fregat rocket. The probe, which is the first Venus mission in 15 years, is due to reach its target on 11 April 2006.

A new European meteorological satellite, MSG-2, was launched by Ariane from Kourou on 21 December. The satellite, which belongs to Eumetsat, but for which ESA oversaw the development and procurement, will ensure the continuity and reliability of high-quality imagery for European users. This is another good example of the excellent partnership between ESA and Eumetsat.

The Galileo Programme reached a significant milestone with the launch of the GIOVE-A satellite on 28 December. Besides validating critical components, the successful launch and in-orbit positioning of the satellite will secure the frequency filing for the Galileo system. Even if much hard work lies ahead, this marks a major step towards making this ambitious European programme a reality.

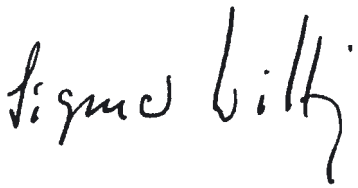
2005 was also the year ESA that celebrated its 30th birthday. Greece and Luxembourg became ESA's 16th and 17th Member States. Two Space Councils (joint and concomitant meetings of the Council of the European Union and of the ESA Council) took place, on 7 June and 28 November. They represent important steps in the building of a stronger link between the European Union and ESA and in the development of a genuine European Space Policy.

2005 was also a very busy year for the Agency's Council, with eight meetings taking place at Delegate level. At its June meeting, Council adopted the new Financial Regulations and fixed the value of the geographical-return coefficient for the Agency's mandatory activities and for each new optional programme at 0.84% as a guaranteed minimum, versus 0.94% for the cumulative

return for the period 2005-2009. In this context, I would like to pay tribute to my predecessor as Council Chairman, Per Tegnér from Sweden, who steered the Council with great skill and personal commitment over the last three years.

Much of the work of Council was dedicated to the preparation of the Ministerial Council, held in Berlin on 5-6 December under the Chairmanship of Minister Laurens Jan Brinkhorst from The Netherlands. The watchwords for the meeting were 'discovery and competitiveness'. The Ministers took important decisions regarding the launcher procurement policy and Space Station operations, and approved a series of programmes, including new initiatives in the area of space exploration (ExoMars), environmental monitoring (GMES) and technology, which will allow Europe to maintain critical space expertise and contribute to maintaining industry at the forefront of exciting technology developments in Europe.

I am convinced that after the highs of 2005, and building on the successes of 30 years of space cooperation in Europe, the Agency and European space can look to the future with optimism.



Sigmar Wittig
Chairman of Council

Year in Review

2005 was a crucial year in the Agency's long-term development, with a great deal of time and effort inevitably devoted to preparing for the political and programmatic decisions to be taken at the ESA Council Meeting at Ministerial Level in Berlin at the beginning of December. Those decisions by the Ministers put ESA on the correct trajectory, providing a long-term vision based on strategic guidelines, allowing us to prepare for the future, and addressing a consistent set of policies and programmes, aiming at increased efficiency and coherence within the Agency and in the European space sector. Overall, the decisions taken during this Ministerial Council represent 8.5 billion Euros of investment for the continuation of ongoing programmes and for new programmes.

ESA accumulated a long list of successes in 2005, many of which were instrumental in the successful outcome of the Ministerial Council. I believe that there were three reasons in particular for its success. First of all, the Agency's space missions were highly successful throughout the year. Secondly, the preparations for the Ministerial Council were very well executed and timely, and adhered to the roadmap that was presented to the Delegations in June. The new activities that were presented for decision in Berlin were based on exactly the same priorities that had been presented to Council in March 2004, namely Telecommunications, Exploration and GMES. Thirdly, there was the highly skilled chairmanship of Dutch Minister Laurens Jan Brinkhorst, who had an excellent rapport with his fellow Ministers.

An essential political decision taken in Berlin concerns the European launcher procurement policy, allowing full coherence to be ensured between ESA's satellite and launcher policies. We must now strive to ensure that this policy can be widened at overall European level. Another key topic concerned technology, which Ministers agreed is critical for the future of the European space sector and requires an approach coherent with the programmatic developments. Finally, another keyword was efficiency; ESA must demonstrate its efficiency, and where possible improve it, so as to maintain Member States' confidence that the Agency can and does deliver value for money.

The programmatic decisions taken by the Ministers were focused on discovery and competitiveness, which were the two themes of the Ministerial Council, and concerned:

1. The Agency's Mandatory Activities and the Level of Resources for 2006-2010 (Scientific Programme and basic activities).

2. Continuation of Ongoing Programmes, with subscriptions for:
   - the Earth Observation Envelope Programme
   - the International Space Station Exploitation Programme (Period-2), and the European ELIPS Programme (Period-2)
   - launcher evolution
   - Advanced Research in Telecommunications Systems (ARTES).

3. New Programmes, with subscriptions for:
   - the Global Monitoring for Environment and Security (GMES) space component
   - the European Space Exploration Programme 'Aurora'
   - the preparation of future launchers
   - the General Support Technology Programme (GSTP), for the preparation of new technology programmes.

Milestones in 2005

14 January: The Huygens probe successfully explores the atmosphere and surface of Saturn's largest moon Titan.

19 January: Signature in Moscow by ESA Director General, Jean-Jacques Dordain, and the Head of the Russian Federal Space Agency, Anatoly Perminov, of an Agreement for long-term cooperation and partnership in the development, implementation and use of launchers.

10 February: The ESA Science Programme Committee (SPC) approves a four-year extension of the Cluster mission, to December 2009.

4 March: The Rosetta spacecraft makes a close flyby of the Earth, passing within just 1900 km.

9 March: Greece formally becomes the 16th ESA Member State.

17 March: The ESA Council approves a cooperation agreement between the Agency and ISRO for India's first Moon mission, Chandrayaan-1, planned for launch in 2007/2008.

15 April: ESA astronaut Roberto Vittori is launched to the International Space Station aboard Soyuz-TMA6/10S, returning to Earth on 25 April.

21 April: The ERS-2 satellite and all its instruments continue operations 10 years and 52 289 orbits after launch.

2 May: Maser-10 is launched from Kiruna (S), providing 6 minutes of microgravity to five experiments and reaching 252 km altitude.

31 May: ESA celebrates its 30th birthday.

31 May: Launch of Foton-M2 from Baikonur carrying 385 kg of European experiments, returning to Earth on 16 June.

31 May: ESA and the European Centre for Medium-Range Weather Forecasts (ECMWF) sign a long-term Agreement to exchange information and expertise.

1 June: René Oosterlinck takes up duty as ESA's Director of External Relations.

7 June: The Second Space Council is held, in Luxembourg.

16 June: The development contract for the AlphaBus platform is signed by ESA, CNES, EADS Astrium and Alcatel Space.

22 June: The ESA Council elects Sigmar Wittig (D) as its new Chairman from 1 July, taking over from Per Tegnér (S).

27 June: ESA and ISRO sign an Agreement to include European instruments onboard India's first mission to the Moon, Chandrayaan-1.

30 June: Luxembourg formally becomes the 17th ESA Member State.

5 August: The SOHO mission discovers its 1000th comet.

27 September: The SMART-1 spacecraft completes 2 years of operations.

28 September: ESA's 35 metre deep-space antenna at Cebreros, in Spain, is inaugurated.

6 October: The Ulysses mission completes 15 years of operations.

8 October: ESA's first Earth Explorer mission, CryoSat, is lost due to the failure of its Russian launcher.

17 October: The Integral spacecraft completes 3 years of operations.

22 October: The Proba-1 spacecraft completes 4 years of operations.

26 October: ESA and the EC's Joint Research Centre sign an Agreement on space-based information services and access to, and provision of, Earth-observation data.

27 October: The ESA-sponsored SSETI Express student satellite is launched from Plesetsk Cosmodrome, in Russia.

9 November: ESA's first mission to Venus, Venus Express, is launched from Baikonur Cosmodrome, in Kazakhstan.

16 November: Successful third flight (V167) of the Ariane-5 ECA launcher.

18 November: Sun Laiyan, Administrator of the China National Space Administration, and ESA Director General Jean-Jacques Dordain sign an Intergovernmental Framework Agreement on space cooperation for peaceful purposes.

21 November: The ESA Science Programme Committee (SPC) approves the extension of the Integral and XMM-Newton missions by 4 years, until 16 December and 31 March 2010, respectively.

26 November: ESA Director General Jean-Jacques Dordain and the Portuguese Minister of Science, Technology and Universities, Prof. José Mariano Gago, sign an Agreement for an ESA transportable tracking station in the Azores.

28 November: Global Monitoring for Environment and Security (GMES) is the main agenda item at the Third Space Council, in Brussels.

1 December: The ESA/DLR-funded Texus-42 sounding rocket is launched from Esrange (S) and provides 6.5 minutes of microgravity for a payload that includes the Electromagnetic Levitator (EML) for the IMPRESS project.

2 December: The SOHO mission celebrates 10 years of operations.

5/6 December: The ESA Council at Ministerial Level, in Berlin (D), approves an increase in Science funding, continued funding to EOEP, ISS Exploitation Phase-2, ELIPS Phase-2 and ARTES, and new projects GMES, ExoMars, Aurora, and future-launchers preparation.

9 December: The Artemis spacecraft achieves the first bi-directional laser link in space, with Japan's Kirari satellite.

21 December: The MSG-2 satellite is launched by an Ariane-5 (V169).

28 December: The GIOVE-A Galileo experimental satellite is launched from the Baikonur Cosmodrome, in Kazakhstan.

In programmatic terms, 2005 was the year of the scientific missions, starting with the Huygens landing on Titan, continuing with Mars Express and the deployment of its Marsis radar, the launch of Venus Express, and the results from Smart-1, all of which could not fail to have had a positive influence in the Ministers' decision to increase the budget for Science, even if it was by a relatively small amount. In the same vein, all that we have achieved in Earth Observation, and especially with the much-publicised Envisat results, was instrumental in the positive decision that was taken on the GMES programme.

On launchers, not only the fact that we had managed to put Ariane-5 ECA back on track, but also the successful test firing of the Vega third stage and the signature of the contract for the Soyuz installation in French Guiana, all contributed to the positive decisions that were taken on the longer-term future of this ESA programme.

Galileo was also a very important example in terms of what ESA was able to achieve in 2005, with the successful resolution at the end of October of a situation whereby progress had been blocked for several months. Immediately thereafter, in just a matter of weeks, we managed to complete the negotiation with Galileo Industries of the industrial contract for the development and construction of the first four satellites for the European navigation system, valued at almost 1 billion Euros. Moreover, on 28 December, we successfully launched and began operating GIOVE-A (Galileo In-Orbit Validation Element), to secure the use of the frequencies allocated by the International Telecommunication Union (ITU) for the Galileo system.

These and the many other successes that ESA enjoyed in 2005 (noted in the accompanying 'Milestones' panel) also changed the way in which some Member States were looking at the Agency. It was also gratifying at the Ministerial Council to see increases in the contributions from several Member States, both large and small. Again, I think that this was also because we have demonstrated to our Member States that money invested in ESA is money well spent. The fact that Greece and Luxembourg formally joined the Agency in 2005, as the 16th and 17th Member States, can be seen as a further vote of confidence in ESA's programmes.

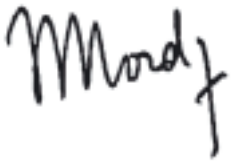
The image of the Agency on the wider international scene has also changed. Two weeks after the landing of Huygens on Titan, I met with my Heads of Agency colleagues regarding the International Space Station, and they were certainly impressed by ESA being the first space agency to land a spacecraft on this remote Saturnian moon. I also signed several important international Agreements for ESA during the year with partner countries and agencies, including one with ISRO concerning cooperation on India's Chandrayaan-1 lunar mission, and another with the Government of the People's Republic of China covering space cooperation for peaceful purposes.

In addition to the Ministerial Council in Berlin, there were two Space Councils in 2005 – joint meetings of the European Union and ESA Councils at Ministerial Level involving a total of 29 Ministers – which were also instrumental for ESA's future. The Second Space Council in Luxembourg in June defined the sharing of roles and responsibilities between the European Commission and ESA. Importantly for the Agency, it recognised the leadership of ESA in science, launchers and technology, as well as in space infrastructure, while that of the EU is recognised primarily in the applications domain, for Galileo and GMES. The Third Space Council, meeting in Brussels at the end of November, put in place the political foundation for GMES, which has already proved useful for the decisions that had to be taken at the ESA Ministerial Council in December.

I would also like to mention one more historic meeting in 2005, namely that of the Council at Delegate level in June, at which the main guidelines for a significant reform of the ESA financial system were decided. It will provide greater and much-needed flexibility in the way the various budgets are administered during the year, and also from one year to next. For the first time in the Agency's history, the Council also managed to agree not only on a minimum geographical return to Member States for the next four-year period, but also on a minimum return per project that is 10% lower than the minimum return on global activity, which also provides some additional flexibility.

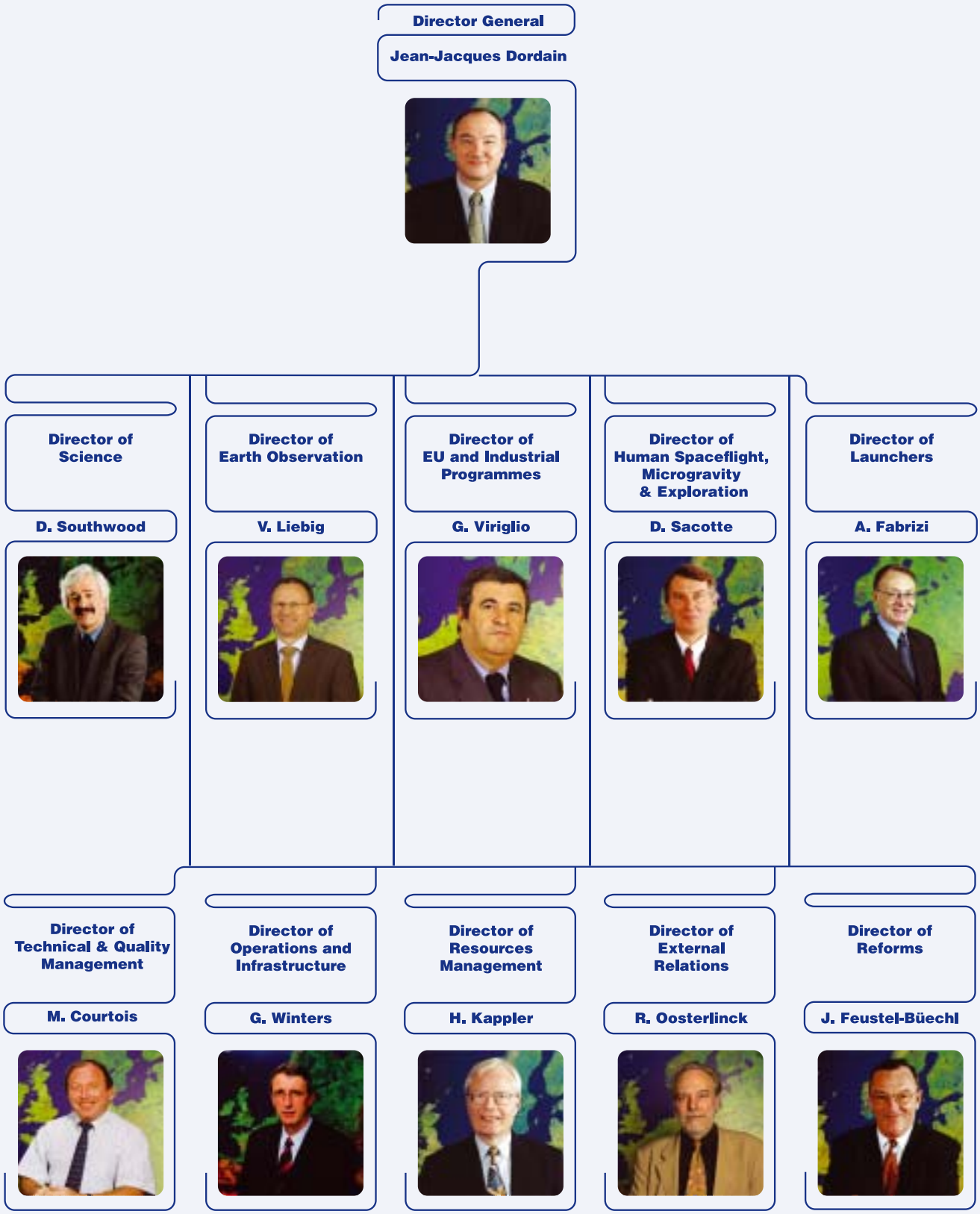
So all that I have recounted above was certainly good news for the Agency and its future. The only sad note in 2005 in terms of missions was the failure of the launch of CryoSat on 8 October. However, considerable progress was made before the end of the year towards the launch of a CryoSat-2; a few obstacles remain to be overcome, but I am confident that a CryoSat-2 will indeed be launched in 2009.

I would like to take this opportunity to thank the Member States for their unstinting support throughout 2005, the ESA Executive and staff for their selfless efforts, often working very long hours indeed, and European space industry for the quality and reliability of its products, all of which together make the European Space Programme such an outstanding success.



Jean-Jacques Dordain
Director General

Organigramme



Activities

Science

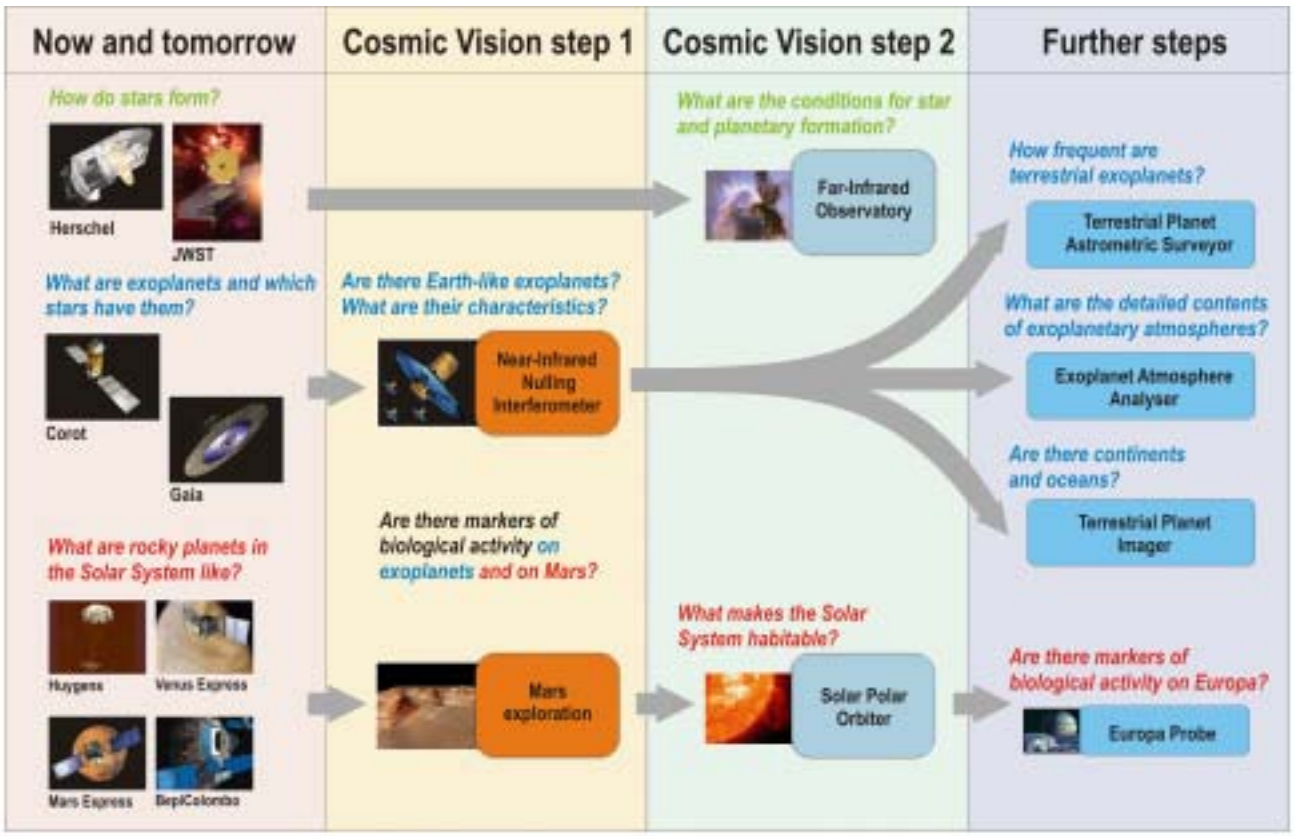
Planning for the Future – 'Cosmic Vision'

The Horizon 2000 Long-Term Plan for Space Science, formulated more than 20 years ago (1984), is almost completed. Its successor, Horizon 2000+, approved 10 years ago, is now coming to fruition, with a wealth of scientific satellites and space telescopes in orbit, producing excellent results. There is a need now to look ahead, building upon a solid past and working today to overcome the scientific, intellectual and technological challenges of tomorrow. 'Cosmic Vision', ESA's long-term scientific programme, is based on a vision built upon strong pragmatism and consolidated, proven ability. It is the starting point for 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 on:

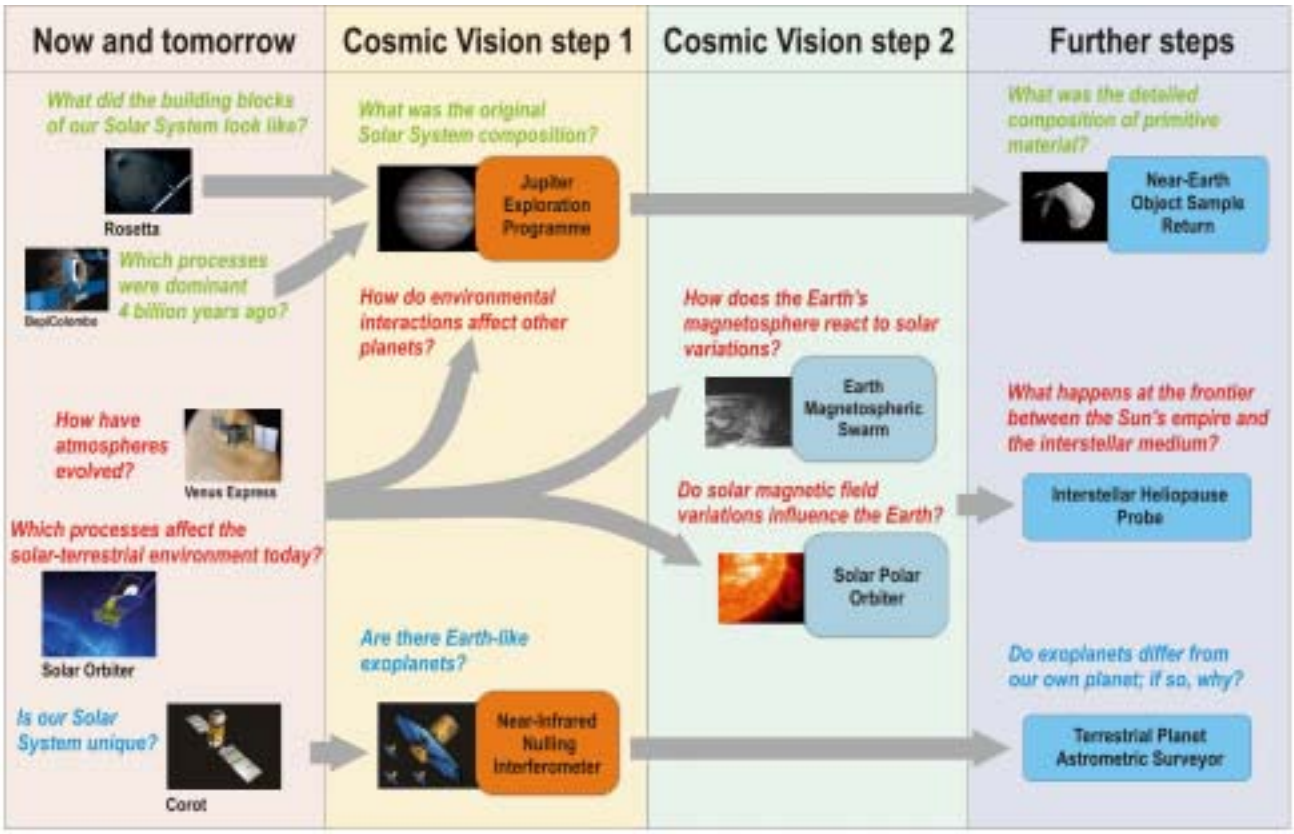
- current scientific challenges
- prevailing priorities in space research
- available knowhow, resources and technological investment aimed at maximum scientific return
- maintenance of European industrial and technological competitiveness
- consolidation of ESA's ability in worldwide space science.

Based on the massive response from the European scientific community and the priorities set by the scientific advisory structure, in May the Agency's Science Programme Committee (SPC) endorsed 'Cosmic Vision Space Science for Europe 2015 to 2025'. This plan identifies today's major scientific questions to be addressed by ESA's future space-science missions (see accompanying panels).

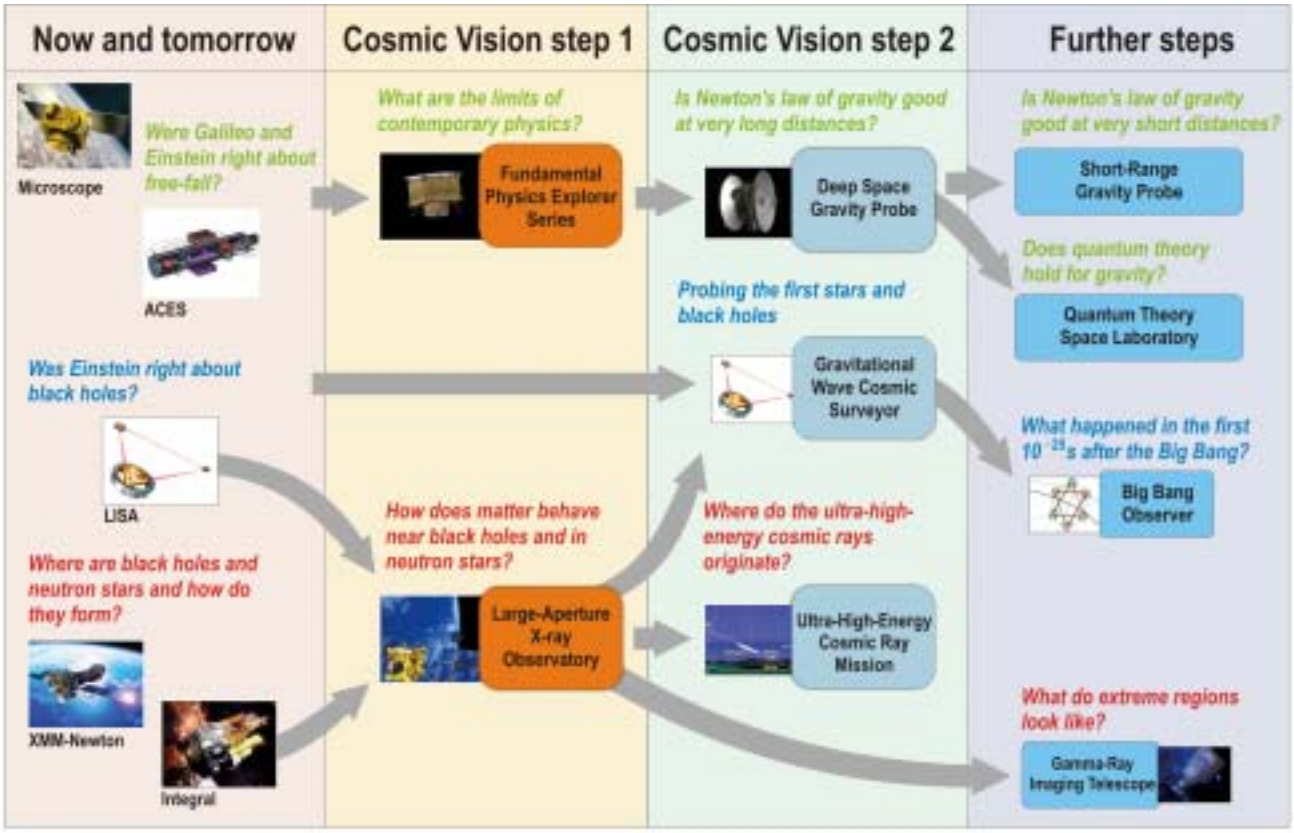
1. What are the conditions for planetary formation and the emergence of life? – Possible strategies



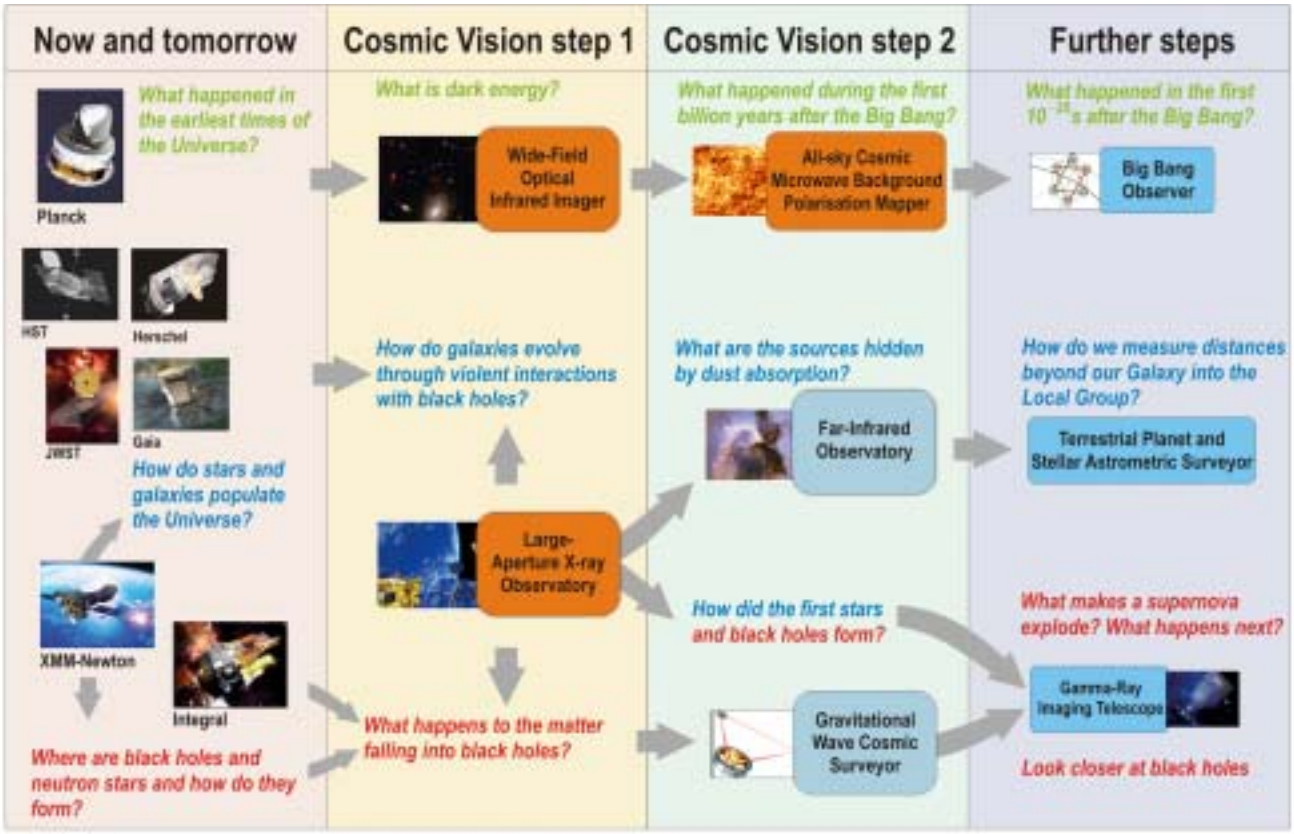
2. How does the Solar System work? – Possible strategies



3. What are the fundamental physical laws of the Universe? – Possible strategies



4. How did the Universe originate and what is it made of? – Possible strategies



Highlights of the Science Programme in 2005

For the Science Programme, the year started with one of the most publicly visible achievements to date – the successful landing on 14 January of ESA's Huygens probe on the surface of Titan. This is the only landing that has taken place in the outer Solar System, and the furthest from Earth, in the history of Solar System exploration.

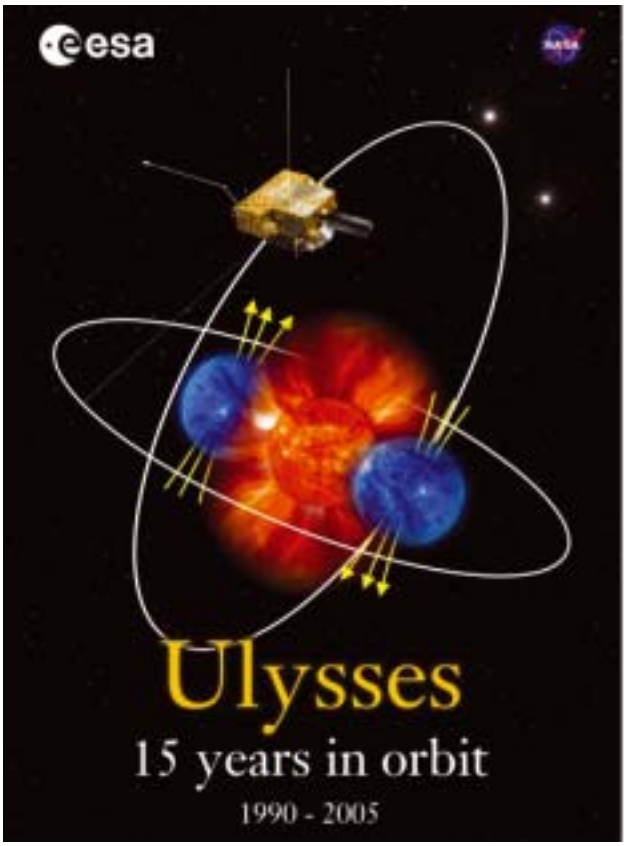
This was, however, only the first great achievement in a resoundingly successful year, which included the launch of Venus Express, the first results from the Mars Express MARSIS probe, and the Ministerial Council in Berlin, which reversed the trend of the previous 10 years by giving the Science Programme what it had requested in terms of funding.

The success of the Science Programme is rooted in a number of unique features:

- Its long-term planning approach initiated in the mid-eighties (Horizon 2000 followed by Cosmic Vision 2020): this has allowed the formulation of a plan with a mix of flagship missions (so-called 'Cornerstones') giving stability and credibility to the Programme, and a set of medium or smaller sized missions to provide planning flexibility.
- Its user-driven character: the Programme's content is determined by the European space-science community to serve their needs, a mechanism that has forged a strong reciprocal link between the users and the Agency.
- Its role as a technology driver: the highly ambitious missions of the Science Programme have always been a driver of new technology developments, which have led to spin-offs in other space areas.

Given its mandatory nature, which provides continuity and credibility and its long-term vision, technological challenges and world-class success, the Science Programme can be justifiably described as the backbone of the Agency. Approximately 3000 space scientists across Europe recognise the ESA Space Programme as their own, and also as the reference for their national programmes.

The Programme currently manages a fleet of 16 satellites.



A poster designed to celebrate the 15th anniversary of the Ulysses mission

Missions in Operation or in an Archival Phase

Ulysses

Launched: 6 October 1990

Ulysses was the first spacecraft ever to be placed in a polar orbit around the Sun. From this unique 'out-of-ecliptic' vantage point covering all solar latitudes, Ulysses is studying in-situ previously unexplored regions of space, such as those above the Sun's poles. It is providing the first four-dimensional survey (three spatial dimensions plus time) of the 'solar wind'. In 2005, Ulysses provided key observations of the unusually high solar activity in January and September from a perspective unavailable to any other space mission. At the same time, its instruments provided further insight into the nature of the outermost regions of the heliosphere. Because of its wide-ranging scientific impact, Ulysses remains a keystone in the 'Great Observatory', the international fleet of spacecraft currently observing the Sun and heliosphere. Since its launch in 1990, Ulysses has already travelled seven thousand million kilometres.

Glowing like a multi-facetted jewel, the planetary nebula IC 418 lies about 2000 light years from Earth in the constellation Lepus. In this image, the Hubble Space Telescope reveals some remarkable textures weaving through the nebula. Their origin, however, is still uncertain (Credit: NASA/ESA and the Hubble Heritage Team STScI/Aura)

Hubble Space Telescope

Launched: 24 April 1990

During 15 years of viewing the sky, Hubble has taken more than 700 000 exposures of more than 22 000 celestial objects. The spacecraft itself has circled the Earth nearly 88 000 times, travelling more than 4000 million kilometres. It generates about 15 gigabytes of data every day, and has already delivered 23 terabytes of data. Nearly 4000 astronomers from all over the World have used the telescope to produce a long list of scientific achievements, including:

- calculating the precise age of the Universe to be 13 700 million years
- confirming the existence of dark energy
- detecting small 'proto-galaxies' that emitted their light when the Universe was less than a 1000 million years old
- proving the existence of 'super-massive' black holes
- seeing a comet hitting Jupiter
- showing that the process of forming planetary systems is common throughout the galaxy.

SOHO

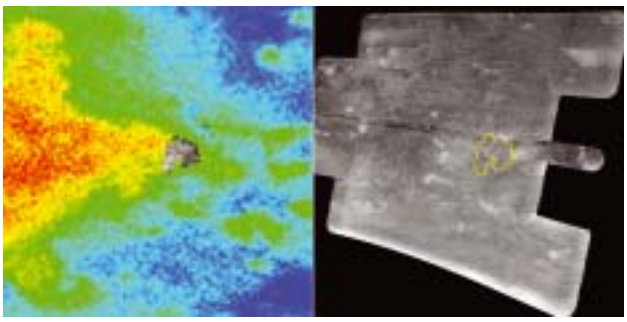
Launched: 2 December 1995

Originally planned to have a lifetime of just two years, SOHO's operations are set to continue until at least 2007, and this despite the spacecraft having been almost lost on three separate occasions. More than 3200 scientists around the World have been involved with the mission. Apart from unmasking the Sun and teaching us how it works, SOHO's images provide early warning of storms in space that can affect astronauts, spacecraft, and power and communication systems on Earth. In August, SOHO achieved a remarkable milestone with the discovery of its 1000th comet.

Cassini-Huygens

Launched: 15 October 1997

The route taken by the mission after its launch involved fly-bys of Venus, Earth and Jupiter to help give it the necessary energy to reach Saturn. On 14 January 2005, ESA's Huygens probe landed on the surface of Titan, the only landing to take place in the outer Solar System, and the furthest from Earth, in the history of Solar System exploration. The probe showed that Titan's surface exhibits Earth-like processes and morphology, complete with evidence of methane rain, erosion, stream-like drainage channels and dry lake beds.

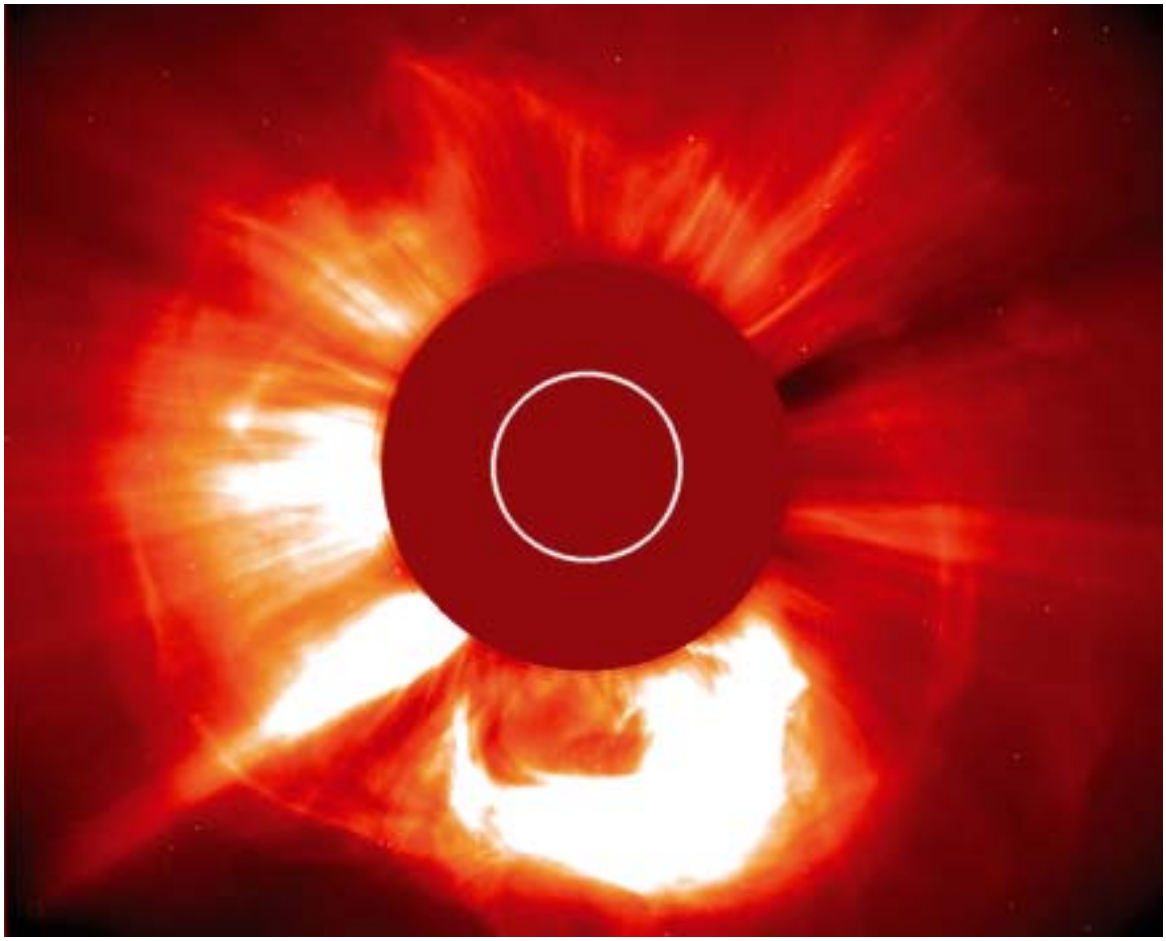


Infrared and radio images of the Huygens landing site, taken by Cassini on 28 October (Copyright: NASA/JPL/Univ. of Arizona/Space Science Institute)

XMM-Newton

Launched: 10 December 1999

The XMM-Newton mission has been routinely providing



SOHO image of Coronal Mass Ejection

high-quality, high-impact science data since its launch, and its operations are currently approved to continue until end-March 2010.

The response to the Call for Observing Time (AO-5) resulted in 632 proposals, representing an over-subscription factor of 7.4. The upgrading of the XMM-Newton ground segment to SCOS 2000 was completed on schedule during the year. Almost 1000 papers based either completely or partially on XMM-Newton observations had been published in the refereed literature by end-2005.

Cluster

Launched: 16 July and 9 August 2000

A Cluster and Double Star Symposium held at ESTEC in September, celebrating the fifth anniversary of Cluster in space, was attended by more than 150 international scientists. During this meeting the Cluster Active Archive was officially opened for beta-testing. The depository of processed and validated high-resolution Cluster data will be a major contribution by ESA and the Cluster science community to the International 'Living with a Star' programme. The ability of magnetic storms to create 'killer' electrons, responsible for damaging spacecraft and posing a serious hazard for astronauts, was reported in the journal *Nature*. For the first time, the currents in the Earth's radiation belts could be directly measured using the unique multi-point measuring capability of Cluster. In July, the four spacecraft underwent a series of manoeuvres (the most complex ever conducted by ESA) to make Cluster the first multi-scale mission, facilitating the simultaneous multi-point investigation of kinetic and macroscopic-scale phenomena in the magnetosphere.

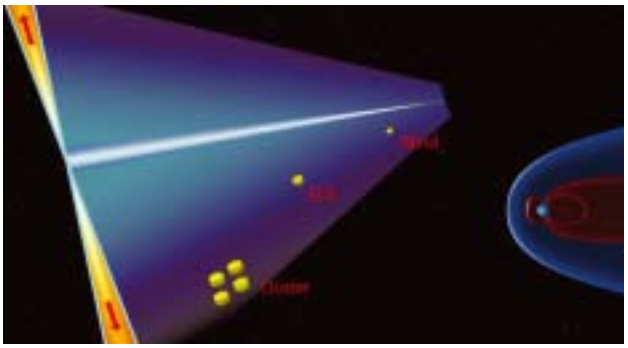
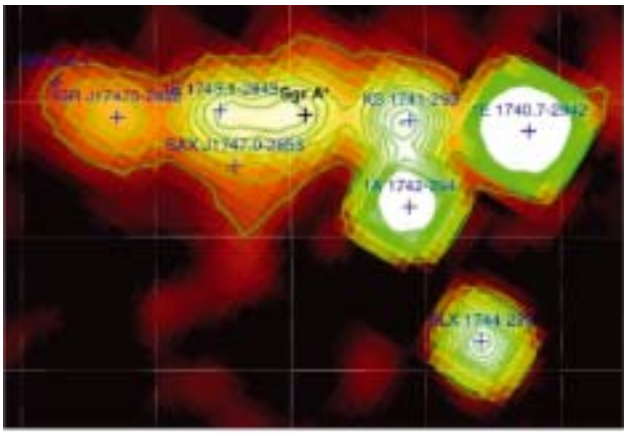


Illustration of the Cluster, ACE and WIND spacecraft observing the magnetic-reconnection region The directions of the plasma jets associated with the magnetic-reconnection process are represented by red arrows embedded in the flows
(Courtesy of Matt Davis and Tai Phan, SSL/UC Berkeley, USA)



An image of X-ray emission from the Galactic Centre taken in September by Integral (IBIS/ISGRI). The grid lines indicate galactic coordinates with a spacing of 0.5 degrees (Credit: G. Bélanger et al./CEA Saclay)

Integral

Launched: 17 October 2002

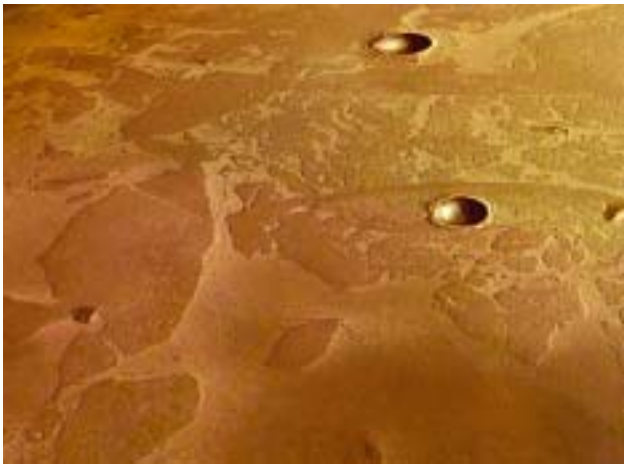
Integral's four instruments provide the possibility for the first time to carry out simultaneous, single-satellite observations at optical, X-ray and gamma-ray wavelengths of the most energetic objects and phenomena in the Universe. Integral thereby discovered a new class of highly-absorbed or 'cocooned' X-ray binary stars, not seen by previous missions. It makes many 'Target of Opportunity' observations of transient sources, and one of the most interesting of these in 2005 was of a new source IGR J00291+5934, which turned out to be the fastest-rotating neutron star known – spinning almost 600 times a second.

Mars Express

Launched: 2 June 2003

The radar booms (dipole and monopole) of Mars Express's MARSIS instrument were deployed in May and June, following comprehensive simulations of boom deployment in order to mitigate potential risks to spacecraft stability. The most significant scientific achievements during the year were:

- Strong MARSIS radar echoes coming from both the surface and the subsurface of the planet, allowing the identification of buried craters and tectonic structures. Also, probing of the planet's ionosphere revealed a variety of echoes originating in surface areas magnetised in very early times.
- The OMEGA instrument discoveries have provided new insights into the evolution of the Martian surface, showing that alteration of primordial volcanic material into phyllosilicates early in Mars' history and into sulphates in more recent times occurred during



This image, taken by the High-Resolution Stereo Camera (HRSC) on Mars Express, shows what appears to be a dust-covered frozen sea (part of the Elysium Planitia) near the Martian equator
(Copyright: ESA/DLR/FU Berlin (G. Neukum))

This Mars Express image taken by the High Resolution Stereo Camera (HRSC) on 25 February shows ice and dust at the Martian north pole in a perspective view for the first time. The cliffs are almost 2 kilometres high, and the dark material in the caldera-like structures and dune fields could be volcanic ash
(Copyright: ESA/DLR/FU Berlin (G. Neukum))

two different water regimes (and thereby climates): abundant liquid water in a warmer climate followed by much more episodic and modest water outflows in a colder and drier climate.

- The SPICAM instrument detected an aurora on Mars related to paleomagnetism in the ancient crust.

SMART-1

Launched: 27 September 2003

The primary technology mission of SMART-1 was successfully completed in February and the mission then entered its scientific phase. In August, a reboost manoeuvre achieved the optimum orbit for the extended mission, during which the emphasis will be on push-broom imaging with the AMIE camera. This reboost manoeuvre consumed all remaining fuel and the electric-propulsion engine was shut down in September.

Rosetta

Launched: 2 March 2004

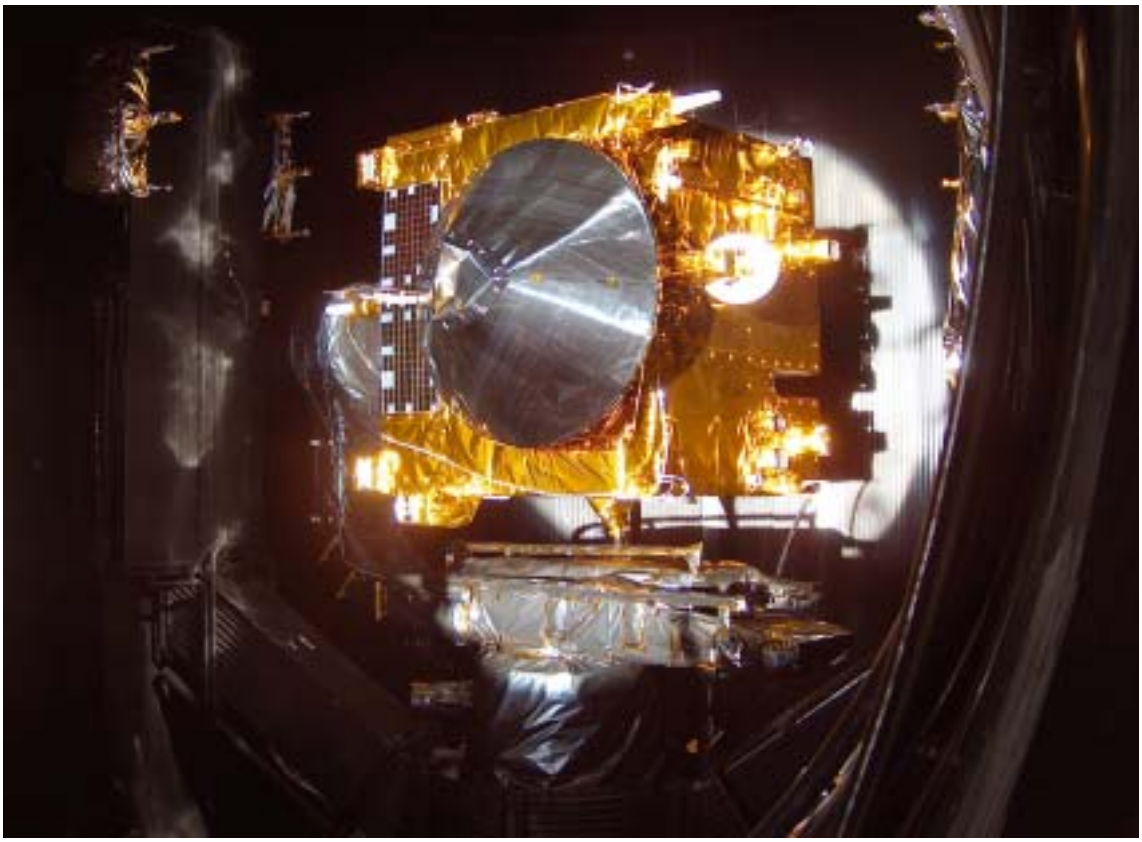
The Rosetta spacecraft performed its first Earth gravity-assist manoeuvre on 4 March, passing within 1954 km of the Earth's surface. Immediately after the closest approach, the asteroid-flyby scenario was tested using the Moon as a target. On 4 July, Rosetta participated in the campaign to monitor the Deep Impact encounter at comet Temple 1, which resulted in excellent data from the OSIRIS camera – the only instrument that could monitor the event continuously for a number of days. The spacecraft is now in a passive cruise phase on its way to Mars for its second gravity assist in February 2007.

Double Star

Launched: 29 December 2003/25 July 2004

Double Star is a landmark, being the first Chinese magnetospheric mission, and continues the collaboration between ESA and the Chinese National Space Administration. A paper based on unique Double Star and Cluster data was published in July, in which European scientists reported the first observational evidence of cracks in a neutron star crust during a star quake.

The Starsem Soyuz-Fregat launch on 9 November carrying Venus Express



The Venus Express spacecraft in the SIMLES thermal-vacuum chamber at Intespace in Toulouse (F)

Venus Express

Launched: 9 November 2005

Venus Express was successfully launched on 9 November from the Baikonur Cosmodrome in Kazakhstan on a Soyuz-Fregat rocket. The subsequent near-Earth commissioning phase proceeded smoothly and the entire spacecraft and payload complement was checked-out operationally before the end of December. The Venus Orbit Insertion manoeuvre is planned for 11 April 2006, to be followed by payload in-orbit commissioning and handover for nominal scientific operations by mid-2006.

Missions to be Launched in the Coming Years

COROT

Launch: Mid-October 2006

COROT is a small mission led by CNES with substantial contributions from the ESA Science Programme and several Member States, namely Austria, Belgium, Germany, Italy and Spain. Devoted to astero-seismology and planet finding, it is the third in the CNES series of missions based on the Proteus platform. It is slated for launch in mid-October 2006 by a Soyuz-Fregat from Baikonur. COROT is the first mission fully dedicated to accurate astero-seismic observations and the detection of extra-solar rocky planets, both of which require the stability and accuracy of space-based photometry.

Herschel-Planck

Launch: Early 2008

Practically all flight hardware for both satellites was completed, delivered and integrated during the year, and acceptance testing was started. With the spacecraft's development progressing well, the overall schedule is driven by the availability of the scientific payload, which has been experiencing some technical difficulties.

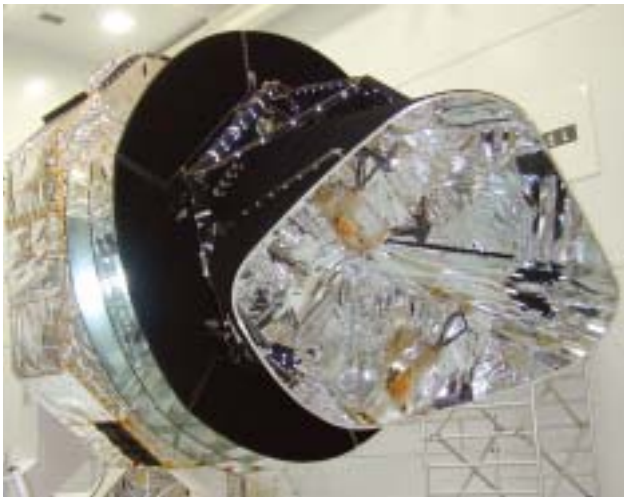
The testing of the Planck qualification model was completed during the year, and the service module was

delivered to the prime contractor Alcatel Alenia Space for system integration. The flight-model payload module was mated later in the year with the service module and the Planck spacecraft is being prepared for its first major environmental acceptance test in early-2006.

The structural model of the Herschel service module was delivered and integrated at the end of 2005 with the flight model of the payload module (the cryostat), to qualify the satellite for the expected mechanical launch loads. The thermal testing in the Large Space Simulator (LSS) facility at ESTEC has been completed.

The Herschel and Planck telescopes were fully assembled and aligned during the year.

The contract between ESA and Arianespace for the provision of the Ariane-5 ECA launcher has also been signed.



The Planck qualification model spacecraft

The Herschel structural and thermal qualification model spacecraft

Microscope

Launch: March 2009

The CNES/ESA scientific mission Microscope, for the measurement of the equivalence principle with extreme accuracy, is due to be launched in 2009 for a nominal duration of one year. ESA is providing the FEEP Electric Propulsion System (EPS) required to give the spacecraft a virtually pure drag-free environment. The EPS design and testing activities at thruster and subsystem level are progressing. An extended firing test concluded in May on the thruster core element accumulated a total impulse of 500 Ns, after 1650 hours of continuous operation. The complete thruster assembly was tested in November and showed very good performance.

LISA Pathfinder/SMART-2

Launch: 4th quarter 2009

LISA Pathfinder, the second of the Small Missions for Advanced Research and Technology (SMART-2), is dedicated to demonstrating key technological aspects of the Laser Interferometer Space Antenna (LISA), a spaceborne gravitational-wave detector mission to be undertaken jointly by ESA and NASA.

Artist's impression of the Gaia spacecraft

The spacecraft Preliminary Design Review was successfully completed in September and the procurement of all subsystems/equipment has been initiated. Development of the LISA Technology Package (LTP), the main experiment and hence the core of the mission, has started through several industrial and institutional procurements, involving seven national funding agencies (in CH, D, E, F, I, NL, UK) and ESA. The launch towards the Sun-Earth Lagrangian Point 1, by either a Vega or Eurockot launcher, is currently planned for the fourth quarter of 2009.

Gaia

Launch: December 2011

The two competitive definition-study phases came to a successful end in June, with the study contractors delivering their final presentations. Gaia requires a customised design and a very large number of CCDs. Therefore, to safeguard the December 2011 launch date, ESA placed the contract for the flight model's production in June, about nine months before the official kick-off of the Gaia implementation phase. Two companies, Astrium SAS and Alcatel Alenia Space, submitted their proposals for the development phase, and contractor selection will take place early in 2006.

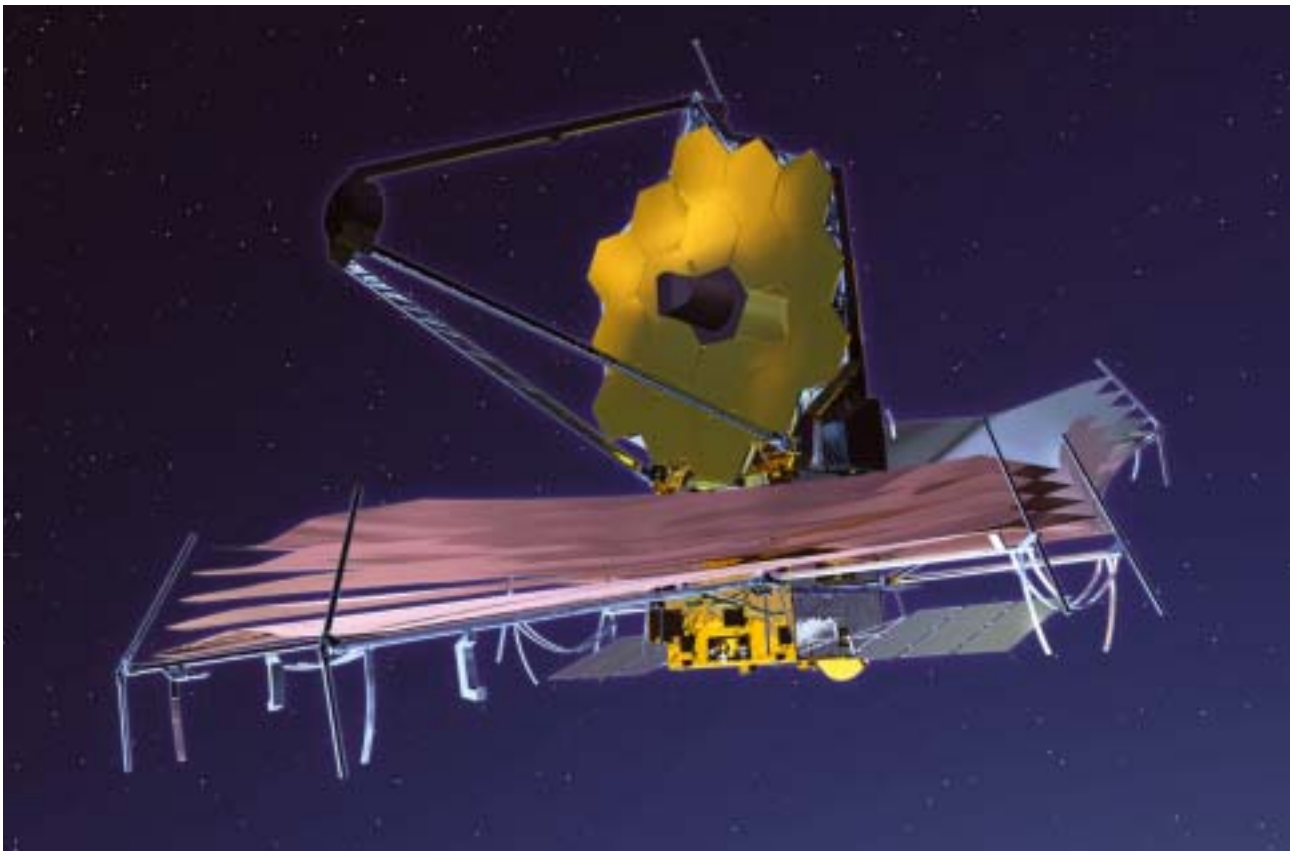
Two major activities were initiated in 2005, namely a competitive design activity on a cold-gas micro-propulsion system and the industrialisation of the proximity electronics for interfacing with more than one hundred CCDs.

Definition work on the Mission Operations Centre and the Scientific Operations Centre has begun, as well as the detailed work with the launch-service provider.

James Webb Space Telescope (JWST)

Launch: June 2013

Significant architectural design changes were made to recover the necessary margins, with cryo-coolers replacing the solid-hydrogen-based cryostat, and a bi-propellant



Artist's impression of JWST

system replacing the monopropellant propulsion system. Increased costs led to a substantial NASA review. Independent scientific and programmatic review panels confirmed that the mission design should remain unchanged in order to fulfil the intended science objectives, and that the increased cost was realistic. NASA subsequently introduced a launch delay of 22 months to accommodate the cost increase.

The MIRI instrument, developed by a European consortium of scientific institutes, successfully passed its Preliminary Design Review, and the structural thermal model completed its test campaign. The NIRSpec instrument procured directly under ESA's responsibility is presently at the Preliminary Design Review stage. NASA has made significant progress in the development of the micro-shutter chips used to isolate the target stars from the rest of the sky in the instrument field of view.

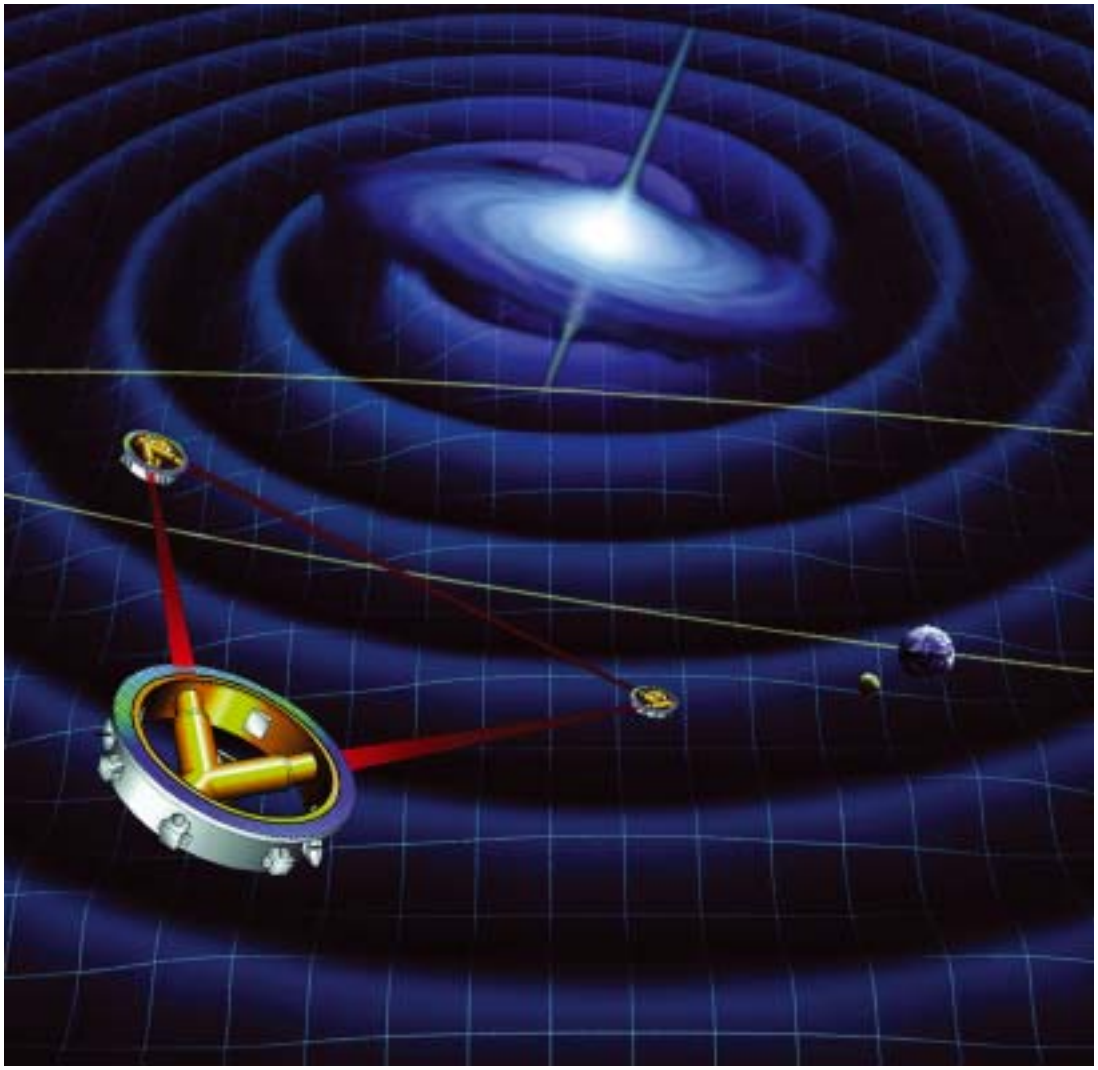
NASA has decided finally to launch JWST on an Ariane-5 ECA vehicle, with initial analyses having clearly demonstrated its compatibility.

BepiColombo

Launch: August 2013

BepiColombo is a collaborative ESA and JAXA (Japan Aerospace Exploration Agency) mission consisting of two scientific orbiters: the Mercury Planetary Orbiter to be provided by ESA, and the Mercury Magnetospheric Orbiter to be provided by JAXA. A Soyuz-Fregat launch in August 2013 is foreseen, leading to spacecraft arrival at Mercury in August 2019. The intervening six-year cruise phase will be achieved through a combination of planetary fly-bys and solar electric propulsion.

JAXA have formally started the Phase-B for the Mercury Magnetospheric Orbiter, with the funding secured in the governmental budget. An extension to the Letter of Agreement between ESA and JAXA is being signed and a joint Memorandum of Understanding is in preparation.



LISA, searching for gravitational waves

LISA

Launch: Mid-2015

The LISA mission, which involves flying three spacecraft separated by 5 million kilometres, is designed to detect the 'ripples' in space-time produced by massive objects such as black holes.

The LISA mission-formulation phase began in January with the kicking off of the industrial contract with Astrium GmbH. The Mission Architecture Review was successfully conducted in October. A Joint Project Management Office, co-led by the ESA and NASA Project Managers, is responsible for all decisions related to mission design, based on the proposals of the Mission System Engineering Managers Office, co-led by the ESA, GSFC and JPL System Engineering Managers. This system works very well and facilitated progress during the year with decisions regarding the consolidation of the mission baseline reference architecture.

Despite its Mandatory Programme status, the Science Programme has not been spared the stringencies in the Agency due to the current difficult economic situation. A major casualty has been the Cornerstone-mission philosophy, which was the basis on which the Horizon 2000 plan was built and through which Europe was brought to the forefront in world space science. Consequently, Gaia, LISA and BepiColombo, which were originally selected as Cornerstone missions, have had to be re-scaled to meet financial targets well below the level of a Cornerstone mission. Equally, the rate of launches is falling from 1 mission per year in the period 1998-2005, to about 1 every 2 years for the foreseeable future. Choices will have to be made in order to reconcile the conflicting demands for new missions and the requirements of missions that are already in the pipeline.

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 Switzerland, Belgium, Ireland, Austria, Norway and Denmark. The projects being developed range from small Earth-observation data-analysis programmes, to fully-fledged instruments for scientific payloads.

Major undertakings in 2005 included the industrial activities in the four PRODEX countries participating in the MIRI instrument for the James Webb Space Telescope (JWST), namely Belgium, Switzerland, Denmark and Ireland. The feasibility study of the Swiss contribution to the BELA instrument for the BepiColombo mission was also successfully completed.

Integration of the baffle and deployable cover on the COROT flight model (Courtesy of CSL)

At the ESA Ministerial Council in December, the way was cleared for the renewal of the PRODEX Declaration financial envelope for the period 2006-2010.

The PRODEX Office has also been entrusted 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. Poland and Romania have now notified the Agency of their intention to join, and a first round of negotiations has been initiated.

PRODEX Experiments or Subsystems Finalised and/or Launched in 2005

HERSCHEL MISSION		
• HIFI instrument – various subsystems:		
- Common optics assembly, mixer assembly, intermediate amplifier IF2	A. Benz	Zurich (CH)
- Verification of optical design	A. Murphy	Maynooth (IRL)
• PACS instrument – various subsystems:		
- Cold Read-out Electronics subsystem (CRE), grating assembly	C. Waelkens	Leuven (B)
COROT		
. COROT instrument – various subsystems:		
- Baffle, cover	C. Jamar	Liège (B)
STEREO		
• PLASTIC	P. Wurz	Bern (CH)
• SECCHI		
- Heliospheric Imager (HI)	C. Jamar	Liège (B)
VENUS EXPRESS		
• SPICAV		
- Solar Occultation at Infrared (SOIR)	D. Nevejans	Brussels (B)
INTERNATIONAL SPACE STATION		
• SOVIM	C. Fröhlich &	Davos (CH)
	A. Joukoff	Brussels (B)
• SOLSPEC	D. Gillotay	Brussels (B)
MASER-10		
• Interfacial Turbulence in Evaporating Liquids (ITEL)	P. Colinet	Brussels (B)
FOTON-M2		
• FLUIDPAC	J-C. Legros	Brussels (B)
• Soret Coefficients in Crude Oil (SCCO)	J-C. Legros	Brussels (B)
MAXUS-6		
• UNESTA material science experiment	L. Froyen	Leuven (B)

Earth Observation

Envisat MERIS image of Europe under snow, taken in March 2005

International Charter on Space and Major Disasters

At the Earth Observation Summit in February, Minister Kandiman of Indonesia praised the International Charter for the assistance provided in response to the tragic Asian tsunami in December 2004. At the Summit, the parties of the International Charter offered it as a practical mechanism of the Global Earth Observation System of Systems (GEOSS) for responding to disasters at the local, national, regional and global level.

In 2005, the Charter was invoked 25 times for events affecting six continents, including the hurricanes Stan and Katrina in the Americas, floods in Africa, earthquakes in Iran and Kashmir, fires in Portugal and floods in Central Europe, especially in Romania and Bulgaria, at the request of national authorities as well as the European Commission's Monitoring and Information Centre and specialised United Nations organisations. On several occasions, ESA took the lead in the response, giving the opportunity to demonstrate the large-scale services being consolidated within the GMES portfolio in the field of disaster response and humanitarian assistance.

The fifth anniversary of the Charter's operation was celebrated in Bangalore, India in October, looking back over a total of 91 activations since November 2000. The year was also marked by an increase in membership of the Charter, with Japan's Aerospace Exploration Agency (JAXA) joining in February and the Disaster Management Constellation (DMC), including Algeria, Turkey and Nigeria, in November, and strengthened American support from the US Geological Survey (USGS). Following the European Union's enlargement, the civil protection agencies in all ESA and EU Member States can now request assistance under the Charter.

Global Monitoring for Environment and Security (GMES)

The ESA/EU-led GMES initiative is the most complex and ambitious Earth-observation programme to date, now being prepared for its operational start from 2008 onwards. In 2005, there were three main types of activities associated with the GMES space component:

The Third Earth Observation Summit in Brussels (B) in February

(a) activities to define the GMES space component programme
(b) preparation of the GMES space component programme, leading to its endorsement and initial funding at the ESA Ministerial Council in Berlin in December, and
(c) programmatic activities related to the governance of the overall GMES initiative.

A GMES Technical Coordination Team was set up within the Directorate of Earth Observation Programmes to monitor and coordinate all preparatory activities and support the preparation of documents for the Ministerial Council.

GMES Preparatory Activities

Based on the decision of ESA's Programme Board for Earth Observation, a total of 15 studies have been initiated to define different elements of the GMES space component. They cover the GMES architecture, the space segment and corresponding ground segment, as well as the evolution of future services.

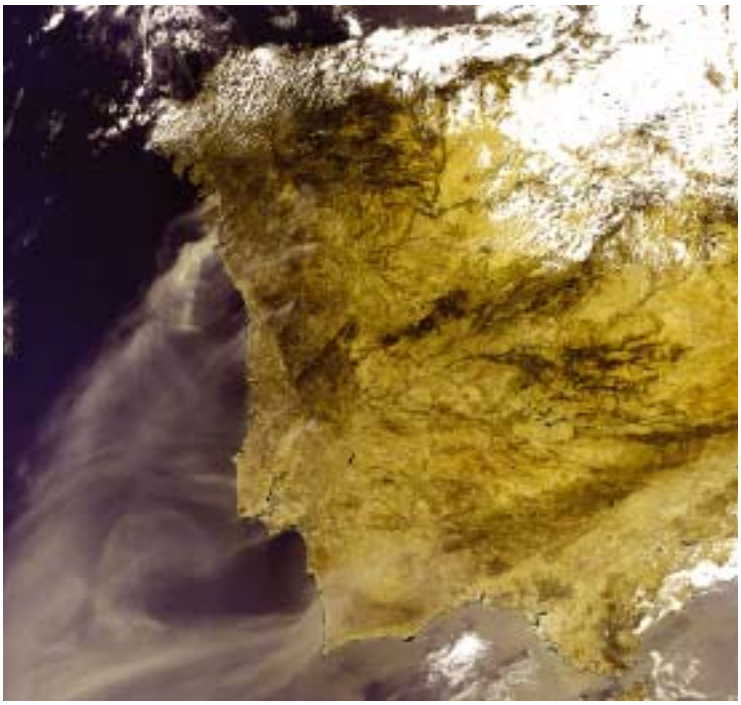
Phase-A/B1 studies have been conducted for future GMES space missions, in particular for Sentinel-1, Sentinel-2 and Sentinel-3. The studies will conclude in early (Sentinel-1) and mid-2006 (Sentinel-2 and 3). Two space segment architecture studies investigated several payload and spacecraft scenarios. A study on the socio-economic impact of GMES, led by PriceWaterhouseCoopers, has been started.

Preparation for the Ministerial Council

The content of the GMES space component programme was defined and negotiated with ESA Member States throughout the year. As GMES is a joint ESA/EC initiative, the EC as well as EU member states that are not members of ESA were consulted on a regular basis. Phase-1 of Segment 1 of the GMES space component, which was put forward for funding in Berlin in December, achieved an impressive 126% subscription from the Ministers. This strong support will allow solid implementation of the programme from the outset. It also confirmed the attractiveness of GMES, and the confidence that the Member States have in the Agency regarding the implementation of the space component.

GMES Governance

Regular meetings of the GMES Programme Office and GMES Advisory Council were held throughout the year, complemented by bilateral meetings with the European Commission and other partners such as Eumetsat or the EU Satellite Centre. The EC adopted a Communication on GMES, which confirms ESA's role as the implementing



Envisat MERIS image of forest-fire smoke plumes in Portugal, taken in August 2005

agency for the GMES space component and that the EC will provide a significant financial contribution. The third EC/ESA Space Council in Brussels in November confirmed the content of this GMES Communication.

Missions in Operation

Envisat and ERS-2

Almost four years after its launch, the Envisat mission is well established. A tangible sign of its success was the steady increase in user demand for Envisat data and services during the year, materialising as new project proposals for data use (950 scientific projects served with Envisat data by end-2005). Hence, the Payload Data Segment performances were further upgraded, allowing the generation of about 250 Gigabytes of products per day. Particular attention was paid to ease of data access, through a gradual offering of data on the Internet or via satellite.

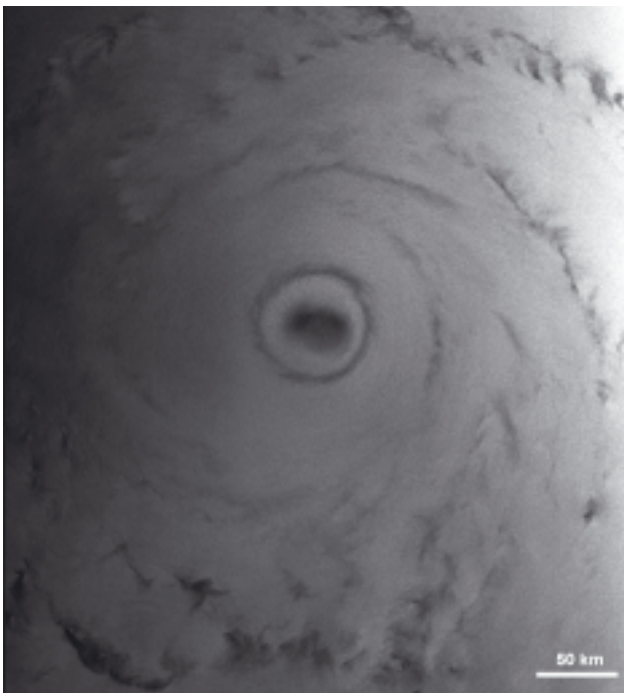
The regular organisation of Workshops, such as those on MERIS/(A)ATSR and SAR Interferometry, continued to be an important element of the interaction between ESA and the user community, aiming at optimal mission data exploitation.

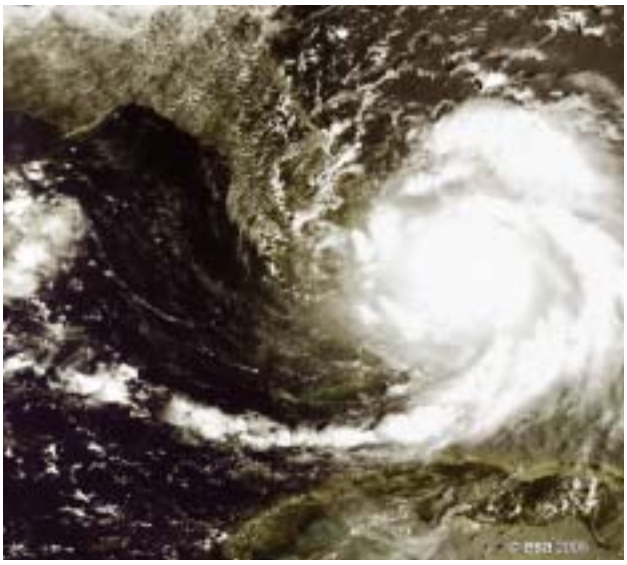
The positive image of the Envisat mission is also the result of the stable performance of both the satellite and its payload, with all instruments fully operational, with the exception of MIPAS for which a non-continuous operation scenario has been put in place.

After ten years of operations and more than 50000 orbits, ESA's second Earth-observation workhorse, ERS-2, continues to function well with all instruments still operating. A growing global network of ground stations is receiving data from the veteran spacecraft, with the low-bit-rate station network having been extended to eleven stations during the year. There is an ever-increasing demand for ERS-2 data, with an all-time record of 18 000 SAR products delivered in 2005, an increase of 33% compared with 2004. A new interferometry service has been established, leading to a revival of classical interferometry for ERS. A solid decade of ERS-2 observations has helped cement a worldwide community of more than 3000 users, and the success story looks set to continue.

The Earthnet Programme

The Earthnet Programme has been part of ESA's Earth-observation activities for more than 25 years, and assures





Two views of Hurricane Katrina acquired on 28 August 2005 with instruments onboard Envisat. The ASAR radar image of the sea surface (left) shows how Katrina's wind fields caused rippling of the ocean surface. The MERIS optical image (right) shows characteristic swirling cloud patterns around the central eye, with the eye 'walls' also visible

long-term sustainability beyond normal programmatic funding periods. In June, the Earthnet Medium-Term Plan 2006-2010 was approved, allowing the continuation of the Programme's main elements: international agreements for access to Third-Party EO missions, technology evolution and operation of a generic multi-mission ground segment, and the continuous international representation and promotion of ESA's EO activities.

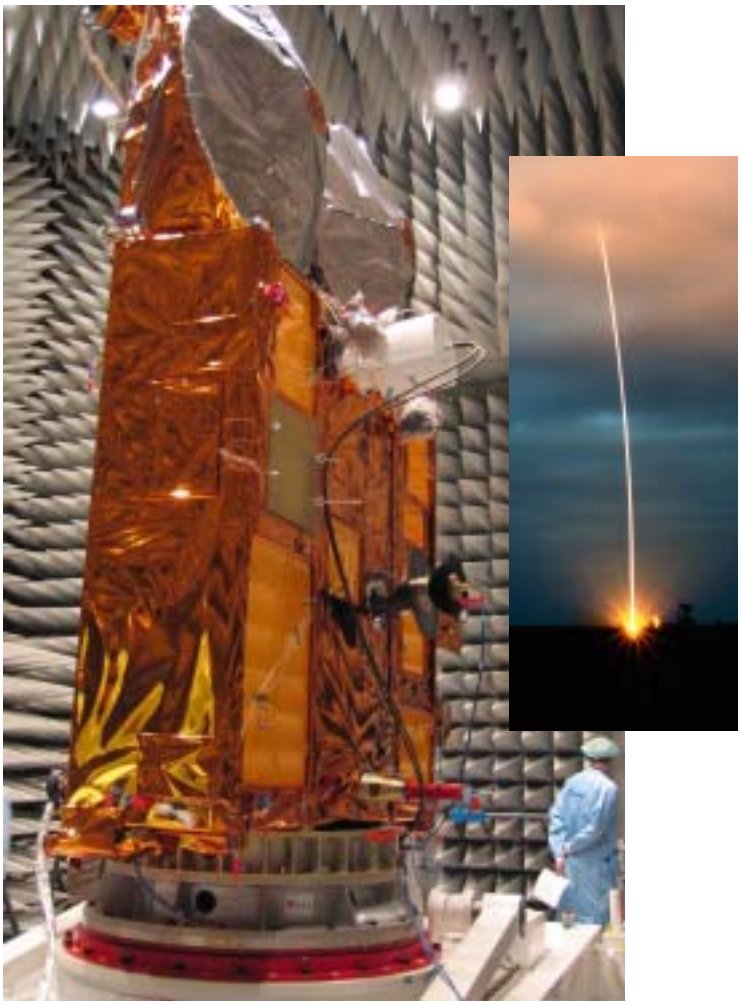
The number of Third-Party Missions grew to more than 20 in 2005. New agreements were established giving European users access to data from Landsat (USA), Scisat (Canada), KOMPSAT-1 (South Korea), IRS-P6/Resourcesat (India), ALOS (Japan) and SPOT-1 to SPOT-4 (France). Access to Third-Party Missions has also been harmonised in terms of a simplified application procedure for Category-1 scientific projects. Online accessibility, catalogues and ordering procedures have been further aligned with those for ESA missions, and the documentation on Third-Party Missions was improved.

Ground Segment Harmonisation

A major milestone was achieved in June, when the Ground Segment Coordination Body was successfully formed, including satellite operating agencies such as ASI, CNES, CSA, DLR, ESA and Eumetsat. The mandate of this group covers the efficient collaboration, cooperation and even sharing of the respective ground segments. Joint activities include the definition and establishment of interoperability standards, the setting-up of interface standards for payload ground-segment architectures, the elaboration of a common policy for long-term data preservation, and the sharing of network infrastructures, tools and other elements.

The Heterogeneous Mission Accessibility (HMA) contracts have been initiated with national agencies owning or operating Earth-observation missions, and these activities should be completed in 2006. The HMA initiative is also coordinated with the European INSPIRE initiative.

2005 saw the start of payload ground-segment architecture definition for the Sentinels, the further evolution towards a multi-mission environment, the beginning of historical archive rationalisation and management, the deployment of a high-speed network allowing high-performance online data distribution to users, the unification of the multi-mission catalogue (containing ERS, Envisat and Third-Party Mission data) and, last but not least, the entry into full operation of the EO Web Portal, providing – on top of the ESA missions portal – a single, neutral entry point to access worldwide Earth-observation information and data.



The CryoSat spacecraft undergoing electromagnetic-compatibility testing at IABG in Ottobrunn (D). Inset: The ill-fated launch from Plesetsk on 8 October

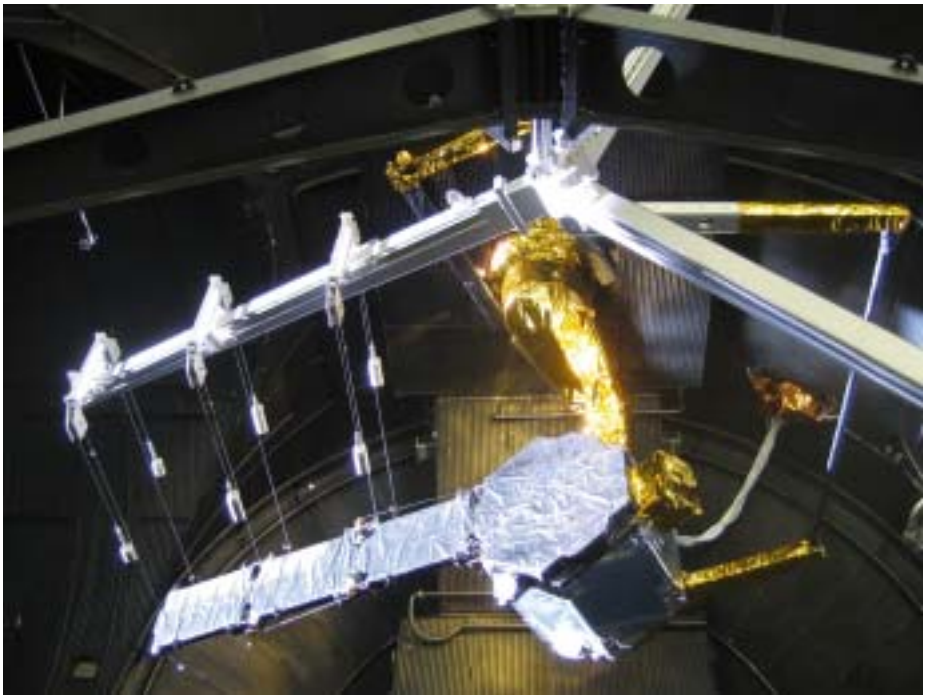
Missions under Development

Earth Explorer Missions

CryoSat

- *a mission designed to measure variations in the thickness of the polar ice sheets and the thickness of floating sea ice, which are important observations for use in Arctic and global climate studies.*

The project proceeded smoothly during the first half of the year, despite a few delays due to the replacement of some



The SMOS structural/thermal model in the Large Space Simulator (LSS) at ESTEC in Noordwijk (NL)

critical components on the proto-flight satellite. The Flight Acceptance Review was successfully completed in early September. The launch took place from Plesetsk on 8 October, but unfortunately the Rockot vehicle failed to put the satellite into orbit. Given the mission's growing importance for studying climate change, ESA is actively pursuing the building of a replacement satellite.

GOCE

- *a mission 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.*

The GOCE system-level Critical Design Review (CDR) was completed, during a year of equipment and payload testing, and in particular functional testing of the Engineering Model Test Bench of the overall satellite. Manufacture and integration of the platform flight model was also brought close to completion and its functional testing was started. On the instrument side, manufacture and integration of the satellite-to-satellite tracking instrument was initiated and advanced well. However, the gradiometer instrument activities were delayed by production problems with the flight models of the ultra-sensitive accelerometer.

The ground segment's development progressed according to plan, with the flight-operations segment successfully completing the first validation tests. The first complete versions of the Payload Data System and the High-Level Processing Facility were accepted, and the off-line Calibration and Monitoring Facility passed its CDR.

The launch is scheduled for February 2007.

SMOS

- *a cooperative mission (ESA, CNES and CDTI) to observe two key variables of the Earth system from space, namely the soil moisture content over land surfaces and the amount of salt dissolved in the oceans.*

Two development models were completed in 2005 for the innovative payload based upon the MIRAS instrument (Microwave Interferometric Radiometer with Aperture Synthesis), namely the reduced engineering model and the structural/thermal model, which allowed the payload to successfully pass the Critical Design Review. Assembly of the Proteus spacecraft platform will begin in January 2006, after completion of the Satellite Preliminary Design Review. SMOS is due to be launched by Rockot, possibly with Proba-2 as a co-passenger, in September 2007.

ADM/Aeolus

- *a mission to provide the first-ever measurements of wind profiles from space, which are expected to enable significant advances in numerical weather prediction, especially for extreme weather events.*

The structural model of ADM/Aeolus mounted on the multi-shaker in the ESTEC Test Centre

The satellite structural-model programme was successfully completed in July, and the Critical Design Review took place in September. The flight-model structures for the platform and instrument have been delivered to Astrium Stevenage and Astrium Toulouse, respectively, and flight-model integration is underway. Most of the difficulties associated with the laser components have been overcome, and the laser qualification model is working well. An airborne version of the instrument produced the first measurement of Mie and Rayleigh backscatter during its inaugural flight on DLR's Falcon aircraft in October. The ADM/Aeolus launch is foreseen for September 2008.

SWARM

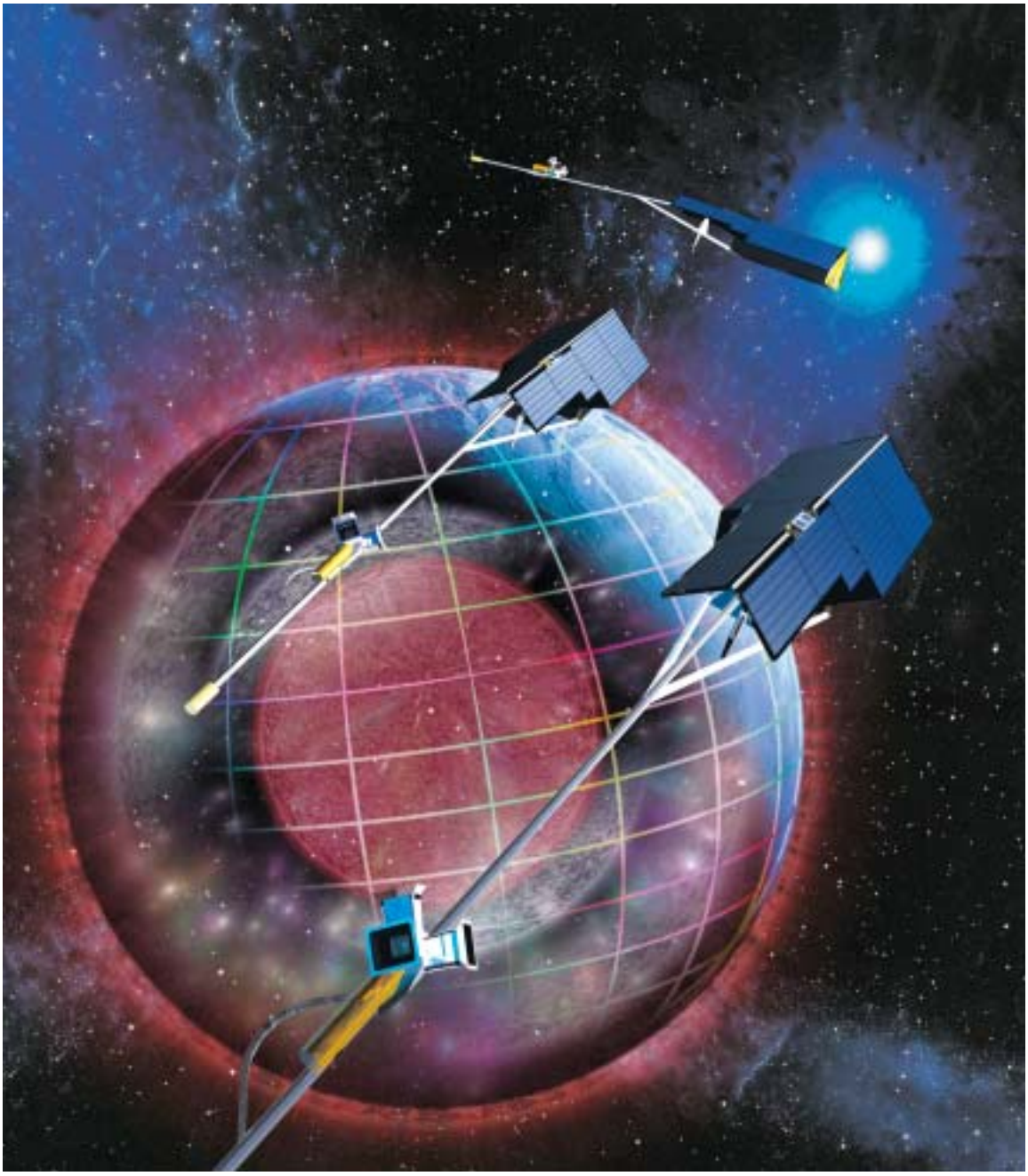
- *a mission based on a constellation of three satellites in three different polar orbits at between 400 and 550 km altitude, which will provide high-precision, high-resolution measurements of the strength and direction of the Earth's magnetic field, allowing modelling of the various sources of the geomagnetic field and study of the interaction of the magnetic field with other physical quantities describing the Earth system.*

Phase-B activities began in December with a consortium led by Astrium (Germany).

Earth Watch Missions

Meteosat Second Generation

- *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.*



Artist's impression of the SWARM satellite constellation (Courtesy of EADS Astrium)

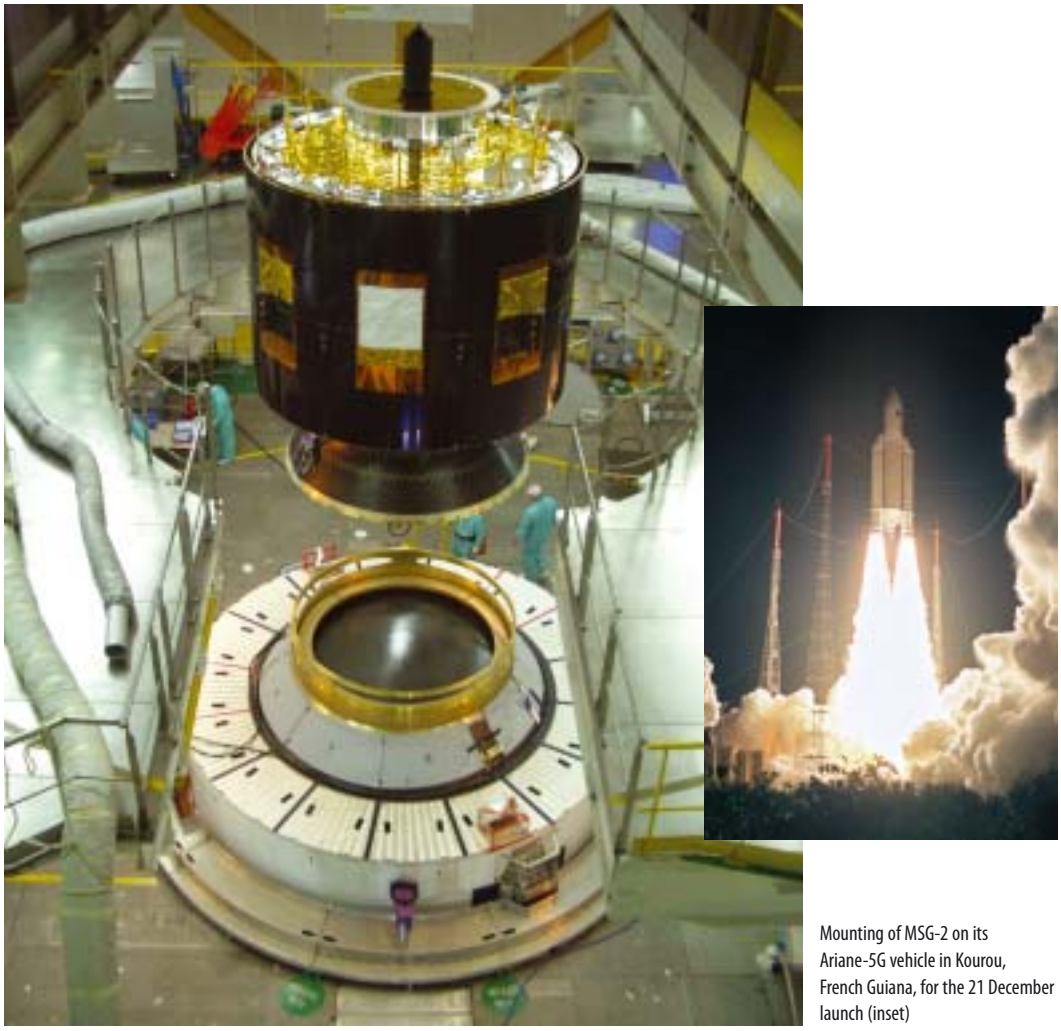
MSG-1 (renamed Meteosat-8) has completed its third year in orbit, and operations are nominal. After a difficult launch campaign, MSG-2 was successfully put into a near-perfect transfer orbit on 21 December by a standard Ariane-5G launcher from Kourou. Release of the first image from MSG-2 is foreseen for January 2006 and the dissemination of imagery to the meteorological user communities for evaluation purposes is expected to start next spring, when the spacecraft will be renamed Meteosat-9.

The MSG-3 spacecraft remained in a short-term storage configuration in the Alcatel clean room until MSG-2's successful launch, and is now in long-term storage, awaiting its own launch foreseen for 2009. The MSG-4 assembly, integration and test activities are proceeding according to plan. The Pre-Storage Review (PSR) is foreseen for the first half of 2007, after which the satellite will be put in long-term storage awaiting its launch in 2012.

MetOp

- *a series of three satellites, being developed by ESA as the space segment of the Eumetsat Polar System (EPS); Eumetsat is responsible for the ground-segment development and future system operations.*

MetOp-2, to be re-designated MetOp-A after launch, passed an important milestone in mid-2005 with the success of its Flight Readiness Review. The satellite is now in a quiescent phase, waiting for its call-up for launch, planned for end-June 2006. Meanwhile, MetOp-1 (MetOp-



Mounting of MSG-2 on its Ariane-5G vehicle in Kourou, French Guiana, for the 21 December launch (inset)

B) and the partially integrated MetOp-3 (MetOp-C) are in storage awaiting their reactivation and completion ready for their planned launches in 2010 and 2015, respectively.

Fuegosat

- *a mission targeting High Temperature Event (HTE) sensing, to provide operational monitoring of forest fire and volcanic activity, both of which have major impacts on the Earth and our living environment.*

After the establishment of the Fuegosat mission architecture, bridging activities were initiated in 2005 to develop a toolbox for product development and for continuous interaction with users in field campaigns. It has been shown that several phases of the fire risk evaluation can be supported by services based on data provided by operational, non-fire-dedicated missions.

Preparation of Future Missions

Earth Explorer Missions

EarthCARE was confirmed as the sixth Earth Explorer mission for launch around 2012, in cooperation with the Japanese space agency JAXA. EarthCARE will deploy two very sensitive active sensors, namely a backscatter lidar operating in the ultraviolet with high spectral resolution and a cloud-profiling radar. A multi-spectral imager and a broadband radiometer complete the payload and will provide contextual information.

EarthCARE will collect essential data for numerical modelling 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 urgent scientific issues.

A new Call for Ideas for candidate missions for the third cycle of Earth Explorer Core Missions was issued in March. Twenty-four proposals had been received by mid-August, showing the strong interest and participation of the scientific community in the ESA Earth Observation Envelope Programme.

Earth Watch Eumetsat Missions

The mission and system architecture studies for the Meteosat Third Generation (MTG) were carried out

The Aladin Airborne Demonstrator mounted in the DLR aircraft for in-flight testing

together with Eumetsat. ESA and Eumetsat are jointly evaluating the results in preparation for the MTG Phase-A start in 2006. Activities were also undertaken in preparation for the future Eumetsat Polar System that should continue the service of the MetOp satellites.

Earth Watch GMES Missions: the Sentinels

A set of preparatory activities was started for the first dedicated GMES space missions, the so-called 'Sentinels', and significant progress was made during the year. These activities include socio-economic benefit studies, studies on implementation scenarios and architectures, as well as definition studies for the first three missions: Sentinel-1, a C-band SAR mission providing continuity with ERS, Envisat and Radarsat SAR data; Sentinel-2, a multi-spectral optical imaging mission providing enhanced continuity with Spot and Landsat; Sentinel-3, a mission devoted to the monitoring of the oceans and of the land/vegetation on a global scale by means of optical imaging in the visible to the thermal infrared and advanced altimetry. The preparation of the initial studies on Sentinel-4 and Sentinel-5, devoted to the monitoring of atmospheric composition from geostationary and low Earth orbits, respectively, was carried out in cooperation with Eumetsat, and will allow these studies to start in early 2006.

Instrument Pre-Development

An airborne Doppler wind lidar (Aladin Airborne Demonstrator) was manufactured in the course of 2005. This lidar is the first available airborne incoherent wind lidar, and will be used for the preparation and validation of the Aeolus mission. Its functionality was successfully tested under in-flight conditions in October.

The pre-development effort on the L-band SAR for the TerraSAR-L mission made good progress. A risk-reduction programme was initiated for the instruments for the EarthCARE Explorer Mission. The contributions to the APEX airborne hyperspectral imager are close to completion.

Services Development and Applications

The Data User Element and Data User Programme activities were once again dedicated to the management of running contracts and the starting of new projects, both in close collaboration with user institutions. Five running contracts were served within DUP, eight within DUE, and eight new DUE projects were kicked-off: GLOBCOLOUR, to develop and demonstrate an EO-based service supporting global-ocean carbon-cycle research; SEVESEO, to develop geospatial techniques for the management of industrial risks and technological accidents; and five TIGER Innovator projects, with the dual objective of giving African users and industry an opportunity to prototype and demonstrate innovative products and services for water management, and of improving the ability of African partners to use EO technology and build the basis for a long-term sustainable service. In addition, a two-day TIGER Workshop and a three-day training seminar were held at ESRIN, the latter demonstrating the use of toolboxes for data handling in application activities.

ESA's good relations with the People's Republic of China within the framework of the DRAGON Cooperation Programme were further developed, with the 2005 Symposium taking place in Santorini, Greece, at the end of June, and the Advanced Training Course on Land Remote Sensing, which took place at the Capital Normal University, Beijing, with more than 100 participants from over 50 different Chinese institutions attending.

The Data User Element (DUE) home page on the ESA portal

ESA continued to grow European industry capabilities in offering EO-based services through the EO Market Development (EOMD) Programme. Two major new initiatives were started: the first consisting of a suite of 16 small-scale, rapid activities exploring innovative prospects to develop the EO services market (examples include: UV exposure warnings via SMS messaging for public health, water quality for fish-farming in Chile, or forest-change monitoring for the electricity industry); the second consisting of seven medium-sized activities to assess the value of EO services within sustainable-development reporting of large multi-national companies - an issue at the heart of current business practices. All these activities bring new global industrial players to EO across a variety of industrial sectors. To date, the reported total spin-off commercial revenue generated directly by EOMD is 5.8 MEuro (and growing).

It was also an important year in terms of ESA's presence at international environment-related events, including: the 7th Conference of the Parties of the UN Convention to Combat Desertification (UNCCD) in Nairobi in October, the 9th Conference of the Ramsar Convention on Wetlands in Uganda in November, and the 11th Conference of the UN Framework Convention on Climate Change (UNFCCC) together with the first conference dedicated to the Kyoto Protocol, together attended by almost 10 000 participants. On all of those and many more occasions, the usefulness of collaboration with ESA and the importance of its contributions to Earth observation were recognised and highlighted in many ways.

Maintaining such an international presence strengthens ESA's leadership in supporting International Conventions through the use of EO data, and in broadening user awareness and promotion. In this framework, the successful cooperation with UNESCO was continued and found an additional focus in the area of World Heritage Site conservation. The ESA contribution to international working groups on education, training and capacity building, such as the CEOS Working Group on Education, was also maintained. The ESA Multilingual EO Web Site for Secondary Schools was enriched with a version in Danish, paid for by the Danish Ministry of Education, whilst the versions in Portuguese and Dutch are nearing completion, together with new modules and study cases on 'Africa from Space' and 'Himalayas from Space'. Within the UNESCO Bilko project, Envisat data products now illustrate the oceanography lessons. This diverse set of initiatives underlines ESA's dedication to fostering the use of Earth observation from space in public outreach and education activities.

Telecommunications

Artist's impression of the AlphaBus platform

Together with its Member States, the Agency's objective is to build and run as efficient a Telecommunications Programme as possible to support European Industry's competitiveness on the World market in the best possible way. The year saw, inter alia, the signature of the AlphaBus Phase-C/D contract, the start of several Applications Initiatives, expressions of satisfaction from the Artemis user community, and the success of the AmerHis switchboard in space.

Based on an analysis of trends in the telecommunications market, on the observed evolution of the satellite operators, and on the perceived needs of Industry, the Telecommunications Department has prepared a Telecommunications Long-Term Plan (TLTP), which maps out ESA's course of action for the period 2006-2010. It includes preparatory/strategic, systems/equipment/technology, applications, and mission related activities and goals.

The successful outcome of the ESA Ministerial Council in Berlin in December allows the Agency to proceed with new programmes such as AlphaSat and the Small Satellite initiative whilst also pursuing the necessary technology development and focused competitiveness enhancements.

Major Contracts Signed

AlphaBus

ARTES Element 8 is ESA's Large Platform Mission programme to develop, in co-operation with CNES, the next generation of large platforms for geostationary telecommunications satellites. The AlphaBus main development phase (Phase-C/D) contract was signed in Le Bourget on 16 June, with the formal contract kick-off taking place a week later. Attention focussed in 2005 on consolidation of the system design and the negotiation of subcontracts with equipment suppliers.

The new AlphaBus platform will be able to accommodate up to 200 radio-frequency transponders, which will allow Europe to compete effectively on the World market for high-power telecommunications satellites. AlphaBus will facilitate a wide range of commercial missions ranging from TV broadcasting to multimedia applications, and including Internet access, mobile or fixed services in the widest sense, and hybrid C+Ku+Ka / Ku+Ka multi-spot access / S-band multi-spot missions.

The AlphaBus concept relies on a combination of cutting-edge equipment supplied by leading European companies working together under the joint prime contractors, EADS Astrium and Alcatel Space. The first AlphaBus protoflight satellite model is included in the current Phase-C/D development contract.

New Initiatives in 2005

Technology

Several technology-development contracts were placed with industry during the year, for items ranging from telecom satellite equipment to network-control software, and including significant efforts on next-generation telecom satellite payloads, with the emphasis on flexible and cost-effective designs.

AlphaSat

The Large Platform Mission (AlphaSat programme) is a key element in the successful introduction of the new AlphaBus product line into the global commercial

marketplace. It will provide operators, investors and insurers with the confidence that commercial bids based on the AlphaBus platform are founded on a sound policy of risk mitigation through in-orbit demonstration.

An Announcement of Opportunity (AO) was issued in July and attracted 19 expressions of interest. The Executive subsequently invited the respondents to the first AlphaSat Selection Contest, in order to select the best proposals for Phase-A studies at the beginning of 2006.

Applications

The Applications line of the ESA Telecommunications Department was particularly active in 2005, with the launch of twelve new activities in the areas of: telemedicine and medical education (REACH, IGEA-SAT and V4DL projects), broadband connectivity on transport systems (Wired Ocean, SAET and Satellite Internet Access for High-Speed Trains projects), interactive broadcasting applications (IMSATTV, 2EDIBS and LyngBox projects), triple-player solution for nomadic users based on SATMODE (CampNet project), multimedia services for e-government (ADMiNiSTRA project), and DVB-RCS with local wireless for Internet access and advanced multimedia services (INSPIRE project).

ESA has established a joint working team with the French Directorate of Civil Defence and Security in order to prepare a common position paper on the rationale for a European initiative for the development of satcom-based civil-protection services.

In addition, broadband access on trains has become an important issue, with huge potential. To address this need, the Agency launched an initiative in 2005 to provide a real broadband-access service solution for all European railways.

ESA, Alcatel Space and EADS Space Services have joined forces in the Mobile Satellite for Automotive Applications [MSAA] initiative, which seeks to understand the motivations and expectations of the car industry and vehicle users concerning communications and navigation satellite systems as well as multimedia possibilities.

The International Atomic Energy Agency (IAEA) and ESA have decided to join forces to assess the relevance of a satcom infrastructure for meeting the IAEA's future safeguards and security needs.

Potential civil-protection applications

INSPIRE

The INSPIRE project addresses the provision of broadband-access services to consumers in rural areas. By combining the use of two-way satellite dishes with wireless LAN equipment, the cost of service provision can be reduced, paving the way for a service proposition at a price level comparable with that of similar consumer offerings such as DSL.

Artist's impression of the OICETS–Artemis optical link

INSPIRE will offer, in a pre-operational pilot, the standard services that form part of the commercial broadband internet packages, but will also include the provision of innovative applications (including voice over IP, videoconferencing and datacasting) and promote technological innovation in the field of interoperability and enhanced transmission schemes. The design of the system was completed during the year, and its development and validation is now entering the final phase.

Ongoing Activities

Artemis

Artemis has now been operating for almost three years since its arrival in geostationary orbit. The services to the main data-relay, land-mobile and navigation services have been consolidated and preparations for new users are now underway.

Envisat has relied heavily on Artemis for the acquisition of both real-time and recorded data since June 2004, and two-thirds of the mission's science data is now downloaded via Artemis. In 2005, Envisat accumulated more than 10 000 links with Artemis, totalling 5000 hours. Spot-4 is still making relatively modest use of Artemis, at the rate of two optical data links per day; in 2005 it made 1200 links, totalling 230 hours. The Artemis navigation payload is now being used continuously by EGNOS for its Initial Operations Service.

The highlight of 2005 was the success of the OICETS optical-link experiment with Artemis. This was the culmination of several years of cooperation between ESA and JAXA in the area of data relay and free-space optical communication. Following the launch of Japan's OICETS spacecraft in August and its subsequent commissioning, the first optical links were established at the end of December. All links up to now have been successful, with very short acquisition times and excellent tracking performance. OICETS is the second optical user for Artemis, and the first demonstration of optical inter-operability between agencies.

AmerHis

AmerHis

Launched aboard Hispasat's Amazonas satellite on 5 August 2004 and now located in a geostationary orbit at 61ºW, the AmerHis payload heralds a new era in satellite communications. As the first European telecommunications satellite with onboard processing, thanks to AmerHis, Hispasat will provide high-performance interactive multimedia services to North and South America and Europe. Ground-segment tests for the

AmerHis 'switchboard in space' were successfully completed at several locations in Spain on 4 February. After the initial qualification tests, the AmerHis system was subjected to comprehensive tests and demonstrations with the establishment of networks directly inter-connecting terminals in the different coverage areas, made possible by the novel onboard regenerative DVB S/DVB RCS switch.

BGAN

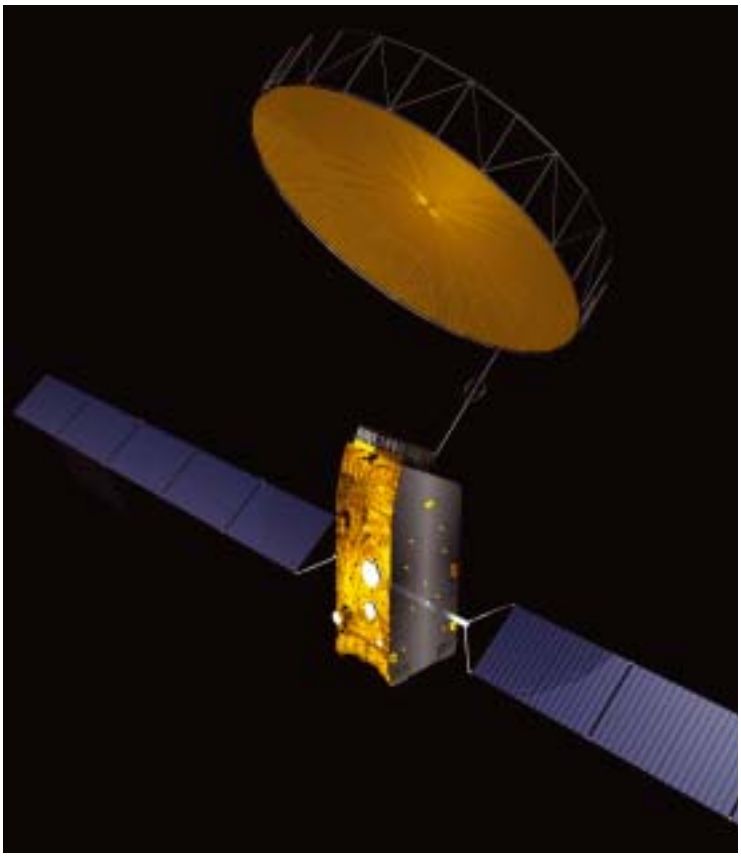
The BGAN payload was launched aboard the first Inmarsat-4 (I-4) satellite on 11 March. It will cover Europe, Africa, the Middle East, the Indian subcontinent, most of the Asia Pacific region, and Western Australia. The Inmarsat Broadband Global Area Network (BGAN) system has been designed to support point-to-point telecommunications services on portable and semi-fixed land-mobile platforms with low to medium gain, nontracking antennas providing bit rates of 216 to 432 kbps in downlink, and 72 to 432 kbps in uplink, depending on the type of terminal. The BGAN air interface is optimised for a land-portable environment with directional antennas.

SATMODE

SATMODE is a joint programme to develop a low-cost, two-way communication channel for satellite TV users. Newtec Cy of Belgium and Sinosat of China signed a Memorandum of Understanding in June covering the development of Digital iTV via satellite based on the ESA Telecom supported project SATMODE. This represents the first large-scale commercial field trial of the SATMODE system outside Europe. The SATMODE modem layer specification is currently in the process of being approved as a Cenelec Standard (prEN 16768).

SatLabs Group

The SatLabs Group is an ESA-supported, international association whose members are committed to encouraging large-scale deployment of the DVB-RCS Standard. The latter is an open standard, targeted mainly towards broadband communications and Internet access via satellite. The majority of the current 33 members of the Group are service providers, satellite operators, satellite and system manufacturers, or equipment and technology vendors, representing the key DVB-RCS players worldwide.



Artist's impression of the Inmarsat-4 spacecraft

In 2005, the SatLabs Qualification Programme, which undertakes DVB-RCS interoperability testing and certification, was launched and three DVB-RCS vendors have already received certification for their products. Interoperability is key for the benefits of an open standard to be fully exploited, and the SatLabs Qualification Programme is recognised as an essential tool for its verification.

Start-up Initiative – Round 5

The 'Satellite Communication System Elements and Technologies – Opportunities for Start-up Projects – Round 5' Invitation to Tender was issued on 29 March, with the activities split into three areas: Applications and Services (AAS), Enabling Technologies (ET) and Location-Based Communications Services (LBCS). Fifty-eight outline proposals were received from 12 countries, and eight were subsequently assigned to co-funded ESA ARTES-3 and ARTES-4 programmes.

Navigation

The EGNOS concept

EGNOS Delivered by industry

A key step forward for satellite navigation in Europe was achieved in June, with the formal completion of the technical qualification of the European Geostationary Navigation Overlay Service (EGNOS) and the acceptance of the EGNOS system delivered to ESA by an industrial consortium led by Alcatel Space and involving more than forty European companies. This formal review, known as the Operational Readiness Review (ORR), marked the completion of more than eight years of intensive work by ESA and European Industry.

More than 60 international experts from ESA gathered in Toulouse (F) in May for the comprehensive ORR, in which Eurocontrol, the Galileo Joint Undertaking and the EGNOS Operator and Infrastructure Group also took part. These experts focussed on such aspects as the functional qualification of the system and its operability, the stability of the system in its real environment, the system's performance and compliance with the requirements, and safety and product-assurance issues, including the qualification of the software and the completeness of the deliverables.

Following the ORR, EGNOS initial operations were started through a contract with the European Satellite Service Provider (ESSP). By early 2006, the EGNOS open service will be declared formally and freely available across Europe to the general public for non-safety-of-life applications.

EGNOS is a joint project involving ESA, which is responsible for the systems development and technical qualification, the European Commission, and Eurocontrol (the organisation overseeing air navigation safety in Europe). It is Europe's contribution to the first stage of the Global Navigation Satellite System (GNSS), paving the way for Galileo, a joint ESA/EU initiative, which will be the first satellite navigation system geared to the needs of civilian users and offering the enhanced accuracy, reliability and continuity of service required by modern applications.

Galileo In-orbit Validation Contract Signed

In December, ESA and Galileo Industries GmbH signed a 950 million Euro contract for the development and construction of the first four satellites of the Galileo navigation system and their associated ground systems. Following the preliminary authorisation to proceed with work worth 150 million Euro, signed a year earlier, this contract covers the overall In-orbit Validation Phase, drawing on ESA and EU funds accessible under the GalileoSat programme. This contract comprises four satellites (the basis for satellite navigation), in order to set up a 'mini constellation' along with its associated ground segment to validate the Galileo system concept.

Following the in-orbit validation, the full deployment phase of Galileo will cover the manufacture and launch of the remaining 26 satellites, plus the completion of the ground segment comprising a worldwide network of stations and service centres.

First Galileo Satellite in Orbit

GIOVE-A, the first Galileo in-orbit validation element, was launched on 28 December from Baikonur in Kazakhstan, by a Soyuz-Fregat vehicle operated by Starsem. This 600 kg satellite, built by Surrey Satellite Technology Ltd. (UK), has a threefold mission. The first is to secure the use of the frequencies allocated by the International Telecommunication Union (ITU) for the Galileo system; the second is to demonstrate critical technologies for the navigation payloads of future operational Galileo satellites; and the third is to characterise the radiation environment in the orbits planned for the constellation.

Formerly known as GSTB-V2/A (Galileo System Test Bed Version 2), GIOVE-A carries two rubidium atomic clocks, each with a stability of 10 nanoseconds per day, and two signal-generation units, one of which is able to generate a simple Galileo signal and the other more representative Galileo signals. These two signals are to be broadcast via an L-band phased-array antenna designed to cover all of the visible Earth beneath the satellite. Two instruments will monitor the types of radiation to which the satellite is exposed during its two-year mission. All systems on the satellite, which is being controlled from SSTL's own ground station, are performing well.

The GIOVE-A satellite at ESTEC, during the naming ceremony conducted by Dutch Minister Karla Peijs on 9 November

A second demonstrator satellite, GIOVE-B, built by the European Galileo Industries consortium, is currently being tested and will be launched later. It will demonstrate the Passive Hydrogen Maser (PHM), which, with a stability of better than 1 nanosecond per day, will be the most accurate atomic clock ever launched into space. PHMs will be used as primary clocks onboard the operational Galileo satellites, with rubidium clocks serving as backups.

Launchers

The CSG office and museum complex in Kourou, French Guiana

It was a very remarkable year for launchers-related activities. The Ariane Recovery Plan was completed by successful launches of Ariane-5 ECA and GS, the single-launch and double-launch versions. Also, the Vega and Soyuz at CSG Programmes reached important development milestones, with firing tests at stage level for Vega, and the design review and construction work for Soyuz at CSG. In addition, the Ministerial Council in December approved and subscribed to important activities that will secure the maintenance and development of the industrial and technological capabilities in Europe needed for the development of any future new launcher.

Ariane

After the implementation of the Ariane Recovery Plan during the previous two years, in 2005 Ariane's position in the commercial launch services market was successfully re-established. A total of five Ariane launches took place, all of which were successful. In this framework, it was important to implement new programme elements for completion of the Ariane qualification process (Slice 10) and to prepare Ariane programme proposals (ARTA and ACEP) for activities until end-2010, to be presented at the Ministerial Council. All of these objectives were achieved, making it a very successful year for the Ariane-5 programme and for its commercial exploitation.

For the Ariane-5 ECA heavy-lift launcher, the year started with a flawless qualification launch on 12 February (L521), putting the XTAR-EUR telecommunications satellite into its geostationary transfer orbit (GTO) and also releasing the Sloshsat experimental satellite. Post-flight analysis revealed that critical elements such as the Vulcain-2 engine and the ESC-A upper-stage (never separated and ignited prior to this launch) performed within specification. During a second launch on 17 November (L522), Ariane-5 ECA again performed flawlessly, putting Spaceway-F2 and Telkom-2 into their respective geostationary transfer orbits. After these two successful launches, Ariane-5 ECA is clearly ready for the commercial marketplace and will be Arianespace's launch-service workhorse for the coming years.

The successful qualification launch of Ariane-5 ECA on 12 February

The Ariane-5 GS with the Vulcain-1 engine made its successful maiden flight on 11 August (L523) in a single-payload configuration carrying the telecommunications satellite Thaicom-4, the largest telecommunications satellite ever placed in GTO. Two more launches of Ariane-5 GS in

double-launch configuration were equally successful, putting a total of four satellites into GTO: Syracuse-3A and Galaxy-15 on 13 October (L524), and MSG-2 and INSAT-4A on 21 December (L525). With these flights, Ariane-5 GS is now qualified for single- and double-launch configurations and will be exploited in parallel with Ariane-5 ECA.

The adaptation of Ariane-5 for launching the Automated Transfer Vehicle (ATV) continued on schedule and the related qualification process is in progress. The first flight of the launcher, which will also be the qualification flight for ATV, is scheduled to take place in the first half of 2007.

The first hot-firing test on the new upper-stage, re-ignitable Vinci engine took place on 20 May with a 1 second long ignition and spin-up of the turbines to 50% speed. Engine ignition was flawless and all parameters were within their predicted ranges. Further tests were subsequently performed to gradually increase the firing time, culminating on 27 July in a successful 60 second firing with all parameters at full test conditions. The new P4.1 test-facility at DLR, Lampoldshausen (D) also performed according to expectations and valuable experience was gained for fully tuning the facility for future tests.

Industrial activities on the Slice 10 Programme, aimed at bridging the gap until new programmes are implemented, started on 3 October. This day was also a new milestone in implementing the decisions of the 2003 Ministerial Council, with the signature of the Slice 10 Ariane Development contract, making EADS ST the prime contractor, responsible for all other stages and subsystem suppliers for Ariane launchers.

At the 2005 Ministerial Council in December, two new programmes were approved. On one side, the extension of ARTA for the period 2007-2010 is aimed at continuing the already established Ariane support activities, and dealing in addition with issues concerning the Ariane production facilities. This domain requires particular attention, as the launch and production facilities have now been in service for some 15 years, to ensure their availability for the exploitation of Ariane in the years to come. On the development side, the Ariane-5 Consolidation and Evolution Preparation (ACEP) programme has been proposed, to consolidate the knowledge of the launcher and allow its optimum utilisation. The positive outcome of the December Ministerial Council means that in the coming years the Ariane production-accompanying activities will be continued and the necessary maintenance of the ground facilities will be performed, to consolidate the Ariane launcher's position and to prepare for future evolutions.

In parallel with the Ariane development programmes, the European Guaranteed Access to Space (EGAS) programme is now in place. The envisaged industrial audits have also been initiated by the Agency to achieve an overview of production costs at the various companies involved.

Vega

The first firing test of the Vega Zefiro-9 third-stage solid-rocket motor was successfully conducted on 19 December at the test range in Sardinia (I). This test was particularly important, since the data collected will allow verification of ballistic performances, internal thermal protection efficiency, performance of the thrust vector control system and the induced thermal and dynamic environment. A first assessment of the data showed that the test proceeded according to plan and that the necessary data have been recorded.

The AVUM engine firing test had already been conducted in October, and again the data analyses confirmed performances in line with forecasts.

Fabrication of the qualification model of the case for the Zefiro-23 second-stage solid-rocket motor was completed

Artist's impression of Vega in flight

by the end of the year, and manufacture of the Development model for the first firing test also progressed well during 2005. The vibration tests on the Interstage-2/3 structural model were also successfully concluded in November, as well as the stiffness tests on the full qualification model of the fairing.

System activities at the Vega prime contractor progressed towards the System Critical Design Review, with two key checkpoints reached in July and December, when progress on all ongoing analyses and issues was confirmed.

All P80 activities are progressing towards the realisation of the first full-size motor. Manufacture of the case for this motor began in October. All of the key technology problems associated with the manufacture of the components of the first nozzle destined for the first live motor have been resolved.

The contract for the development and qualification of the thrust-vector control systems for the Zefiro and AVUM stages was finalised at the beginning of April. Activities during the year led to production of the two types of control systems, in time for the first Zefiro-9 firing test and in line with the P80 planning, respectively.

The main contract for the ground segment was signed on 21 July. Preliminary Design Reviews for the site's mechanical, civil and fluids infrastructure have already been completed, as well as consolidated analyses of the environment at lift-off and related dimensioning cases. The new design of mobile platform has been accepted, and the design of the mobile gantry has been revised to be compatible with the existing foundations and maximum load factors.

Definition of the Vega Research and Technology Accompaniment (Verta) Programme was a major effort in 2005. Several meetings and discussions were held with potential participating Member States, leading to a final proposal that was accepted at the Ministerial Conference in December. The new Verta Programme consists of five flights of ESA payloads aimed at demonstrating Vega's capabilities and flexibility for different types of missions, as well as of activities to improve customer service and to maintain production quality at the necessary high level. As a prerequisite of Verta, a business plan for the initial and for the mature phases of Vega exploitation has also been defined, in agreement with the launch vehicle prime contractor and Arianespace, the future operator.

Soyuz at CSG

Several major milestones were achieved within the Soyuz at CSG Programme during the year. On 21 March, the Rider to the ESA-Arianespace Convention was signed by the Agency and Arianespace. On the same occasion, the French Government signed the guarantee, to the European Investment Bank, for the loan given to Arianespace. In June, a complementary Preliminary Design Review took place at CNES in Evry (F). All issues raised during the Review were successfully dealt with, with the exception of the safety aspects for the launcher's operation from CSG. A detailed analysis of the safety environment during launch operations was subsequently carried out and several meetings took place with the Russian partners. The final results are expected early in 2006.

Artist's impression of the new Soyuz Launch Site

The System Architect contract was signed on 19 July, along with the contract between CNES and Arianespace for the so-called 'Russian deliveries', giving the final go-ahead to the Programme.

In October, Austria joined the Soyuz at CSG Programme as a Participating State.

In November, CNES secured the contract for the mobile gantry, and in early December the so-called 'Infrastructure contract', which comprises the majority of the European activities, was signed between CNES and a European consortium led by GIE InfraSoyuz.

As far as the technical achievements are concerned, the earthworks at the future Soyuz Launch Site (SLS) have advanced at a more rapid pace than expected, thanks to a very favourable dry season in French Guiana. Completion of the ground works is now expected by June 2006, which is more than six months ahead of schedule.

Following the early arrival of the infrastructure industrial contractor, the construction site was 'officially opened' on 16 November and work on the excavation of the exhaust ducts started immediately.

The Future Launchers Preparatory Programme (FLPP)

After the start of the first industrial activities the previous year, the main objective in 2005 was to accelerate the implementation of the various system and technology activities. The system activities, covering Re-usable Launch Vehicles, a Re-entry (IXV) and a Re-usability (Re-use X) Experimental Vehicle, also allowed the definition of a Technology Development and Verification Roadmap, as one of the cornerstones of the technology activities.

Propulsion activities initiated include the elaboration of reference architectures for re-usable engines, as well as the design and manufacture of key technology demonstrators, including subscale staged combustion assessment. The technology activities related to materials and structures cover a range of hot and cold as well as metallic to composite types of systems. The high-temperature-material activities contribute directly to the preparation of the IXV vehicle. Some contracts have also been placed on issues related to solid propulsion, cryogenic Ariane-5 structural interfaces, and an improved Ariane-5 thrust frame.

A major milestone was achieved in the cooperation with Russia through the signature in May of the Implementing Arrangement between ESA and the Russian Space Agency on cooperation in Research and Technology for future launchers. It includes a comprehensive set of activities in the field of reusable liquid engines, reusable liquid stages and experimental vehicles.

The preparation of the follow-on FLPP Period-2 Step-1 also represented a major achievement, with numerous interactions with Delegations at various levels. The final programme volume and content, as well as its successful subscription, are strong signals that the preparation of Europe's future launchers is a shared major objective.

Europe's Spaceport

After two successive years of low launch rates, in 2005 the Guiana Space Centre (CSG), Europe's Spaceport, witnessed a resumption of operational and development activities, much to the satisfaction of the whole launch base. Five successful Ariane-5 launches and nine flawless satellite campaigns took place during the year. In parallel, the Vega launch pad's construction was pursued according to plan, and the earthworks at the Soyuz Launch Site progressed spectacularly quickly.

The outcome of the CSG reorganisation project started in 2004 was presented to the managements of ESA, CNES and Arianespace on 27 July. The selection process for the awarding of the main service contracts at the launch base was kicked-off at the end of the year. This process will end in 2006 and ultimately pave the way for a new industrial landscape being established at CSG for the coming years, enhancing both the operational efficiency and the economic competitiveness of Europe's Spaceport.

Human Spaceflight, Microgravity and Exploration

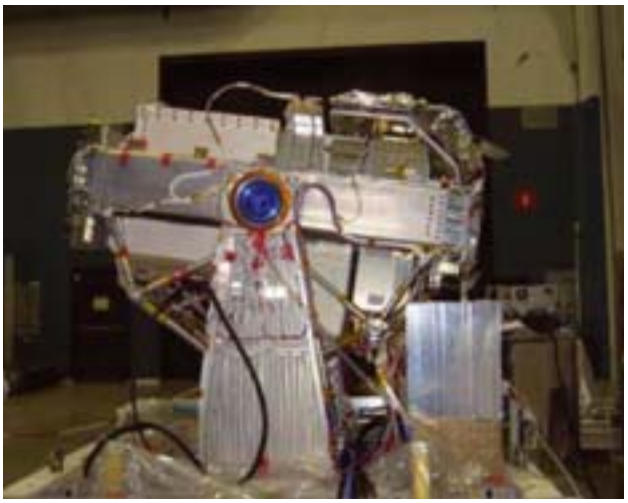
ISS/STS

At a meeting of the International Space Station Partners Heads of Agency (HoA) in January, a revised Assembly Sequence and overall ISS configuration was agreed by all parties, based on a Shuttle-flight programme of 28 missions before end-2010. Subsequently, during the summer, following internal studies ordered by the new Administrator Dr. M. Griffin, NASA announced that there would be 18 flights to the Station, and a revised plan for these flights had to be established. In cooperation with all of the International Partners, ESA has worked to optimise the assembly sequence and its associated schedule, aiming to advance the launch of the Columbus module in the process, with a view to achieving agreement at a further HoA in spring 2006.

Meanwhile, the ISS continued to remain in good technical shape throughout 2005, celebrating the fifth year of permanent human presence on the Station. The European elements already in orbit, namely the Data Management System for the Russian Segment and the Microgravity Science Glovebox, have performed flawlessly. Four logistic flights and two crew-rotation flights were made to the Station, one carrying ESA astronaut Roberto Vittori on his second mission 'Eneide', as well as the first Shuttle flight for two and a half years.

This Shuttle Return-to-Flight mission (LF-1) took place successfully in July, but some foam loss from the external tank and the consequences of hurricane Katrina led to the postponement of its next launch (flight ULF1.1) to no earlier than May 2006. ESA astronaut Thomas Reiter will fly on ULF1.1 to become the first European long-duration ISS crew member, and during this 'Astrolab' mission he will perform the normal ISS crew system activities as well as a programme of European scientific and educational activities.

ESA astronaut Roberto Vittori (right) during the Eneide mission to the ISS in April



The SOLAR flight model

EuTEF during interface testing at EADS in Bremen (D)

Columbus

During the year the Columbus system successfully completed an extensive system test campaign involving the module, its payload complement and the ground segment. A final end-to-end system validation test involving the User Support and Operations Centres (USOCs) will be performed prior to the Final Acceptance Review and shipment to Kennedy Space Centre in May 2006. The module itself has achieved its Certificate of Qualification from ESA.

The payload-rack facilities – Biolab, Fluid-Science Laboratory, European Physiology Module, and European Drawer Rack – completed their qualification and were installed in the module to support the successful testing of the flight configuration. They will be delivered to the launch site in their launch configuration inside the module. The external payloads SOLAR and EuTEF were also successfully tested with the module. They have since been returned to the developers for final closeout activities prior to their separate shipment to the launch site, also by mid-2006.

The Columbus Control Centre (Col-CC) completed much of its qualification, and the Qualification and Final Acceptance Reviews will be concluded by mid-2006. With the completion of the Col-CC infrastructure development, the flight control team for the upcoming ISS missions – the long-duration 'Astrolab' mission and the Columbus launch – can take over. A dedicated Mission Operations Service has been set-up with EADS-ST and DLR. An ESA Flight Operations Team located at the Col-CC has been formed with an ESA Operations Manager on-site to interact with the Service's Flight Director Office. The USOCs are also in an advanced stage of completion and, together with the Col-CC, will support the final end-to-end testing of the Columbus system early in 2006.

The Columbus Control Centre at Oberpfaffenhofen in Germany

Artist's impression of ATV cargo transfer

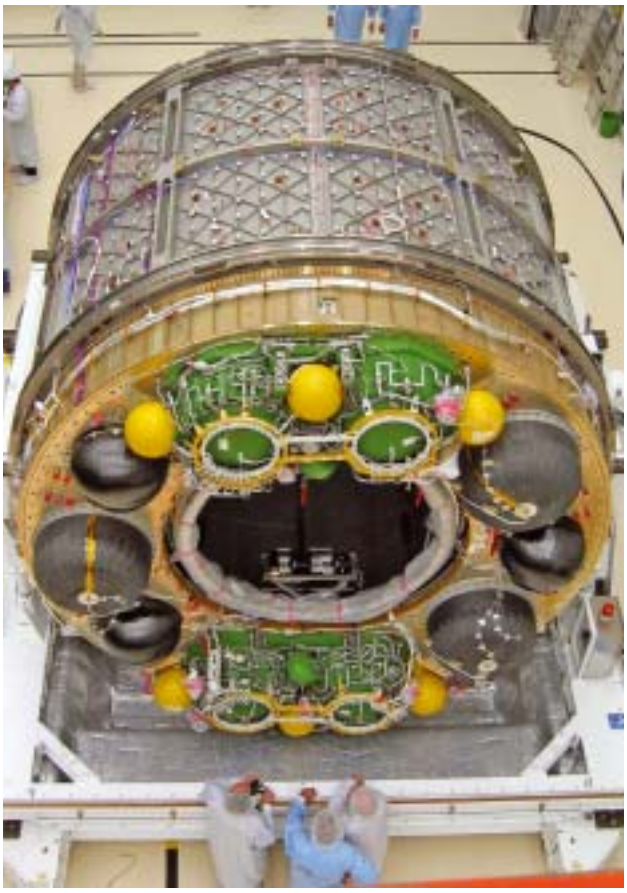
With respect to crew training for the Columbus system, the 'user- and operator-level' training development was completed and the respective training dry-runs were performed. The 'specialist-level' training is also well advanced. The training team is ready to train the ISS Assembly flight 1E Shuttle crew and the subsequent Station crews for Columbus.

The Columbus Trainer at EAC was successfully connected to the Control Centre's mission control system and has participated in integrated tests. The corresponding trainer at NASA/JSC (Houston) also successfully supported integrated tests.

ATV

Major advances were made during the year in freezing the Automated Transfer Vehicle's overall mission scenario, which had led to many design changes in the past. The flight applications software, which was previously a major problem area, is now stable.

The first ATV spacecraft, 'Jules Verne', successfully passed its integrated system EMC tests, various crew interface tests and the first end-to-end system interface tests. However, the test campaign was seriously impacted by various hardware problems, in particular the failure of latch-valve



The ATV propulsion module in the test facilities at ESTEC in The Netherlands

Participants in the ATV Increment training at EAC in Cologne-Porz (D) in August

rods (all 44 of which have had to be replaced), noise in the potentiometer of the solar-array drive (which necessitated adding a back-up position-reading mechanism), and failures of the ISS camera target (since redesigned). The system functional qualification test programme on the engineering model progressed, but proved far more difficult than originally planned. All of these problems led to significant slippages in the qualification and acceptance programme, but by the end of the year the situation had stabilised and the project was back on track.

Production of additional ATVs was deliberately slowed and adapted to the progress of the ISS assembly and 'Jules Verne' development. The number of additional ATVs to be procured was also reduced from 6 to 4 in order to accommodate the current ISS scenario.

The ATV Control Centre successfully performed the planned system validation test, and the monitoring and control system is ready to undergo formal acceptance. The remaining open areas from the Flight Operations Readiness Review were finalised and development of the multi-segment operations products is proceeding. The full Flight Control Team is in place and the development of the engineering support tools has started. Official inauguration of the ATV Control Centre is planned for mid-2006.

The Cargo Operations Team finalised the second analytical integration cycle and established a reference cargo manifest. All the ATV-related equipment required on the ISS Service Module ('Zvezda') was transported to, and installed on, the ISS, including the proximity communication system, the new camera, a new Russian GPS and a new crew display.

From the crew perspective, the material for the first part of ATV training was finalised by the training team and successfully used to train all ISS Increment-13 prime and backup crew members for one week at the European Astronaut Centre (EAC). All Service Module crew hardware and software interfaces have been defined and the final testing is now taking place. The crew-monitoring concept was agreed by all International Partners and most of the new procedures were developed and are now under review.

The testing of the adaptations to Ariane-5 for ATV was completed on the Vehicle Equipment Bay and the upper-stage engines. The qualification review for the adaptations will be held in mid-2006.

A credible schedule is now in place for all elements of the 'Jules Verne' mission to the ISS, leading to its readiness for launch in spring 2007.

Other Flight Elements

Node 2 integration at Kennedy Space Centre (KSC) is complete and interface tests with the JAXA JEM module

Node 2 at Kennedy Space Centre in Florida (USA)

Node 3 at Alenia in Turin, Italy

have been successfully completed. Node 2 is currently being closed-out ready for launch on ISS Assembly flight 10A. The integration activities on Node 3 in Turin (I) were completed during the year and the testing and verification programme started on schedule to support a delivery to NASA in December 2006/early-2007.

The planned Cupola activities at KSC were completed and it is currently in storage, awaiting a launch flight allocation.

Activities required to prepare the European Robotic Arm (ERA) for launch on the Russian Multipurpose Laboratory Module (MLM) started, and the related modifications to the operations planning and training scenarios were performed. The Mission Preparation and Test Environment (MPTE) was prepared for shipment to Russia after the Russian Instructors had completed their training at ESTEC.

Utilisation

A steadily expanding European life and physical sciences user community now numbering some 2000 resulted in the solicitation, within the framework of ILSRA-2004 and AO-2004, of many new, highly ranked, fundamental and applied research proposals, which were subsequently peer-reviewed and approved by the Programme Board. Some 200 projects are targeting the ISS as a research platform, while a similar number use other mission platforms or are ground-based (e.g. bed-rest studies or artificial gravity).

The international WISE bed-rest study was extremely successful. The results will be of major importance for crew health during future long-duration space flights.

The Zarm drop tower in Bremen, Germany

Various European Commission projects such as those in human physiology (Telemedicine; Advanced Detection of Bone Quality) were successfully performed. Joint activities with the EC were also initiated in education and the resulting products were widely distributed within the ESA Member States.

The Maser-10 launch from Esrange (S) in May

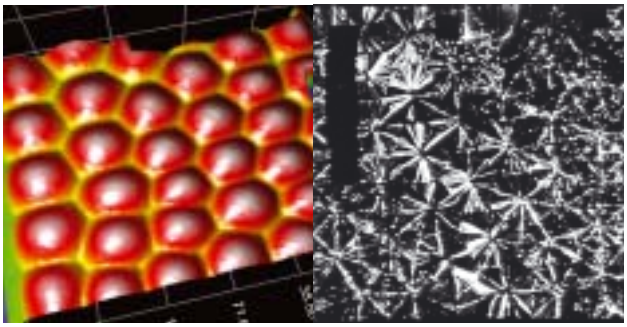
The Zarm Institute's drop-tower infrastructure in Bremen (D) supported various preparatory research experiments in fundamental physics and combustion. In the future, the catapult function will facilitate a doubling of the time available in microgravity.

The Airbus A300 aircraft was used for three ESA flight campaigns, with further experiments being flown on national CNES and DLR campaigns.

The Maser-10 sounding-rocket mission, comprised of five modules containing experiments in biology and fluid physics, was launched in May from Esrange in Sweden.

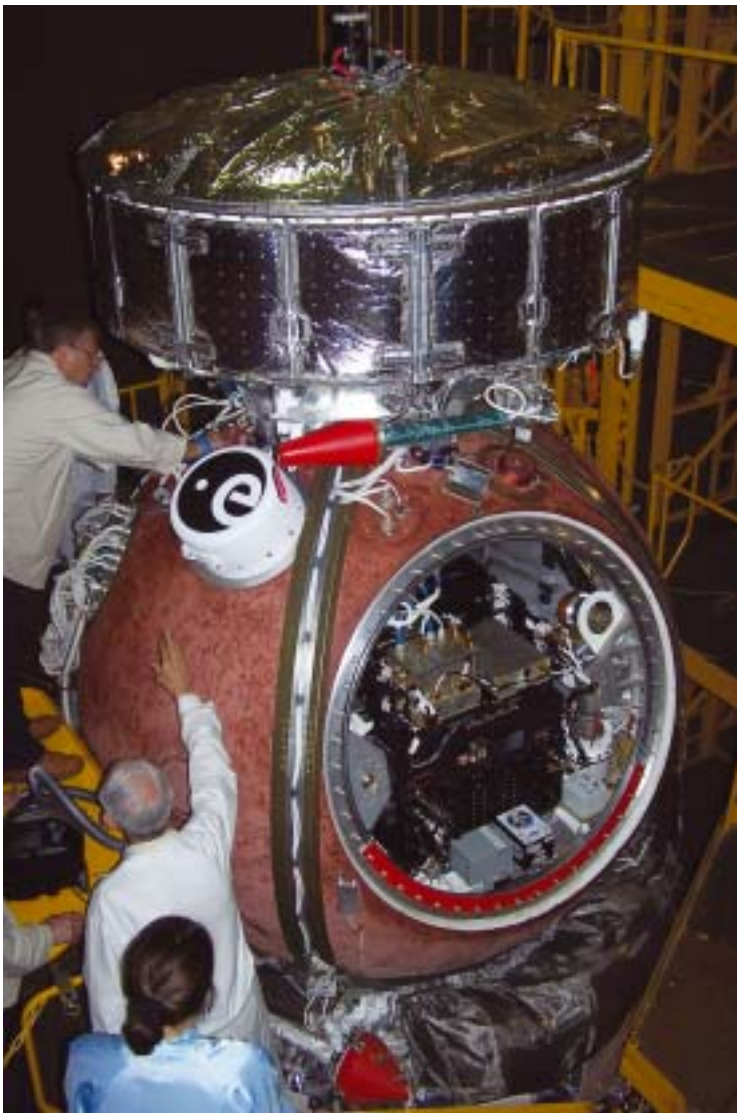
The maiden flight of the Electromagnetic Levitation Module on a Texus sounding rocket facilitated the delivery of the first space-experiment results for the ESA/EC IMPRESS project.

Interfacial turbulence in evaporating liquids (from the ITEL experiment on Maser-10)



Marangoni convection in microgravity (from the BAMBI experiment on Foton-M2)

The Electromagnetic Levitation Module, flown for the first time on the Texus-42 sounding-rocket flight



Foton-M2 during integration in Baikonur

The Foton-M2 free-flyer mission was launched for the first time from the Baikonur cosmodrome and accumulated about 380 hours of orbital flight with a 385 kg ESA payload comprising 39 internal and space-exposure experiments. A total of eight agencies and 19 industrial entities were involved.

In April, the Italian-sponsored 'Eneide' mission to the ISS with ESA astronaut Roberto Vittori included a wide range of life/physical sciences, technology and education experiments. During this and previous ISS expeditions, a continuous series of European experiments has been

The European Modular Cultivation System (EMCS)

performed by Russian cosmonauts and US astronauts. Preparation of a substantial experiment package for the long-duration flight of ESA astronaut Thomas Reiter is progressing.

ESA's Pulmonary Function System (PFS), launched with Shuttle flight LF-1, was successfully commissioned in the US 'Destiny' laboratory as part of the Human Research Facility (HRF), which will be transferred to Columbus once in orbit. In preparation for the next Shuttle mission, ULF-1.1, the -80ºC freezer rack (MELFI) and the European Modular Cultivation System (EMCS) were integrated into the Multi-Purpose Logistics Module (MPLM). These ESA payloads will substantially enhance the ISS's research capabilities and support further European research onboard.

Development of ESA's ISS internal-rack and external payloads was successfully completed. Following their launch with Columbus and subsequent commissioning, the full European utilisation of the ISS will commence.

The European life and physical sciences community produces more than 40% of the worldwide publications in their domain each year, with an even higher citation ratio.

Exploration

The year opened with a significant increase in contributions to the Aurora Preparatory Programme. Many new activities were initiated, the most significant of which was the awarding of the ExoMars Phase-B1 contract. At the end of the year, the European Space Exploration Programme - Aurora - was approved at the Ministerial Council in Berlin. This represents a decision of paramount importance for European space policy. The approval includes the full development and operation of ExoMars, and also creates the framework for the preparation of Europe's long-term engagement in space exploration.

With the help of the Exploration Programme Advisory Committee (EPAC), the Programme was organised into a Core element and an element devoted to Robotic Missions, of which ExoMars is the first. Aurora remains a programme with a long-term vision for the robotic and human exploration of the Moon and Mars.

Throughout the year, special attention was paid to refining the ExoMars mission configuration and its model payload, and a large scientific workshop, jointly organised by ESA and BNSC, was held in Birmingham (UK) in April. There, the scientific community favoured an approach to ExoMars that safeguarded the scientific value of the mission while calling for enhanced international cooperation. The European scientific community also reaffirmed its strong interest in a Mars Sample Return mission before the end of the next decade. Subsequently, in August, an ExoMars/Pasteur scientific workshop was held at ESTEC.

The ExoMars definition phase benefited greatly from the technology activities that had been started in the first phase of the Preparatory Programme and drew to a close during the year. The results could be injected into the mission's Phase-B1, in particular the first round of tests that were conducted for the vented airbags concept, yielding very positive results.

Further studies of lunar missions were conducted in the ESTEC Concurrent Design Facility, and further development activities on key capabilities for future exploration endeavours, such as the docking mechanism and the regenerative air-revitalisation system ARES, were carried out. In addition, a variety of research activities in human physiology (Concordia) and life support (Melissa) were pursued.

Activities related to the transportation aspects of exploration, such as planetary and Earth re-entry systems,

A concept for the ExoMars Rover

science and sample-return systems, and human transportation systems were studied. Of particular note was the initiation of discussions with the Russian Federal Space Agency Roskosmos on human transportation and the Clipper programme.

The definition of a long-term strategy for space exploration was addressed in meetings and workshops with a large community of stakeholders, including several from outside the space sector, to analyse the international context and the potential European role. Also in the context of international cooperation, the First Workshop on International Cooperation for Sustainable Space Exploration, which was organised jointly with ASI in Italy, took place in May, with participants from the USA, Canada, Japan and several European countries.

Activities with academia included two major events organised at ESTEC, and a call for innovative ideas and concepts for lunar exploration, which was issued in connection with an architecture study awarded to industry.

Technical and Quality Management

Electrical Engineering

Power Systems

The 7th European Space Power Conference, organised by ESA in Stresa (I), was an opportunity to measure the progress made in space power systems over the last three years. Major highlights were:

- The first reports on the operation of lithium-ion batteries in space, including the SMART-1 and Proba-1 missions and, even more significantly, the operational telecommunications satellites being manufactured by Astrium and Alcatel Alenia Space, giving Europe a definite lead over the USA in this technology domain.
- The presentation of the status of European high-efficiency multi-junction solar cells, which now rival the US competition in terms of end-of-life performance for the equivalent of 15 years in orbit.
- The development of new maximum-power-point tracking systems, which are being used more and more for all types of missions.

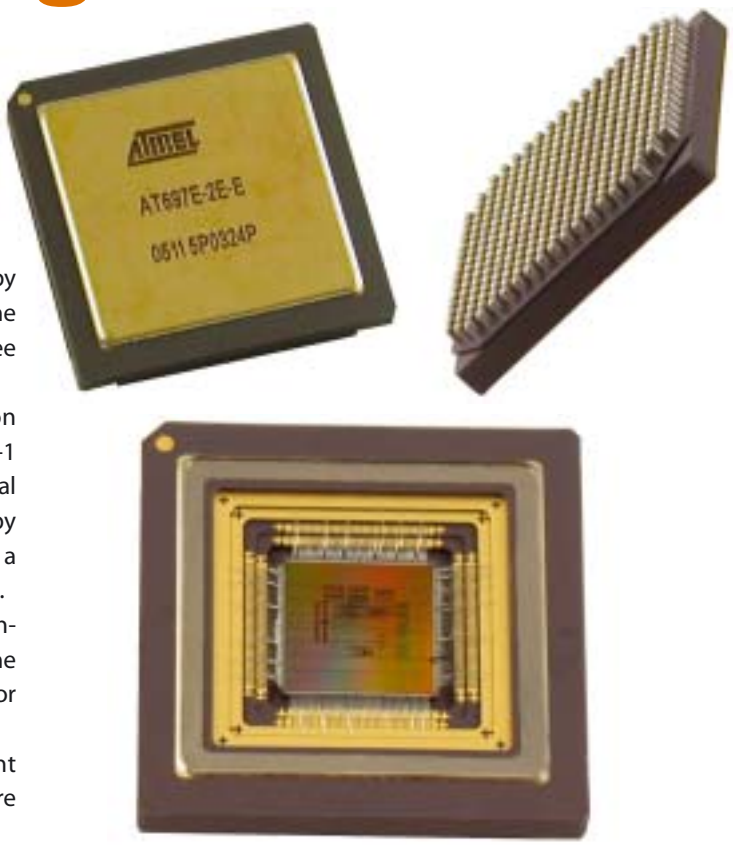
Two patents were filed, one relating to high-voltage power-supply efficiency improvement, and one to a simple modular maximum-power-point tracking concept, which were a good reflection of the Power and Energy Conversion Division's efforts to remain at the forefront of design solutions for space applications.

Data Systems

Prototypes of high-performance, radiation-hardened, LEON microprocessors, resulting from ESA contracts with Atmel (F) and Gaisler Research (S), were released for evaluation. These 100 MHz microprocessors, which make use of the latest 0.18-micron silicon technology, will be at the heart of future European spacecraft computers.

More than 50 'ESA IP Cores' were provided to various space companies and research centres across Europe. These cores are hardware description language (VHDL) design databases that can be reused as building blocks in larger integrated circuits (ASIC or FPGA), thereby saving on design time and cost.

Triggered by reliability problems associated with currently used Field Programmable Gate Arrays (FPGA), special emphasis was put on guiding projects in how to use FPGAs for onboard applications with better quality control. An innovative test system called FT-UNSHADES was also developed to validate the effectiveness of logic introduced to mitigate radiation-induced upsets, serving as a powerful alternative/complement to expensive and less deterministic radiation test campaigns.



Prototype radiation-hardened microprocessor chips from Atmel, France

Control Systems

Significant milestones were achieved in the development and validation of cutting-edge guidance, navigation and control (GNC) system technologies in support of future ESA missions. They included studies and prototyping for: formation-flying systems, autonomous hybrid navigation systems, safe precision entry, descent and landing systems, robust ascent vehicles, and solar-sail techniques.

Considerable effort was also devoted – together with national agencies and European Industry – to preparing detailed roadmaps for AOCS sensors and actuators, defining the most appropriate products for different classes of missions. In the gyroscope area, development of MEMS (Micro-Electromechanical System) rate sensors was

initiated based on upgraded terrestrial technology, which will provide a significant improvement compared to today's units for acquisition and safe modes, and also for star trackers.

A high-accuracy, four-axis, fibre-optic gyroscope is being manufactured for the Planck and ADM-Aeolus spacecraft, while a more compact redundant single-axis version has been designed for Galileo.

Radio Navigation

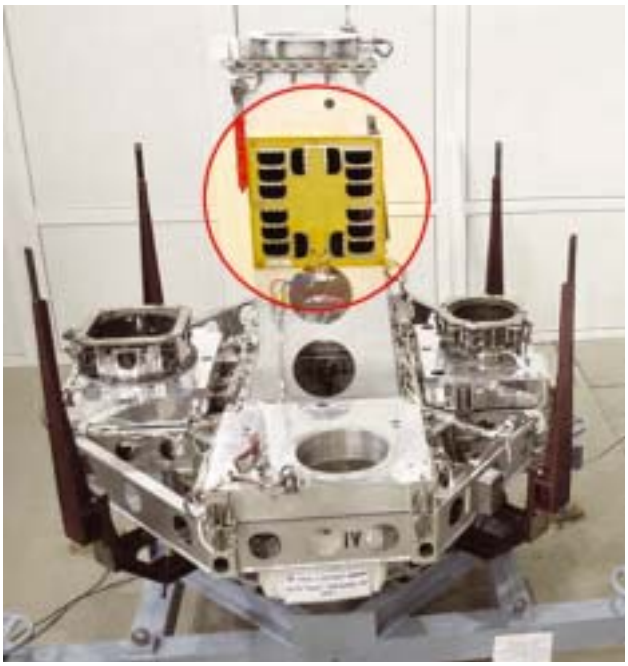
Direct hands-on support was provided in the development and testing of the GIOVE and Galileo IOV payload Customer Furnished Items (CFIs) and for the GIOVE payload review and acceptance tests. On the system side, the RF Payload Division was heavily involved in the preparation and execution of the GIOVE system tests. On the ground-segment side, the Division's support covered the development of the Galileo mission segment and reference receivers. All of these efforts contributed to the timely launch of GIOVE-A in December.

Support was also provided for the EGNOS Operational Readiness Review, and in the deployment and expansion of the EGNOS infrastructure.

Communications

Activities in this domain included support in the preparation of the AlphaSat proposal for submission to the Ministerial Council, and the analysis of several missions

European low-mass, low-cost MEMS rate sensor unit



An Asolant antenna unit mounted on a launch adaptor

and payload scenarios demonstrating the latest technologies and possible new services, examples being:

- Support to the introduction of Digital Video Broadcasting with Return Channel via Satellite (DVB-RCS)
- Support to SpaceForScience, setting up DVB-RCS collaborative platform development. SpaceForScience aims to facilitate scientific cooperation in Europe, and southern and eastern Europe in particular, by providing virtual, collaborative working and education applications for research institutions, via either fast academic networks or bi-directional telecommunications satellite links using the HellaSat space segment.

Electromagnetics and Antennas

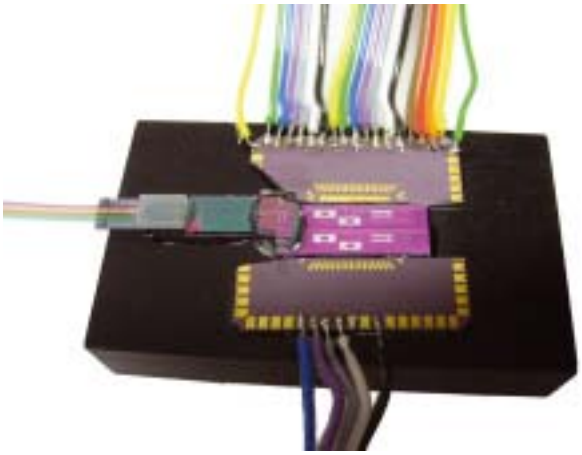
In-flight testing of an ESA-funded R&D activity to combine spacecraft solar arrays and antennas began in October, when a test unit was launched into low Earth orbit. Combining these two spacecraft components into a single unit promises substantial mass and cost savings for future missions. The successful in-flight demonstration of the Advanced Solar Antenna (Asolant) means that this novel technology is now available for future space missions.

A new ADF-EMS antenna design system provides extensive design capabilities using several electromagnetic modelling tools. Conceived and implemented by a team of European SMEs, research centres and universities, it can be used to design ground-based antennas as well as those installed on spacecraft.

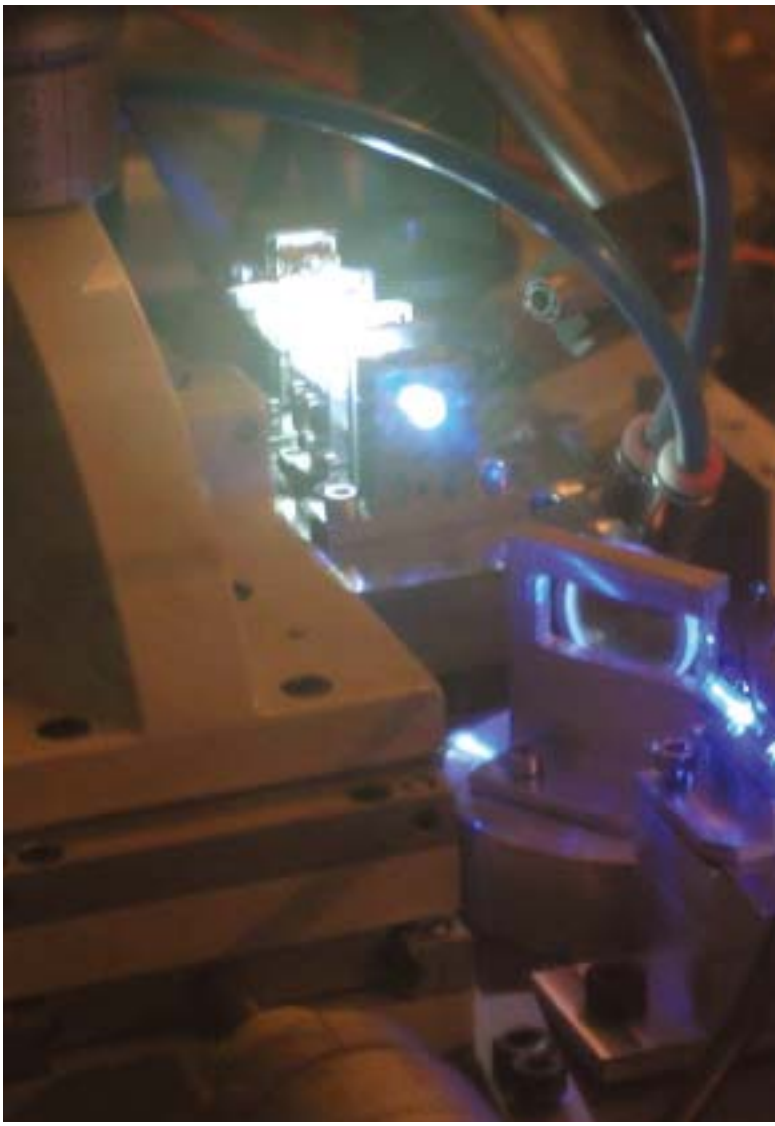
Mechanical Engineering

Mechatronics and Optics

The Mechatronics and Optics Division undertook a wide range of technology-development, engineering-support and laboratory-infrastructure activities. In the area of optical engineering, development effort was concentrated on enabling and emerging technologies like lightweight telescopes and optical micro/nano technology, primarily in support of ESA's scientific and telecommunications missions. High-precision optical metrology sensors were breadboarded that will enable the formation flying of the Darwin constellation of satellites with micrometre precision over inter-satellite distances of up to 250 metres. A demonstrator of the Gaia primary telescope mirror made of SiC100 material was realised, to allow interferometric performance testing at cryogenic temperatures. Similarly, a telescope assembly was produced using this material for the NIRspec instrument, one of ESA's contributions to the NASA James Webb Space Telescope. For Herschel-Planck, support focused on the verification and metrology of the Planck reflectors and the procurement of the Herschel SiC telescope.

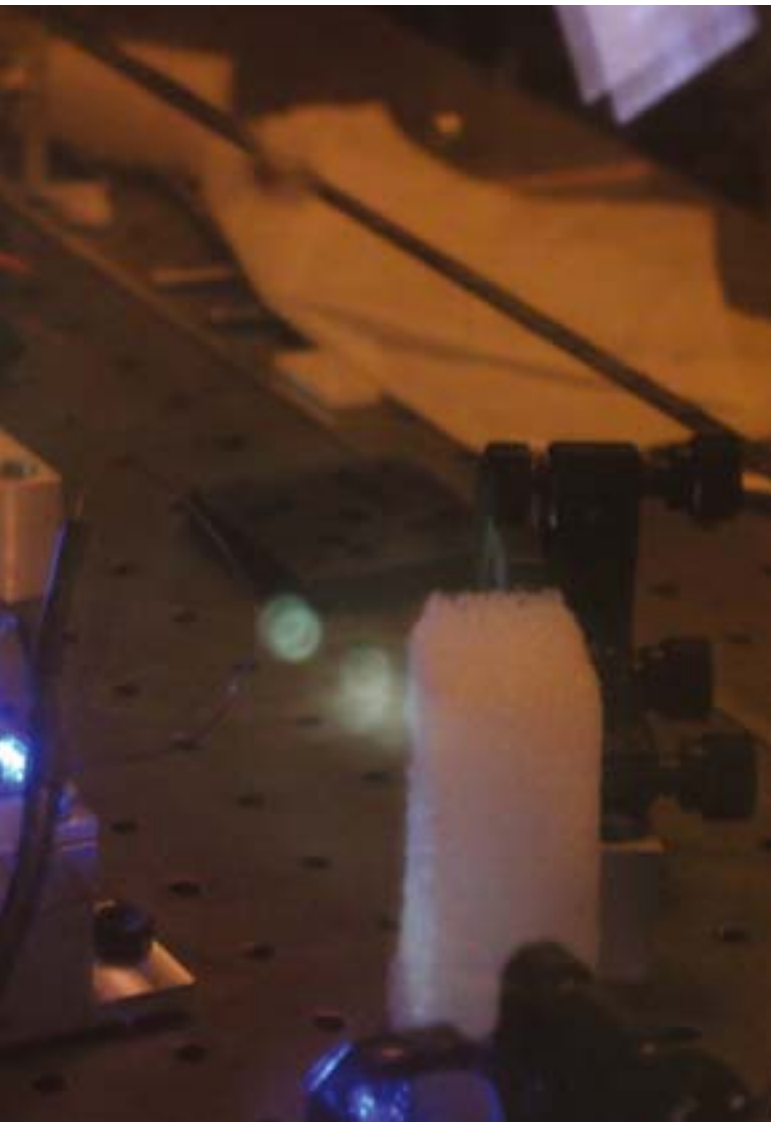


A multi-functional, silicon-on-insulator integrated-optics chip



Investigation of the many aspects of using optical techniques for handling electronic signals onboard satellites led to the design of a 'photonic payload' for next-generation space telecommunications systems. Generic integrated-optics silicon-on-insulator (SOI) waveguide technology was developed to demonstrator level, in pursuit of producing easily applicable building blocks such as bends, mirrors, vertical tapers, couplers and switches.

Extensive use was made of the Optical Ground Station (OGS) at Izaña on Tenerife. A laser communication campaign was performed between the islands of Tenerife and La Palma on behalf of DLR to evaluate free-space ultra-high-data-rate transmission through the atmosphere in preparation for a bidirectional space-to-ground optical link experiment between the German TerraSAR-X satellite and the OGS. Significant progress was also made in the development of laser technologies for applications in science, navigation and Earth observation. A compact laser system meeting the stringent frequency-stability and noise specifications for the LISA mission was also produced. In anticipation of future needs in the satellite navigation and telecommunications domains, a diode-laser-pumped, rubidium atomic-frequency standard was realised, achieving a frequency stability of 4×10^{-14} over a



Low-shock clamp-band opening device

Testing of an Nd:Mixed-garnet Q-switching laser

The dexterous Exoskeleton human/machine interface for Eurobot

few hours from a compact device. Significant effort was also directed towards the development of tunable laser sources for future-generation, Earth remote-sensing missions involving lidars (DIAL).

Expertise was provided to many ESA projects in the assessment and use of automation and robotics technologies. For planetary science, the development of a micro-rover and related geochemical investigation instrument suite was pursued up to engineering-model stage. The development continued of a communication and localisation subsystem for micro-probes to be released into the Venusian atmosphere. Activities in the field of planetary exploration focused on preparations for the ExoMars mission, addressing the development of terra-mechanics test equipment and the breadboarding of rover autonomous navigation. In the domain of orbital robotics, the Eurobot project was supported through the development of critical subsystem breadboards, such as the dexterous arms, the tool-exchange device, and the dexterous human/machine interface (Exoskeleton).

In the area of mechanisms, technical guidance and project support were provided to virtually all ESA projects, with mechanisms experts participating in many project reviews

Finite-element model used for MSG-2 dynamic shock analysis

and in-orbit-anomaly investigations. Much effort was devoted to preparing miniaturised mechanical devices for the Aurora Exploration Programme, such as moles, drills, seals, and capture and docking mechanisms. The development of electric-propulsion pointing mechanisms was stepped up to ensure their availability for the next generation of high-power electric-propulsion systems. The momentum-wheel development for the Galileo testbed GIOVE-A was achieved within a very tight schedule, allowing the timely delivery of flight units, a key factor in the mission's success. Special emphasis was also placed on electro-mechanical thrust-vector control systems for launchers, berthing and docking mechanisms for the International Space Station and Exploration Programme, and hold-down and low-shock release mechanisms for payload adaptors.

Important technology developments in the area of life and physical science instrumentation included the completion of the development of a confocal laser scanning microscope and the realisation of a gradient bioreactor. Technological preparations for a Pasteur-mission-related payload were heavily supported through work on the water sensor for Mars, the UV/Vis spectrometer, and the life marker chip.

Thermal and Environmental Control

In the structures domain, support was provided to almost all ESA programmes – e.g. Herschel-Planck, CryoSat, ADM-Aeolus, MSG, AlphaBus, Galileo, ATV, and Vega – ranging from conceptual-design phases in the Concurrent Design Facility (CDF), through to the actual design, test and validation phases. Further advances were made in terms of shock-load verification for spacecraft and payloads, applying new methodologies in support of various ESA projects, notably the MSG-2 spacecraft which was successfully launched in December.

Studies of loading interactions between launchers and spacecraft were further developed, establishing detailed dynamic models and applying advanced numerical-analysis methods in support of various ESA projects, including ATV, Vega and Aeolus.

The development of inflatable structures in Europe progressed well in order to demonstrate the feasibility of manufacturing, folding, deploying and rigidising large structures for satellite appendages, including possible in-flight demonstrations. The development of a large deployable antenna with 12 metre aperture for mobile communications advanced significantly, with two deployment tests successfully performed under gravity-compensation conditions.

Reflector surface-accuracy measurements in progress on a large deployable antenna (Courtesy of NPO-EGS, RSC Energia and Alcatel Alenia Space Italy)

Product Assurance and Safety

European Component Initiative

Launched in 2004 to ensure the timely and unrestricted availability of space-qualified components for European Industry by creating alternative sources for parts that are subject to export controls, this Initiative is supported both at ESA and national level, and coordinated with CNES and DLR. The first phase will provide new European manufacturing capabilities for a range of space-qualified components, from fuses to high-performance microprocessors. By the end of 2005, 15 of the 20 activities covered by the first phase were underway, with the first deliveries of qualified components expected during the fourth quarter of 2006. Preparation of the second phase has already been initiated in the framework of the Component Technology Board (CTB).

Global coordination of non-dependence programmes with non-European agencies was also pursued. As a first step, co-operation with the Japanese Aerospace Exploration Agency (JAXA) was initiated to establish mutually recognised procurement procedures for Japanese and European suppliers and to identify overlapping activities.

EEE Components

The main focus of the Components Division's support to ESA projects was on mission-critical technologies, such as the evaluation of a high-power laser diode that is a key component in the main instrument on the Aeolus satellite. Another example was a new thermal-management technique for hybrid microcircuits, which was flown on a Foton mission. Round-table events were organised on MEMS/nano-technologies and wide-bandgap semiconductors that are under development, attracting large numbers of European and overseas participants.

Wide-bandgap technology: a package containing two parallel, 12 x 125 micron, high-gain, high-efficiency microwave transistors

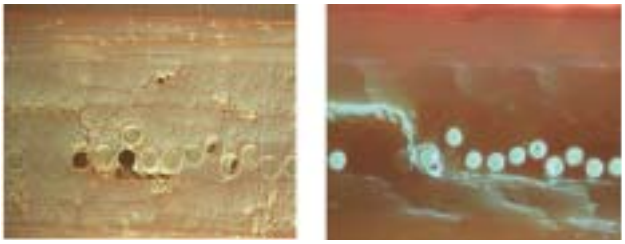
To cope with the growing demand for beam time for Single Event Effects (SEE) testing, in May the RADEF laboratory at the University of Jyväskylä in Finland was officially commissioned as the third ESA-supported external SEE radiation test facility.

The updating of the ECSS Standards and the Specification System under the European Space Components Coordination (ESCC) continued throughout 2005. Dossiers are in place that set the strategic aims for the next five years in each of the technology areas, and are closely coordinated with the European Component Initiative. The signing of executive implementation agreements by ESA, CNES, DLR and Enterprise Ireland was another highlight during the year, with commitments to the Annual Qualification Programme (AQP) for EEE parts.

Materials and Processes

A total of 304 Materials Reports were published – the largest number in the Division's history – covering such topics as the examination of rubber fuel-tank membranes, testing of solar cells and their coverglass adhesives, development of special cleaning methods for highly polished mirrors, and development of a shock-damper material for the ATV's solar-array drive mechanism. Failure investigations included an ATV latch-valve assembly that failed during acceptance vibration testing.

The Laboratory provided considerable support to the upcoming ESA science missions to the inner Solar System, namely Venus Express, Bepi-Colombo and Solar Orbiter. Due to their closer proximity to the Sun, these missions face severe challenges in terms of materials and processes. The Division also actively supported the Aeolus project by pulling together the main expertise on laser damage within Europe, setting up an internal ESA laser test facility in



Self-healing composite materials: Left, optical micrograph showing self-healing hollow fibres end-on; Right: UV light image, showing healing agent (in green) and healing of crack damage (courtesy of University of Bristol, UK)

collaboration with the Optical Division, and running a number of test programmes within established laser testing houses in Europe.

Work on advanced materials and processes covered nano-structured materials, self-healing materials, space-durable polymers and hybrid materials, new joining and manufacturing processes, etc.

The ESMAT website, created in 2005, contains the latest materials and processes data on outgassing, flammability and corrosion and a collation of special materials datasheets in a searchable format (they also exist as ECSS-Q-70-71, available as a hardcopy reference standard).

European Cooperation for Space Standardization (ECSS)

It was another productive year in the generation of ECSS standards, leading ultimately to the availability of a set of standards for almost all core space-related activities (see table).

The updated ESA Approved Standards list (version 1.8) containing 125 Standards (besides the core ECSS: ESA-PSS, MIL STD, CCSDS), was approved by the ESA Standardization Steering Board (ESSB) at its December meeting.

To facilitate the application of ECSS Standards, ESA has developed an automated tool, which was used during 2005 in a prototype form to support the tailoring of ECSS requirements to various Agency programmes. The ECSS Steering Board also set up a task force to revisit the present working modalities of the Standards.

An ECSS Developer's Day at ESTEC in September provided valuable feedback from the European space community involved in the development of the ECSS Standards. International recognition of the ECSS system and ESA's standardization activities was further enhanced in November by an exchange of views with a large Chinese delegation working in the field.

Systems, Software and Synthesis

Concurrent Engineering

Concurrent engineering continued to be used for the conceptual analysis of future missions, payloads and the impact of advanced technologies, in the Agency's Concurrent Design Facility (CDF). Lunar and planetary exploration missions, heavy-lift and Vega launcher missions, near-Earth-orbit missions, alternative energy-storage systems, and the Proba-3 mission for the demonstration of satellite formation flying were all studied. The CDF was also used extensively for education

	Engineering (ECSS-E Series)	Management (ECSS-M Series)	Product Assurance (ECSS-Q Series)	Total
Published	33	11	45	89
Under review	19	3	14	36
In drafting	34	0	12	46

ECSS Standards – status end-2005

and technology-transfer purposes, attracting considerable attention from both specialists and the media.

The process of consolidating the CDF integrated-design model and developing an open-source design server was started, the objective being to spread the Facility's expertise throughout Europe and Canada. The application of GRID technologies is also being explored with a view to setting up a Virtual Collaborative Facility to enable concurrent engineering activities by the geographically separated teams involved in international space projects.

A design session in progress in the Concurrent Design Facility (CDF) at ESTEC

Software Systems

Efforts continued in the critical area of system/software compatibility to prevent the occurrence of failures and to automate the design and verification process. The ASSERT initiative, which is coordinated by ESA and forms part of the EC's Sixth Framework Programme (FP6), draws together the academic and industrial expertise of 29 partners from 11 countries to improve the development process for critical embedded real-time systems.

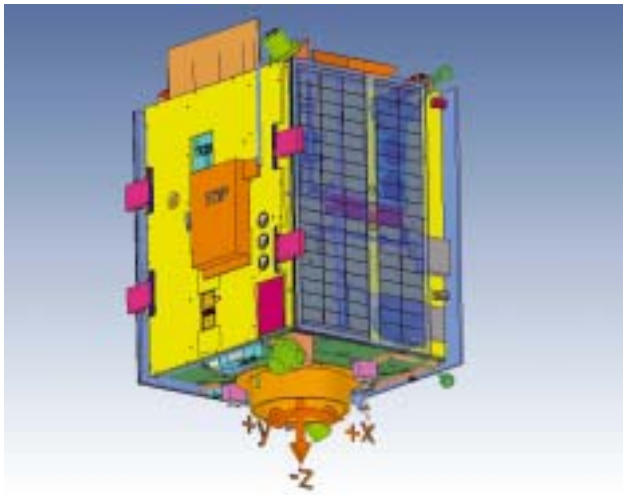
The prototype of the Generic Architecture for Mass Memory Access (GAMMA) was delivered in November. Running on the LEON-2 processor, its flexibility, scalability and file-management services allow multiple users to access mass-memory simultaneously and at high speed.

The GAMMA prototype (Courtesy of EADS Astrium SAS, France)

In-orbit Technology Projects

The Proba-1 mission has completed four years in orbit. All subsystems are in good health and no platform redundancy has had to be used. More than 10 000 images have been acquired by its Compact High-Resolution Spectrometer (CHRIS) for use by scientists around the World. The High-Resolution Camera and the Earth-environment monitoring instruments have also performed flawlessly. The mission has therefore been extended for a further year.

Proba-2, a microsatellite mission for technology demonstration, is in its main development phase (Phase-C/D), with launch planned for mid-2007. Most of the technology flight units have been delivered or are close to delivery. The payload instruments, a UV Sun imager (SWAP) and a radiometer (LYRA) will be delivered early in 2006.



The Proba-2 spacecraft concept (launch configuration)

Technology Programmes

Basic Technology Research Programme (TRP)

While TRP-initiated developments are at the root of today's major technological successes such as SMART-1's electric-propulsion system and Galileo's atomic clocks and new developments such as the LEON-2 processor are ongoing, the plan of work for the coming years has been thoroughly prepared in the context of the new Agency-wide approach to the definition of future technology programmes. This required extensive consultation with the users across Europe and the scrutiny of requirements by networks of expert groups, including representatives of technology users and developers and the relevant ESA Programme Boards.

NewPro

A thorough analysis of technology-development requirements and capabilities showed the need for a new technology programme, called 'NewPro', with three key objectives:

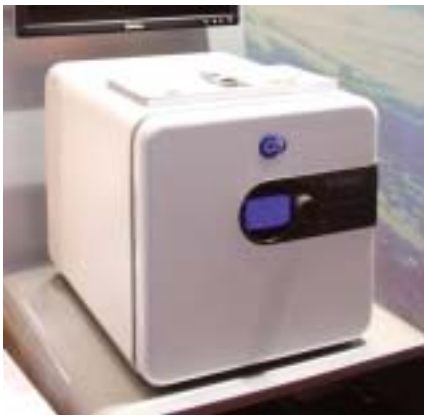
1. To ensure European independence in the critical technological capabilities required for space-based solutions.
2. To enable the use for space applications of multiple-use technologies, development of which is driven mainly from outside the space domain, through systematic spin-in.
3. To prepare the technological base for future civil security programmes and applications.

Conceived to be co-financed with the European Commission, a three-year interim period has been proposed for NewPro's implementation under the GSTP.

General Support Technology Programme (GSTP)

GSTP contracts worth more than 33 MEuro were awarded during the year. In addition, the GSTP provided special support to the SMOS Earth-observation mission and Vega, the European small launcher, worth nearly 15 MEuro.

Subscriptions to the 4th period of the GSTP had reached more than 90 MEuro by the end of the year, and an additional 215 MEuro were committed by Participating States during the Ministerial Council in December.



The O3-Ozonizer, to be marketed by the newly formed company DutchOzone BV

Technology Transfer Programme (TTP)

The TTP continued its efforts to open new markets for space technologies. Members of the Technology Transfer Network (TTN) added seven space spin-offs, with a total value of over 7 MEuro. More than 50 new space technologies were identified for potential spin-off, fifteen of which were eventually retained and commercial agreements signed. A further 64 new market needs on the part of non-space companies were also extracted. Similarly, non-space technologies were promoted to give their providers the opportunity to offer them to ESA and the space industry. A total of twelve spin-in technologies were extracted.

Eighteen start-ups or entrepreneurs were identified and/or assisted by the European Space Incubator (ESI), or one of the 35 incubators of the ESINET members in 2005. More than 80 proposals for new start-up companies were submitted to the ESI, 18 of which successfully passed the selection criteria and evaluation boards. Four selection committees sat during the year, resulting in the creation of 15 more start-ups, bringing the total number of companies within the Incubator to 38. During the year, three companies left the Incubator, and a further five are expected to 'graduate' at the beginning of 2006. The ESI is an integral component of ESINET – a network of incubators throughout Europe having a strong space connection and supported by both ESA and the European Commission.

One technology-transfer example is the O3-Ozonizer, derived from ESA's Microgravity Science Glovebox onboard the ISS. The Ozonizer is undergoing intensive validation and testing before technical certification for use as a steriliser by the medical and dental professions. Desert Seal is another example of the transfer of space technology to ground applications. This one-person tent for extreme environments borrows from space technologies for its inflatable structure and flexible solar panels.

Technology Harmonisation and Strategy

The timely mastery of technology is crucial for the future of the European Space Programme, in order to limit project development risks, to find solutions for complex challenges, to improve the competitiveness of Industry in commercial markets, to limit European dependence, and to attract young talent. Technology is also a major Industrial Policy instrument, particularly in terms of the restructuring of European Industry. ESA's efforts with the technology harmonisation process have also demonstrated their usefulness for better organising Europe's space activities, but given the growing challenges coming from the USA and Japan and new competitors such as India and China a lot still remains to be done.

The ESA Technology End-to-End Process

A significant achievement in 2005 was the introduction of a single new End-to-End Space Technology R&D Management Process for all ESA technology programmes. Being user driven and aimed at meeting both the institutional and commercial needs of Europe, it is based on the following key elements:

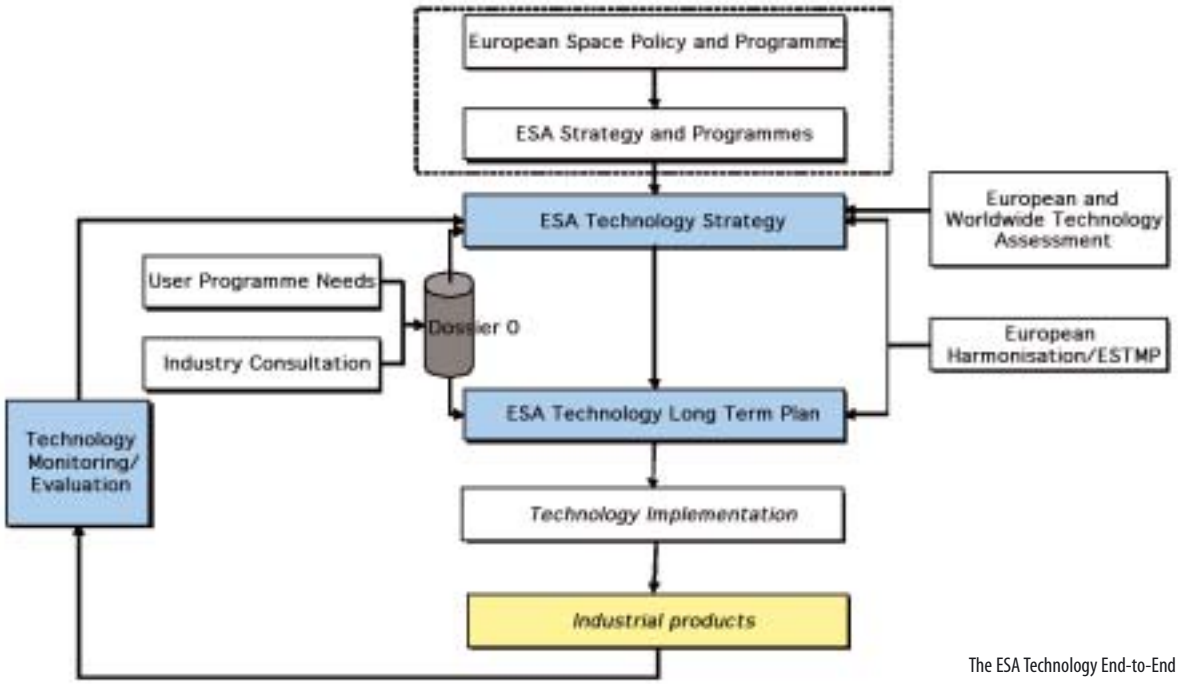
- The ESA Technology Long-Term Plan.
- The ESA Three-Year and Annual Space Technology Research Plan.
- Technology Monitoring and Evaluation.

To support this new ESA Technology End-to-End Process, two groups have been established:

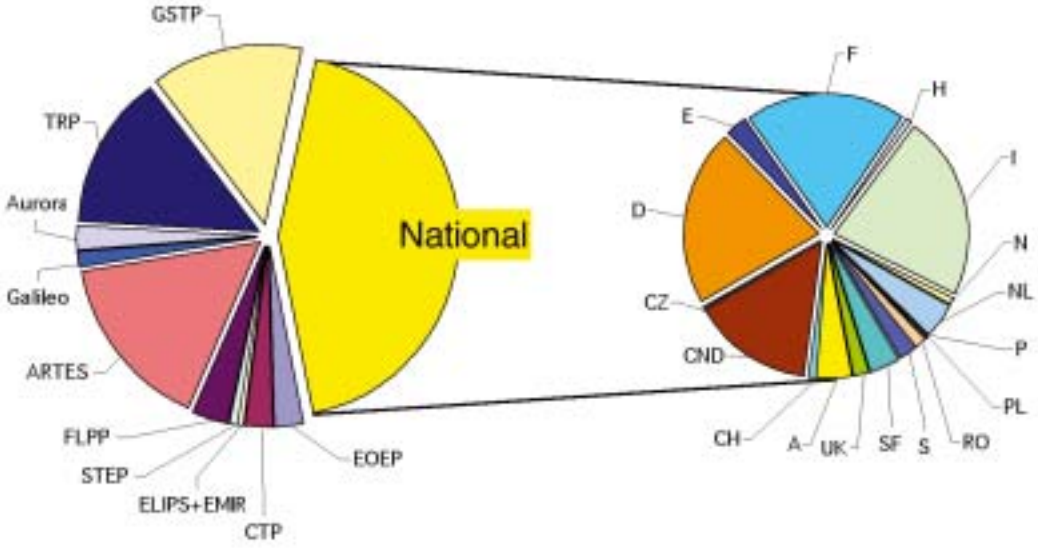
- The Technology Steering Group (TSG), made up of senior ESA managers and Directors, to oversee the complete process and to interact with ESA's Director General.
- TECNET, made up of ESA managers and senior technical experts, to ensure the efficient implementation of the complete process.

Although the complete process was only put in place in 2005, positive benefits can already be identified. The ESA Technology Strategy and Long-Term Plan were finalised as essential inputs to the Ministerial Council in December. A complete analysis was carried out identifying areas of space technology in which Europe may risk being dependent on other countries, to the detriment of its institutional and commercial aspirations. It led to the creation of a new Technology line known as 'NewPro'.

The European Space Technology Requirements Document (Dossier 0) is one of the key elements of the End-to-End Space Technology R&D Management Process. It provides the European space community with as complete an overview as possible at European level of all the envisaged missions, their associated top-level technology



The ESA Technology End-to-End Process



Budget for European space technology R&D in 2005 (~ 380 million Euros)

requirements (user pull), and the technology requirements related to 'technology push'. The updating of the document in 2005 resulted in a printed version of the Dossier 0 introductory document and an updated Dossier 0 electronic database, accessible via the Internet (http://dossier0.esa.int). A major review of the requirements was carried out to consolidate and prioritise the content of the database, which now contains 101 missions and 712 technology requirements, more than half of which were generated in the context of this latest update.

European Space Technology Harmonisation

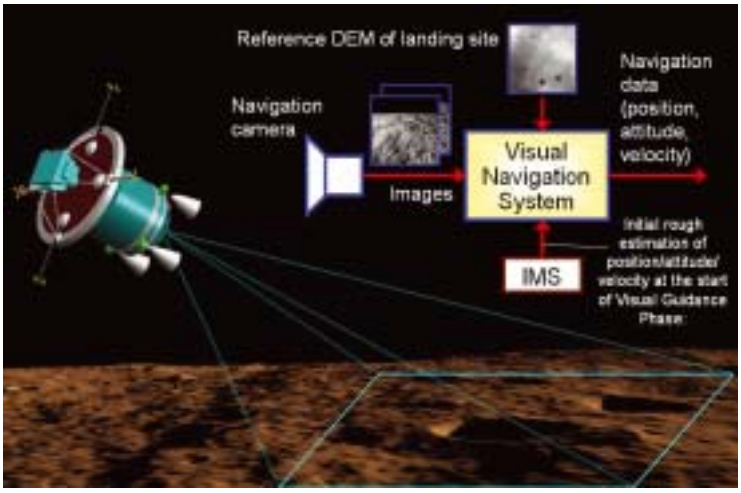
The European Space Technology Harmonisation effort, mandated by the 2001 ESA Ministerial Council in Edinburgh, is designed to achieve better coordinated space technology R&D activities among all European actors, with the 'filling of strategic gaps' and the 'minimising of unnecessary duplications' as major objectives. The harmonisation process takes into account the various European developments, capabilities and budgets in order to enhance the complementary roles of the various stakeholders in meeting common objectives, and covers the different situations in terms of technology maturity, industrial competitiveness, funding needs and political interests. Based on voluntary participation and two review cycles per year, the process is strongly supported by all stakeholders and recognised by the European Commission White Paper as a leading instrument for space technology in Europe. Since its pilot launch in 2000, approximately 40 technologies have been harmonised, with the participation of all ESA Member States, the European Commission, Industry, and more than 700 professionals from 170 European space companies and research organisations.

Proposals to adapt the Technology Harmonisation Process, approved by ESA's Industrial Policy Committee (IPC) in May, are now being implemented, which will ensure that recommendations stemming from the harmonisation process are applied in ESA programmes, promoted and duly considered by Member States and their industries in national and commercial programmes. A significant step forward in this context was the creation of a Technology Harmonisation Advisory Group (THAG), reporting to the IPC.

European Space Technology Master Plan (ESTMP)

The ESTMP is a key element of the overall European Space Technology Coordination and Harmonisation Process. After four releases, the first of which was in 2002, the ESTMP has now achieved a high degree of maturity and strategic relevance in Europe, being distributed to over 400 stakeholders (ESA Member States, European Commission, Industry, etc.).

The 2005 edition of the ESTMP provides stakeholders with the most comprehensive single source of information on space technology in Europe, reporting on the latest developments and defining roadmaps for future action, and reflecting the new ESA Technology End-to-End Process and the plans submitted to the Ministers meeting in Berlin on 5/6 December. European Union initiatives that have an impact on space technology (such as GMES, Galileo and security issues) are described in more detail, more closely linking technology-development plans with applications responding to end-user needs. Particular attention is also given to ESA-EC cooperation on space technology and to the European Space Technology Platform (ESTP).

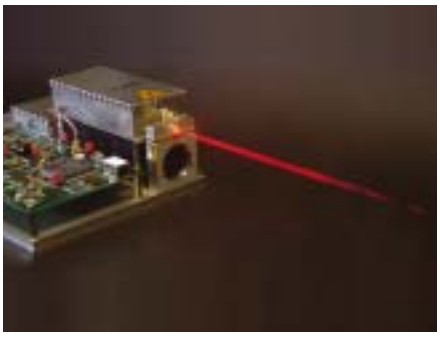


A visual navigation system – an example of ITI technology

Cooperation with the European Commission on Space Technology

Following the work in 2003 by the Working Group on Technology of the EC/ESA Joint Task Force (JTF), the EC White Paper on Space recommended greater investment in space technology using the ESTMP as a basis, including investment in technologies for non-dependence, upstream research on multiple-use/spin-in technologies from non-space sectors and technologies for civil security, through EC technology programmes – in particular Framework Programme 7.

To respond to the needs of an enlarged Europe, a European Space Technology Platform (ESTP) has been proposed in the context of the European Space Policy, to complement the ESTMP/Harmonisation process on technological issues with a European strategic dimension. The ESTP is basically a Europe-wide umbrella bringing EU actors and programmes together for a long-term coherent vision on space-technology development. It will provide interfaces with other related technology platforms on upstream issues of common interest, it will promote research on multiple-use technology, and it will formulate the rationale for the necessary EC financial commitment to space technology through the identification of harmonised stakeholder needs.



A micro-laser ranging system – an example of ITI technology

The Innovation Triangle Initiative

The aim of the Innovation Triangle Initiative is to explore applications technologies or services that are not currently being used or exploited in the context of space. Since the ITI's launch, 235 unsolicited proposals have been received, resulting in 48 approved activities covering a wide range of technologies. The number of high-quality proposals submitted demonstrates both European Space Industry's interest in the Initiative and the validity of the approach. 12 ITI contracts have already been concluded and the results were presented at an ITI Final Presentations Day in ESTEC on 21 November. One example of an ITI-supported development is a novel micro-laser ranging system to guide a landing vehicle; it allows the vehicle to find the exact landing position to an accuracy of 3 cm from an altitude of 7 km. Another example is a visual navigation system that continuously acquires images of a planet's surface, and calculates the difference from one image to the next in real time to determine the exact location, orientation and speed of the lander with only a 1% error.

Operations and Infrastructure

The Agency's excellence in mission operations was again demonstrated in 2005 with the landing of the Huygens probe on Titan, and the successful launch and injection of Venus Express into its interplanetary orbit. The exceptional media coverage of these missions further increased the general public's awareness of European space activities. Other highlights were the insertion of SMART-1 into its operational lunar orbit and the impressive performance of the spacecraft's innovative electric-propulsion system, the start of operations of the MARSIS radar onboard Mars Express, and the smooth launch and early operations phase (LEOP) for MSG-2. The ground-segment and mission-operations preparations for the CryoSat launch were also flawless, and can be reused for the CryoSat-2 mission. The inauguration of ESA's second deep-space ground station at Cebreros in Spain added another key element to the operations infrastructure.

One of the Directorate's prime strategic objectives is the strengthening of its strategic position in the provision of mission-operations support both for ESA's own and for external customer's programmes. The ESA Member States' subscriptions to the ExoMars mission and the decisions on the way forward for the Galileo IOV Phase offer welcome opportunities, to which the Directorate is well prepared to respond. In parallel, efforts will continue on adequate positioning of the well-proven mission operations competencies for other future programmes like the Galileo Operational Phase and GMES.

Another main strategic objective of the Directorate is to further improve the value of the services delivered to its customers. The matrix approach with the Programme Directorates resulted in the concentration of competencies, creating synergies at Agency level. A strengthened, but also more cost-effective organisation at each ESA site will in future provide one face to internal customers. A merger of the Information Systems and Site Services Departments is therefore being prepared for roll-out by mid-2006. These measures go hand in hand with a new structure for the IT service portfolio. The extension of ISO certification to the entire Directorate's Quality Management System is another cornerstone for meeting customer expectations in all areas.

The ESA deep-space antenna at New Norcia in Western Australia

Artist's impression of the Huygens probe's landing on Titan

The goal of establishing closer cooperation with other European spaceflight operations centres resulted in a cross-service Framework Agreement with DLR, under which both agencies will share network facilities, communication networks and flight-management data. A highlight of the international cooperation was the observation of NASA's Deep Impact collision with comet Temple-1 by ESA's XMM-Newton and Rosetta spacecraft.

Ongoing Missions

Cassini-Huygens

On 14 January, the Huygens mission was completed with the successful descent and landing of the probe on Titan. The data sets returned by the onboard instruments were astonishing and provided the scientists with an amazing first glimpse into this remote world. As part of the joint NASA/ESA/ASI mission to Saturn and its moons, the Cassini spacecraft, after flawlessly supporting the Huygens mission, is continuing its tour of Saturn with its rings and satellites, producing ever more exciting new views of and data about the Saturnian system.

A Huygens image of Titan's surface

The Main Control Room at ESOC during the launch preparations for Venus Express

Venus Express

Venus Express was launched on 9 November from Baikonur in Kazakhstan. The space and ground segments performed so well that, after an almost perfect injection of the spacecraft onto its interplanetary trajectory, the launch and early orbit phase (LEOP) was completed in record time (just 53 hours). One of the highlights was the transmission of the first commands from ESA's new 35 m deep-space ground station in Cebreros, Spain. A final trajectory-correction manoeuvre put the spacecraft on a direct course to Venus. Full spacececraft platform commissioning was accomplished within just one week, allowing payload switch-on and testing to be completed by mid-December. These tests demonstrated that the instruments work together very well, with adequate spacecraft performance and within required margins.

Rosetta

About a year after its launch, Rosetta was back completing its first Earth swing-by on 4 March at a distance of 1900 km. During this period, the Moon was used as a target to validate the asteroid flyby mode and operations planned for 2008 and 2010. Rosetta is now on its way to Mars, which it is due to swing-by on 27 February 2007.

Mars Express

The Mars Express operations profile involves 30 to 40 ground-station passes per week, interleaved with up to 150 different observations during 25 Mars orbits. With a moderate Earth-Mars distance and favourable planetary-illumination conditions for the optical instruments, the second half of the year allowed maximum communications capability with all ground stations. Despite a very tight 70% power-management limitation, two major eclipse seasons were endured without impacting on the science return. ESOC also prepared and executed the successful deployment and commissioning of the MARSIS payload's single 10 m and two 20 m antenna booms.

SMART-1

With its entry into lunar orbit in March, SMART-1 became the first European spacecraft to orbit the Moon, delivering a continuous stream of scientific data. The spacecraft's novel electric-propulsion system demonstrated excellent performance, with xenon utilisation reaching 99.5% after optimisation of the lunar orbit. The spacecraft will impact on the Moon's surface in August 2006, thereby completing the first European lunar exploration mission.

XMM-Newton

By year's end XMM-Newton, launched on 10 December 1999, had completed 1111 orbits, involving the flawless execution of almost 5 million telecommands and close to 16 000 attitude manoeuvres to view selected X-ray science sources. The available fuel will allow operations well beyond the already extended end-of-mission in March

2010. Migration to a new mission control system was successfully completed at ESOC and the Science Operations Centre at ESAC.

Ulysses

6 October marked the 15th anniversary of the spacecraft's launch. After several mission extensions, Ulysses is now on its third orbit over the poles of the Sun, and continues to deliver first-class science data from this unique perspective. With each revolution, however, the output from the Radio-isotope Thermoelectric Generator (RTG) decreases and there is less power available to heat the spacecraft when it is far from the Sun. Recent operational activities by the ESA flight control team at JPL have therefore focused on avoiding propellant freezing, and the first indications of increasing temperatures were noted as Ulysses once again makes its way towards perihelion.

Cluster-II

After more than five years of formation flying, the Cluster fleet started its second mission-extension phase with an increase in the inter-spacecraft distance from 1000 to 10 000 km. This new formation strategy will allow future formation changes to be implemented faster and with significantly less fuel. The 'triangle multi-scale constellation' established during the summer – with three satellites forming a 10 000 km triangle and two satellites just 1000 km apart – allowed the neutral sheet of the Earth's magnetosphere to be analysed on two scales simultaneously. The constellation was changed to a 10 000 km tetrahedron in November to probe the magnetosphere's northern cusp.

Integral

While conducting extensive observations, platform and payload calibrations and upgrades to the instrument-related onboard software were performed during the year, which helped to improve the scientific return. The good performance of the onboard and ground systems was an important factor in the decision to extend the mission until 2010. To keep the ground systems up-to-date, several upgrades were implemented, including the swap to the new ESOC control system infrastructure.

ERS-2

With the new gyroless operating mode and X-band, low-bit-rate, real-time mission control, the primary ground stations and the satellite itself could be operated without major anomalies or degradations. To compensate for the failure of the onboard tape recorders, the real-time X-band ground-station network, operated from ESRIN, was increased to 12 stations, including seasonal and permanent Antarctic stations. ERS-2 still generates data from all of its instruments for more than 98.5% of the planned time, and the spacecraft's yaw pointing continues to be tuned to improve product quality. The ability to remove ERS-2 from orbit at the end of its lifetime has been reinforced with new onboard software that will allow de-orbiting even with significant degradation of the gyroscopes that are still operating.

Envisat

The mission's very high scientific data return continued, with 75% of the science data now directly downlinked through the Artemis data-relay satellite to the Payload Data Handling facilities at ESRIN. Support was provided to numerous disaster-monitoring operations, such as the Indian Ocean tsunami, Hurricane Katrina over New Orleans, and a major oil-storage-depot fire near London. Upgrades were made to the Envisat ground segment to support the mission beyond its initial five-year lifetime, preparing now for operations until 2010.

Proba-1

This mission celebrated four years in orbit, and continues to support the Earth Observation Programme and requests received via the International Charter on Space and Major Disasters.

Missions in Preparation

CryoSat

The ground-segment validation tests were successfully concluded, verifying all internal and external interfaces and product-generation tools. Facilities and tools to support launch and routine operations phases were validated, including the mission control system, simulator and ground stations. The simulation campaign was also

successfully completed, including two network countdowns with the ground stations and the dress rehearsal with the satellite. When, on 8 October, CryoSat failed to reach orbit due to a launch-vehicle malfunction, all ground-segment and operations-related activities were suspended and secured for re-use during the anticipated CryoSat-2 mission.

GOCE

Flight operations segment development was completed on schedule, and both the mission-specific and new-infrastructure components were delivered and underwent significant unit-level testing. An important milestone was the execution of the first system validation test, during which the flight operations segment successfully commanded a wide range of unit-level operations on the satellite engineering model. By year's end, preliminary compatibility testing with the rest of the ground segment had started, in preparation for overall ground-segment validation in 2006.

Aeolus

Preparation of the flight operations segment progressed according to plan. Important milestones included the successful closure of the spacecraft Critical Design Review and the assignment of the development contracts for the spacecraft simulator and mission control system. The last quarter of the year saw the start of preparations for system testing.

Herschel/Planck

The Herschel and Planck ground systems are beginning to take shape, with the first deliveries of the mission control system and simulator installed and operating. A first contact was made with the Planck spacecraft in the Cannes integration facilities, and telemetry was received and processed successfully. Flight dynamics utilities were delivered for incorporation into the science operations planning systems.

LISA Pathfinder

The main ground-segment activities were the consolidation of the mission-analysis and space-to-ground interface designs. The new launch date in the second half of 2009 will allow the Cebreros ground station to support the mission (instead of a 15 m ground station), thereby allowing some spacecraft design constraints to be relaxed. The Ground Segment Requirements Review was successfully concluded, allowing the go-ahead to be given for the detailed specification of the operational ground segment and the initial definition of the science ground segment.

Gaia

To help ensure that mission design and deliverable items meet the standards required for successful and cost-effective operations, ESOC participated in the preparation of the technical specifications for the spacecraft and its instruments. Preliminary requirements for the operational ground segment are under evaluation.

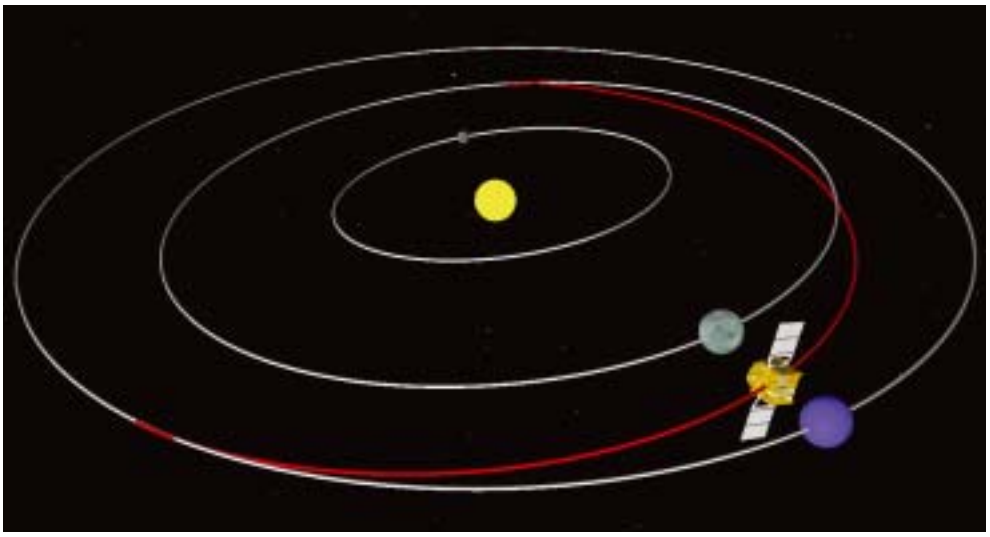
Bepi Colombo/SOLO

Support was provided in the preparation of the industrial Invitation to Tender (ITT), planned for release in early 2006.

Flight Dynamics and Mission Analysis

Flight dynamics and mission analysis shared the honours in terms of mission highlights in 2005. Rosetta's successful Earth gravity-assist manoeuvre on 4 March was performed using the ORATOS flight-dynamics system. Passing within just 1900 km of Earth, its fly-by could even be observed by amateur astronomers. Interplanetary activities were again the focus when Venus Express was sent on its way to our neighbouring planet, with ESOC's experts determining the injection orbit and performing the planned correction manoeuvre to put the spacecraft on the right trajectory for Venus Orbit Insertion on 11 April 2006. The year closed with the successful launch and early orbit phase (LEOP) operations for the MSG-2 mission for Eumetsat.

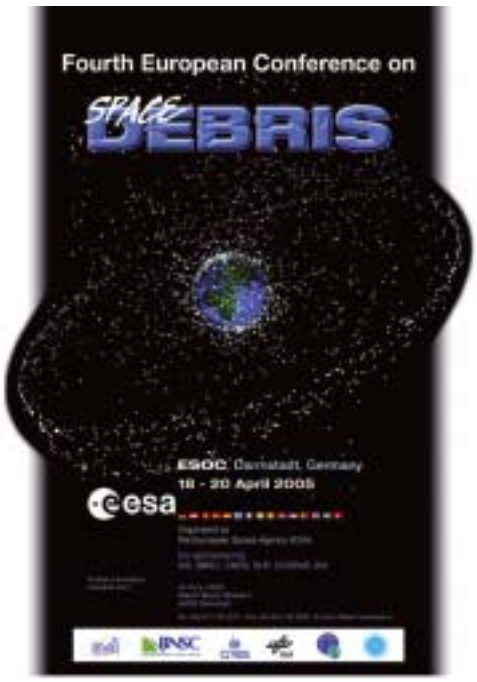
Mission analysis focused on mission baselining and refinement for Galileo and the various other ESA missions in preparation. One example was LISA Pathfinder, which must reach an orbit around the L1 Lagrangian point, some 1.5 million kilometres away from Earth in the direction of the Sun.



The flight path of Venus Express through the Solar System

Space Debris Office

ESOC's space-debris analysts routinely monitor close encounters between Envisat and ERS-2 and known, catalogued debris objects, and if necessary initiate avoidance manoeuvres. On 26 November, for example, a 1400 kg Cosmos-3M orbital stage passed within just 500 metres of Envisat.



In April, around 300 experts from all of the major space-faring nations met at ESOC for the Fourth European Conference on Space Debris, the World's largest event dedicated to this subject. 120 papers were presented, summarising the current state of research on space debris and meteoroids. Discussions focused on the future path for research and methods of debris reduction, protection and control, and also provided a forum in which to discuss policy issues, regulations and legal aspects.

Ground Systems Engineering

ESA continued to upgrade and expand its ESTRACK tracking network, including the development of specialised communications and ranging equipment. The inauguration of the ESA deep-space ground station at Cebreros, near Madrid, in September was a major milestone for the ESTRACK network. Like its sister station in New Norcia, Western Australia, it has a 35 m diameter antenna, but the Cebreros antenna is designed both for X-band up- and downlinking (8 GHz) and for the newly allocated Ka-band frequencies (32-34 GHz). With these new facilities, ESOC is well prepared to serve the needs of ESA's current and near-term scientific missions. A third deep-space antenna is being considered for the medium term to improve capacity for additional Mars missions and to achieve greater coverage and redundancy for future ESA exploration missions.

During 2005, a new and very ambitious ranging project known as 'Delta DOR' was initiated. It supports faster and more precise orbit determination for deep-space satellites for critical manoeuvres like swing-by orbit insertion. The concept is based on an interferometric measurement of the satellite's position (angle) by two compatible, but widely separated ground stations, such as New Norcia and Cebreros. With highly precise atomic clocks and a very stable reception system, the data at the two ground stations are synchronised using a common quasar before and after the transmission of a spacecraft signal. A lengthy correlation process follows, during which about 10 Gbytes of data have to be processed. The first test campaigns were carried out using Rosetta and Venus Express, with the goal of being ready for the latter's Venus Orbit Insertion in April 2006. The project is very ambitious due not only to the technical installations and algorithm development needed, but also the extremely tight timeline.

As in previous years, ESA provided extensive support to the European Technology Harmonisation effort for ground-segment software. EGOS, the ESA Ground Operation System, is attracting a lot of attention from flight operations centres and Industry. The first EGOS Workshop took place in November at Eumetsat in Darmstadt, Germany, and attracted 160 participants from Europe and the USA. EGOS provides a general architecture for all ground-segment data subsystems in order to improve interoperability and, being based on Unix/Linux, will ensure vendor independence. ESOC's operational software includes an open-licence policy and support for Member State industries on product lines such as SCOS-2000, SIMSAT, PSS and TMTCS. Today, more than 70 licences for SCOS-2000 have been granted in Europe. New users in 2005 who are integrating and validating their control centres based on this software include SES for Astra-1M, and Galileo for the In-Orbit Validation phase.

EGOS
ESA Ground Operation System

As the cost-effective provision of mission-control systems and simulators depends on good standards, ESA is taking a key role in actively contributing to ECSS and CCSDS standardisation. Some 23 data systems for ongoing missions are currently supported, and 10 systems are being developed for missions in preparation.

Navigation Support

The ESA Navigation Support Office is active in the governing body and technical areas of the International GNSS Services (IGS). It participates in an IGS Working Group interacting with Galileo and other Global Navigation Satellite System (GNSS) developments. ESA is one of seven global IGS Analysis Centres delivering high-quality products to the scientific community. Significant expert support is provided to Galileo in the design of satellite-navigation-related algorithms and systems, their verification and operation. In collaboration with European partners, a prototype facility to accurately define and maintain the terrestrial reference frame and the setting up of a GIOVE receiver network for experimentation with prototype receivers at several ESA sites were initiated. A new GNSS tracking site was established at Faaa in Tahiti, in collaboration with Météo-France.

The ESA Navigation Facility has been fully integrated and began operations in May with the validation of the GRAS GSN service. It will be used for ESA and third-party projects, including high-precision orbit determination for Earth-observation satellites – currently ERS-2 and Envisat – and various types of GNSS-related activities.

Third-Party Support

ESA continued to market spare operations-facility capacity and expertise to external customers. The level of activities was similar to previous years, with an average of one enquiry received per week, 15 proposals generated and 11 contracts awarded. Major third-party activities included the successful LEOP service for MSG-2, the LEOP preparation for MetOp-1, and the development of the GRAS ground-support network for Eumetsat. From Redu, in-orbit testing support was provided to Eutelsat, precise GPS orbit/clock data were provided to Fugro, and various

The ESA Navigation Facility at ESOC

hosting services were provided to New Skies and Vitrociset. Activities also included LEOP support to Syracuse-3A for CNES from Perth (W. Australia), to OICETS for JAXA from Kiruna (S), preparation of LEOP support to Kompsat-2 for KSAT and to DLR's TerraSAR-X, and various navigation projects for the Galileo Joint Undertaking.

Network of Centres Initiative

ESA/ESOC and the national European flight operations centres of CNES (F), DLR (D) and Telespazio (I) were involved in the Network of Centres proposal for the Galileo IOV Operations Segment in 2004. The proposal was further refined in 2005 and expanded to include additional partners, namely Aena, Hispasat and Inmarsat. Thus, the Network of Centres has been able to propose a coherent solution for the Galileo IOV system operations, serving as a good precedent for the applicability of Network of Centres solutions for future European space missions.

In parallel, coordination continued with CNES and DLR on joint Phase-A activities for projects from each agency and a roadmap for further harmonisation of flight operations infrastructure. Practical implementation of this cooperation is manifested in the cross-service Framework Agreement with DLR for Network Services, through which ESA and DLR will share network facilities, including ground tracking stations, communication networks and flight-management data and the LEOP support provided to CNES for Syracuse-3A and to DLR for TerraSAR-X.

ESA Site Management

It was another challenging year in terms of site management, with continuing severe limitations on budget, exacerbated by knock-on effects from 2004 and continuous pressure to provide the required level of facilities and services. Only a limited number of new infrastructure projects were initiated, strictly related to compliance with statutory health, safety and security regulations. The only exception was the enhancement and extension of the ESAC operations facilities needed to house the additional scientific staff arriving on site.

Major steps were taken to improve security, including the installation of an Agency-wide security-badge access system, as well as video surveillance systems and security command centres at a number of sites.

The new Operations Building at ESAC

Regarding health and safety, ESTEC and ESA Headquarters had to re-quantify the presence of on-site asbestos and to establish plans and funding for its removal. The on-going asbestos removal at ESTEC continued apace and immediate actions were initiated for the Asbestos Removal Plan 2.

An often overlooked workload is support to the programme and communications offices at the various sites for launch and similar events, for conference organisation and meetings of official bodies, as well as for visits by high-ranking officials like heads of government. In this respect also, 2005 was an exceptionally busy year.

The Department has been instrumental in the preparation of the five-year ESA Infrastructure Strategic Plan, which brings together the Directorate of Operations and Infrastructure and Directorate of Technical and Quality Management strategies regarding future infrastructure investments.

Over and above these 'traditional' activities, new tools were introduced to improve the financial management of the Department, which also achieved ISO 9001 certification by end of the year. Last but not least, in the drive for greater efficiency in terms of cost and customer service, further organisational changes will take place in 2006 to ensure that the Department can succeed in its mission to provide all of the facilities and services necessary for ESA staff to operate in a safe, healthy and secure environment.

ESA Corporate Information Technology

The specification for the largest outsourcing contract ever placed by ESA for corporate IT and related services was issued and tendering started. The contract will be managed from ESRIN as the main ESA corporate IT centre and implemented in 2006, after having grouped together the different IT services and having improved infrastructure standardisation.

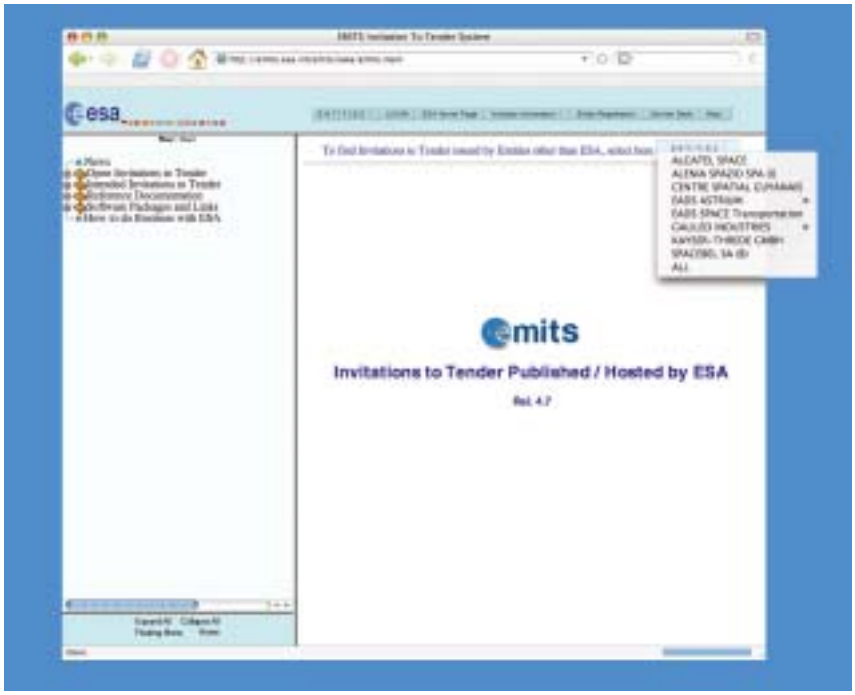
A major refurbishment of the corporate computing centre at ESRIN, where all major ESA Management Information Systems reside, was completed in 2005. A detailed review of some of these information systems was also started, in view of the changes needed to support the Agency's ongoing administrative reform activities.

An upgrading of the informatics infrastructure at ESAC was initiated with the procurement of 1 Gigabit/s high-capacity connections to Europe's major research networks. Full upgrading to ESA corporate establishment standards will be achieved in 2006. Another highlight of the year was the successful rollout of the new 'flexitime system', for which Establishments were equipped with automated badge readers that also provide an identity check for all staff.

As part of the preparations for new projects that will involve classified information, information security was thoroughly reviewed. The most important aspects are implemented in the latest ESA Security Regulations, which were adopted by Member States in 2005. In cooperation with national security authorities, a project team, leveraging the Directorate's skills in information systems, physical and document management security, established the formal and technical framework and finalised the technical requirements for an ESA Security Office.

Synergies between the Directorate's corporate and mission-operation information and communication technologies and the corporate IT and site-management activities were analysed in depth, with a view to their merger into a single organisational unit by mid-2006. This new Department will bring the services closer to the users, whilst at the same time reducing the cost of day-to-day operations.

Industrial Relations



Expanding communication with European Space Industry and improving the Agency's knowledge of its capabilities, and those of European research organisations, was a continuing priority in 2005, in pursuit of greater speed and efficiency in the ESA decision-making process.

An analysis of the potential for space activities in Industry and research institutes in Greece, Luxembourg, Hungary, Poland and Romania, was presented to the Agency's Industrial Policy Committee (IPC) and Industrial Relations Committee (IRC). The study identified the scientific communities, and major and niche competencies that these States can bring to ESA, their degree of maturity in the different fields, and promising areas for future cooperation in European space programmes. In preparation for the Ministerial Council in December in Berlin, an analysis was made together with Industry to identify key critical industrial capabilities, and projections of associated workload. The results were synthesised in a document package prepared for the Ministerial Council Preparatory Working Group.

A new release of EMITS (Electronic Invitation to Tender System) was prepared, simplifying access for Industry and research organisations working with ESA. ESID (European Space Industry Database) was considerably updated based on significant contributions from Member State Delegations, and its scope was enlarged to include the PECS (Plan for European Cooperating States) countries.

Industrial Policy measures for non-Large System Integrators were applied to R&D programmes. The results of their past implementations were analysed and a way forward was proposed and discussed with the Delegations in the framework of the IPC. In order to improve the quality of both technology action selection and the technology-harmonisation process, a new analysis process was initiated to develop market estimates, and the first contributions were provided during the latest European Space Technology Harmonisation meetings.

The Small and Medium-size Enterprise (SME) Initiative continued to support SMEs through the specific mechanisms that have been put in place. Training courses organised at ESTEC allowed more than 100 engineers from 70 SMEs and research organisations to familiarise themselves with specific aspects of space activities. In the framework of the Announcements of Opportunity (AO) for the Leading-Edge Technologies for SMEs (LET-SME) initiative, launched at the end of 2004, eight contracts were issued. The second brochure highlighting the successful results of past SME spin-in activities was published. Last but not least, cooperation between the European Commission and ESA on support to SMEs was reinforced by an EC contract to ESA to define and develop an expert network focussing on engineering and processes.

General Studies Programme

The General Studies Programme (GSP) and the Advanced Concepts Team (ACT) focused in 2005 on formulating and conducting the preparatory activities needed to provide ESA and its Member States with the knowledge, tools and roadmaps that will allow them to meet the following challenges with confidence:

- The main challenges facing society today, namely energy, environment and security.
- The coordination and optimisation of the synergies between the short-, medium- and long-term planning of innovative and advanced R&D in the space sector, on both national and European scales.
- The advent of new concepts for future space missions and systems, stemming either from the maturation or the merging of different scientific disciplines, or from scientific areas that until now have been of only theoretical interest.

The Advanced Concepts and Studies Office has undertaken several concrete actions to provide Europeans with an adequate set of answers, solutions and plans in these domains

With the increase in worldwide population density, natural disasters, such as the earthquake-generated tsunami in the Indian Ocean in December 2004, are resulting in ever more devastating human catastrophes. The GSP therefore includes activities to explore new monitoring and warning concepts that involve a space segment, aimed at identifying the physical precursors of violent seismic events on Earth.

It is now widely accepted that the Earth's climate is undergoing a dangerous set of changes caused by human activities. By preparing new Earth-science missions, the GSP is contributing to the design and preparation of space missions to monitor these radical changes.

AIDS, tuberculosis and malaria kill over 6 million people each year, and the numbers are growing. GSP-initiated activities are currently seeking to understand how and to what extent space-based technologies can support the logistical efforts required to meet the burgeoning demand for a wide range of medicines across sub-Saharan Africa.

Guaranteeing security on aircraft, trains and other mass-transportation systems has become a major issue in our day-to-day lives. By investigating the theoretical possibilities offered by teraHertz camera technologies for the detection and safe destruction of landmines, and for the remote detection of chemical and biological substances (a spin-off from the development of novel Earth-observation camera systems), and by sponsoring the preparatory studies needed to implement the GMES Programme together with the European Commission, the GSP is helping ESA and its Member States to shape a safer future for Europe's citizens.

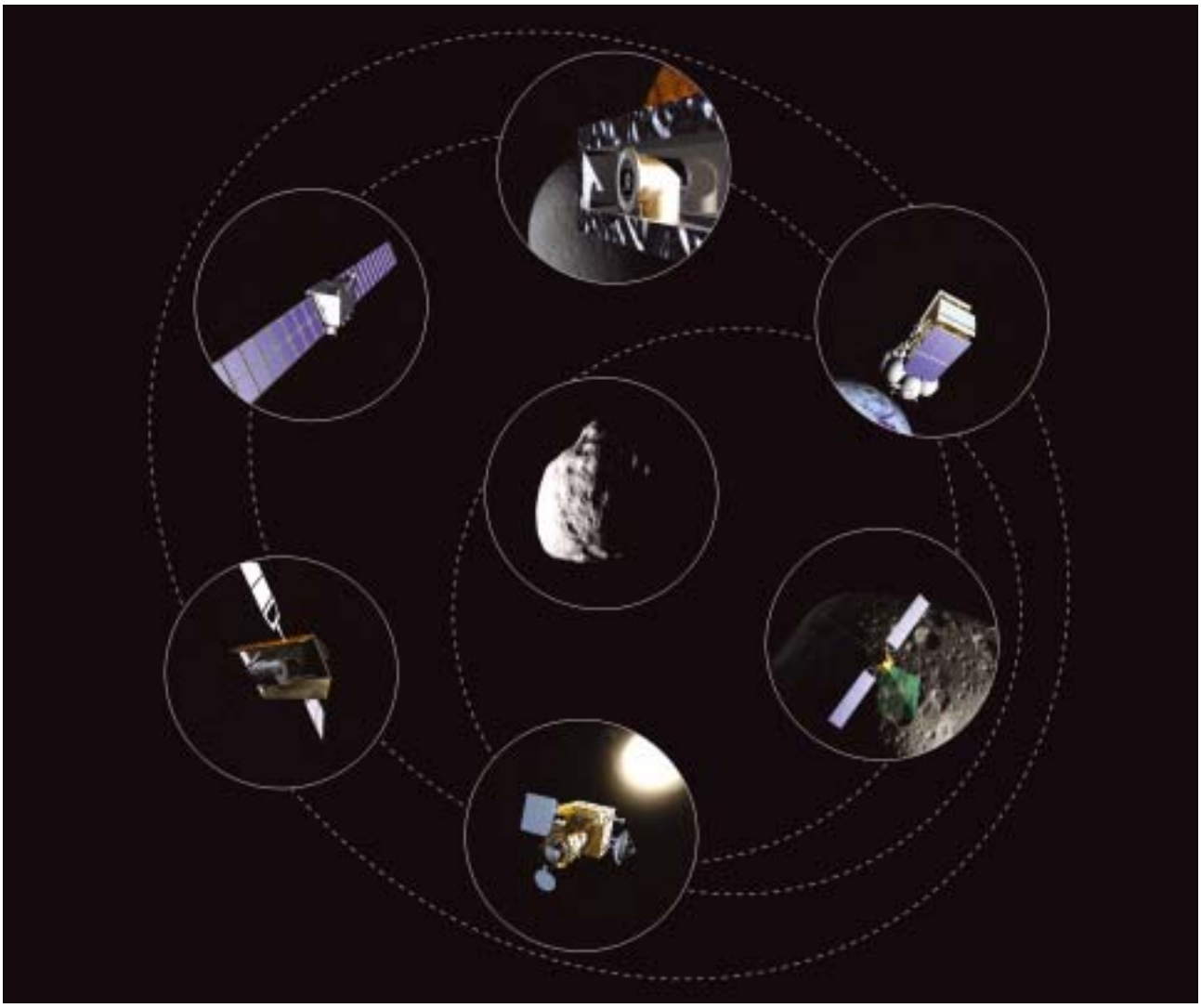
A major natural threat is posed by Near-Earth Objects (NEOs) in space, even if the risk of an impact is only significant over geological timescales. The ACT is currently implementing a pragmatic approach to exploring that risk by developing three successive responses, ranging from the short- to the long-term in application:

- The ongoing characterisation and monitoring of the orbital dynamics of NEOs by ground-based observatories.
- Investigation of the structural composition and reaction to perturbations of NEOs (by means of a small demonstrator mission).
- Definition of an operational mitigation system.

Europe must address the challenge associated with its dependence on fossil fuels. By exploring new hydrogen storage concepts, and defining a realistic roadmap for using solar-power satellites, the GSP is helping Europe to find the right balance in terms of energy sources for the future.

In defining the GSP planning for the period 2005-2006, a special effort has been made to put the activities to be undertaken into the broader perspective of the national space programmes. Some new working methodologies were introduced into the latest Call for Ideas, with the aim of stimulating the interaction between different ESA Directorates, and raising the overall quality of the study proposals vis-a-vis their eligibility for a GSP study. Pursuing the Director General's vision of 'one ESA', only proposals elaborated through the collaboration of at least three different Directorates were accepted, and a deeper internal assessment was requested from the proposing team before the procurement of a study by European industry and academia.

The activities needed for the secure implementation of the major ESA programmes and missions, such as XEUS, Darwin, GMES, the future post-Galileo positioning systems, and the



Different mission concepts to investigate and characterise Near-Earth Objects

next generation of meteorological satellites, were also defined. Common features required by these future programmes are the ability to gauge time and measure distances between spacecraft very accurately, and to perform precise formation flying. These capabilities presently require the identification or validation of new concepts derived from optical clocks and femto-laser technology, new technologies for which GSP system studies are defining the necessary requirements. A complete set of activities, with a budget of 20 MEuro, has been approved and was being implemented at a good pace by year's end.

In addition to having facilitated interaction with the GSP's external academic partners through the Ariadna programme in 2004/5, the electronic archiving of all past GSP reports is in progress with the support of the Technical Information and Documentation Centre (TIDC) at ESTEC. The GSP website (www.esa.int/gsp) has also been restyled and will carry monthly updated information on new GSP results and activities, and links to other resources such as the new ACT and NEO websites. As these initiatives come to fruition, new ones will be introduced to replace them, helping Europe to stay at the forefront in space activities.

Reform of the Agency's Internal Operations

In every aspect of the way in which ESA manages its internal operations, there is a constant requirement to adapt to evolving needs and standards and to continually improve rules and procedures. Only in this way can one ensure the most efficient running of the Agency and its programmes. In Agenda 2007, the Director General formulated a number of objectives and the reforms, which the Council and Administrative and Finance Committee (AFC) are encouraging and supporting, needed to achieve this. The Ministerial Council in December, in Berlin, gave strong encouragement to the Director General to apply the most up-to-date processes and tools for the Agency's day-to-day operations, stressing the need to adapt its internal operations to the changing environment.

For the definition and execution of those reforms that are of an inter-Directorate nature, a new Director of Reforms was nominated, Jörg Feustel-Büechl, who took up duty on 1 September. Since then, under his management, a number of inter-Directorate reform projects have already been started, including:

- the development of an ESA risk-management policy and appropriate procedures at corporate and programme level
- the introduction of an Agency-wide control function
- the introduction of Project Plans and Integrated Project Reviews
- the review of the General Budget's structure and charging policy
- the provision of corporate information systems for the reforms currently underway.

The project related to the establishment of an overall Risk Management Policy includes a coherent set of associated risk-management procedures. These elements, together with the Project Plans and the information that will be provided via the Agency-wide controlling system, will ensure that risk management, at both the corporate and programme levels, will be given the high priority needed for the most effective and efficient running of ESA's activities.

The introduction of an ESA-wide controlling system, together with the new functions of a Corporate Controller and Business Unit Controllers, is intended to provide an improved overview of the status of all activities, to enable better budget and programme management on an Agency-wide scale. An in-year budget-execution reporting system has already been introduced as the first step.

Project Plans have already been generated for a variety of projects, programmes and activities across the Agency. They contain essential technical, cost, schedule and other information relating to the execution of a project. The Project Plan is the reference for performing regular Integrated Project Reviews at Director General level, and will contribute to the overall orientation of activities and to better knowledge and management of project risks.

Reform of the General Budget structure and charging policy has already led to a number of improvements and simplifications, aiming at greater accountability and transparency and more efficient use of funds.

The project on Corporate Information Systems will provide the solid and viable IT support for the reforms currently underway, in particular for the Project Plans, Agency-Wide Controlling and Long-Term Plan processes. It will further provide guidelines for ESA CIS management, including reference applications and technical architecture, procedures for ensuring adequate CIS governance and an ESA CIS policy.

Over the coming months, these measures will be systematically improved and refined to ensure the very best execution of ESA's programmes.

International Relations

Signature of the Framework Agreement between ESA and the People's Republic of China on 18 November

New and Future Member States of the European Union

During the year, Poland and Romania started and essentially concluded negotiations to become European Cooperating States. Hungary and the Czech Republic, both of which already have such status, successfully drew upon the Plan for European Cooperating States (PECS), obtaining several ESA contracts. Hungary formally requested negotiations for accession to the Convention.

A Latvian delegation visited ESA Headquarters in February to enquire about the possibilities of closer cooperation with the Agency. Slovakia approached ESA later in the year with the same query.

Space-faring Nations

United States

Following the Space Shuttle's return to flight in July, ESA and the other International Partners reaffirmed their commitment to the International Space Station (ISS). A final ISS configuration and its associated assembly sequence have yet to be firmly established and agreed.

Consultations continued with NASA to identify possibilities for cooperation on missions to the Moon and Mars.

ESA and NASA continued their cooperation on missions currently in orbit – namely SOHO, Cluster-II, Ulysses, Cassini/Huygens, the Hubble Space Telescope, Integral, Rosetta and Mars Express – whilst also further defining cooperation on the James Webb Space Telescope, LISA, and Herschel and Planck missions.

Russian Federation

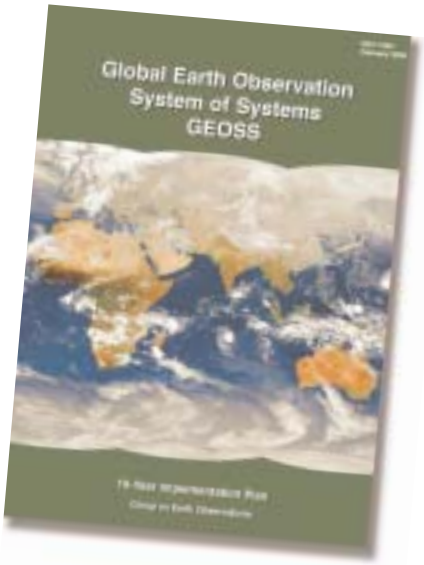
Cooperation with Russia was strengthened. The agreement on Soyuz at CSG (formally known as the 'Agreement on Long Term Cooperation and Partnership in the Field of the Development, Implementation and Use of Launchers') was signed on 19 January by ESA's Director General and the Head of the Russian Space Agency. An 'Implementing Arrangement on Cooperation in Research and Technology Development for Future Launchers' was subsequently signed on 19 May by ESA's Director of Launchers and the Deputy Head of the Russian Space Agency. The signature of these two agreements formally opened the way for a Euro-Russian partnership in the launchers domain.

ESA participated in the Moscow Air Show (MAKS) in August.

Japan

ESA and the Japanese Aerospace Cooperation Agency (JAXA) finalised the text of a Memorandum of Understanding on the ALOS (Advanced Land Observing Satellite) data node. This provides for the provision of environmental data and imagery to European and African users.

ESA and JAXA pursued their cooperation on the ASTRO-F mission, and continued to plan for the ESA BepiColombo



The GEOSS Ten-Year Implementation Plan

Mission to Mercury, for which JAXA will provide the magnetospheric orbiter. ESA and JAXA also continued discussions on coordination of the data-collection campaigns in lunar orbit between JAXA's Selene and ESA's SMART-1 missions.

Following the successful launch of the Japanese telecommunication satellite OICETS on 24 August, ESA and JAXA were finally able to implement their long-planned cooperation on the Artemis/OICETS optical inter-orbit link experiments.

The 30th Japan/ESA Annual Meeting took place in Tokyo on 24 and 25 October. One of its results was a decision to explore cooperation possibilities regarding components, software and simulation.

China

Cooperation with the People's Republic of China took a big step forward on 18 November when ESA's Director General and the Head of the Chinese National Space Agency signed a Framework Agreement.

A second Dragon Workshop took place on the island of Santorini in Greece in late June, and some 70 Chinese scientists took part. The Dragon project stimulates joint European-Chinese exploitation of Earth-observation data from ESA's Envisat satellite. The scientific content of the programme remains at an exceptionally high level, with some of its results being published in the journal *Nature*.

The first contracts with Chinese industries for the Euro-Chinese cooperation on Galileo were signed in the autumn.

India

ESA's Director General and the Chairman of the Indian Space Research Organisation (ISRO) signed an agreement for the European provision of instruments for Chandrayaan-1, an Indian lunar mission scheduled for launch in 2007.

Others

Republic of Korea

Negotiations continued on an agreement on the exchange of data between Envisat and the Korean satellite Kompsat-2, due for launch in spring 2006. The Korean space sector is growing rapidly.

Vietnam

The Agency took an active part in a workshop in Hanoi, both to encourage the use of Envisat data and to support European industry.

Australia

Negotiations with Australia on tracking stations to service future ESA missions continued, notably for Ariane-5 (Galileo and ATV).

Africa

The year saw a transition of responsibilities for the Tiger Project (water management in Africa) to ESRIN in Frascati (I). The north-south technology-transfer projects initiated in 2003 through the Data User Element (DUE) Programme proceeded, and 50 proposals in reply to the specific Tiger Announcement of Opportunity were selected. A Steering Committee composed mainly of African stakeholders was set up. It adopted a three-year Implementation Plan, which was presented to the stakeholders at the Tiger 2005 Workshop at ESRIN in October.

The deployment of EGNOS Testbed Reference and Integrity Monitoring Stations (RIMS) at sites across the African Continent was finalised. A demonstration flight took place in May between Senegal and Kenya, paving the way for the African EGNOS pre-operational service. A Framework Agreement between ESA and ASECNA (Agence pour la Sécurité Aérienne en Afrique et à Madagascar) was approved by the ESA Council in June.

International Organisations

UNCOPUOS (United Nations Committee On the Peaceful Uses of Outer Space)

ESA continued to coordinate European views in the COPUOS and its subsidiary bodies.

GEO (Group on Earth Observations)

ESA participated in the Third Earth Observation Summit in Brussels in February, which adopted a Global Earth Observation System of Systems (GEOSS) Ten-Year Implementation Plan.

Communication

Communication Campaigns

2005 was an exceptionally eventful year involving many launches and requiring the Communication Department to conduct a large number of campaigns, in close cooperation with the respective ESA Programme Directorates and Member State Delegations:

Cassini-Huygens

The media campaign built around the Huygens probe's landing on Saturn's largest moon Titan in January was ESA's most successful communication event so far. More than 300 media representatives joined more than 350 other invited guests to follow the event live from ESOC. The rapid distribution of the first images and the Press Conference the day after the landing contributed greatly to the positive coverage that the mission received around the World. The TV viewing ratings were twice as high as the previous best, and web-portal figures surpassed the previous record set for Mars Express with almost 1 million visitors on 15 January alone.

Ariane-5 ECA

The launch of the latest version of Ariane-5 on its initial qualification flight in February attracted strong media interest.

Eneide mission

The communication campaign for the Italian Soyuz mission in April carrying ESA astronaut Roberto Vittori to the International Space Station (ISS) for the second time generated higher than expected media and political interest in Italy, especially given the other high-profile news events (health of the Pope and resignation of the Italian Government) that were happening in parallel. A steady promotional effort, the timely availability of good video images, and a daily mission diary on the web were key factors in the campaign's success.

NASA's Deep Impact mission

ESA's communication activities, coordinated with ESO, and observation of this event in early July with European telescopes and satellites, especially Rosetta and XMM, produced very good results in terms of promoting the Agency using a non-ESA event. New ESA video material and an ESA TV live event organised at ESTEC generated excellent coverage in television news programmes across Europe. Web-portal coverage of the mission from an ESA angle attracted a large number of visitors to the site.

Shuttle return-to-flight

Although no ESA astronaut was involved, high media interest in this flight at the end of July provided ESA with the opportunity to promote its expertise and programmes in the human-spaceflight area. Higher than expected demand for interviews and explanations was generated by launch delays and the series of in-orbit safety issues. Many TV news programmes featuring ESA content were broadcast, with particular emphasis on the relation between the Shuttle's return-to-flight and Europe's involvement in the ISS.

CryoSat

The CryoSat communication campaign, coordinated with Member State Delegations and Industry, resulted in very positive coverage of this mission despite the negative outcome of the launch itself in October. A pre-launch Press trip to Baikonur and Press events at IABG in Munich and the Science Museum in London were organised. The main launch event, held at ESRIN in Frascati (I), saw the participation of 600 VIPs, including the Chairman of the ESA Ministerial Council, the Dutch Minister for Economic Affairs Laurens Jan Brinkhorst, and European Industry and media representatives. There were numerous coordinated 're-transmission' events in other countries, including France, Germany and the Nordic countries.

The SSETI launch event at ESTEC/Space Expo in October

Earth & Space Week in Brussels (B) in February: the young winners of the 'Design a Flag for Planet Earth' competition, being addressed by the Head of the European Astronaut Centre (EAC) Michel Tognini, with Prince Philippe of Belgium (2nd from right) and Günter Verheugen, Vice-President of the European Commission (3rd from left) looking on

SSETI Express

The communication campaign for this student mission was conducted in cooperation with the ESA Education Department, with the Space Expo visitor centre at ESTEC as the main venue for the young guests. The media impact was enormous, with an estimated 100 000 000 TV viewers watching the launch, which took place in October.

Venus Express

Public interest in ESA's first mission to Venus was maximised through a wide variety of communication activities, including a drawing competition organised in association with the Planetary Society and media partnerships with women's magazines. In-depth reporting on the scientific aspects of the mission, new TV material and a detailed ESA web special further heightened interest. Roughly the same record TV figures were recorded as for Cassini-Huygens.

Vega

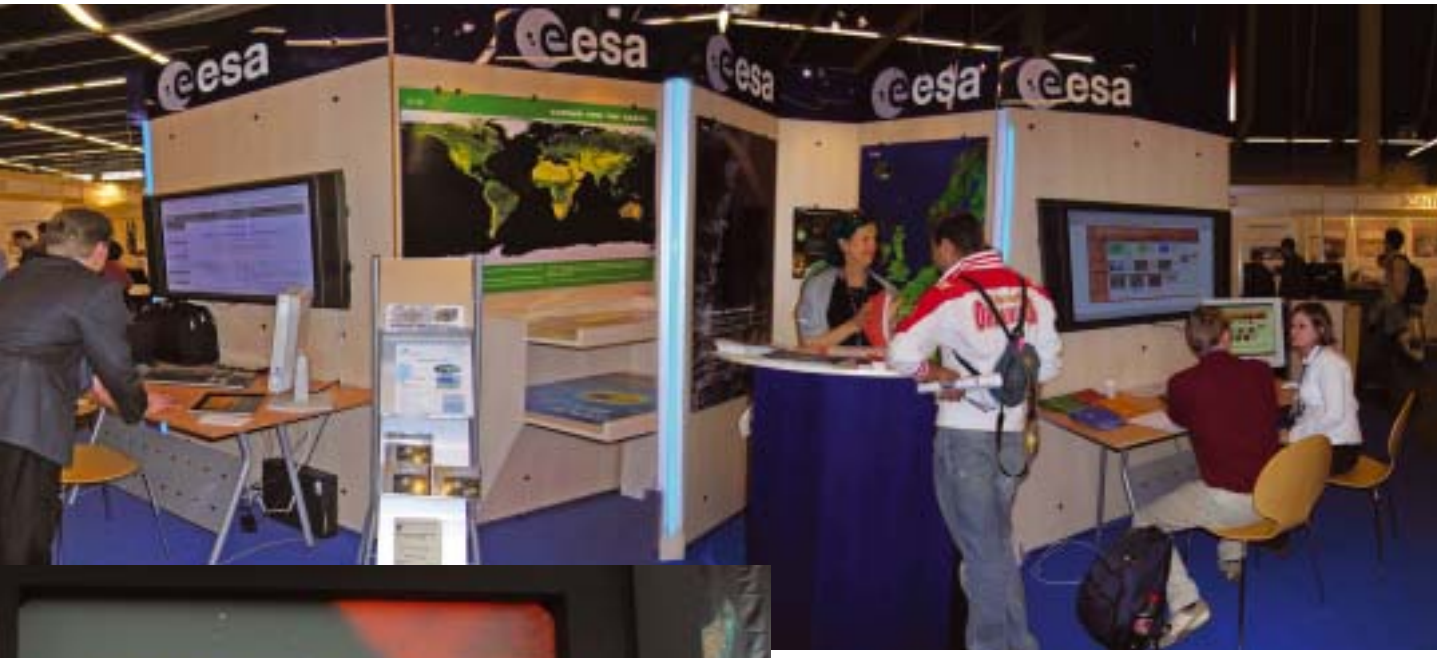
Various communication activities were carried out in 2005 in the framework of the small-launcher programme. Press-related activities were organised to coincide with the signature of the Vega Ground Segment contract in Rome in July. A new Vega web site was created and the general launcher web site was updated. A Customer Day was organised in Rome in November, jointly with Arianespace, for potential institutional and industrial customers. Press and web activities were organised around the first test firing of the launcher's Zefiro engine in Sardinia (I) on 19 December.

MSG-2

For the MSG-2 launch in December, a joint communication campaign was organised with Eumetsat, which included TV broadcasts, a competition for children, and coordinated web activities. A joint ESA/Eumetsat launch event was also arranged at Eumetsat's premises in Darmstadt (D), together with a visit to ESOC for European Press representatives attending that event.

GIOVE-A

Pre-launch activities at ESTEC in November drew media attention to the first of the Galileo satellites, which was



The ESA stand at the General Assembly of the European Geosciences Union (EGU) in Vienna (A) in April

undergoing testing in the Test Centre in Noordwijk (NL). The importance of Galileo for Europe was underlined at this highly attended VIP and Media Day, at which Dutch Minister Karla Peijs officially announced the new name GIOVE (Galileo In-Orbit Validation Element) for the first two satellites. The launch itself on 28 December also generated high media interest despite the Christmas break. Thirty international media representatives took part in a Press trip to the launch, and ESA Headquarters opened its doors to allow other media representatives and guests to follow the live launch transmission. Scores of interviews were also given and an ESA web special contributed to making this a very successful launch event.

MetOp

Despite the postponement of the launch to 2006, communication activities were started based on a coordinated campaign agreed with Eumetsat. A joint logo for the mission was agreed, and plans for a major launch-coverage re-transmission event at ESOC were drawn up.

Media Relations

The Media Relations Division handled more than 650 interviews and approximately 3400 requests for photographs, and issued 54 Press Releases and Information Notes. It also organised several Press trips and Press Conferences, working with some 300 journalists from ESA Member States who regularly follow the Agency's activities. It also participated directly in the promotion of the Agency's main missions and mission-related events. In the first half of the year alone, more than 1300 articles on ESA programmes were published, with a potential audience of more than 150 million readers.

The production and media-relations efforts of the ESA TV Service were rewarded with record television coverage of missions and launches. On three occasions (the Huygens landing and the Venus Express and GIOVE-A launches), more than 150 news reports were broadcast on mainstream TV networks in the seven Member States sampled. The cumulative ratings for these three events alone exceeded one billion viewers. With 68 productions in 2005, ESA TV featured all ESA programmes. Improved processes have made funds available for new initiatives in 2006, notably in the areas of Internet broadcasting and seamless monitoring of the use of ESA video material.

The floating astronauts, Wubbo Ockels and André Kuipers, with the Dutch illusionist Hans Klok

Exhibitions and Events

A major space exhibition was jointly organised by ESA and the European Commission in Brussels during 'Earth & Space Week', to coincide with the Third Earth Observation Summit and a major conference on international cooperation in space. ESA presented Europe's space programmes, with a special focus on Earth observation and on GMES to underline the strategic importance of a global policy for satellite Earth observation and increased cooperation in space. The exhibition became a focal point for all conference delegates throughout the week, and numerous guided tours of the exhibits were organised for world leaders, policy makers and space experts. More than 40 000 members of the general public and school children visited the exhibition.

Although ESA did not have its own space pavilion at the 2005 Paris Air Show, support was given to space Industry to ensure the visibility of European space programmes. Support was also provided for an exhibition stand at MAKS 2005, the Moscow Air Show.

Events organised in ESA Member States throughout the year included a special exhibition to highlight Luxembourg's accession to the ESA Convention. Cooperation with various science and space museums and other institutions organising exhibitions for the general public allowed further promotion of ESA's programmes, with particular emphasis on the successful Cassini-Huygens mission.

Online Communication

The intense launch-related activity in 2005 brought record numbers of visitors to the ESA Web Portal. Between 14 and 21 January, when interest in the Huygens mission was at its peak, there were 3 636 000 visitors to the portal. Owing to the very advanced technologies employed, these visitors from around the globe were able to receive the latest information continuously and flawlessly. Throughout the year, the portal continued to deliver information on all aspects of ESA's activities at a rate of roughly one new story per working day. Special web stories were issued for all major events, as well as on significant ESA activities such as the opening of the Earth Images Gallery, the new ESRIN web site, the ESOC virtual tour, an overview of Technology Transfer, and new Mars Express images. The portal's audience consults an average of 5 million pages per month.

By now, practically all of the major online media in the Agency's Member States, as well as many more worldwide, use the ESA web portal as their main source of information on European space activities. Many of them also link directly to the portal in their articles.

The process of harmonising the portal structure was successfully completed during the year. National web pages are regularly updated in all relevant ESA Member State languages with information relating to specific space events taking place in these countries, including Greece and Luxembourg, ESA's newest Member States.

Internal Communication

Internal communication with staff members during the year was supported by: 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 coinciding with the main ESA missions, during which presentations are given by key project personnel.

Dutch Minister Laurens Jan Brinkhorst (centre) at ESTEC/Space Expo

ESTEC

The first 30 years of ESA and 15 years of the Space Expo visitor centre were jointly celebrated in June with a formal event attended by the Dutch Minister of Economic Affairs, Laurens Jan Brinkhorst. On behalf of three Dutch ministries, he presented ESA with a 'birthday gift' in the form of 4.5 ha of land adjacent to ESTEC for future extension of the existing site. A stunning illusion involving two 'floating' ESA astronauts marked the formal re-opening of Space Expo after extensive refurbishment of the exhibition. Less formal festivities in October enabled the whole ESTEC family – staff, contractors and pensioners – to participate in the 30-year celebrations.

Some 350 journalists visited ESTEC in 2005 to interview ESA specialists, and 65 TV teams made use of the excellent filming locations that the Centre can provide – namely the Test Centre, the Erasmus User Centre and Space Expo. Turning to the general public, 56 invited groups received some 'space education' during the year, and there were 350 Space Train departures from Space Expo for the 'ESTEC experience'. This brought the number of communications-activity-related visitors in 2005 to 10 000, not counting the strong staff attendance at the many launch-related events. This meant that, with the ever-increasing numbers of conferences, workshops and meetings taking place at the Centre, there were more than 60 000 visitors to the site.

As part of ESTEC's role of providing a 'country desk' service to Scandinavia, nine special events were organised in the Nordic countries.

Chancellor Schröder (centre) at ESOC for ESA's 30th Anniversary celebrations

ESOC

The Centre organised several prestigious events during the year, starting with the Huygens probe's descent and landing on Titan on 14 January which was followed live from ESOC by more than 650 VIPs and media representatives. The next day the first scientific results were presented to over 100 media representatives, and hence millions of TV viewers. In July, Rosetta took pictures of the target comet during the Deep Impact mission, which generated considerable media interest. There were other peaks in interest in ESA's space missions on 9 November with the Venus Express launch and 21 December with the MSG-2 launch and the associated visits of the media to ESOC.

On 1 June, German Chancellor Gerhard Schröder was welcomed to the Centre to participate in the celebration of ESA's 30th Anniversary.

VIPs and media representatives at ESOC for the Huygens landing event

The opening of the Cebreros Deep Space Ground Station in September provided an opportunity to remind the media of ESOC's worldwide network of antennas and its cooperation with other space institutions around the World.

ESOC staff gave 67 lectures at the Establishment, in many cases for political and industrial decision makers, with the support of the local Communication Office. By the end of the year 793 interviews had been organised with the European media, in Germany, Switzerland and Austria in particular.

The growing popularity of space activities was reflected in the growing number of visitors to the Centre, which totalled more than 11 000, an increase of 27% over the previous year.

Members of the Bavarian Parliament visiting ESRIN on 2 November: from left to right, Otmar Bernhard, Deputy Head of the CSU Party, Volker Liebig, ESA's Director of Earth Observation Programmes, Otto Wiesheu, Minister of State for Economy, Infrastructure and Technology, and Erwin Huber, Head of the Bavarian Minister President's Office

ESRIN

The Communication Office managed all ESRIN and ESAC-related communications activities in Italy, Spain and Portugal. Activities at ESRIN itself included launch re-transmission events for all ESA missions, particular highlights being those for the Eneide and Huygens-Cassini missions, as well as the many Press activities in Spain centred around astronaut Pedro Duque.

Open Days at both ESRIN in Frascati (I) and ESAC in Villafranca (E), organised in conjunction with the 'Science Weeks' in Italy and in Spain, drew large attendances by students and the general public. Communications support was also provided for major scientific conferences held at the two sites.

A Portuguese Space Day organised in Lisbon in May attracted strong participation from Industry and the local scientific community. The inauguration of the new ATV Ground Station site in the Azores in November was also supported.

New PR tools were developed for both ESRIN and ESAC in the form of virtual web tours of the sites, video material and brochures.

EAC

In 2005 there were more than 800 requests for public appearances by ESA's astronauts. With only 17% of all such requests ultimately rejected during the vetting process, the ESA astronauts, supported by their ESA colleagues, worked hard in coping with the growth in

Students learning about ESA during the ESRIN Open Day on 14 March

The ESA stand at the 'Scienza Orienta' exhibition in April at the Tor Vegata University in Rome

requests and in furthering the visibility and public awareness of ESA, EAC and Human Spaceflight activities throughout Europe.

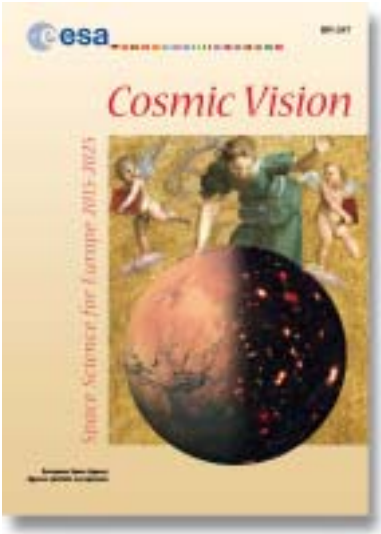
As the ESA astronauts' home base, the European Astronaut Centre is committed to organising events related to specific astronaut missions. On the occasion of the announcement of the Astrolab mission with astronaut Thomas Reiter, a Press Conference gave the media an opportunity to meet the astronaut and his back-up, Léopold Eyharts, during training. The take-off and landing of the Space Shuttle's return-to-flight mission were covered live at EAC, which attracted seven TV channels.

EAC also promoted ESA activities in general by providing support to events such as the 'Earth & Space Week' which took place in Brussels. To further increase the visibility of ESA and EAC during these events, a considerable amount of supporting material was produced, including photographic and video material shot during actual missions and mission training.

EAC welcomed more than 7000 visitors during the year.

Mr Günter Verheugen (fourth from right), Vice-President of the European Commission, during his visit to EAC. From left to right: the Head of EAC Michel Tognini, ESA astronauts Frank De Winne and Hans Schlegel, Chairman of ESA Council Sigmar Wittig, ESA Director General Jean-Jacques Dordain, Mr Verheugen, and ESA astronauts Pedro Duque, Gerhard Thiele and Reinhold Ewald

ESA astronaut Thomas Reiter during the Astrolab Press Conference at EAC



Publications

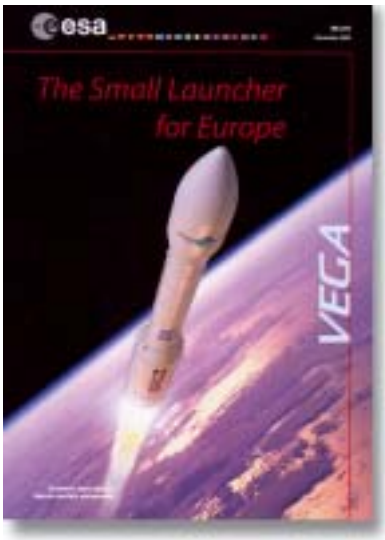
In 2005, the Division processed more than 200 publications, including the Agency's Annual Report to Council in English and French, 4 issues of the ESA Bulletin, 45 Brochures, 15 Scientific/Technical Monographs, 29 Conference and Symposia Proceedings, 8 Scientific and Technical Reports, 18 European Standards (ECSS), and 77 Contractor Reports.

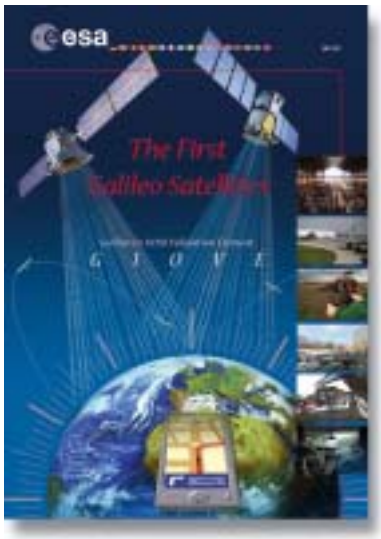
Demand for the Division's services was higher than ever, with frequent requests for writing/editing and publishing support coming from all of the Agency's Directorates. Emphasis, as always, was on the provision of high-quality publications with quick turnaround times and at minimum cost. Many of the brochures and other publications requested by Directorates were linked to the political preparations for, or for distribution at, the ESA Ministerial Council in Berlin in December.

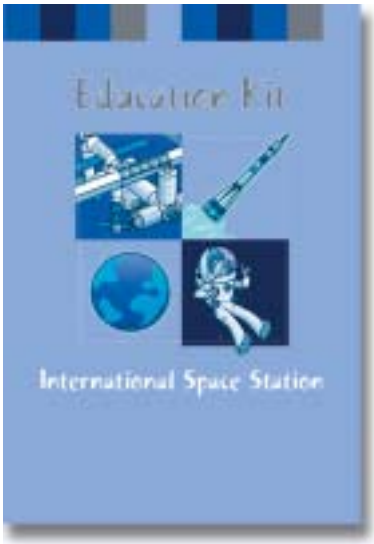
Examples of the broad range of publications produced in 2005 include:

- ESA's Achievements: More than 30 Years of Pioneering Space Activity (BR-250)
- The ESA Convention: Sixth Edition (SP-1300), in twelve Member State languages
- The European Space Sector in a Global Context - ESA's Annual Analysis 2004 (BR-242)
- Cosmic Vision: Space Science for Europe 2015-2025 (BR-247)
- Venus Express: Welcome to the Cryptic Planet (BR-245)
- The Telecommunications Long-Term Plan 2006-2010 (BR-256)
- The First Galileo Satellites: GIOVE (BR-251)
- Vega - The Small Launcher for Europe (BR-257)
- Soyuz at the Guiana Space Centre (BR-243)
- The ISS Education Kit for Primary Schools (BR-241)
- Tania - A European Astronaut (BR-219), a children's comic in various languages
- ADM - Aeolis: ESA's Wind Mission (BR-236)
- The TIGER Initiative (SP-1293).

The full catalogue of the Division's output can be found in the ESA Bulletin and on the ESA Publications web site.



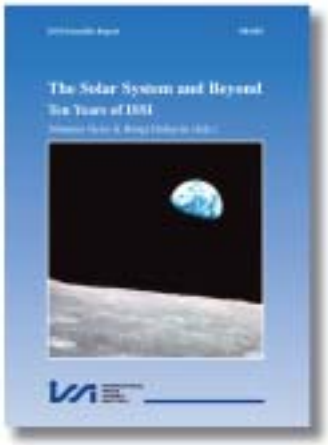




Work also continued on the latter to further enhance its attractiveness and user-friendliness.

The Division's reputation for high-quality service resulted in requests to ESA from two of its sister organisations for publishing support, namely GEO and ISSI. The Division was thereby responsible for preparing and publishing the GEOSS Reference Document and the GEOSS 10-Year Implementation Plan (endorsed by 60 countries and the European Commission in February) for the setting up of the new Intergovernmental Group on Earth Observations (GEO) in Geneva. The Division's efforts attracted highly complimentary feedback for ESA from the GEO founding/ participating countries and the EC's Director for Research.

The support to the International Space Science Institute (ISSI) in Bern, in which ESA is a major partner, included the publication of its Annual Report, and the preparation and publication of a 250-page book on the Institute's accomplishments to date, titled 'The Solar System and Beyond: Ten Years of ISSI'.



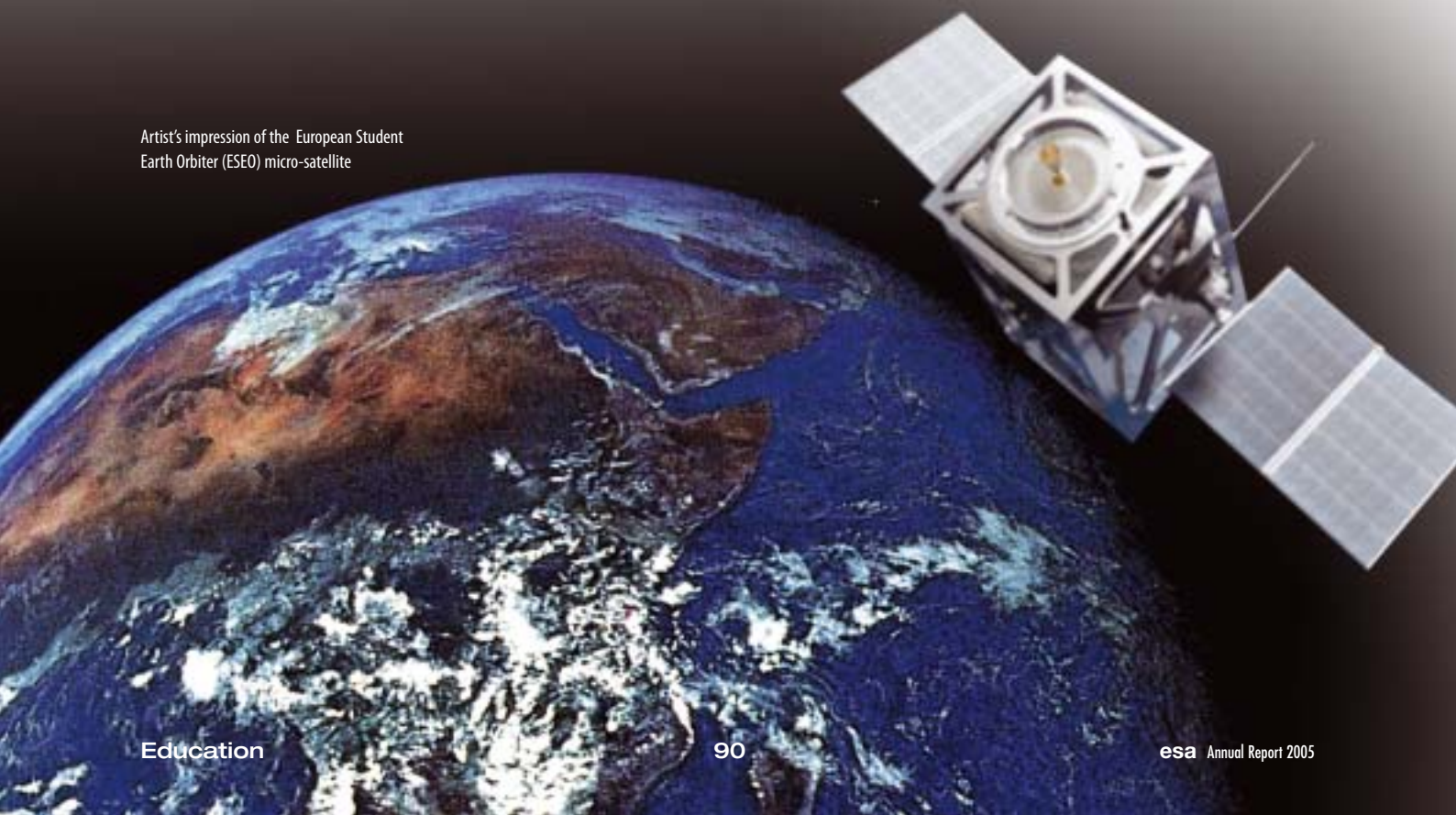
Education

Europe is facing a severe decrease in young people's interest in science, engineering and technology (SET) subjects, as well as a decline in the uptake of SET careers. This general disinterest, particularly on the part of young women, is more evident in the classical SET school and university subjects, such as mathematics, physics and chemistry, than in emerging fields such as information and communications technology or the applied sciences, such as medicine and biotechnology. Combined with an overall ageing of the European SET workforce, this trend could have serious consequences, affecting not only the future tertiary education systems in Europe, but more importantly the SET-related industries and their employment markets. Moreover, without an appropriate quantity and quality of human expertise in SET-related areas, the basis for a knowledge-based society and economy in Europe will be jeopardised.

Although education was included from the outset as a basic activity in the ESA Convention, it is only in the last few years that a dedicated education effort has been undertaken both at corporate level and within the Directorates. The importance given to education in both Agenda 2007 and the EC White Paper led the Director General to establish, late in 2004, an overall policy that centralises all activities inherent to education within the Education Department. As a result, a new operational structure for education activities has been set up, aimed at a joint effort by the Education Department and Directorates to implement a common strategy according to a corporate set of rules. It was then decided: to pursue a new and ambitious project called the 'European Space Education Resource Office (ESERO)'; to re-structure the hands-on activities for young people, in particular university students; and to reinforce cooperation with Member States, the EC and other international space agencies and organisations.

ESERO

Reaching the primary target audience directly, i.e. millions of students, professors and teachers, is an impossible task for ESA. In addition to the various languages, the educational systems are very different from one Member State to another. Therefore, to implement its education policy efficiently the Agency had to opt for a 'Member State by Member State approach'.



Artist's impression of the European Student Earth Orbiter (ESEO) micro-satellite

ESERO's objective is therefore to establish contact points (ESA contractors - preferably located at existing facilities) in all ESA Member States who are education experts, already well integrated into the national educational systems and networks. This should allow the Education Department to support the specific educational needs of the Member States and to gain easy access to the existing national networks (publishers, museums, teachers' associations, etc.). ESERO, whose primary task is to share the enthusiasm for European space exploration, will be responsible for the development of close relations with national education stakeholders and the participation in education activities tailored to the specific situation in each Member State. It will promote SET careers in the European space sector and provide support for the delivery of national curricula.

To maximise the chances of success, it was decided – with the full support of the ESA Delegations concerned – to begin the project's implementation with three ESERO contact points, in Belgium, The Netherlands and Spain. The first contract was signed in late 2005 with the National Science and Technology Centre (NEMO) in Amsterdam. Sharing ESA's objectives, the Dutch Government is co-funding the initiative. The contracts with Belgium and Spain are expected to be signed early in 2006. The United Kingdom, via 'Yorkshire Forward' a regional development agency, has also shown strong interest in the project, and the possibility of installing several ESERO contact points throughout the UK is now being studied in collaboration with the British National Space Centre (BNSC). An overall evaluation of the pilot projects is planned at the end of 2007 and a decision on whether to further expand into other Member States will then be taken. If positive, at least one office per Member State will be opened by 2010 at the latest.

Hands-on Projects

ESA's educational hands-on projects are designed 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. High levels of academic expertise in specific space-related fields exist throughout European universities, but 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 spacecraft mission-design workshops. It is estimated that about 5000 students will be involved in these projects over the next ten years, and that more than 100 Masters and PhD theses will result.

Satellite Projects

The Student Space Exploration and Technology Initiative (SSETI) consists of a series of three micro-satellites:

- Express, a 62 kg satellite successfully launched on 27 October by a Cosmos-3M from Plesetsk (Russia) into a low-Earth, Sun-synchronous orbit
- the European Student Earth Orbiter (ESEO), a 120 kg satellite to be launched at the end of November 2008 into a Geostationary Transfer Orbit (GTO)
- the European Student Moon Orbiter (ESMO), a 240 kg spacecraft to be launched in 2011/12 into GTO and then transferred, using a combination of chemical and electric propulsion, into a lunar orbit.

The micro-satellites are designed and built entirely by student teams. The ESA Education Department provides network facilities for the teams to exchange information and discuss problems, solutions and schedules, 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 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.

The highlight of the year was the successful launch of ESA's first student satellite SSETI Express on 27 October. Unfortunately, the mission lasted only 12.5 hours because the solar array was unable to charge the batteries due to an electrical power subsystem malfunction. Nevertheless, in lots of respects the mission was still a great success and

The launch of SSETI Express from Plesetsk in October

many valuable lessons were learned. Of the 19 subsystems onboard, 12 operated successfully, five could not be tested because the mission ended prematurely, and only two failed (one of which had a backup). The media impact was enormous, with the televised launch being watched by an estimated 100 000 000 viewers.

Another series of micro-satellites is the Young Engineers' Satellite (YES) programme. YES 2, currently being prepared for launch into a low Earth orbit, together with a Russian Foton-M3 capsule, in September 2007, consists of three elements, two of which will be lowered from Foton-M3 using a 32 km long tether to reduce orbital energy. Once the tether is fully unreeled, it will be cut and a small spherical capsule called 'Fotino' will re-enter the Earth's atmosphere and land in Russia. The Fotino payload comprises a GPS receiver, thermocouples, accelerometers, pressure sensors, gyroscopes, and a magnetometer; a parachute will reduce the impact velocity to less than 10 m/s.

A 710 kg spacecraft is foreseen for launch on the maiden flight of ESA's new small launcher Vega in November 2007. The allocation of 75 kg for an educational payload entirely provided by students is under discussion. It would comprise a GPS receiver, a camera, a data-handling and power interface unit, a downlink telecommunications system, six pico-satellites, and a physics and a biology experiment box.

Student Parabolic Flight Campaigns

The 8th campaign took place from 12 to 29 July in Bordeaux. A total of 145 students participated, 120 of them flying aboard the Airbus 300-Zero G aircraft. They performed 30 physics, chemistry, biology and life-sciences experiments under microgravity conditions, with the Airbus flying 130 parabolas, each providing about 20 seconds of microgravity conditions.

Sounding-Rocket Campaigns

In 2005, exploratory discussions were held with representatives from Esrange (Sweden) and the Andoya Rocket Range (Norway) to explore the possibilities for European students to fly small payloads (typically20-30 kg) to an altitude of 100 km on sounding rockets. As a result, the first launch of an experiment selected by the Education Department will take place from Esrange in April 2006.

STRAPLEX

The STRAtospheric PLatform EXperiment is a collaboration between Portugal's University of Porto and the ESA Education Department which began in 2005. It offers

Participants in the 8th Student Parabolic Flight Campaign in July

European students the possibility to send experiments into the stratosphere using balloons filled with helium, and also to participate in future capsule development. The balloons, to be launched from Evora (Pt), can reach altitudes of up to 40 km, depending on the mass of the payload attached. Other launch sites will be Madeira and Kiruna (S). The first qualification flight took place on 19 December. Starting in 2006, two campaigns each involving six balloon launches are foreseen every year.

SCDE and Mission Design Workshops

The distribution of the Student Concurrent Design Environment (SCDE) started in 2005 with the International Space University (ISU) as the first 'customer'. This enabled the Department to receive feedback with which to improve the design tool before it is distributed to a wider community. It is now being distributed via the ESA Portal to other universities.

Science on Stage: David Featonby (UK) demonstrates magic tricks based on physics

The second Student Mission Design Workshop, using the Concurrent Design Facility (CDF) at ESTEC, will take place in 2006 and be devoted to the ESMO mission.

Student Participation at Conferences

Presentation of the results obtained by the students is regarded as an integral part of the hands-on projects. 81 students were therefore selected (from almost 400 applicants) and sponsored to present papers at the 56th International Astronautical Congress (IAC) in Japan in October. The Department also made a major contribution to the Congress's International Student Zone (ISZ), in cooperation with NASA, CSA, and JAXA. During the year, the Education Department also sponsored a number of students participating in Masters courses and Summer School sessions.

Science on Stage

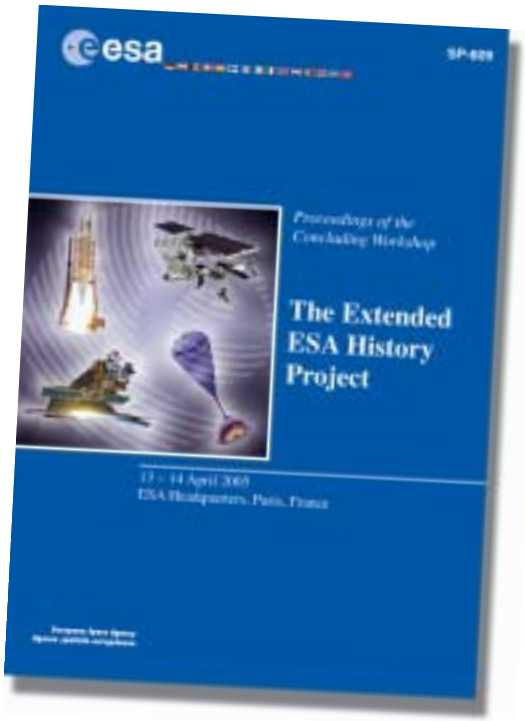
Science on Stage is a unique, week-long, European-wide festival for science teachers that takes place every 18 months to assess the current situation in science education and to identify innovative teaching methods and projects in physics and related sciences. The Education Department has been the main organiser of this event since the beginning in 2000. In 2005, it was held from 21 to 25 November at CERN in Geneva (CH) and more than 400 teachers from 35 countries participated. There were 20 national events leading up to the main festival, some of which were also supported by the Education Department.

History Project

In the framework of the Extended ESA History Project, another short history, namely that of France, was completed during the year and is due to be published in May 2006.

A Concluding Workshop for the Project took place in Paris on 13-14 April, and the Proceedings were published in September as ESA SP-609 by ESA Publications Division.

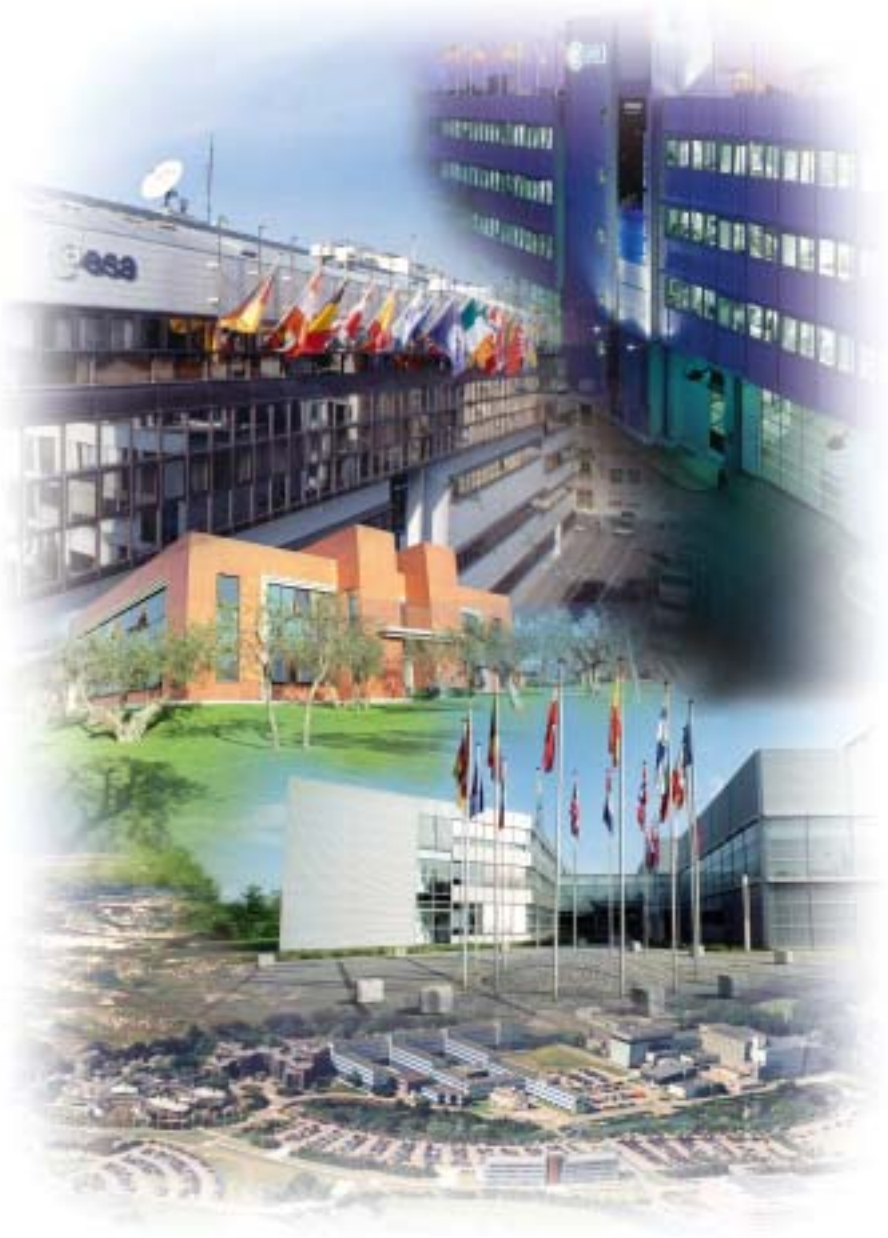
At the end of 2005, an agreement was reached with Prof. Halleux from the International Academy of the History of Science, to publish eight longer studies in a dedicated collection of space history books in the course of 2006/07.



History Studies in Preparation (status end-2005)

Country	Project	Author(s)	Date of delivery	Pages
Austria	Austria's History in Space	Bruno Besser	End 2005	140-150
Belgium	La Belgique et l'Espace	Dawinka Laureys	April 2005	455
Finland	The History of Finnish Space Activities	Ilkka Seppinen	End 2005, English version	366 (original)
Germany	Deutsche Raumfahrtpolitik 1923-2002	Niklas Reinke	English translation received in August 2005	303
Italy	Italy in Space, 1957-1975	Michelangelo de Maria et al.	April 2005	264
Spain	Spain in Space - 5 essays for Phase-2 - 5 essays for Phase-3	José Manuel Sànches-Ron et al.	End 2005	581
Switzerland	A Place in Space – The History of Swiss Participation in European Space Programmes 1960-2000	Stephan Zellmeyer	September 2006	250-300
United Kingdom	British Sounding Rocketry: Skylark and ESRO 1957-71	Matthew Godwin	End 2005	307

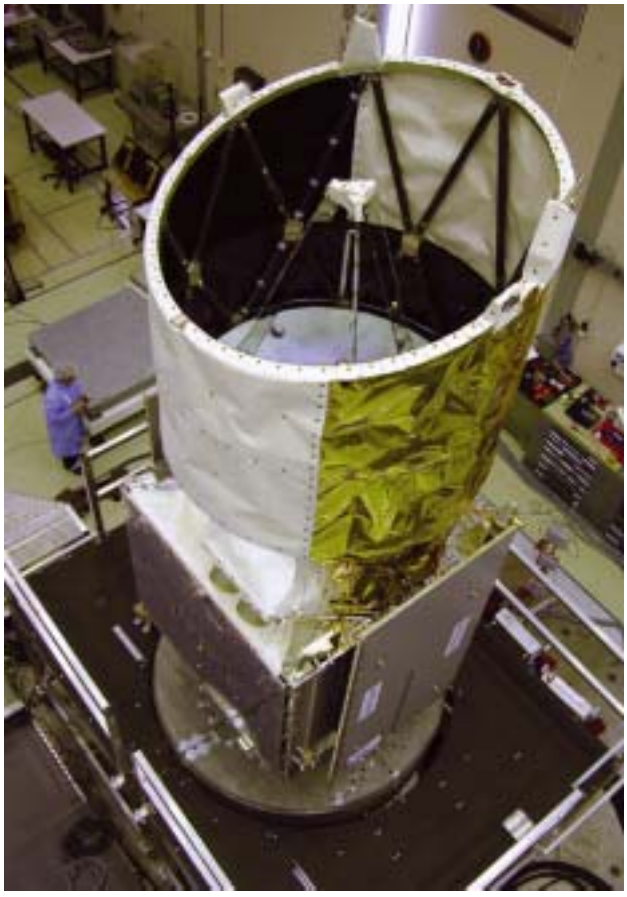
Facilities



ESTEC

ESTEC Test Centre

The Automated Transfer Vehicle (ATV) was undergoing integration and verification activities in the Test Centre throughout the year. The Aeolus structural model arrived in April for mechanical testing. It was directly followed by the Herschel Service Module structural model for thermal and mass-property testing, and the SMOS Payload Module structural model for mechanical and thermal tests. After SMOS's departure in mid-July, its place was taken by the GIOVE-A flight model for a test campaign lasting until its departure for Baikonur at the end of November. Aeolus left at the end of July, making way for the thermal testing of the Herschel Payload Module structural model. In parallel, a number of smaller test campaigns were conducted on satellite equipment, instruments, antennas and solar arrays, both for ESA projects and external customers.

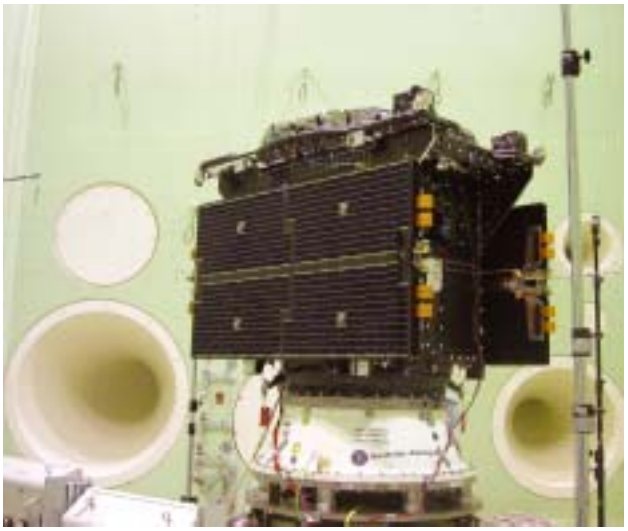


The Aeolus structural model on the Multishaker at ESTEC in Noordwijk (NL)

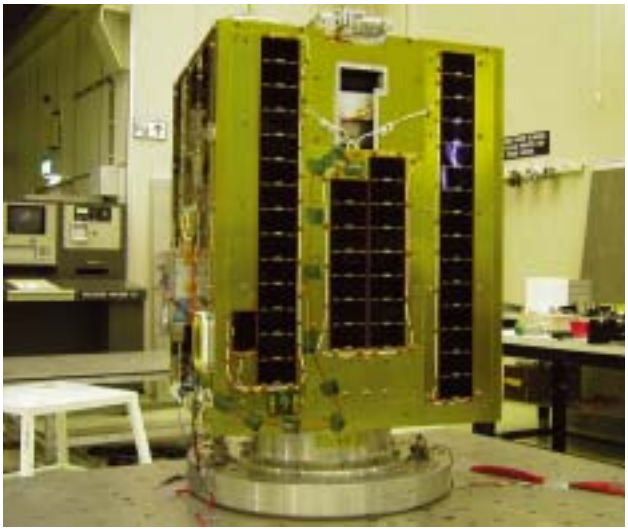
Hands-on support was provided by the Centre's Engineering Services Section for the integration and testing of the student satellite SSETI, in cooperation with the ESA Education Department. Integration and optical alignment of the flight model of the COROT telescope baffle took place in the Metrology Laboratory. A videogrammetry measurement technique with micro-cameras was developed for the Herschel-Planck project.

The installation of a new light plate for the large slip table of the Multishaker extended the latter's performance range, which now covers the excitation levels required for large antenna vibration tests and for the quasi-static testing of small spacecraft. The new large-force measurement device, allowing for an interface diameter of 2.6 m, was completed and used for the Herschel Structural Model system-level tests. The acceptance of the new mass-property measurement facility is close to completion. Refurbishment of major subsystems of the Large Space Simulator was initiated, including the control-command system and new mirror segments. The replacement of other ageing equipment will be pursued in the coming years to ensure the provision of an optimum service to the Centre's many customers.

The European Environmental Test Facility Inventory Database (EETFI) was launched on the ESA web site for the benefit of facility providers and users.



GIOVE-A in the LEAF acoustic facility at ESTEC



The SSETI spacecraft during vibration testing at ESTEC

European Coordinated Test Centres

ESA-related activities at the coordinated test centres included tests at Intespace (F) for MetOp Service Module flight model 3, at IABG (D) for the Cryosat flight model, and at CSL (B) for the Planck cryogenic qualification model.

Electrical Engineering Laboratories

Several new instruments were procured during the year to upgrade the solar-generator testing capabilities to handle the latest generation of high-efficiency, III-V compound multi-junction solar cells and panels, including new mini-flasher equipment, a large-area pulsed solar simulator and spectral-response measurement equipment.

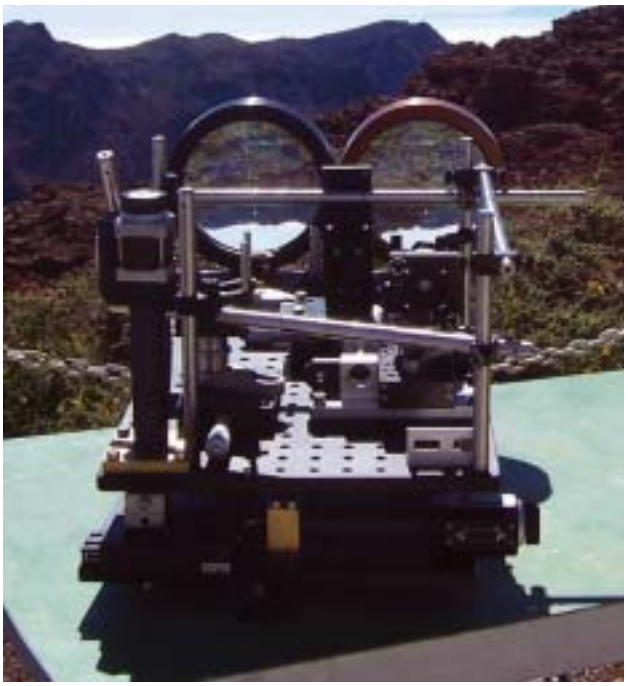
The engineering qualification model of the GSTB-V2 satellite L-band antenna array, designed and manufactured by EADS CASA Spain, was calibrated in the Compact Payload Test Range (CPTR) at the request of the Galileo Project. The purpose of the test was to verify that the antenna's performance is not degraded due to other equipment mounted on the spacecraft.

The European Navigation Laboratory (ENL) has played a key role in a number of radio-navigation-related programmes, including GOCE, MetOp, ATV, EGNOS and Galileo. The focus in 2005 was on supporting the EGNOS verification and Galileo System Test Bed (GSTB-V1 and GSTB-V2) activities, including navigation receiver and signal testing, system simulations, and monitoring of system performances. The RF signal generators that were extensively used for this purpose can simulate the signal that would be received by a mobile platform equipped with a real receiver, taking into account such aspects as host-vehicle characteristics (aircraft, ships, cars and spacecraft), satellite constellation parameters and mission profiles.

Mechanical Engineering Laboratories

The Optical Ground Station (OGS) infrastructure at Izaña in Tenerife was used to prove novel concepts for future secure space-communication systems based on the principles of quantum physics by transmitting encryption keys optically (via entangled photons) between Tenerife and La Palma. The OGS was also used regularly during the year for astronomical observations, space-debris monitoring and scientific campaigns, including the observation of the Deep Impact event on comet Tempel-1.

Engineering qualification model of the GSTB-V2 antenna under test in the ESTEC Compact Payload Test Range



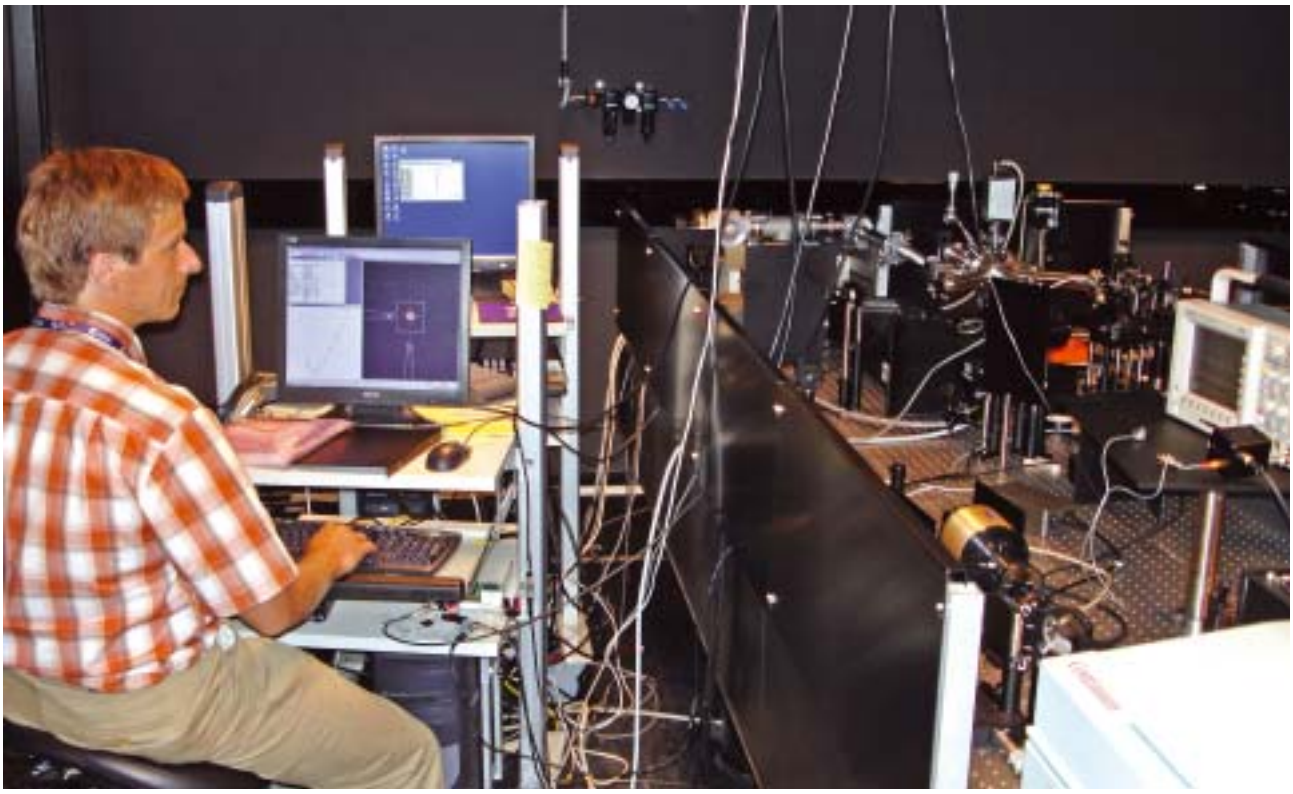
Photonic receiver aligned for encryption-key exchange between the Canary Islands of Tenerife and La Palma

Responding to the needs of the ADM-Aeolus project, a new test capability to support the development of high-power lasers for use in space was purchased. The laboratories can now perform laser-induced-damage tests on high-power optics in vacuum to investigate the performance of laser components and qualify them for space operations.

Considerable effort was devoted to the design and implementation of a new Microgravity Laboratory building at ESTEC, including a large centrifuge for hyper-gravity experiments, which is expected to be completed in mid-2006.

Several tests were performed in the ESA Propulsion Laboratory (EPL) in support of the LISA Pathfinder, Gaia, GSP and CryoSat projects.

A new Avionics System Laboratory has been set up by integrating elements from the Control, Data and Software Laboratories. This provides for an end-to-end avionics



Laser-induced damage testing under way at ESTEC

The new microgravity laboratory facility under construction at ESTEC

testbed that will allow avionics technology (software and hardware) to be validated in a representative context, thereby achieving the higher technology-readiness level required by projects. The first element of this infrastructure is the Virtual Spacecraft Reference Facility, which will be used to create a formation-flying test bench for Proba-3.

The Establishment

There were many significant changes on the ESTEC site in 2005. A major project to enhance main-entrance security was completed and the road layout was adjusted to ensure smooth and safe traffic flow. A large new office and laboratory complex to replace many ageing facilities built some 30 years ago, which also contain varying quantities of asbestos, commenced construction. A major project was also initiated in May to ensure removal of all remaining asbestos on the ESTEC site, with a commitment from Member States to fund the work needed to provide all staff with asbestos-free working conditions by 2007.

ESTEC continued to pursue a wide range of initiatives to ensure the highest possible health, safety and environmental standards. With full compliance with Dutch national regulations as its baseline, many actions were completed to upgrade infrastructure and put processes in place to mitigate any risks associated with the Establishment's core business.

ESOC and The Stations

The Establishment

The fascination of space exploration attracted a new all-time high of some 13 000 visitors to ESOC, 30% more than in 2004. Over 600 guests were on site to witness the successful landing of the Huygens probe on Titan, which was extensively covered by the World's media and resulted in more than 1000 interviews in one week.

A Chancellor of the German Federal Republic visited ESOC for the first time, with Gerhard Schröder joining ESA's Director General Jean-Jacques Dordain and more than one hundred top industry executives and politicians to celebrate 30 years of ESA in space. ESOC also received visits from several Federal Ministers and Secretaries of State, demonstrating the strong political support for ESA and ESOC in Germany. Among the most distinguished space-aware visitors in 2005 was Prince Friso van Oranje of The Netherlands, himself an aerospace engineer.

ESOC hosted the 179th ESA Council Meeting and several International Conferences and Workshops during the year, including the 4th Conference on Space Debris, which attracted 300 participants from 22 countries, and the Symposium on Reducing Costs in Spacecraft Ground Systems, which had over 120 participants.

Building work in 2005 focused on the refurbishment of existing facilities, including the installation of over 100 km of data cabling for state-of-the-art operations. A new badge-operated site-access security system was introduced and the video surveillance system was enhanced. A 9000 m^2 plot of land provided by the German Government in the immediate vicinity of ESOC will give some much-needed growth potential for the existing densely populated site. Under a joint initiative with the state of Hesse, an incubator for new Galileo navigation-application business start-ups is planned near ESOC and its ESA Navigation Support Office.

The Control Centre

To keep up with the rapid evolution in mission requirements and technology, the ESOC Control Centre was equipped with new voice-intercom and video-display systems. A Backup Main Control Room with project-support areas was established to cater for two launches simultaneously. A dedicated Venus Express control area also entered operation. Overall communications, particularly with the deep-space ground stations, were enhanced by commissioning high-speed network rings, both reducing the number of international lines needed and increasing the available capacity.

The Stations

The ESTRACK station network delivered more than 50 000 hours of tracking services to the various classes of missions, including:

- New Norcia and Cebreros for the scientific Mars Express, Rosetta and Venus Express deep-space missions
- Kourou, Maspalomas, Perth, Redu and Villafranca for the near-Earth scientific missions XMM-Newton, Cluster-1 to 4, Integral and SMART-1
- Kiruna for the low-orbit Earth-observation missions ERS-2 and Envisat.

In 2005, ESA's second deep-space ground station at Cebreros in Spain complemented the ESTRACK network. It

The German Chancellor Gerhard Schröder celebrating '30 Years of ESA' at ESOC

was validated with Mars Express and Rosetta just in time for the launch of Venus Express, which it has been supporting on a daily basis since mid-November.

The X-band upgrade in Perth was finalised, enabling ESA to provide LEOP service in this frequency band. The migration to TCP/IP continued and the deployment of standardised telemetry and telecommand services based on the CCSDS Space Link Extension (SLE) Services started in Cebreros, Perth and Malindi. Once implemented at all ESTRACK stations, it will allow a fully harmonised tracking service to be delivered to all customers.

The Villafranca-1 and 2 terminals provided primary or backup TT&C support to a number of ESA missions during the year, including Cluster, XMM-Newton, Integral, Envisat, ERS-2 and SMART-1. China's Double Star mission was also

Press coverage of the Cebreros station's inauguration on 28 September

The Villafranca-2 ground-station antenna

regularly supported. Villafranca-4 was used occasionally to operate the KaTE experiment onboard SMART-1.

Since 2002, the Artemis Mission Control Centre has been at the Redu station in Belgium, from which in 2005 the first bi-directional optical link in space was established between JAXA's OICETS (Optical Inter-orbit Communications Engineering Test Satellite) and OPALE, the optical terminal onboard Artemis. During the year, the antenna for the in-orbit testing (IOT) of the GIOVE-B satellite, foreseen to take place in mid-2006, was also installed at Redu. The station's IOT expertise has also been made available to other European telecommunications operators, including Eutelsat and SES Astra. In addition to preparing for Proba-2's launch in 2007, Proba-1 operations were successfully run using the local mission-control system and S-band antenna at Redu. Redu also continues to be the primary TT&C station for the Integral scientific mission. Refurbishment of the site was started in 2005 and will continue in 2006.

International Cooperation

There was excellent cooperation between ESA, CNES and DLR with the support of Syracuse-3A for CNES from the ESA's Perth station, the support of SMART-1 by DLR's Weilheim station, and the preparation of CNES's Kerguelen station for supporting the forthcoming ESA/Eumetsat MetOp-1 mission. In addition, the Esrange (S), Malindi (Kenya) and Svalbard (N) ground stations are regularly used to complement the heavily loaded ESA network. ESA also provided support to JAXA (Japan) from the Kiruna (S) ground station for the OICETS launch and early-orbit phase.

The introduction of internationally agreed CCSDS cross-support standards, the suite of Space Link Extension (SLE) Services, also helped in consolidating the cross-support activities with NASA/JPL, so that all deep-space ground stations - Goldstone, Canberra, New Norcia and Cebreros - can now support the missions of both Agencies. This is an important achievement also for the Inter-Operations Advisory Group, in which ESA is participating with the five other leading space agencies (ASI, CNES, DLR, JAXA and NASA) and which has been promoting the implementation of SLE standards for many years.

Several exchanges of staff took place with Chinese space organisations such as XSCC, CLTC and CNSA. They proved very productive and resulted inter alia in the continuation of cooperation in the TT&C services area, which began in 2003 with the Double Star mission

ESRIN

ESRIN is ESA's lead centre for Earth Observation and conducted numerous activities in this field in 2005. It also hosted about 20 000 participants for high-level scientific workshops, industrial meetings and reviews as well as VIP visits.

As an example, ESRIN hosted the MERIS and FRINGE workshops with a very high participation of worldwide scientists, as well as two co-location meetings of GMES (Global Monitoring for Environment and Security). ESRIN made a major contribution to the Earth and Space Week event jointly organised with the European Commission in February in Brussels, where demonstrators of GMES Services developed by ESA and the Commission were presented. During the same week ESA also participated in the high-level Earth Observation Summit in Brussels.

In March during the Italian Science Week, an Open Day was organised for the general public and attracted the participation of over 1000 students. Over 80 school visits were organised during the year as well as numerous visits for VIPs (e.g. Korean and Chinese Space Agencies) and decision-makers (Members of Parliament, the CSU delegation from the Bavarian Government and Parliament, EU Satellite Centre, European Commission Representatives, etc.).

An agreement with the Italian CNR (Centro Nazionale delle Ricerche) was signed in June to cover cooperation in the field of broadband connectivity and the bilateral agreement with the Tor Vergata University in Rome was renewed, including in particular the hosting of well-qualified PhD students and post-doctoral fellows at

The MERIS/AATSR Workshop at ESRIN on 26-30 September

ESA astronaut Paolo Nespoli talking with students at the ESRIN Open Day on 14 March

Signature of the ESA-JRC Agreement at ESRIN on 26 October by Volker Liebig (left), ESA's Director of Earth Observation, and Freddy Dezeure (right), Head of JRC's Corporate Development Unit

ESRIN for research in the field of advanced ERS and Envisat SAR applications.

Five incubators for the start-up of Small and Medium Enterprises have been hosted since July at ESRIN, following the agreement signed between ESA and BIC Lazio (Business Innovation Centre for the Lazio Region).

In October ESRIN signed an agreement with the European Commission Joint Research Centre (JRC), concerning the development of space-based information services and the access to and provision of Earth Observation data.

ESRIN served as the main centre for the retransmission event for the Cryosat launch. The Dutch Minister for Economic Affairs, Laurens Jan Brinkhorst, and the Italian Minister of Education, Universities and Research, Guido Possa, participated in the event together with over 400 VIPs, decision-makers, scientists and industry representatives. Launch retransmission events were organised for all ESA missions and the site also hosted numerous TV companies for dedicated interviews and reportages (e.g. Arte TV Channel).

A new ESRIN web site was launched in 2005, including a virtual tour of the site and facilities.

The CryoSat launch event at ESRIN

EAC

The 'Eneide' mission

Activities at the European Astronaut Centre focused in 2005 on the flight of one ESA astronaut in April, the preparations for two further flights in the coming years, the commencement of training on a European element of the ISS, and further preparation for Columbus operations.

The 10-day Italian-sponsored 'Eneide' Soyuz mission was successfully conducted between 15 and 25 April. ESA astronaut Roberto Vittori took an active role in spacecraft operations during the ascent and docking phases and the return journey, and all of the mission's main objectives, which included an extensive programme of 21 experiments, were successfully accomplished. Crew operations, medical support, training coordination with Russia and the coordination of payload-related training activities were all the responsibility of EAC. An important feature of this mission was the participation as back-up astronaut of Robert Thirsk from the Canadian Space Agency, whose extensive experience in the role of CapCom, and presence at the Columbus Control Centre, enhanced communication between the ESA and NASA ground controller teams.

The next Shuttle mission will carry a third crew member to the ISS, and will mark the start of the six-month ESA long-duration 'Astrolab' mission. The nominal ESA crew member is Thomas Reiter, with Leopold Eyharts as back-up. Training for the mission began in 2004 and continued throughout 2005, both at the Johnson Space Center (JSC) and at the Gagarin Cosmonaut Training Centre; two additional periods of training took place at EAC. In parallel with the flight crew training, preparation of the ground-support activities also progressed well.

In addition to the scientific benefits that the comprehensive Astrolab experimental programme will provide, ESA astronauts and ground personnel will be able to acquire and validate operational experience in long-duration flights on the ISS, which will be of direct benefit for the start of Columbus operations. It will also see the first usage of the ESA-developed Pulmonary Function System (PFS), which will support medical operations by enabling the evaluation of the physical fitness of the astronauts and the fine-tuning of countermeasure exercises.

Christer Fuglesang, who is scheduled to fly on Shuttle mission STS-116 as a NASA Mission Specialist, continued training throughout the year. Three space-walks (EVAs) are planned during his mission.

André Kuipers, back-up astronaut for the Canadian Space Agency (CSA) Increment, and Frank de Winne, have been assigned to long-duration flight training in preparation for Increments 14 to 18; this training will provide a good basis for that needed once they are assigned to an Increment flight.

Other astronauts were assigned to collateral duties, working in various areas supporting projects. Operations support was also provided by Hans Schlegel, who was assigned as Lead CapCom for the ISS Expedition 10 at the JSC Control Center.

Training activities at EAC are progressing well. With the newly designed end-to-end training service, EAC will become responsible for the training and certification of the Columbus flight control team, in addition to the

European Commission Vice-President Günter Verheugen (centre) sampling space food during his visit to EAC

existing crew training. To support this new role, the Columbus simulator at EAC has been converted to be identical to that available at the Columbus Control Centre (Col-CC). Simulation scripts and malfunction scenarios were prepared by the EAC instructor team and a first 'integrated simulation' was run on the Columbus trainer at EAC, with the Flight Control Team at Col-CC interfacing with an EAC simulation team and a surrogate crew operating the Columbus simulator at EAC. Communication with the crew was also performed from EAC, implementing the 'Eurocom' position for which EAC is responsible. A Eurocom team has been set up and the training has started.

With the Astrolab flight and the implementation of the first ATV training at EAC for Increment 13, ISS training coordination has turned into a truly multilateral function, with ESA becoming a full member of the Increment Training Integration Working Group.

Columbus training at user level was implemented for three ESA/NASA flight controller teams, and for one international astronaut class from ESA, NASA and JAXA.

The development of EVA pre-familiarisation training was supported by NASA, which welcomes the enhancement of the qualifications of ESA astronauts prior to entering EVA training at JSC. This training will be officially recognised by NASA following qualification, which is currently planned for mid-2006.

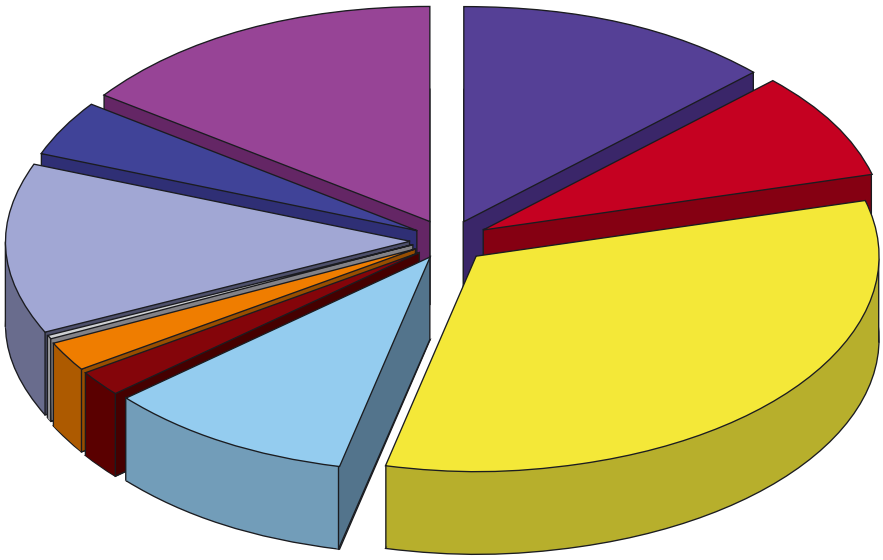
A self-standing European Human Behaviour and Performance (HBP) training package was developed and successfully tested. The astronauts of the ISS Partners have been invited to participate in the next training session, planned for April 2006.

International cooperation in the field of operations is demonstrating ESA's credibility as a partner. Support was provided to NASA by the EAC medical operations team for organising services to allow use of the French Air Force base at Istres as an emergency landing site for the Shuttle. On-call support in case of such an event is also provided by the Crew Medical Support Office during launches, and was first implemented for the Space Shuttle's return to flight in July.

Demand for astronaut participation in, and the support of EAC for, public events remained high throughout the year. One of the many visitors to the centre was the Vice-President of the European Commission, Mr Günter Verheugen, who received 'accelerated training' concerning the use of food items in space, concluded by a tasting session, which provided a real insight into living and working in space.

ESA astronaut Roberto Vittori back on Earth after his successful 'Eneide' mission to the ISS

Resources Management



Finance and Corporate Controlling

Income and Expenditure

The Agency's overall budget for 2005 (including appropriations carried forward from 2004) for the financing of its programmes and other activities was:

- 3805.2 MEuro in Contract Authority (CA), and
- 2951.8 MEuro in Payment Appropriations (PA).

The Agency's Mandatory Activities represented approximately 23% of the total expenditure (667.3 MEuro), whereas 72% was allocated to the Optional Programmes (2137.9 MEuro) and 5% to Programmes for, and financed by, Third Parties (152.7 MEuro). The minor decrease in participation in Mandatory Activities in favour of Optional Programmes – almost 3 percentage points – was reversed compared with the trend in recent years. This was basically due to a substantial budgetary increase of more than 200 MEuro for the Optional Programmes. The Ministerial Council meeting in Berlin in December proved extremely positive, demonstrating a renewal of Member States' confidence in ESA's performance, which was reflected in their subscriptions to the financial envelopes of both the new and the ongoing programmes. In 2005, the Agency also continued its active role in the management of programmes financed by Third Parties, consolidating this steady trend as an additional source of income.

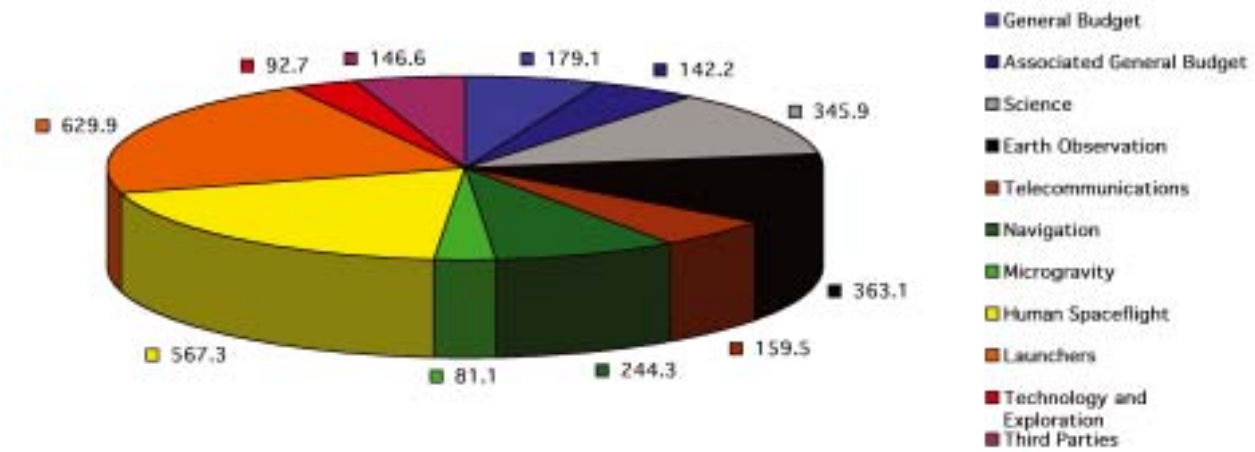
The core of the Agency's Mandatory Activities consists of the Science Programme, a Technological Research Programme, and the technical and managing infrastructure, which together enable ESA to fulfil its role as a scientific and technical organisation.

During 2005, the Science Programme's budget decreased by 4% (14 MEuro), to 345 MEuro. Taken together with the previous years' budgets, this means that the Science Programme has stabilised within the overall Level of Resources at approximately 370 MEuro per annum, and is entering a budget consolidation phase that will pick up in following years, with all projects progressing as planned. In line with the 2003 Council decision, a first 30 MEuro installment on the loan from the General Treasury was reimbursed.

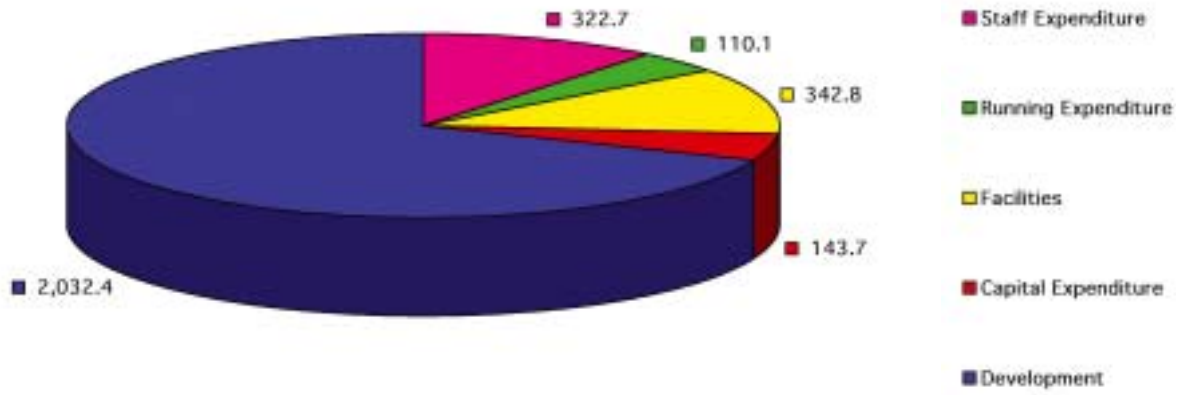
The funds for the development of applications are largely provided through the Agency's Optional Programmes, to which Participating States sign up through voluntary subscriptions.

In 2005, about 21% of the total ESA budget (629.9 MEuro) was allocated to the Launchers Programme. Events that had a significant impact on launcher-related budgets, and help to explain the 13% increase compared with 2004, included the heavy investment needed for the construction of the Soyuz launch facilities (ELS) at CSG in Kourou, and the increased funding involvement in Ariane-5 Slice 10 for the completion of Ariane-5 Recovery Plan endorsed by the Ministers at the May 2003 Council.

19% of ESA's 2005 budget (567.3 MEuro) was devoted to the Human Spaceflight, Microgravity and Exploration Programme. This amount remained constant in real terms compared to 2004, with the 2.4% nominal increase merely preserving the Programme's purchasing power.



Budgetary expenditure by programme (MEuro)



Budgetary expenditure by function (MEuro)

Nevertheless, a large number of significant milestones could be achieved thanks to the stable budgetary situation.

The Earth and Environment Monitoring from Space Programme represented 12% of the 2005 budget (363.1 MEuro). The strong increase of 42% compared with 2004 was due mainly to the positive evolution of the EOEP Period-1 and 2 development contracts.

The Telecommunications Programme accounted for 5% of the Agency's expenditure in 2005 (159.5 MEuro). The 21% increase compared to 2004 brought the ARTES family of programmes, i.e. extensions 3, 4 and 5, but especially 8, back up to their foreseen levels, reflecting the confidence and interest that the Participating States have in the ARTES concept.

The Navigation Programme represented 8% of ESA's total expenditure (244.3 MEuro), a 28% increase compared with 2004. The main cost drivers were the GalileoSat programmes co-funded with the European Union: the development contracts for the GIOVE satellite series, and the launch of GIOVE-A. The GNSS programmes also continued on their positive development path.

The Budgetary Management System, a financial tool that optimises the allocation of budgetary credits and Member States' funding for the Optional Programmes, was used to centrally manage budgetary risks in 2005. The main beneficiaries of this mechanism were the ISS, EGAS and EOEP-1 programmes. A more stable contribution profile for Participating States and more efficient allocation of budgetary resources to the relevant Optional Programmes were positive outcomes of this mechanism for greater flexibility, as well as the improved control over budgetary risks.

Value-for-Money Actions: An On-going Reform Effort

As in 2004, around 85% of the Agency's 2005 budget was spent on contracts with Industry 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. The Member States also benefited at a national level from the investment multipliers and the job creation resulting from their industrial and scientific relationship with ESA.

The Agency is investing both time and resources to gradually align its procedures with European best-practices, in particular by introducing International Public Sector Accounting Standards, and to assess the possibility of making further progress in the area of analytical cost accounting and full-accrual compliance. The outcome of the latter analysis will be evaluated in 2006.

Some far-reaching reforms have already been carried out. One year after Council's request, the Resolution on the introduction of in-year flexibility and a new budgetary planning process into the Agency's financial system was adopted in June. This Resolution will lead to a new set of Financial Regulations coming into force on 1 January 2006, and to transitional measures for the 2006 budgets. The implementing principles of this reform are reinforcing sound decision-making for the Agency's finances based on improved corporate control, and the most efficient management of its financial resources. A new budgetary planning process with more transparent and more regular reporting to Member States will be also introduced.

Contributions to Mandatory Activities (%)		Contributions to Optional Programmes* (%)	
AUSTRIA	2.26	AUSTRIA	0.87
BELGIUM	2.83	BELGIUM	7.37
DENMARK	1.82	DENMARK	0.78
FINLAND	1.37	FINLAND	0.54
FRANCE	15.63	FRANCE	31.55
GERMANY	23.41	GERMANY	21.45
GREECE	1.50	GREECE	0.12
IRELAND	0.95	IRELAND	0.30
ITALY	12.88	ITALY	14.59
LUXEMBOURG	0.21	LUXEMBOURG	0.13
NETHERLANDS	4.43	NETHERLANDS	2.87
NORWAY	1.70	NORWAY	1.02
PORTUGAL	1.20	PORTUGAL	0.19
SPAIN	6.87	SPAIN	5.76
SWEDEN	2.61	SWEDEN	2.11
SWITZERLAND	3.40	SWITZERLAND	3.49
UNITED KINGDOM	16.93	UNITED KINGDOM	5.91
TOTAL MEMBER STATES	100.00	TOTAL MEMBER STATES	99.06
CANADA	3.43	CANADA	0.83
CZECH REPUBLIC	-	CZECH REPUBLIC	0.06
HUNGARY	-	HUNGARY	0.06
TOTAL Cooperating States **	3.43	TOTAL Cooperating States **	0.94
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 Co-operation Agreement.

Calculation of the Contribution Scale for Mandatory Activities

The ESA Convention dictates that the Mandatory Programme be financed using a contribution scale for the period 2003-2005 based on the national incomes of the Member States over the last three years for which statistics are available. The calculations are based on national-income statistics expressed in national currency and converted into Euros at average annual conversion rates.

The entry of two new Member States, Greece and Luxembourg, into the Agency in 2005 required an adjustment to the said scale of contributions taking into account their relative national incomes.

The resulting total contributions from Member and Cooperating States to the Agency's Mandatory Activities and Optional Programmes in 2005 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 2005 are presented in the following pages.

Notes to the Financial Statements

The Agency's Annual Accounts are summarised in four financial statements presented herewith (in unaudited form at the time of this publication), including comparative information for the year 2004.

Among the assets, the 312 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 at 761 MEuro, the not yet financed portion is shown as a receivable amount.

The main current asset represents 396 MEuro of advance payments to suppliers, made across the Agency's on-going programmes. Until the relevant services are tested and accepted, these payments are considered as a claim towards the contractor companies.

The 40 MEuro Investment in Associates represents the Agency's interest in the Galileo Joint Undertaking with the European Commission.

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 2005 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 111 MEuro debit balance in 2005 can be considered as the net accumulated excess of liabilities over assets recognised in the accounts.

Provisions and accruals are included in the Statement of Assets and Liabilities 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. The net effect of reversed accruals of the previous year and new accruals is therefore 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 2005, this balance amounted to a 263 MEuro net reversal 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 2005 Surplus amounts to 606 MEuro, including 303 MEuro of underspending of the budget allocations, 40 MEuro of excess actual income over the budget, with other minor balances, and a 263 MEuro net reversal of restated prior-year accruals.

FINANCIAL STATEMENTS 2005

1. Income and Expenditure for the year ended 31 December (in Euro)

	2005		2004		Increase/ Decrease
OPERATING INCOME					
Contributions	2,854,432		2,636,209		218,223
Other Income	264,878		189,267		75,611
		3,119,310		2,825,476	293,834
Third Party Programmes Income	169,580		210,646		-41,066
Plan for European Cooperating States	3,845		2,181		1,664
Management Outputs/Esrange Income	486		16,975		-16,489
Suspense Output	2,794		0		2,794
Internal Tax Income	103,332		102,950		382
		280,037		332,752	-52,715
Total operating income		**3,399,347**		**3,158,228**	241,119
OPERATING EXPENDITURE					
General Budget	187,573		188,010		-437
Scientific Programme	345,723		360,038		-14,315
Earth Observation	362,810		320,963		41,847
Telecom	159,312		131,393		27,919
Navigation	244,051		216,197		27,854
Manned Spaceflight	574,396		553,940		20,456
Microgravity	81,036		69,118		11,918
Launchers	648,666		557,596		91,070
Technology	85,025		83,499		1,526
CSG Kourou and other activities	82,711		86,933		-4,222
Pensions	59,496		54,900		4,596
Total financed by contributions		2,830,799		2,622,587	208,212
Third Party Programmes	145,796		151,954		-6,158
Plan for European Cooperating States	1,196		533		663
Management Outputs Expenditure	-24,880		16,494		-41,374
Esrange/Andøya special project	193		189		4
Internal Tax	103,332		102,950		382
Variation of accruals/provisions	-242,582		220,012		-462,594
Restatement of expenditure to assets	-20,000		-10,000		-10,000
		-36,945		482,132	-519,077
Total operating expenditure		**2,793,854**		**3,104,719**	-310,865
NON-OPERATING CHARGES	0		0		0
Net Surplus for the Period		**605,493**		**53,509**	551,984

REPRESENTED BY		
Bank and Cash	311,779	345,591
Other Assets	1,637,461	1,518,919
Prepaid Contributions, Other Liabilities	-1,420,137	-1,673,681
Loans on Outstanding contributions	0	-4,000
Reserves	76,390	-133,320
Net Surplus for the Period	**605,493**	**53,509**

2. Assets and Liabilities on 31 December (in kEuro)

	2005		2004		Increase/ Decrease
ASSETS					
Current assets :					
BANKS AND CASH	311,779		345,591		-33,812
AMOUNTS RECEIVABLE :					
Outstanding contributions	353,270		251,557		101,713
Other customers (net)	20,615		54,230		-33,615
Other amounts receivable	66,280		68,767		-2,487
PREPAYMENTS	396,296		379,365		16,931
		1,148,240		**1,099,510**	**48,730**
Non-current assets :					
Investments in associates	40,000		20,000		20,000
PENSION SCHEME to be financed	569,152		557,161		11,991
PENSION SCHEME Buffer Fund	191,848		187,839		4,009
		801,000		**765,000**	36,000
Total assets		**1,949,240**		**1,864,510**	**84,730**
LIABILITIES					
Current liabilities:					
Prepaid Contributions and other payables to Member States	194,466		228,997		-34,531
Regulation Fund	72,574		81,214		-8,640
LOANS IN LIEU OF CONTRIBUTIONS	0		4,000		-4,000
ACCRUED PAYABLES	339,803		571,782		-231,979
OTHER AMOUNTS PAYABLE	9,279		7,061		2,218
UNTAKEN STAFF LEAVE	43,015		39,627		3,388
		659,137		**932,681**	**-273,544**
Non-current liabilities:					
PENSION SCHEME (*)	761,000		745,000		16,000
		761,000		**745,000**	16,000
Total liabilities		**1,420,137**		**1,677,681**	**-257,544**
NET ASSETS		**529,103**		**186,829**	**342,274**
NET ASSETS/ RESERVES					
RESERVES Telecom 3 bis, GNSS2, ARTES, PPF Envisat, Marecs, Exchange gains	34,635		34,333		302
Reserve for Accruals and Provisions	-111,025		98,987		-210,012
SURPLUS	605,493		53,509		551,984
		529,103		**186,829**	**342,274**

MEMORANDUM ACCOUNTS					
Property, plant and equipment	2,739,381		2,597,453		141,928
Fixed Assets in progress	217,945		513,373		-295,428
INVENTORY OF FIXED ASSETS		**2,957,326**		**3,110,826**	**-153,500**

3. Consolidated Cash Flow for year ended 31 December (in MEuro)

CASH FLOWS FROM OPERATING ACTIVITIES		
Receipts		
2005 Contributions received (net of loans)	2,094.4	
Contributions received for Regulation Fund	216.0	
Previous years contributions cashed in 2005	142.8	
Prepaid contributions cashed	48.5	
		2,501.7
Proceeds of Third Party Programmes	110.2	
Proceeds of Plan for European Cooperating States	2.0	
Other proceeds of ESA Programmes	262.8	
Net movements of other receivables	2.5	
Net movements of other reserves	5.0	
		382.5
		2,884.2
Payments		
Payments for ESA Programmes	-2,759.4	
Payments for Third Party Programmes	-145.8	
Payments of Plan for European Cooperating States	-1.2	
Net movements of other amounts payable 2005/2004	2.2	
Reimbursement of contributions	-9.8	
		-2,914.0
Net cash flow from operating activities		-29.8
CASH FLOWS FROM FINANCING ACTIVITIES		
Proceeds of loans taken in lieu of contributions	0.0	
Reimbursement of bank loans in lieu of contributions	-4.0	
Net cash flow from financing activities		-4.0
Net increase (decrease) in cash		-33.8
CASH AND BANKS 31.12.2004		345.6
CASH AND BANKS 31.12.2005		311.8

4. Changes in Net Assets/Equity for years 2004-2005 (in MEuro)

	SURPLUS	RESERVES	RESERVE FOR ACCRUALS AND PROVISIONS	TOTAL NET ASSETS
	(A)	(B)	(C)	(A+B+C)
Balance at 31 December 2004 ESA/AF(2005)1	53.5	34.3	99.0	186.8
Allocation of Surplus 2004 to income 2005:				
- Programmes funded by contributions	-193.9			
- Plan for European Cooperating States	-1.6			
- Programmes funded by Third Parties	-57.0			
- Management and Suspense Outputs	-0.3			
Reimbursement to Participants	-7.5			
Allocation to exchange gains reserve	-1.7			
Allocation to Marecs reserve	-1.5			
Adjustments for accrued expenditure 2004	210.0		-210.0	-210.0
Sub-total Allocation of Surplus 2004	-53.5			-53.5
Surplus 2005	605.5			605.5
Net movements in reserves		0.3		0.3
Balance 31 December 2005	**605.5**	**34.6**	**-111.0**	**529.1**

Human Resources

Human Resources Policy

Following the review of the Human Resources Reform activities and the publication of its findings, the Human Resources Department set out to further develop, improve and fine-tune implementation concepts in eight key areas: Grade A5 Ad Personam, Promotion and Merit Recognition, Career Management, Human Resources Advisory Services, Annual Assessment, Competency Modelling, Recruitment and Mobility. To this end, a tri-partite committee was formed with members drawn from the ESA Management, the Staff Association Committee (SAC) and the HR Department. This committee developed a set of criteria with which priorities, and subsequently the implementation schedule, could be developed. All of the projects made good progress during the year and are expected to be completed in 2006.

In 2005, ESA became a non-smoking organisation, with appropriate information and medical support provided to all staff and contractors.

Staff Training and Development

The wide range of training and development activities made available to staff included those centrally driven to serve corporate needs and priorities under the auspices of the Internal University (the principle of which was approved in February), and those instigated locally in each Establishment in response to needs identified by staff members and their managers. They ranged from courses/seminars designed to ESA specifications, to the financing of participation by staff members in external professional training or academic programmes.

In addition to generally promoting networking and the exchange of ideas among staff members, the 15 Internal University programmes available in 2005 focused on:

- Increasing knowledge of ESA, its business and its inner workings.
- Developing technical and functional skills.
- Harmonising practices and reinforcing horizontal skills.
- Promoting understanding of key issues.
- Developing leadership and management skills.

External Training

Almost 2700 applications for the Young Graduate Trainee (YGT) programme resulted in the successful recruitment of highly motivated recent graduates, contributing to the total of 196 YGTs working at ESA during the year. The YGTs gain valuable 'hands-on' work experience, preparing them for future employment in space industry or research.

The Internal Research Fellow Programme provided 51 Postdoctoral candidates with the opportunity to carry out research in a variety of disciplines, mainly related to space science, applications or technology, under the supervision of ESA scientists and engineers.

In 2005, 20 External Fellows received ESA funding to conduct research in a university or research institute, and the Agency also hosted 143 university students on internships, the average duration of which was 4 months. In addition, 20 more graduates – 12 Spanish and 8 Portugese – gained practical experience in space-science and space-applications related disciplines at ESA within the framework of bilateral agreements with these two countries.

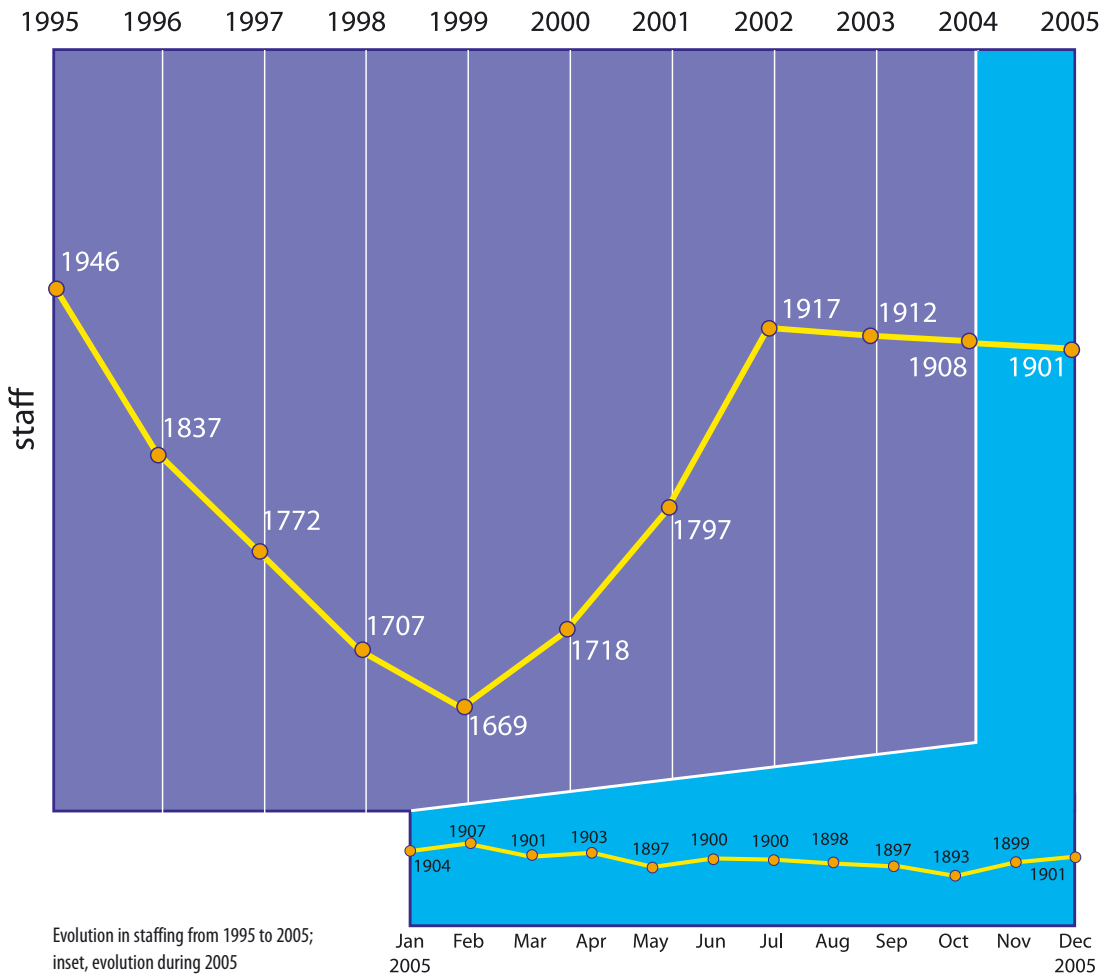
Equal Opportunity and Diversity Policy

All of the targets defined in the 2002 Action Plan for Phase-1 of ESA's Equal Opportunities and Diversity Policy have been implemented: the NOW programme (for young female trainees) and the female-candidate database for recruitment; childcare facilities in most Establishments and the spouse work-support programme for work/life-balance improvement; self-awareness, communication and leadership training for female career support; a web site dedicated to women working in aeronautics and space (CELEST-IN); the annual International Women's Day event; and seminars for managers providing increased awareness of these issues.

The number of female A-grades increased from 8.1% in 2001 to 12.67% in 2005, with a noticeable increase in female representation particularly in A4, but also in A5 and A6 positions. This was a clear signal that ESA is well on its way to removing the 'glass ceiling' if it maintains the proactive approach adopted a few years ago.

Coordination

The Coordinating Committee on Remuneration (CCR) finalised a recommendation on the reform of the Education Allowance. This is the first application of the reform of Coordination proposed by the CCR and adopted by the Administrative and Finance Committee (AFC) in



Evolution in staffing from 1995 to 2005; inset, evolution during 2005

2004, which gives the individual Organisations some flexibility in the application of proposed reforms.

Coordination began discussions on the general review of the method for remuneration adjustment, as the method currently in force will end in December 2006.

Workforce Management

At the end of 2005, ESA had 1901 permanent staff in post, compared with 1908 at the end of 2004 (see graph). Whilst overall staffing therefore remained stable, additional efforts were made to optimise the use of staff in meeting the Agency's mid-term objectives, which resulted in the following guidelines for workforce management:

- Stability of staff resources assigned to space programmes and projects.
- Increase of common technical expertise.
- Decrease of staff resources allocated to basic non-technical functions.
- Rebalancing of project staff between direct team and functional support.

This led, in particular, to more resources being attributed to the Technical and Operational Directorates and to the initiation of a review of the Agency's non-technical processes.

Pensions and Social Security

At the end of 2005, there were 959 persons in receipt of an ESA pension, compared with 909 at the end of 2004. The Agency's Social Security Scheme was further enhanced with provisions for those persons needing long-term care.

Procurement

Evolution of the Agency's Procurement and Industrial Policies

FINPOL Results

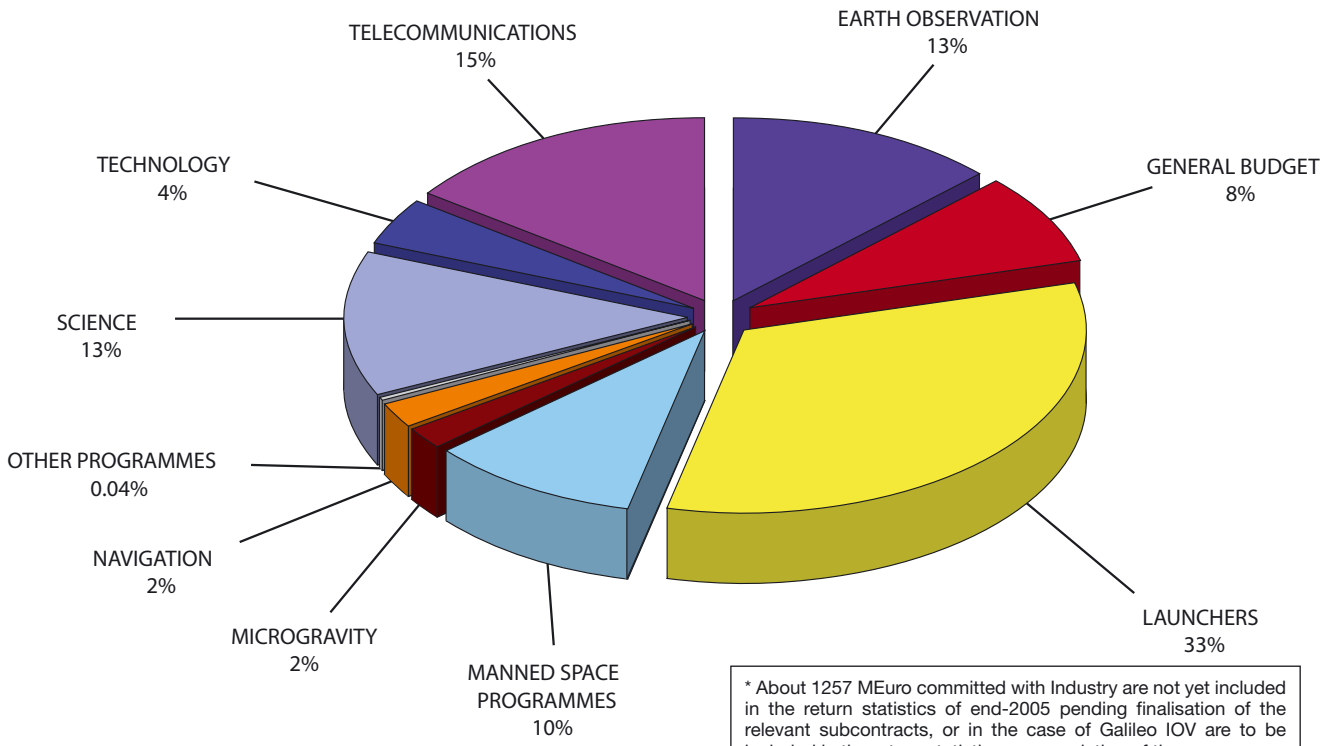
The industrial landscape within which the Agency is operating has profoundly changed in the last years, and the Director General's Agenda 2007 document provided the guidelines and objectives for the Agency's adaptation in the medium- and long-term. In this context, the ESA Council decided in December 2003 to set up a Working Group known as FINPOL. In June 2004, the Council unanimously approved Resolution ESA/C/CLXXI/Res.2 (Final), endorsing the major findings of FINPOL. At its June 2005 meeting it adopted three Resolutions (ESA/C/CLXXIX/Res. 4, 5 and 6) that changed the industrial- and procurement-policy rules applied for all ESA programmes. Resolutions 4 and 5 provide for greater flexibility in the application of its industrial-return rules by giving priority to overall return and establishing returns constraints at programmatic level. Subject thereto, Resolution 6 enables the Director General to pro-actively correct adverse trend return situations for a Member State throughout the formal five-year period.

Another important milestone in 2005 was the decision by Council on the lower limit of the return coefficient to be achieved for each Member State at the end of the period 2005-2009.

In addition to the new set of industrial and procurement policies implemented in the programmes proposed at the December Ministerial Council meeting in Berlin, two other important milestones were achieved with the adoption of Resolution ESA/C-M/CLXXXV/Res. 3 (Final), which put in place a European preferred launch-service procurement policy for ESA missions, and Resolution ESA/ C-M/CLXXXV/Res. 5 (Final), which requires the Director General to propose a plan of action to govern risk sharing between the Agency and Industry, and to provide fair access to all categories of firms in order to enrich the European space sector's capabilities and competitiveness.

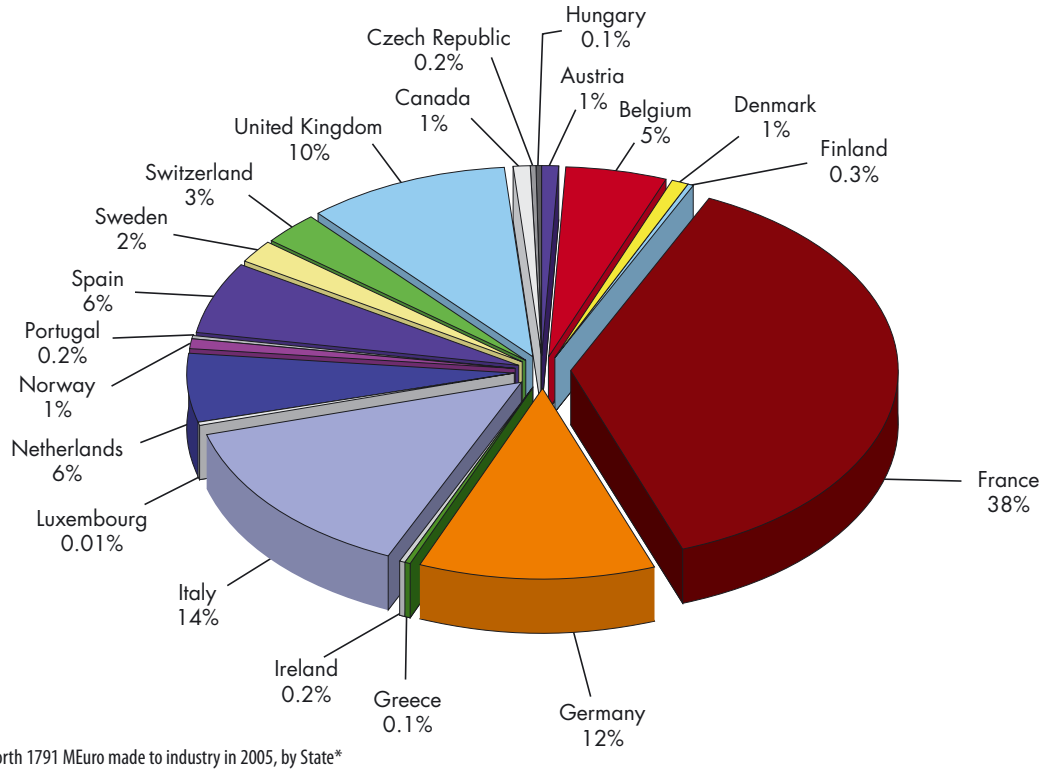
Procurement Rules and Procedures

A revised 'Code of Best Practices' was presented to the Agency's Industrial Policy Committee (IPC) for approval.



Commitments worth 1791 MEuro made to industry in 2005, by Programme*

* About 1257 MEuro committed with Industry are not yet included in the return statistics of end-2005 pending finalisation of the relevant subcontracts, or in the case of Galileo IOV are to be included in the return statistics on completion of the programme.



Commitments worth 1791 MEuro made to industry in 2005, by State*

The main changes with respect to the previous version are twofold: the inclusion of an 'Industrial Procurement Plan' (Make or Buy Plan), which will be established by Industry and evaluated by the Agency, and the incorporation of a number of recommendations made by the 'Industrial Ombudsman for ESA', which were reported in his annual report to the IPC.

Following a thorough review and a number of analyses and consultations in 2005, it was decided that effort should be put into the streamlining of small simple procurements (with values below 250 000 Euro), which represent an ever-increasing part of the Procurement Department's work. A small task force was established to try to reduce the duration of the procurement process and establish the conditions for such activities. The new procedure that has been devised for these small contracts will be implemented by March 2006.

Procurement Auditing

One of the Procurement Auditing Division's main roles is to ensure that the purchasing power of the Agency's budget, which is to a large extent determined by the evolution in industrial rates, is maintained to the maximum extent possible. The Division has therefore initiated a new concept with the industrial partners by concluding multi-year agreements on labour, facility and overhead rates to be applied for ESA-wide procurements. The new concept, based on a combined audit/negotiation approach, conducted wherever possible in consultation with national audit authorities, has resulted in approximately 140 industrial rate agreements since its presentation to Council in March 2004. In view of the rapid changes taking place in the industrial landscape, it has also been decided to assign dedicated audit staff to multi-national companies starting in early 2006.

The other main procurement auditing activity is the continuation of the EGAS Ariane Programme audits, linked to the production of the Ariane-5 batch PA consisting of 30 launchers. The consolidated data from these audits are presented annually to the Ariane Programme Board, and were used in 2005 to establish the initial scale of contributions for the EGAS Ariane Programme.

Facts and Figures

Procurement Activities

497 Invitations to Tender (ITTs) were sent to Industry in 2005:

- 238 in open competition
- 8 in restricted competition
- 251 in direct negotiation.

ESA also placed:

- 778 contracts
- 124 riders
- 353 work orders
- 2327 Contract Change Notices (CCNs)

with total released funding of 3048 MEuro.

Among the most significant contracts prepared or placed were those for:

- Swarm Space Segment Phases-B, C/D and E: 86 MEuro
- AlphaBus Phase-C/D: 202 MEuro
- System Architecture for Soyuz Launcher at CSG: 390 MEuro
- Galileo Development and In-Orbit Validation Phases-C/D and E: 794 MEuro.

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

- 172 procurement proposals were submitted to the AC, of which 110 were presented to the IPC
- 57 contract proposals were submitted to the AC, of which 13 were submitted to the IPC.

The value of the contracts and procurement proposals submitted to the AC was 2282 MEuro. Of these, 110 MEuro were finalised at AC level, and the remainder, worth 2172 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 contracts worth some 1791 MEuro placed 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 30% of the total contract value, 33% was related to Launchers, 11% to the Human Spaceflight, Microgravity and Exploration Programme, and 13% to the Scientific Programme, with the remaining 12% split between the General Budget and Technology.

The return situation regarding the geographical distribution of contracts for the period 2000-2004 was presented to the IPC in March.

Support to Third-Party Activities

In addition to handling ESA's own procurement requirements, support was also provided to third parties, involving limited use of the Agency's expertise, facilities, services or products. These third parties were often legal entities in the ESA Member States, and the costs incurred by the Agency were fully charged to those customers (not to be confused with activities performed under Cooperation Agreements, with or without exchange of funds).

ESOC continued to make spare capacity available to external customers, in terms of operations, facilities and expertise. The overall level of this activity remained similar to that of previous years, with roughly 1 enquiry per week received, leading to 15 proposals being generated in the course of the year and 8 contracts being received. The total value of orders received for ESOC support in 2005 amounted to 2.2 MEuro.

Major activities included the Launch and Early Orbit Phase (LEOP) service for the MSG-2 satellite (successfully concluded at the end of the year), preparation of the LEOP service for MetOp-1 and development of the GRAS ground-support network for Eumetsat, the provision of telemetry, telecommand and ranging services and in-orbit testing from Redu (B) for Eutelsat, and the provision of precise GPS orbit/clock data to Fugro (N).

Other third-party activities included support to the Syracuse-3A LEOP from ESA's Perth ground station for

CNES (F), support to JAXA (Japan) from ESA's Kiruna ground station for the OICETS LEOP, preparation of support to the Kompsat-2 LEOP from Maspalomas and Malindi as a service to KSAT (N), preparation of support to DLR (D) for the TerraSar-X LEOP, implementation of a prototype Galileo geodetic service for the Galileo Joint Undertaking, and various hosting services to New Skies (NL) and Vitrociset (B) from Redu.

Through ESTEC, the Agency also provided a considerable volume of assistance in the areas of general technical support, individual consultancies and testing. The Centre handled 86 enquiries, of which 11 were carried forward from previous years and 75 were newly received in 2005. This resulted in the receipt of 59 contracts with a total value of 0.79 MEuro, including 9 for the Battery Test Centre and 38 for the Laboratories. The major clients were EADS (D), SAFT (F) and CNES (F) for test activities, and Eumetsat for project-review support.

Under ESA's contract with ETS (European Test Service) to run the management, marketing, sales, operations and maintenance of the ESTEC Test Facilities, the contractor performed 16 tests for external customers. In addition, 6 of the 13 tenancy agreements for office accommodation and services in the European Space Incubator were signed in 2005.

At the Galileo Joint Undertaking's request, technical support was provided for GNSS signal evaluation, and two further contracts were also signed: one for activities related to the strategic steps towards GNSS signal and service provision in the MEDA region as well as other training and awareness activities, and another for studies concerning the development and evolution of the EGNOS system.

Participation in EC Research Contracts

ESA was involved in several research contracts awarded to groups of companies and research institutes by the European Commission, especially in the context of the 6th Framework Programme, often being invited to coordinate such groups of co-contractors. The costs for these research and management activities undertaken by ESA and its partners are fully or partially reimbursed by the EC. In 2005, 3 contracts were awarded to groups that included ESA, 8 contracts placed in 2004 or earlier were being executed, and 8 new proposals were submitted to the Commission.

Annexes

Chairs of Council, Programme Boards and Other Delegate Bodies

Council

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

Programme Boards

Communication Satellite Programme	Heikki Hannula (FIN)
Satellite Navigation Programme	Frank Udnaes (N)
Earth Observation Programme	Jorge Lomba (E)
Ariane Launcher Programme	Christoph Hohage (D)
Human Spaceflight, Research and Applications Programme	Simonetta Di Pippo (I)
Aurora Participants	François Spiero (F)

Other Delegate Bodies

Administrative and Finance Committee	Rowena Sirey (UK)
Industrial Policy Committee	Monique Wagner (B)
Science Programme Committee	Geneviève Debouzy (F)
International Relations Committee	Jean-François Mayence (B)
Security Committee	Albert le Goué (F)

Statutory Bodies

Appeals Board	Jean Massot (F)
Audit Commission	Wieland Flecken (D)
Staff Association Central Committee	Rémi Bourgoin (F)

National Delegations to Council

AUSTRIA
Klaus Pseiner
Ulrich Stacher

BELGIUM
Eric Beka
Monique Wagner
Jacques Nijskens

DENMARK
Henrik Grage
Birgitte Sode-Mogensen
Gorm Petersen

FINLAND
Kari Tilli
Antti Joensuu
Esa Panula-Ontto

FRANCE
Yannick d'Escatha
Patrice Bonnal
Stéphane Janichewski

GERMANY
Sigmar Wittig (Chair)
Ludwig Baumgarten
Walter Döllinger

GREECE
Ioannis Tsoukalas
Christos Zerefos
Ioannis Papadakis

IRELAND
Páraig Hennessy
Tony McDonald
Val Hayes

ITALY
Sergio Vetrella
Fabio Cassese
Augusto Cramarossa

LUXEMBOURG
Pierre Decker
Eugène Berger

NETHERLANDS
Hans de Groene
Robert van Akker
Joris van Enst

NORWAY
Rolf Skår
Nils Ihlen
Magnus Mathisen

PORTUGAL
Virginia Corrêa
João Rosa Lã

SPAIN
Maurici Lucena
Mercedes Sierra
Juan-Carlos Cortés

SWEDEN
Per Tegnér (Vice-Chair)
Lennart Lübeck
Oskar Thorslund

SWITZERLAND
Marc Bertschi (Vice Chair)
Daniel Fürst
Pascal Vinard

UNITED KINGDOM
Colin Hicks
Paula Freedman
Raj Sivalingam

CANADA
Marc Garneau
Virendra Jha
Hugues Gilbert

Agreements Signed

Agreement between the European Space Agency and the Russian Federal Space Agency (FSA) on Long-Term Cooperation and Partnership in the field of the Development, Implementation and Use of Launchers, signed in Moscow (Russia) on 19 January 2005 by Mr Jean-Jacques Dordain, ESA's Director General, and Mr Anatoly Perminov, Director General of Russia's Federal Space Agency.
(ESA/LEG/291)

Rider 5.3 to the Convention between the European Space Agency and Arianespace on the exploitation of the Soyuz launcher, signed in Paris on 21 March 2005 by Mr Jean-Jacques Dordain, ESA's Director General, and Mr Jean-Yves Le Gall, Director General of Arianespace.
(ESA/LEG/292)

Agreement between the European Space Agency and the French Government concerning the Soyuz Launch Site (ELS) at the Guiana Space Centre (CSG) and linked to the execution of ESA's optional programme entitled 'Soyuz at the CSG' and the operation of Soyuz from the CSG, signed in Paris on 21 March 2005 by Mr Jean-Jacques Dordain, ESA's Director General, and Mr François d'Aubert, Vice-Minister for Research for the French Government.
(ESA/LEG/293)

Multilateral Agreement concerning the Provision of the LISA Technology Package for the LISA Pathfinder Mission signed in Helsinki (Finland) on 9 May 2005 by Prof. David Southwood for ESA, Mr Richard Bonneville for CNES, Dr. Thomas Galinski for DLR, Mr Manuel Serrano Arriza for MEC-PNE, Mr Alberto Tuozzi for ASI, Dr David Parker for PPARC and Mr Joost Carpay for SRON. It entered into force on the day of its signature by all Parties.
(ESA/LEG/294)

Agreement for Co-operation between the European Centre for Medium-Range Weather Forecasts (ECMWF) and the European Space Agency on exchange of information and expertise, signed in Paris on 31 May 2005 by Mr Jean-Jacques Dordain, ESA's Director General, and Mr Dominique Marbouty, Director of ECMWF. This Agreement entered into force on the day of its signature and will remain in force for a period of five years.
(ESA/LEG/295)

Implementing Arrangement between the European Space Agency and the Russian Federal Space Agency (FSA) on Cooperation in Research and Technology Development for Future Launchers, signed in Moscow (Russia) on 19 May 2005 by Mr Antonio Fabrizi, ESA's Director of Launchers, and Mr Alexandr Ivanovich Medvedchikov, Deputy-Head of the Federal Space Agency. This Arrangement entered into force on the day of its signature and will remain in force until 31 December 2008.
(ESA/LEG/296)

Agreement between the European Space Agency and the Indian Space Research Organisation (ISRO) concerning Cooperation on the First Indian Moon Mission Chandrayaan-1, signed in Bangalore (India) on 27 June 2005 by Mr Jean-Jacques Dordain, ESA's Director General and Mr G. Madhavan Nair, for ISRO. The Agreement entered into force on the day of its signature and will remain in force until 31 December 2015.
(ESA/LEG/297)

Signature of the Agreement for Cooperation between ESA and the European Centre for Medium-Range Weather Forecasts (ECMWF), by ESA's Director General, Mr Jean-Jacques Dordain (left) and the Director of ECMWF, Mr Dominique Marbouty (photo ESA - P. Sebirot)

Arrangement between the European Space Agency and the Centre National d'Etudes Spatiales (CNES) concerning the management of the P80 Programme, signed in Darmstadt (Germany) on 21 June 2005 by Mr Jean-Jacques Dordain, ESA's Director General, and Mr Yannick d'Escatha, Director General of CNES. It entered into force upon signature by the Parties and will remain in force until the completion of the P80 programme.
(ESA/LEG/298)

Agreement between the European Space Agency, the Centre National d'Etudes Spatiales (CNES) and the Agenzia Spaziale Italia (ASI) concerning the participation in and operation of the Vega Integrated Programme Team and the P80 Project Team, signed in Darmstadt (Germany) on 21 June 2005 by Mr Jean-Jacques Dordain, ESA's Director General, Mr. Yannick d'Escatha, Director General of CNES, and Mr Sergio Vetrella, Director General of ASI. The Agreement entered into force upon signature by the Parties and will remain in force until the completion of the Vega and P80 programmes.
(ESA/LEG/299)

Agreement between the European Space Agency and the Government of the People's Republic of China concerning space cooperation for peaceful purposes signed in Beijing (China) on 18 November 2005 by Mr Jean-Jacques Dordain, ESA's Director General, and Mr Sun Laiyan, Administrator of the China National Space Administration.
(ESA/LEG/300)

Agreement between the Portuguese Republic and the European Space Agency on the setting up and use of monitoring facilities for the purpose of the Agency's launcher programmes and activities, signed in Lisbon (Portugal) on 26 November 2005 by Mr Jean-Jacques Dordain, ESA's Director General, and Mr José Mariano Gago, Portugal's Minister of Science, Technology and Higher Education.
(ESA/LEG/301)

Patents

PAT 499 AN OPTICAL REFLECTOR ELEMENT, ITS METHOD OF FABRICATION, AND AN OPTICAL INSTRUMENT IMPLEMENTING SUCH ELEMENTS

US Application	11/059,108
JP Application	2005-039799
Filed	16 February 2005
Applicant	European Space Agency
Inventors	M. Bavdaz & M. Beijersbergen
Other Applications	France

PAT 500 MINIMUM PHASE SWITCH-MODE BOOST CONVERTER WITH SWITCH NEAR GROUND

US Application	11/036,823
Filed	14 January 2005
Applicant	European Space Agency
Inventor	P. Rueda Boldó
Other Applications	France

PAT 501 MULTIFUNCTIONAL ELECTRONIC WRIST WATCH TO SUPPORT NAVIGATION, NOTABLY FOR A SPACE MISSION

International Application	PCT/FR2005/050676
Filed	18 August 2005
Applicant	European Space Agency
Inventor	J.-F. Clervoy
Other Applications	France

PAT 506 PROCESS AND DEVICE TO ORGANISE AND TRANSMIT DATA PACKETS FROM A COMMON TRANSMITTER TO A MULTITUDE OF USERS SHARING ONE COMMON TRANSMISSION CHANNEL

US Application	11/254,678
Filed	21 October 2005
Applicant	European Space Agency
Inventor	M.-A. Vázquez Castro
Other Applications	France

PAT 507 REAL-TIME SYNTHETIC-APERTURE-RADAR PROCESSING SYSTEM AND METHODS

International Application	PCT/FR05/00052
Filed	10 January 2005
Applicant	European Space Agency
Inventors	B. Harnisch, A. Bergeron & P. Bourqui

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

French Application	FR 05 00934
Filed	31 January 2005
Applicant	European Space Agency
Inventors	E. Casini, O. Del Rio Herrero & R. De Gaudenzi

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

French Application	FR 05 01772
Filed	22 February 2005
Applicant	European Space Agency
Inventor	C. Dujarric

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

French Application	FR 05 04995
Filed	18 May 2005
Applicant	European Space Agency
Inventor	C. Buck

PAT 513 MICROWAVE FILTER FOR OUTPUT MULTIPLEXER

French Application	FR 05 08005
Filed	27 July 2005
Applicant	European Space Agency
Inventors	N. Ortiz, M. Sorolla, D. Schmitt, M. Guglielmi & J. Gil

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

French Application	FR 05 51563
Filed	9 June 2005
Applicant	European Space Agency
Inventors	C. Semprimoschnig, S. Hetzel & M. van Eesbeek

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

French Application	FR 05 06518
Filed	27 June 2005
Applicant	European Space Agency
Inventor	S. Weinberg

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

French Application	FR 05 05912
Filed	10 June 2005
Applicant	European Space Agency
Inventor	M. Lopriore

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

French Application	FR 05 04441
Filed	2 May 2005
Applicant	European Space Agency
Inventor	P. Rueda Boldó

PAT 520 MICROWAVE WAVEGUIDE FILTER WITH NON-PARALLEL WALLS

French Application	FR 05 09264
Filed	12 September 2005
Applicant	European Space Agency
Inventors	J. Hueso Gonzalez, D. Raboso & D. Schmitt

PAT 522 DEVICE AND METHOD FOR MATERIAL TESTING

French Application	FR 05 10396
Filed	12 October 2005
Applicant	European Space Agency
Inventor	G. Bussu

GAL PAT 004 SPREADING CODES FOR A SATELLITE NAVIGATION SYSTEM

International Application	PCT/EP2005/007235
Filed	1 July 2005
Applicant	European Space Agency
Inventors	B.J. Barnes & S. Legate

European Space Agency
Agence spatiale européenne

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